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Impact of embalming and burial on decomposition rates and diffusion of volatile fatty acids in Kentucky

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Impact of Embalming and Burial on Decomposition Rates and Diffusion of Volatile Fatty Acids in Kentucky

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DEDICATION

This thesis is dedicated to the many, many generous individuals who donated their time, expertise, and materials so that this study could come to fruition. It is only because of all of you that this was a success.

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Abstract

Six still-born fetal pigs were divided into two groups (three were embalmed, and three non-embalmed) to determine a postmortem interval on decomposing remains in eastern Kentucky. One pig from each group was placed on the surface, one from each group was interred at a depth of two feet, and one from each group was buried at four feet. This study focused on observing necrophagous insect succession as well as how far on both a horizontal and a vertical plane volatile fatty acids leach from a body. Soil samples were taken from near all specimens at the time of respective termination of the project in order to determine leaching distances.

Results show that embalmed remains mummify, and, hence, attract more beetles than non-embalmed remains. Results also demonstrate that volatile fatty acids are not degraded by embalming fluid and leach out both vertically and horizontally, with higher concentrations running vertically. Soil associated with buried remains tend to retain higher concentrations of volatile fatty acids than do soils associated with surface remains.

Embalming, Volatile Fatty Acids, Insects, Burials, Surface Remains, Kentucky

Chapter 1: Introduction

Embalming the dead has become a standard practice of body preservation in the United States. Though embalming is designed to preserve, it does not halt the process of decay, but merely slows down the natural decomposition process. Despite the prevalence of this mortuary practice in America, little research has been conducted concerning the fate of preserved remains once they are interred in the ground. Many factors affect the preservation process and, currently, little information exists concerning how to determine the interval of time that preservation can be conserved (Mayer, 2005). While the inevitable decay process is occurring, a variety of organic compounds are leaching into the surrounding soil. These volatile fatty acids remain in the soil for a considerable amount of time, though how far both vertically and horizontally they travel from the body is unknown. Also, little data exist concerning insect activity and postmortem interval associated with the degradation process of the embalmed body. Data from the current research concerning the embalmed body will provide a basis for comparison and contrast to unpreserved decomposition, which at this point is lacking in direct comparison.

One goal of this project was to determine how far on a horizontal and vertical plane volatile fatty acids from remains are leached into the surrounding soil. Soil samples were taken from subjects placed on the surface as well as below the surface for both embalmed and unembalmed remains. Also, this project includes collection and evaluation of necrophagous insect succession and postmortem interval between the preserved and non-preserved subjects. Forensic anthropology and taphonomy are relatively young fields, and any data that can be added are vitally important to the body of knowledge as a whole. I hypothesize that embalmed remains will decompose at the same rate as unembalmed remains found on the surface as well as buried

beneath the soil. I also suspect that volatile fatty acids will not diffuse in high concentrations from embalmed bodies.

The results of this study expand the amount of knowledge available concerning postmortem interval in eastern Kentucky, as well as the postmortem fate of the embalmed. The study also sets a baseline for determining how far from the body volatile fatty acids are leached from both embalmed and non-embalmed bodies, thereby, allowing clandestine graves or disinterments to be discovered through soil analysis. The results have implications for embalmers, funeral directors, law enforcement, entomologists, archaeologists, forensic anthropologists, and issues concerning human rights violations.

Chapter 2: Literature Review

The Culture of Preservation

Every culture has some form of funerary practice and associated ritual. As humans, we connect with one another socially, emotionally, mentally, and spiritually. Because our species has an innate and irrepressible need to make and maintain social connections, the loss of a beloved member of humanity is a very prominent aspect of culture. How we experience grief, loss, and death are all interconnected, and the expression of these intense emotions differs from culture to culture. The manner in which a society deals with its dead tells a great deal about how it views the living. Some cultures, such as the Egyptians and some Chilean and Chinese cultures, practiced intentional mummification to preserve the body for the afterlife. Other cultures, such as those in Iron Age Europe, created unintentional preserved mummies known as bog bodies (Ross and Robins, 1991). Though the preservative qualities were unknown at the time, the low oxygen content of the peat bog prevented bacterial decay, thereby preserving many of the body's attributes (Ross and Robins, 1991).

Embalming is another more widely practiced method of preservation, especially in the Western World. The purpose of preservation of a body in America as a whole seems to have changed. Many cultures preserve the body or conduct various other types of funerary rites according to their particular cultural belief in the afterlife, whether the goal is to release the soul from the remains or preserve the body for use in the supernatural realm. Since the rise of embalming, Americans seem to have taken a dissociative step back. Embalming today seems to have more to do with the living than the deceased. Embalming has turned into a way to view death with "rose colored glasses." It is a manner in which the living can deny that their recently

departed ones will return to the earth. While there is no fault in this, perhaps it could be one major explanation for embalming in present day America.

One of the most famous cases of embalming is Vladimir Ilyich Lenin. Lenin was a Russian politician who was embalmed in 1924 and is currently on display in pristine condition in Moscow's Red Square. Lenin is viewed as a national hero of Russia even today and many visit his body yearly (Forest and Johnson, 2002).

Another famous case of a well-preserved embalmed body is known as the "Wife of the Marquis of Dai." In the Changsha city of China, archaeologists uncovered three tombs, all belonging to the Marquis of Dai's family. Upon being exhumed, researchers discovered that the occupant (eventually named "Lady Dai") was immersed in a red liquid, eight to twelve inches deep (Bahn, 2003). Likewise, the Sui Xiaoyuan mummy was found in China and was preserved as well as Lady Dai. This adult male, was found in similar conditions with the same red liquid. In ancient China, cinnabar was used as a funerary antiseptic and preservative, so cinnabar might be one component of the liquid. More tests are needed to determine the specific chemicals in the red liquid, but favorable environmental conditions are thought to have played a role in this level of preservation as well (Bahn, 2003).

Yet, another example closer to home is the famed example of a body examined by Dr. William Bass. Bass misinterpreted the postmortem interval of a grave he was called in to consult upon in Tennessee. Due to unusually pristine preservation, he stated that the body had been deceased no more than a few months. In reality, the body had been dead for almost 113 years. The body was that of an American Civil War soldier who had been embalmed. This led to the first anthropological human decomposition facility (Bass and Jefferson, 2003).

History of American Embalming

Embalming first became widespread in the United States between 1862-1865, while the American Civil War raged. Many soldiers perished far from their homes, and since transportation technology was not as advanced as it is currently, the bodies of soldiers decomposed before they could be transported back to their family. This situation was highly problematic and distressful, since the deceased soldier's loved ones desired to perform the culturally-accepted American tradition of saying goodbye to the dead. Wakes were often held in the home, as the modern day funeral home was not yet a predominant part of the community. With transportation slow, the putrefaction process had often not only begun, but at times could be advanced, making a traditional open casket wake impossible. To afford families the opportunity to view their fallen soldier one last time, the practice of embalming increased (Whiskind & Spiegel, 1998).

Dr. Thomas Holmes is credited with popularizing embalming in the United States during this time period (Scandura, 1997). Dr. Holmes embalmed deceased soldiers so they could be shipped home. He charged seven dollars to embalm a soldier and thirteen dollars for an officer, according to the National Museum of Funeral History. The arterial method of embalming emerged at this time as well, making embalming more efficient (McGlashan, 2006). Though Holmes worked under less than ideal conditions with rudimentary equipment, he managed to embalm many soldiers expertly. After the Civil War drew to a close, the practice of embalming set off on the path to professionalism.

During the early 1800s, embalming and funerary practices had not yet become commercialized (McGlashan, 2006). In eastern Kentucky, where the current study was conducted, relatives and loved ones handled all mortuary practices privately. Wakes were

usually held in the home, and those in attendance sat up all night with the dead. Friends and relatives brought food to the home where the wake was being held and this practice served as a way to knit the community together. Relatives attempted to prevent discoloration of the body by mixing baking soda with water and placing a cloth in this solution and covering the face of the deceased. The damp cloth would remain in place while the body was not being viewed. A coin was placed over each eye to keep the eyes shut and prevent them from opening. A body was usually kept above ground for three days and three nights so that premature burial of a person who was still alive, but perhaps in a coma, would not take place. In instances of trauma, where there was certainty that a person was dead, the burial was immediate and the three-day rule did not apply.

The three-day rule was also affected by the seasons. In the summer, when temperatures were at their highest, a body would occasionally be buried before the three days were up because the decomposition process was becoming too advanced. Environmentally friendly burials known as "green burials" were the norm, and a wooden coffin was constructed by a relative (Bonnie Watkins McQuinn, personal communication). Green burials were prominent due to the economic situations of the families, as well as the lack of embalmers in rural areas. Even if a professional embalmer had been available, many would have been unable to afford such services.

Most graves were positioned to face an eastward direction, a practice that is still continued today. Historically, this orientation has ties to the Christian religion's Judgment Day prophecy. According to this prophecy, by interring an individual in a supine position, with the head pointing toward the West, the dead will be facing in an eastward position when they sit up

and arise on Judgment Day (Rathbun and Buikstra, 1984). This presumably is due to the eastward orientation of the city of Jerusalem, Israel, which is a prominent country in Christianity.

During the 1880s the practice of embalming and funeral directing emerged as a profession, and the National Association of Funeral Directors held its first conference in 1882 (McGlashan, 2006). Today, all US embalmers and funeral directors must be licensed, and strict federal and state laws must be followed. Most families in North America no longer take care of the dead, but instead rely upon funeral homes to handle all preparations. Gone are the days when a family member constructed a wooden coffin. Funeral homes now offer a variety of commercially-manufactured coffins in an array of colors and materials. Modern day funeral homes essentially have distanced the living from the dead.

Methods and Manner of Present Day Embalming Arts in America

Embalming today is done in either one or a combination of four methods. The first method is arterial/vascular embalming. This method is the most common method used in America. It takes advantage of the natural efficiency of the circulatory system by injecting embalming fluid into one of the major arteries of the body (usually the jugular or femoral artery) and gradually replacing the blood with preservative. The circulatory system does most of the work by allowing the preservative to flow through the arteries to arterioles to capillaries, thus hydrating tissues of the body. Embalming fluid is pumped into the body using an embalming tank that regulates the rate and the flow of pressure. All blood is removed from the body through a drain tube in conjunction with the introduction of the arterial embalming fluid (Frank Porter, personal communication).

The second method that can be employed is cavity embalming. This method first aspirates the contents of the fluid-filled organs of the body. It also removes any gases and fluids

that may have accumulated in the body. Tube-like instruments called arterial tubes, or Luer-Lock syringes, are then used to inject embalming fluid into the body cavities (Mayer, 2005).

The third possible method is called hypodermic embalming. This method uses hypodermic needles to inject embalming fluid into the body's tissues. This is designed to treat any area of the body that was not effectively embalmed through the arterial method and is usually avoided unless necessary because it can be costly (Mayer, 2005).

The fourth method of embalming is surface embalming. This is done by painting or spraying embalming fluid onto the skin. This method can be effective on small areas, such as the eyelids, but is the least used method due to obvious inefficiency to permeate below the skin's surface (Mayer, 2005).

Kentucky Laws Concerning Embalming and Interment

At present, the state of Kentucky has no law requiring that a corpse be embalmed. The only exception to this law is if there is a public viewing. If a public viewing is held, the deceased individual must be embalmed due to health regulations. If a body is designated for cremation, the body does not have to be embalmed first unless there is public viewing (Frank Porter, personal communication).

Currently, no law is in place in the state mandating that a corpse be placed inside an outer rigid container, such as a casket. However, city-wide laws or individual cemetery restrictions require outer rigid containers. For example, the city of Lexington, Kentucky, requires a casket, whereas no cemetery in the county where the current research took place requires an outer container. The Attorney General of the Commonwealth of Kentucky dictates that there be at least two feet of dirt covering the surface of the burial; most funeral homes dig graves to a depth of four or four and a half feet (Frank Porter, personal communication).

Taphonomy

In order to account for all variables that impact decomposition, multiple factors must be taken into consideration. These factors include such aspects as temperature, elevation, moisture, soil type, wind, shade, vegetation, and season. Given the multitude of variables that can influence the decomposition process, the study of taphonomy is a necessity.

The term taphonomy originates from the Greek term "taphe," which translates in the English language to "grave" or "tomb." Taphonomy is the study of death and the processes by which the body decomposes. This includes trauma, decomposition, postmortem interval, scavenging, mummification, and necrophagous insect succession (Haglund & Sorg, 2001). By studying taphonomic processes, trained personnel can work backward to determine important information concerning when and how long an organism has been dead, whether a body has been moved from a primary dump site to a secondary one, and even in what season the death occurred.

Factors such as daily maximum, minimum, and average temperatures, climate, cloud cover, ecosystem, rainfall, elevation, wind, weathering, contact with the ground, and geomorphological features affect insect activity and the types of insects that invade the body. Even the presence of shade verses direct sunlight can speed up or slow down decomposition processes, as well as body weight, bloat size, and number of insects (Shean et al. 1993). It cannot be stressed enough how taphonomic processes are varied and dependent upon climate and environmental differences. Postmortem interval can differ by altering any one of these factors.

The depth at which a body is buried also affects the level of decomposition. In a study conducted by Rodriguez and Bass (1985), multiple unembalmed bodies were buried at varying depths (one, two, and three feet) and exhumed at different times (one month, two and a half

months, six months, and one year) to determine taphonomic changes that occurred on the bodies as well as changes on the surface vegetation, surrounding soil pH, and access to arthropods. Results from this study determined that indeed, surface vegetation is affected depending upon the depth at which a body is interred as well as insect access to the body. Also, deeper burial depth results in enhanced preservation., and the most shallow burial depth still allowed for some arthropod activity (Rodriguez and Bass, 1985).

Preservative chemicals applied to corpses have an impact upon decomposition rates. Both Meadows et al. (1988) and Bass(1988) conducted studies concerning embalmed cadavers placed upon the surface of the ground at the Bass Anthropological Research Facility in Knoxville, Tennessee. Both concluded that the sequence of decay stages remains the same, but on a delayed time frame. An article by Berryman et al. (1991), discusses the confusion that can arise from cemetery remains versus forensic remains.

Berryman (1991) found that while subtle visual clues, such as presence of facial hair, can hint as to whether or not a body has been embalmed, toxicology analysis must be performed. One must be familiar with embalming practices through the ages, as different chemicals were employed over time. He concluded that the best method for determining cemetery remains from those of a forensic context lay in the burial artifacts associated with the body (Berryman et al. 1991).

In the current study, fetal stillborn pigs were used due to their manageability of transport and handling and their anatomic similarities to the human body. Though donated human remains would be preferred specimens for study, swine are a scientifically-approved surrogate. Next to primates, swine are the most biologically similar to humans, and they are by far the easiest organism to acquire for research purposes. Pigs resemble humans in that they have similar sized

torsos and amounts of body hair by comparison (Catts and Haskell, 1990). Parts of the swine anatomy have been transplanted into the human body to support and maintain life. Though their heart structure may differ from that of humans in that they have only two chambers instead of four, their circulatory system is so close to that of human beings that they have been involved in cardiovascular research (Crick et al. 1998). Thus, pigs are acceptable stand-ins for humans when undergoing arterial embalming. Forensically, pigs decay in the same manner as humans, and, therefore, taphonomic and entomological data can be recorded and analyzed (Gremillion, 2003).

The process of decomposition usually begins inside the corpse and proceeds to the outside of the body. Each researcher may identify and define his or her own phases of decomposition. Byrd and Castner (2009) have identified five stages of decomposition observed in terrestrial environments. The first is referred to as the "fresh stage." This stage begins at the moment of death of an organism and ends when bloat is first observed. Depending upon the environment and climatic conditions, this stage can last anywhere from hours to days. At this initial stage, no odor may be detectable, but bacterial processes are beginning to occur. Additionally, blowflies and flesh flies are attracted to the body orifices or any area where trauma is present.

The second stage is known as the "bloated/putrefaction stage." This stage is when the highest numbers of flesh flies and blowflies are present on the body. Odors increase during this phase, making the body even more attractive to insects, which begin depositing eggs. This stage is characterized by a distended abdomen that is highly visible. Due to metabolic breakdown inside the body, gases are produced that cause the body to swell in size and appearance. The bloated/putrefaction stage lasts from the point that the body begins to bloat until it starts to deflate (Byrd & Castner, 2009).

Phase three is the "decay stage." The body deflates, and maggot masses are highest in number and produce extremely high amounts of heat. The large numbers of maggots pour out of the corpse and attract beetles which feed on them. By this stage, the skin on the body is split apart and is mostly deteriorated (Byrd & Castner, 2009).

Phase four is the "dry stage" in which most of the body fluids have already leaked out of the body. In this stage, most of the body's skin and soft tissue has been desiccated and fly and maggot activity is virtually over. Beetles are the main insect type that show up during this phase (Byrd & Castner, 2009).

The "skeletal stage" is the final phase in the decomposition process. At this point, all that remains are the bony elements of the body. Little insect activity is present except for mites (Byrd & Castner, 2009). The bones are fully exposed at this point and are subject to weathering or some scavenging by rodents or other wildlife that may try to crack open the bone to reach the marrow.

Other researchers have identified their own phases of decomposition based upon the visual changes of the remains. For example, Allison Galloway et al. (1989) identify five stages of decomposition that differ from Byrd and Castner's stages. Galloway et al.'s stages of decomposition are perhaps most applicable to dry, arid climates.

Galloway et al.'s first stage of decomposition is called the "fresh" stage. This initial stage applies to remains that have suffered no insect disturbance or color alteration (Galloway et al., 1989).

The second stage according to Galloway et al. is the "early decomposition" stage. During this time, the color of the flesh begins to turn a green, gray, or black color. Skin slippage begins and the body may either bloat or deflate.

The third stage is termed "advanced decomposition" and includes more extreme flesh sagging as well as the possible appearance of adipocere. Maggot and insect activity is at its peak, and the internal organs are no longer present. The outer skin may begin to mummify at this point as well (Galloway et al., 1989).

"Skeletonization" is the fourth stage and is defined as the point when over half of the bones become exposed. At this point, the bones may still be wet and greasy, or completely dry. Any tissue still present is now becoming desiccated (Galloway et al., 1989).

The fifth and final stage is termed "extreme decomposition." At this point the bones are now completely visible and becoming weathered and bleached. The bones are beginning to deteriorate from exposure to the elements, and the trabecular bone may be visible at this point (Galloway et al., 1989).

The Galloway et al. taphonomic classification works well for arid climates, where decomposition generally proceeds rather rapidly, and involves a time span of days to weeks. This classification is not adequate for all climates, and varying stages, descriptions, and time allotments are needed for colder climates. Komar (1998) defined her own set of taphonomic stages for colder climates, where decomposition can occur much more slowly. Komar's stages span a window of months to almost a decade. In colder climates, insects are less active or not active at all, which can greatly slow the decay of surface remains. Lower temperatures also decrease the rate at which moisture and decomposition fluids evaporate from the body, thereby delaying decomposition.

Komar (1998) termed her first stage of cooler climate decomposition as "moderate." During this initial stage, bone may become slightly exposed, and therefore accompanied by a

reduction in soft tissue. If conditions allow for enough moisture, then adipocere may form on the remains as well.

Komar's second stage is called "advanced" and includes such visual cues as excessive adipocere and more extensive bone exposure. At this point, there is an increased loss of internal organs. The third stage is "skeletonization." Very little tissue is left on the remains. Most bones have become exposed (Komar, 1998). By Komar's fourth and final stage, "completely skeletonized," all bones are completely exposed and are entirely devoid of any tissue (Komar, 1998).

Scavenging can also be a taphonomic factor that can influence the rate of decay. While insects are major taphonomic players, they are not the only organisms that can hasten decomposition. Animals frequently visit remains as a source of food. Scavenging fauna can disarticulate and reduce a fleshy body to bone in a short span of time. Haglund and Sorg (2001) created a classification system for scavenging animals. Stages begin with the number zero to denote fresh remains, and progress to the number four stage, which represents a skeletonized state. These stages span a time span of days to a few years.

Cases involving buried remains currently have no clear and concise scale of decay stages (Haglund and Sorg, 2001). Since buried remains cannot be directly observed and factors such as depth, moisture level, slope grade, and soil type all serve as variables in the degradation of buried remains, stages are difficult to assign.

For this study, I created my own taphonomic stages based primarily upon Byrd and Castner's (2009) classification system. The first stage is denoted as "fresh." During this stage, there is an absence of decay and skin color is maintained. Fly activity is minimal to absent. No odor is present.

The second stage is "bloat/putrifaction." For this stage, I defer to Byrd and Castner's definition (Byrd & Castner, 2009). My third stage is "active decomposition." During this phase, fly activity has increased exponentially and maggots are present in minimum to moderate numbers. Beetles are present at this stage as well. Remains are also accompanied by a strong odor of decomposition. Skin color has changed to a darker hue and is disappearing at this point. Some bones are becoming exposed.

The fourth stage is the 'advanced decomposition" stage. At this point, flies are at their maximum numbers. Maggots, too, are at a maximum and many of the bones are exposed. Very little soft tissue remains at this point. Beetles are becoming more numerous, though there is still a strong odor of decomposition associated with the remains. If there is any tissue remaining, it has turned a dark brown color, and the remains are still very moist.

The fifth stage is the "dry/skeletal" stage. All bones are exposed and any small amounts of remaining skin have become desiccated. Odor associated with the remains has decreased or may be absent. Bones are dry, and there is no longer moisture associated with the remains. Flies and maggots are absent, but beetle larvae may still be seen in small numbers.

The sixth stage is "mummification." In some instances and under certain conditions, the other stages may be skipped in lieu of entering directly into the mummification stage. During this stage flies and maggots are absent, but beetles and beetle larvae are present. The outer skin has dried out and the internal organs have become desiccated as well. Little to no odor is associated with the remains, and the outer skin coloring has turned a dark shade of brown. Some bones may be exposed, especially in the head and extremities. Holes may even be present in the hide. Little or no moisture is present at this stage.

Soil Leaching and Volatile Fatty Acids

In addition to observing postmortem interval and insect succession, the leaching of volatile fatty acids (VFA) from the body was measured. Little information is available concerning VFA leaching, and this study would add to the current knowledge base. This project will not only focus on presence or absence of VFAs, but will incorporate concentration as well as how far from the body on both a horizontal and vertical plane that VFAs travel.

Volatile fatty acids are composed of fatty acids attached to short chains of carbon atoms (Evershed, 1993). They remain biologically active in soil for great lengths of time and form during the period a body undergoes active decomposition (Tuller, 2002). Archaeological excavations frequently reveal the presence of volatile compounds long after an organism has died and a site abandoned. At the archaeological site of Qasr Ibrim, Egypt, volatile compounds from plant matter were detected throughout various phases of settlement (Evershed et al. 1997). Human volatile fatty acids were also present at a cemetery tested in Duz, Kosovo, and a mass grave site in Knin, Croatia, six years after the bodies had been buried (Tuller, 2002). Volatile fatty acids are byproducts of decomposition and may also be used to assist in determining the weight of the deceased (Vass et al. 1992). Since VFAs can be tested for and detected, they have the potential to yield a wealth of information concerning clandestine graves, secondary burial sites, archaeological data, and overall soil composition.

Chapter 3: Materials and Methods

In this study, the taphonomic processes of decomposition and the succession of necrophagous insects were observed in both embalmed and non-embalmed specimens on the ground surface and interred in the ground. The leaching of swine volatile fatty acids and the distances they travel away from the body in both a horizontal plane and vertical plane were measured for as well. The swine (*Sus scrofa*) used in this project were acquired from Rebecca Lirette, at the Swine Unit of Louisiana State University's Ben Hur Farms. All were still-born and frozen immediately after birth at the swine facility (Table 1).

This study took place in the mountains of eastern Kentucky, specifically, in the community of Rogers, which is located in Wolfe County (Figure 1). Rogers lies at an elevation of 1217 feet above sea level, a latitude of 37.35 degrees North, and a longitude of 83.65 degrees West (National Weather Service). The freeze zone is approximately twenty inches in this area of the country (Haglund and Sorg, 2001). The pigs were transported to eastern Kentucky using coolers, dry ice, and styrofoam. The pigs were checked routinely to confirm that they remained solidly frozen, until which time they were placed back into a freezer. The freezer was maintained at a constant zero degrees Fahrenheit. All pigs should be considered sterile as a result of their still-born state.

Figure 1. Wolfe County, Kentucky, and a close up view of Rogers, Kentucky (Google maps)

The pigs were thawed in a gradual manner. They were moved from the freezer, triple bagged in plastic bags that were sealed with duct tape, and placed in lukewarm water overnight.

No insects were able to make contact with any of the pigs until the time they were placed in the field. All pigs were weighed and all fell into an approximate range between two to two and a half pounds.

Table 1. Pig Weights

Pig	Weight
McQuinn Surface (Embalmed)	2.75 lbs
McQuinn 2 Foot (Embalmed)	1.875 lbs
McQuinn 4 Foot (Embalmed)	2.125 lbs
Kash Surface (Unembalmed)	1.75 lbs
Kash Surface 2 Foot (Unembalmed)	2.375 lbs
Kash Surface 4 Foot (Unembalmed)	1.5 lbs

The duration of this study for the two surface pigs began on June 1, 2010, and was terminated June 30, 2010. For all four buried pigs study began on June 1, 2010, and officially ended October 31, 2010. The specimens that were buried remained undisturbed and in situ until the date of termination, at which time they were exhumed and soil samples were collected.

Embalming Procedure

All embalming was performed by local embalmer, Gary Sparks, who has over thirty years of experience in the field. All embalming equipment used was provided by Porter & Son Funeral Home, located within Wolfe County. Wolfe County Coroner, Frank Porter, also served as a consultant and contributor to this study. All pigs were embalmed in a manner that would be performed on a human comparable in size and weight. A vascular (arterial) method was chosen along with the cavity method since these two are routine in the regular embalming of the human body (Figure 2).

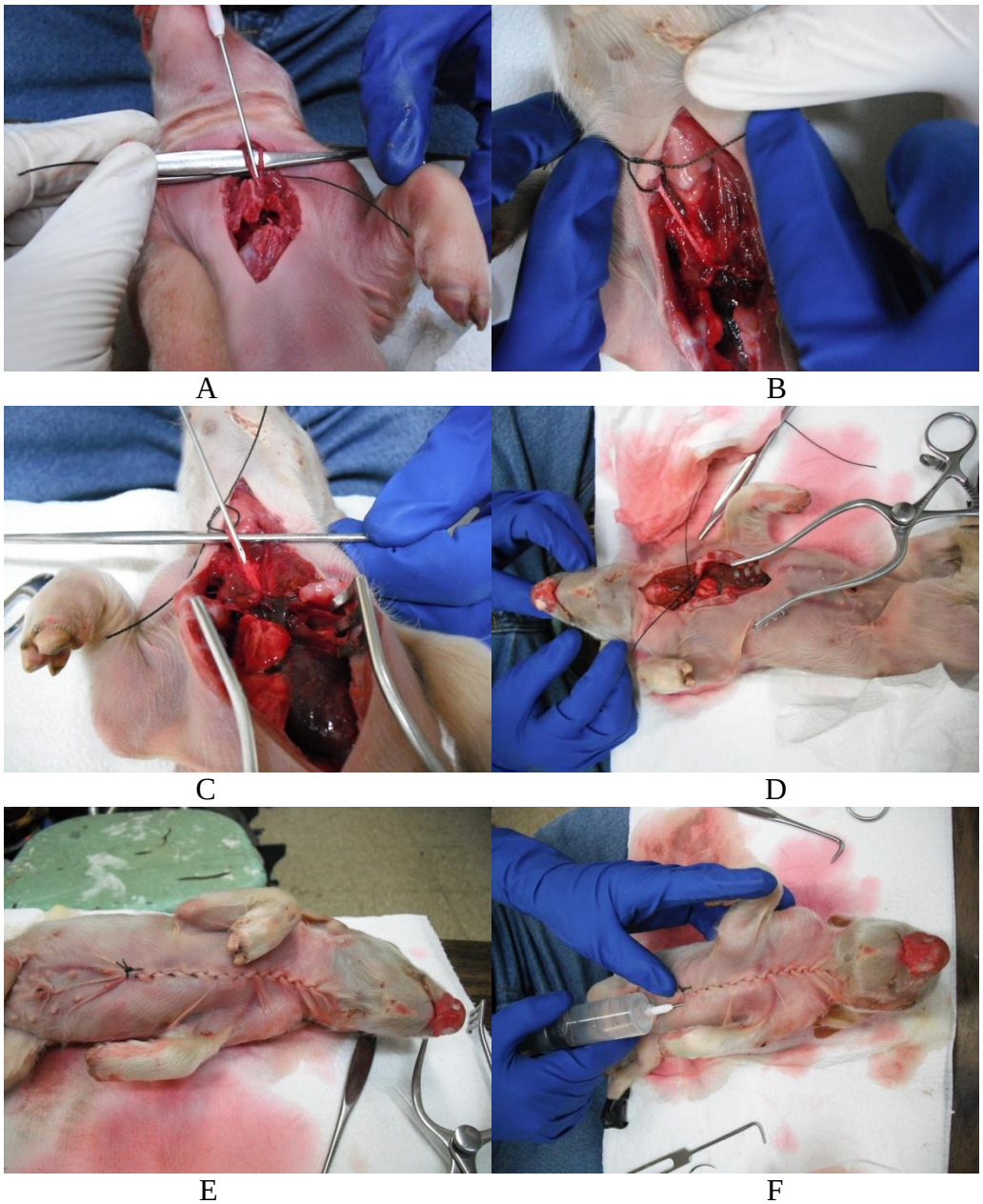


Figure 2. Embalming Procedure Photographs (A-F). (A) Locating major arteries and veins. (B) Tying off carotid artery. (C) Injecting Champion® Arterial Fluid with a Kendall Monoject™ Luer Lock syringe into the descending aorta. (D) Pink froth exiting the nasal opening, indicative of a body that has been thoroughly penetrated with artery fluid. (E) Pig sutured with ligature. (F) Four point cavity injection of Clavicel Cavity Fluid with a Kendall Monoject™ Luer Lock syringe.

Each pig was slit from below the chin to below the sternum. The carotid artery was then located and tied off superior to the injection site. A small slit was then made in the jugular vein to allow for drainage of any residual blood. A 60 mL Kendall Monoject™ Luer Lock syringe was used to regulate the rate of pressure and rate of flow of embalming fluid injected.

Twenty cubic centimeters of Champion® High Cosmetic Arterial Fluid were drawn into the syringe, along with 20 cc of tap water in order to achieve desired dilution. Champion® arterial fluid has an index of 22. The term "index" refers to the percentage of formaldehyde contained within the product. This mixture was then injected into the carotid artery of the pig. This procedure was repeated a total of three times per pig, summing up to a fifty/fifty ratio of artery fluid to water. In total, 60 cc of artery fluid to 60 cc of water were used per pig, equaling 120 cc of diluted artery fluid injected into each individual pig. An arterial embalming method is used in humans and was, therefore, repeated in the pigs because it takes advantage of the organism's extensive vascular system. This ensures total body saturation. Artery fluid preserves and hydrates the tissues of the deceased. It also contains dyes which have a cosmetic effect on the corpse and serves to give a "life-like glow" to the body. Once the total amount of diluted artery fluid had been injected, pink foam began escaping from the nostrils of the pig. This phenomenon occurs in humans and is a sign that the body has been thoroughly penetrated by the arterial fluid. The incision made was then closed using a circular curved needle and ligature twine.

A total of 35 cc of Clavicel cavity fluid were then injected into the pig using a four point entry. Clavicel triple base cavity fluid has an index of 23 and serves to preserve and dehydrate any internal organs and excess moisture that has been added to the pig. All four points were located on the abdomen, and the syringe was shifted back and forth as injection was taking place

as to disperse the cavity fluid and permeate internal organs. Normally, a trocar is used to penetrate internal organs and an aspirator is used to remove fluids associated with these organs. Trocar puncturing and aspiration were not used on the pigs in this study due to their small size, weight, and virtually sterile condition.

Surface Specimen Methodology

This study replicated both a surface-level body dump/disinterment situation as well as a simulated human burial. As noted above, the six pigs were divided into two groups, with one group consisting of three embalmed pigs and the other composed of three non-embalmed pigs. One pig from each group was placed on the surface of the ground in an area that received shade in the late afternoon hours; one from each group was interred at a depth of two feet; and one from each group was buried at a depth of four feet. Each set of pigs was placed at a distance of one-fourth of a mile apart.

Surface specimens were placed inside 16’’x 5’’x 5’’ modified, wire live-trap cages which were staked to the ground using rods of rebar. The cages allowed insect activity to occur unimpeded but prevented the pig carcasses from being disarticulated or dragged away by larger predators. Those that were interred were placed in holes that were dug by backhoe operator Mark White. Buried pigs were not placed stratigraphically on top of one another, but each was buried in such a manner as to represent a separate grave. All graves were clandestine in nature and dug on the same day; all six pigs in the study were put out the following day.

Surface pigs were visited twice daily, and current atmospheric conditions were taken using a Kestrel pocket weather meter each time the pigs were observed. The Kestrel measured current temperature; current, maximum, and average wind speed; humidity; and current heat index. A single high-low thermometer was used to measure daily high and low temperatures and

a rain gauge was placed at each site to record daily rainfall. Ground surface, pig surface, and soil temperature four inches down were recorded at each site for surface pigs using a digital thermometer. Once the surface study was terminated on June 30, 2010, rainfall and weather data were gathered from the National Weather Service (NWS) for the remaining buried four pigs.

Insects were observed and samples collected of the various species and life cycles. Insects were collected from not only the remains, but from the air above the remains as well using an insect net. Adult fly specimens were placed in labeled sandwich bags and then placed in the freezer. Adult beetle and flies were pinned, and eggs and maggots were quickly killed by immersion in boiling hot water. They were then transferred to vials where they were preserved in a mixture of 70% ethyl alcohol to 30% water. Maggot mass temperatures were taken using a digital thermometer. Any beetles or stinging insects collected were killed using 70% ethyl acetate doused onto a section of charge sheet and placed in a kill jar. All necrophagous flies and beetles were sent to the United States Department of Agriculture Systematic Entomology Lab (SEL) in Baltimore, Maryland, for species level identification All Diptera (fly) identifications were done by Norman E. Woodley of SEL. All Coleoptera (beetle) and Lepidoptera (butterfly) identifications were done by Geoffrey White of SEL. Some Coleoptera tentative identifications were done by Maria Allaire of Louisiana State University's Forensic Anthropology and Computer Enhancement Services (FACES) Lab.

Buried Specimen Methodology

Pigs buried at two feet were placed inside a 12''x 7''x 7" live-trap cage and rebar was used to anchor it in place. Pigs at four feet were not caged because the depth made scavenging unlikely. For all buried pigs, each burial pit feature was bisected at the time of exhumation, and soil samples were taken along a horizontal and vertical axis. Horizontal and vertical

measurements were taken from a point where the pig's belly was estimated to have been. Samples were taken immediatly around the pig and then at ten centimeter increments in both vertical and horizontal directions.

Soil Sample Methodology

Prior to the deposition of surface or subsurface pigs, soil samples were taken at all sites and levels of deposition. Soils color was also assessed at time of placement/burial using a Munsell Color Chart (Appendix A and B). Soil samples as well as soil pH and moisture level were recorded at the surface and at each one foot interval down to respective burial depths at the time they were dug.

In order to test for VFAs, soil samples were taken from both sets of embalmed and non-embalmed pigs. Samples were also taken from immediately around the pigs placed on the surface as well as those buried at two-feet and four-feet depths as described above.
All soil samples were collected by trowel. The trowel was washed with distilled water, and the blade scrubbed with a non-reactive scrubber/sponge after each sample. Latex gloves were worn when collecting or handling samples so that there was no cross contamination, and samples were stored in aluminum foil and placed in labeled Ziplock® bags. Samples were taken in larger quantities than needed for testing. Approximately twenty grams or more of soil were taken for each sample regardless of whether it was a control or a variable.

Soil samples were laid out to dry completely in a room that contained two dehumidifiers so that any mold growth was avoided. The soil was laid out on clean and unused plastic bags away from direct sunlight. Once samples were completely dry, they were stored in clean Ziplock® bags.

Control samples were taken for all pigs. For surface pigs, a surface soil sample was taken adjacent to where the pig was placed. For pigs buried at a two-foot depth, a sample was taken from both pits at two feet. For pigs buried at four feet, a sample was taken at four feet.
All soil samples that could potentially yield volatile fatty acids were taken at the respective times of termination or exhumation. Experimental samples were all taken from the fattiest part of the pig (i.e. the stomach) to maximize the potential of VFA results. All experimental samples were taken directly under the pig and then at ten centimeter intervals both horizontally and vertically. Samples were taken at ten centimeter increments up to fifty centimeters, and, in some instances, an additional sample was taken at seventy-five centimeters (Appendix C).

In order to test for VFAs, soil samples were taken from both sets of embalmed and non-embalmed pigs. All samples were taken at the time of respective termination or exhumation. For the surface pigs, samples were taken 30 days after the study began. For all buried specimens, samples were taken 154 days after the study began.

Volatile Fatty Acid Methodology

Gas Chromatography (GC) is a method that allows separation and analysis of both organic and inorganic compounds. GC has become popular method for analyzing volatile compounds (McNair and Miller, 2009). Mass Spectrometry (MS) is used to assess compounds by transforming them into charged ions. The molecular mass of individual components in a compound is also measured using MS (Dass, 2006).

Soil samples taken during this study were analyzed by Buffy Ashton at Louisiana State University's Institute for Environmental Studies, using an HP 5890 Series II 5972 GC with a Mass Selective Detector. Six different volatile fatty acids of a pure/analytical standard were used to create a stock solution with which to generate a concentrated VFA blend. The six fatty

acids used in this study include: acetic, propionic, butyric, isobutyric, valeric, and isovaleric (Table 2).

Table 2. Material Safety and Data Sheet (MSDS) Information Used in Volatile Fatty Acid Analysis

Acid	Linear formula	Molecular weight	Density (g/mL)
Acetic acid	CH_3CO_2H	60.05	1.049
Propionic acid	CH_3CH_2COOH	74.08	0.993
Butyric acid	$CH_3CH_2CH_2COOH$	88.11	0.964
Isobutyric acid	$(CH_3)_2CHCO_2H$	88.11	0.95
Valerie acid	$CH_3(CH_2)_3COOH$	102.13	0.939
Isovaleric acid	$(CH_3)_2CHCH_2COOH$	102.13	0.925

MSDS from Sigma-Aldrich® Company

In order to make the stock solution, one microgram of each of the six acids was combined with ten milliliters of DCM (dichloromethane). Dichloromethane is the standard extraction solvent used by the LSU Institute for Environmental Studies Lab. DCM is insoluble in water, but VFAs are water soluble. When deionized water is added to the soil samples, the VFAs dissolve in the water. DCM is then added to the water phase, and the pH is adjusted and lowered. Once this occurs, the VFAs will be more attracted to the DCM organic solvent than the water. DCM separates very clearly from the water, and it is then injected into the GCMS instrument.

The stock solution contains the highest concentration of VFAs, which is approximately one hundred micrograms per milliliter, or parts per million (1 µL of each VFA in 10 mL of DCM = approximately 100 µg/mL). Six different dilutions from the stock standard were prepared to

achieve varying concentrations to test six different calibration points. Calibration points serve the purpose of demonstrating the range of VFA concentrations detected in the soil samples.

The six different dilutions were all derived from the initial stock solution (Table 3). The dilutions were created from the lowest concentration to the highest concentration so that no cross contamination occurred. Each dilution was made by mixing various amounts of DCM with various amounts of stock. The concentrations created were in a range of 50, 25, 10, 5, 2, and 0.5 μg/mL. After the six dilutions were made, one milliliter of each dilution was poured into separate vials in order to prepare the GCMS instrument.

Table 3. Dilutions Created From Stock Solution for Volatile Fatty Acid Analysis (Least Concentrated to Most Concentrated)

Concentration Range (μg/mL) or (ppm)	Amount of DCM	Amount of Stock Solution
0.5	4.975 mL	0.025 mL
2	4.90 mL	0.10 mL
5	4.75 mL	0.25 mL
10	4.5 mL	0.5 mL
25	3.75 mL	1.25 mL
50	2.5 mL	2.5 mL

Soil samples were then homogenized and weighed. Fifteen grams of each homogenized soil sample were placed into clean amber bottles with fifteen milliliters of deionized water (Appendix D). Bottles were shaken by hand and placed in a sonicator for fifteen minutes. The water phase was then extracted and transferred into a separate vial. Ten milliliters of DCM were added to each vial, and the pH was then adjusted using hydrochloric acid. Vials were sonicated for ten minutes and left to stand for several days.

Since DCM has a higher density than water, it settled at the bottom of the vials. The DCM phase was extracted from the vials and run through a funnel filled with filter paper and sodium sulfate. The sodium sulfate absorbs any water and filters out any dirt that may accidently

pipette out. Beakers containing the extracted DCM phase were then placed on a rotary evaporator or "rotovap" and concentrated down to a volume of one milliliter. Each one milliliter concentrated sample was then pipetted out and placed in separate vials and capped.

At this point, the 0.01µg samples were loaded into the instrument for injection. The instrument was "told" where to look for acids based on the calibration previously calculated. The instrument was run in SCAN mode, and then again in SIM mode. SIM mode searches specifically for VFAs based only upon molecular weight and ion spectra. The resulting chromatogram was then integrated/triangulated by computer software and manually checked by Ashton. Blanks were run between samples to prevent cross-contamination.

Chapter 4: Results

Embalmed Surface Pig (Site: McQuinn Surface)

The study began on June 1, 2010. Figures 3 and 4 detail decomposition from day one to day 30. Though flies were in the area on the first day, a period of approximately twenty-four hours elapsed before any flies or insects arrived on the embalmed surface pig. Flies began arriving late into the evening of June 2. The number of flies was few and the egg masses small. Though flies were present, they only landed on the pig for a short time.

On June 3, the head region began to enter the active stage, though the remainder of the pig's body stayed in the fresh stage. The pig may have skipped the bloat/putrefaction stage entirely. This is most likely due to the fact that the pig's residual blood was removed during the embalming process and replaced with arterial embalming fluid. The torso also had been injected with cavity embalming fluid which most likely prevented it from expanding and entering the bloat stage. These fetal pigs were also considered sterile and most likely had empty gastrointestinal tracts.

Throughout the course of the study, the embalmed surface pig had few flies and a low number of maggots. The maggots tended to avoid the suture on the chest even though it was a portal of entry. The torso remained in the fresh stage until it began to darken in color and become more dehydrated. Ascertaining at what point the torso became mummified was somewhat difficult. I chose to denote mummification as the point when a noticeable color change occurred. Thus, I deemed that the torso began the transition from fresh to mummified on day twelve and entered the mummified stage on day sixteen.

A

B

C

D

E

F

Figure 3. Embalmed McQuinn Surface Photographs - Differential Decomposition (A-F). (A) 06/01/2010 Beginning date (B) 06/02/2010 (C) 06/03/2010 (D) 06/04/2010 (E) 06/05/2010 (F) 06/10/2010

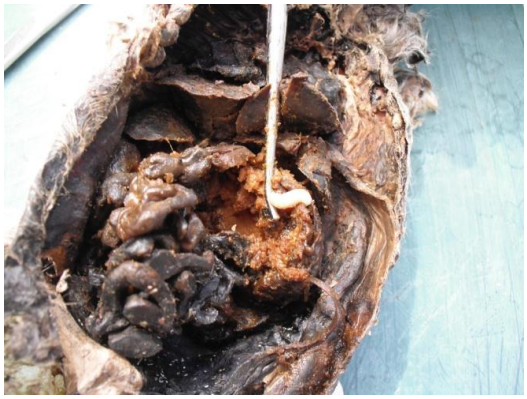
G

H

I

J

K



L

Figure 4. Embalmed McQuinn Surface Photographs - Differential Decomposition (G-L). (G) 06/15/2010 (H) 06/20/2010 (I) 06/25/2010 (J) 06/30/2010 End date (K) Embalmed pig autopsy and adjacent cup with maggots extracted during autopsy (L) Close up of internal organs and maggot removed from pig stomach/intestines

The pig began to decompose from the head back to the proximal end of the torso and then more slowly, from the rear to the distal aspect of the torso. The torso essentially was a

mummified shell housing mummified organs inside its cavity. Considering that the role of cavity embalming fluid is to preserve and dehydrate, this is probably why this pig was not an attractive choice for a majority of insects. Figure 5 contains a color-coded progression of the differential decomposition associated with the embalmed surface pig.

The surface study terminated on June 30, day 30. At this time, the embalmer associated with this study, Gary Sparks, and I performed an autopsy of the embalmed remains to determine if there was any insect life or insect carcasses inside the torso. Initially, upon opening the pig, we saw that the heart, lungs, and liver had mummified. According to Sparks, these results were to be expected due to the chemical makeup of the cavity fluid. What was a surprise, however, was that the stomach and intestines were still moist. Upon closer examination of these organs, we found living maggots inside. We extricated all life forms from the interior of the pig. Some of the largest maggots collected to date were residing inside the stomach and intestinal walls of the pig. We also noticed small holes in the dorsal aspect of the pig where new flies had emerged. I had noticed new emerging flies leaving the pig carcass, but could not ascertain from where they emerged. I found the pupae shells inside the pig and realized that they had hatched from inside the pig and burrowed out through one of the tiny holes in the pig's mummified hide.

In this pig, the stomach and intestines were still moist. Sparks surmised that even though he had injected what he deemed was more than an ample amount of cavity fluid into the torso, that, perhaps, for one reason or another, the stomach and intestines had not absorbed enough of the cavity fluid.

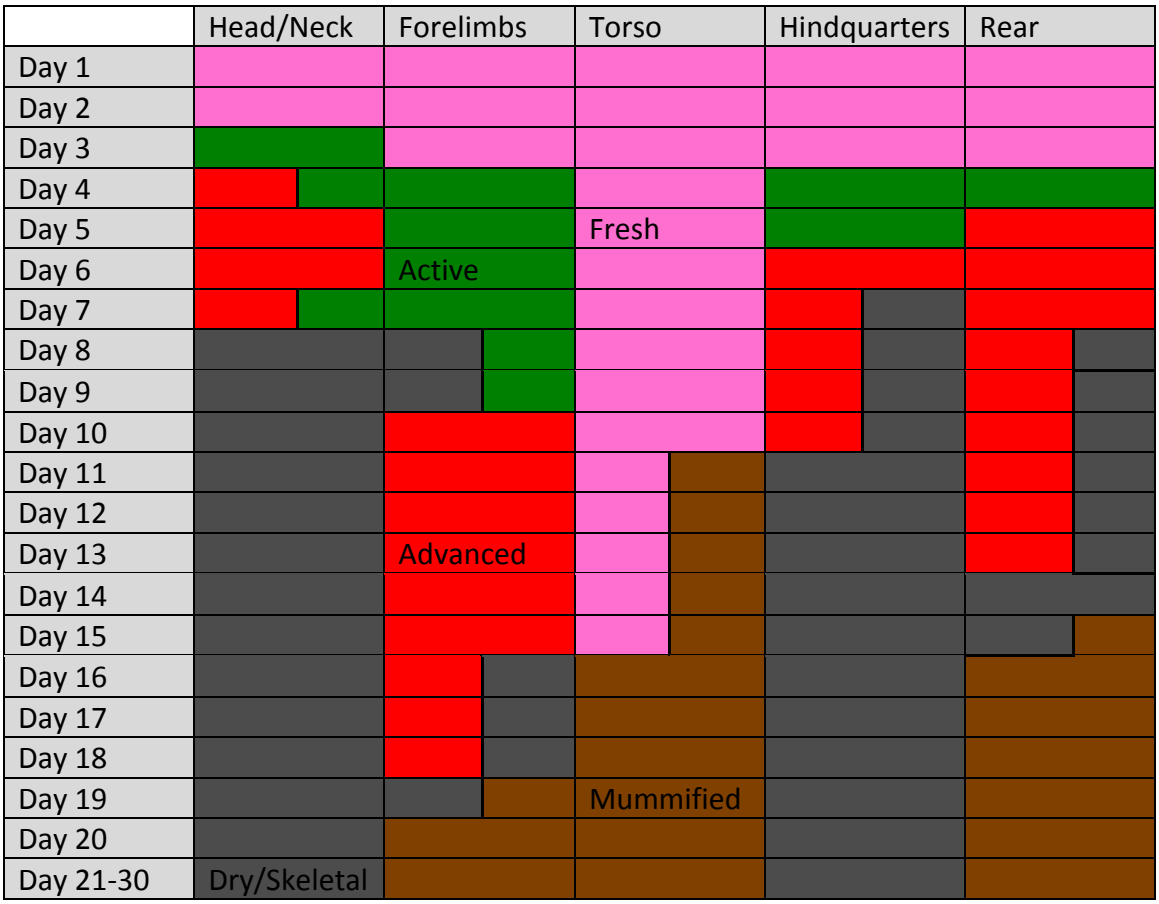


Figure 5. McQuinn Surface Site: Days in Decomposition for Embalmed Pig
Figure depicts color gradient in which differential decomposition occurs/is changing. Pink represents a fresh stage, green denotes the active stage of decomposition, red signifies the advanced stage, gray represents the dry/skeletal stage, and brown denotes a mummified state
.

Unembalmed Surface Pig (Site: Kash Surface)

The unembalmed fetal pig that was placed on the surface had dramatically different results from its embalmed surface counterpart (Figure 6). Within minutes of laying out the unembalmed pig, flies lighted on the remains.

A

B

C

D

E

Figure 6. Nonembalmed Kash Surface Photographs (A-E). (A) 06/01/2010 Beginning date - Fresh stage (B) 06/02/2010 - Active stage (C) 06/03/2010 - Advanced stage (D) 06/04/2010 - Advanced/Skeletal stage (E) 06/05/2010 - Dry/Skeletal stage

The unembalmed pig either skipped the bloat/putrefaction stage due to it previously being placed in the freezer, or it went through the stage in a matter of hours or overnight when observation could not be occur. These fetal pigs were also still-born and considered sterile.

Since their gastrointestinal tract was empty, this also may explain why bloat may not have occurred. By day two, the pig was in the active stage of decomposition (Figure 7). Ants were present and there were a large number of flies that stayed on the body of the pig.

By June 3, the unembalmed pig was in the advanced decomposition stage. The mouth had been eaten away, leaving the underlying bone exposed. The abdomen had begun to compress, and flies were apparent in large numbers. By the fourth day, the pig was in the dry/skeletal stage, but still had an abundance of maggots consuming the remaining moist decomposing tissue and organs that had fallen in the space under the cage. The smell of decomposition was prevalent. All bones were now visible, and more maggots were on the ground than on the remains of the pig itself. By the evening of the fourth day, the bones were dry and becoming whiter from exposure to the sun. The unembalmed pig remained in the dry/skeletal stage for the remainder of the surface study.

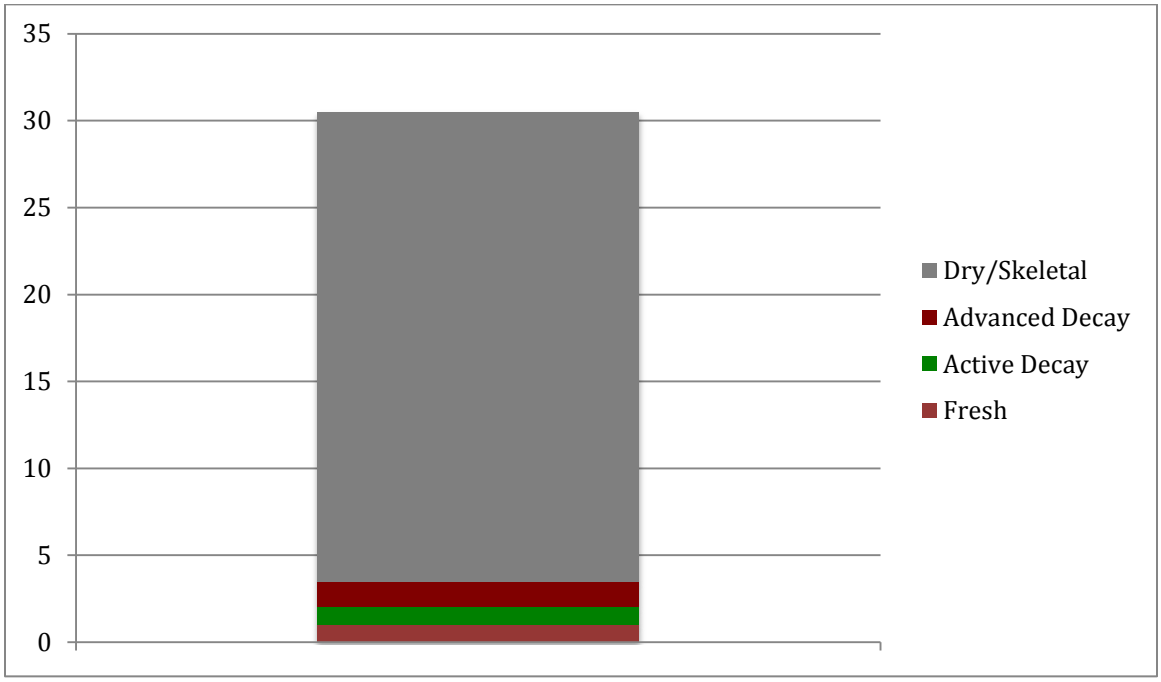


Figure 7. Kash/Unemblamed Surface Number of Days in Decomposition Phases

Embalmed Fetal Pig Buried at 2 Feet (Site: McQuinn 2 Feet)

The embalmed pig interred at two feet was well preserved after 154 days. Body hair was still present, but the skin had turned a dark brown color. The head had completely disarticulated from the rest of the body and all bones of the skull were exposed. The hindlimbs had deteriorated and were disarticulated from the rest of the body. Only one of the forelimbs was still attached, but the region below the knee had disarticulated. The outer skin had dehydrated and shrunk, causing the outline of the ribs to become visible. This pig, like the surface embalmed pig, had become mummified due to the cavity embalming fluid (Figure 8).

A

B

C

Figure 8. Embalmed McQuinn 2 Foot Burial Photographs (A-C). (A) 06/01/2010 Beginning date (B) 10/31/2010 End date (C) 10/31/2010 Close up of head

Unembalmed Fetal Pig Buried at 2 Feet (Site: Kash 2 Feet)

The unembalmed pig buried at two feet had decomposed to a skeleton only (Figure 9). The skeleton had very small amounts of dry tissue present on the cage and it was still articulated. The soil around the pig was dry. The cage the pig was contained in ended up allowing for a vacant space within the cage. Dirt did not completely fill up the cage, so there was a space where air may have allowed for greater drying.

A


B


C

Figure 9. Non-embalmed Kash 2 Foot Burial Photographs (A-C). (A) 06/01/2010 Beginning date (B) 10/31/2010 End date (C) 10/31/2010 Close up of head

Embalmed Fetal Pig Buried at 4 Feet (Site: McQuinn 4 Feet)

At the time of burial on June 1, 2010, the pig was in a fresh state. At the time of exhumation on October 31, 2010, the embalmed pig was still remarkably well preserved (Figure 10). The head and neck region had deteriorated, leaving the underlying bones exposed. The

forelimbs were completely intact, as was the torso. The hindlimbs were intact from the top of the femur, but had been reduced to bone from the middle shaft of the femur down to the hooves. Though the pig had been flattened somewhat from the compression of four feet of dirt, it still retained its overall shape. Its skin coloring was still pinkish with a bit of brown. The body hair was still intact as well. No insects or evidence of insects was present in the grave or near the remains. Overall, this pig was the most well preserved of all six pigs in this study.

A B

C

Figure 10. Embalmed McQuinn 4 Foot Burial Photographs (A-C). (A) 06/01/2010 Beginning date (B) 10/31/2010 End date (C) 10/31/2010

Based upon the embalmed surface pig's condition of its internal organs and its outer skin, one can surmise that this pig is essentially mummified as well. Overall texture of the four-foot embalmed pig also corresponds to the embalmed surface counterpart. The only difference between the two is that the buried pig was only slightly moister than the surface pig. This is

probably due to the fact that the surface pig was exposed to the sun and air, while the buried pig was protected by four feet of dirt and an essentially anerobic environment.

Unembalmed Fetal Pig at 4 Feet (Site: Kash 4 Feet)

The unembalmed buried pig decayed in a manner that was different from any other pig. This pig was the only buried pig that had an odor of decomposition associated with it. Determining what part of the pig I was examining was impossible without looking at the associated bones. This pig was extremely moist and all that remained was some fatty tissue and some adipocere. The remains of the pig had a gelatinous consistency and were a yellow and light pink color (Figure 11). A small amount of body hair was still present and mixed in with the remaining decomposition.

A B

C

Figure 11. Nonembalmed Kash 4 Foot Burial Photographs (A-C). (A) 06/01/2010 Beginning date (B) 10/31/2010 End date (C) 10/31/2010 Close-up remains

Exhumation Comparison of Buried Fetal Pigs

The embalmed buried pigs exhibited greater preservation as compared to the unembalmed buried pigs (Figure 12).

A B

Figure 12. Exhumation Comparison Photographs (A-B). (A) 10/031/2010 McQuinn Embalmed pig at 4 feet and Embalmed pig at 2 feet (B) 10/31/2010 Kash Non-embalmed pig at 4 feet and Non-embalmed pig at 2 feet

Weather Data

The daily maximum and minimum temperatures were recorded using a single high-low thermometer that served to record temperatures for the two surface pigs (Appendix E). Rainfall amounts were recorded using a separate rain gauge at both surface sites (Appendices F and G). Total rainfall for the McQuinn/Embalmed Surface site was 2.72 inches, and the Kash/Unembalmed Surface site received 3.75 inches. The month of June, 2010, was warmer than usual for eastern Kentucky (NWS 2010 Climate Graphs http://www.crh.noaa.gov/jkl/?n=jkl_climate_2010).

Flies are normally active during warmer temperatures and higher humidity (Byrd & Castner 2009) and less active during rainfall (Byers, 2007). Since June had temperatures that often exceeded the normal NWS range, insect activity was unimpeded by weather (Appendix H).

Since volatile fatty acids are water soluble, high rainfall could degrade VFAs (Tuller, 2002). Since weather and precipitation levels can play a major role in both insect succession and VFA detection, these data are included in Appendices I-P.

Surface Pigs Necrophagous Insect Succession Data

A total of 32 insect species were collected from the two surface pig sites from June 1, 2010, to June 30, 2010, (Tables 4, 5, and 6). Of these 32 arthropod taxa, 12 were flies, 14 were beetles, and five were butterflies. Out of the 32 total insect taxa, only nine were present at both the embalmed and unembalmed surface sites. Five taxa of flies overlapped as well as four taxa of beetles (Tables 4 and 5). The fly taxa that overlapped included species of Calliphoridae: C. *Lucilia coeruleiviridis*, C. *Lucilia illustrious*, and C. *Phormia regina*. Species of Muscidae overlapped between the sites, though no specialist at SEL was available for Muscidae identification. One type of Sarcophagidae *Ravinia* was found at both sites, though the species could not be determined.

Table 4. Fly Taxa: Presence, Absence, or Overlap at Surface Sites

ORDER	FAMILY	GENUS and SPECIES	McQuinn Surface	Kash Surface
Diptera	Anthomyiidae	unidentified genus and species		X
	Calliphoridae	*Calliphora vomioria* (Linnaeus)		X
		Cochliomyia macellaria (Fabricius)		X
		Lucilia coeruleiviridis (Macquart)	X	X
		Lucilia illustris (Meigen)	X	X
		Lucilia sericata (Meigen)	X	
		Phormia regina (Meigen)	X	X
	Muscidae	unidentified genus and species	X	X
	Sarcophagidae	*Ravinia*	X	X
		Ravinia		X
	Syrphoidea	unidentified genus and species	X	
	Tabanidae	unidentified genus and species	X	

Diptera identifications by Norman E. Woodley, Systematic Entomology Laboratory, Agriculture Research Service, US Department of Agriculture. Blue denotes insect exclusivity at the McQuinn site only, yellow denotes insect exclusivity at the Kash site only, and green denotes an insect overlap at both sites.

Table 5. Beetle Taxa: Presence, Absence, or Overlap at Surface Sites

ORDER	FAMILY	GENUS and SPECIES	McQuinn Surface	Kash Surface
Coleoptera	Anobiidae	unidentified genus and species *	X	
	Buprestidae	unidentified genus and species		X
	Carabidae	unidentified genus and species *	X	X
		unidentified genus and species *		X
	Dermestidae	unidentified genus and species *		X
	Histeridae	unidentified genus and species	X	X
	Scarabaeidae	unidentified genus species	X	
	Silphidae	Necroses surinamensis *		X
		Nicrophorus *		X
		Nicrophorus tomentosus *	X	
		Oiceoptoma noveboracense *	X	
		Oiceoptoma *	X	X
		Silpha americana *	X	X
	Staphylinidae	Creophilus maxillosus (Linnaeus) *	X	
		Platydracus comes *	X	

Coleoptera identifications by Geoffrey White, Systematic Entomology Laboratory, Agriculture Research Service, US Department of Agriculture. A (*) sign denotes a tentative identification by Maria Allaire, Louisiana State University Forensic Anthropology and Computer Enhancement Services Lab. Blue denotes insect exclusivity at the McQuinn site only, yellow denotes insect exclusivity at the Kash site only, and green denotes an insect overlap at both sites.

Table 6. Butterfly Taxa: Presence, Absence, or Overlap at Surface Sites

ORDER	FAMILY	GENUS and SPECIES	McQuinn Surface	Kash Surface
Lepidoptera	Crambidae	Desmia funeralis (Hübner)	X	
	Hesperiidae	Epargyreus		X
	Lycaenidae	unidentified genus and species	X	
	Nymphalidae	Phyciodes tharos	X	
	Nymphalidae	unidentified genus and species		X

Lepidoptera identifications by Geoffrey White, Systematic Entomology Laboratory, Agriculture Research Service, US Department of Agriculture. Blue denotes insect exclusivity at the McQuinn site only, yellow denotes insect exclusivity at the Kash site only, and green denotes an insect overlap at both sites.

Overlapping beetle taxa include Hister, one type of Carabidae, one type of *Silphidae Oiceoptoma*, and *Silphidae americana*. Insects were not present in the remaining four buried specimens.

Kash Surface/ Unembalmed Insect Succession Data

The majority of insects arrived at the unembalmed surface pig (Kash Surface) during the first few days of exposure, and no additional insects were collected after June 13, 2010 (Table 7).

Table 7. Succession of Necrophagous Insects Collected at Kash Surface/Unembalmed Site

Date Collected	Number	AM	PM	Taxonomy
06/02/2010	4	X	X	*Phormia regina* (Meigen)
	4	X	X	*Lucilia illustris* (Meigen)
	4	X	X	Muscidae
	4	X	X	*Lucilia coeruleiviridis* (Macquart)
	1		X	Syrphoidea
06/03/2010	2	X		Nymphalidae
	1	X		*Hesperiidae Epargyreus*
	11	X	X	*Phormia regina* (Meigen)
	3	X		Muscidae
	1	X		*Calliphora vomioria* (Linnaeus)
	4	X		*Lucilia coeruleiviridis* (Macquart)
	1	X		Sarcophagidae *Ravinia*
	2	X		Silphidae *Oiceoptoma* *
	1		X	Silphidae *Silpha americana* *
06/04/2010	22	X		*Phormia regina* (Meigen)
	1	X		*Cochliomyia macellaria* (Fabricius)
	1		X	Muscidae
	1	X		Silphidae *Necroses surinamensis* *
	4		X	Hister
06/05/2010	1	X		Sarcophagidae *Ravinia*
	1	X		Sarcophagidae *Ravinia*
	1		X	Hister
	2		X	Coleoptera *Buprestidae* *
06/06/2010	3	X	X	Hister
06/07/2010	1		X	Coleoptera Carbide *
06/08/2010	1	X		Anthomyiidae
06/11/2010	1		X	Dermestidae *
06/13/2010	1	X		Muscidae
	1	X		Silphidae *Nicrophorus* *
	1		X	Carbide *

Diptera identifications by Norman E. Woodley, Coleoptera and Lepidoptera identifications by Geoffrey White, Systematic Entomology Laboratory, Agriculture Research Service, US Department of Agriculture. A (*) sign denotes a tentative identification by Maria Allaire, Louisiana State University Forensic Anthropology and Computer Enhancement Services Lab. Purple denotes fly taxa, blue denotes beetle taxa, and orange denotes butterfly taxa.

Though beetles were present, they were fewer in number when compared to flies at the Kash Surface site. Flies associated exclusively with the unembalmed surface pig include Diptera Anthomyiidae, *Calliphora vomioria* (Linnaeus), *Cochliomyia macellaria* (Fabricius), and one type of Sarcophagidae *Ravinia* (Table 4). The most prevalent type of fly by far was *Phormia regina* (Meigen).

Beetle species collected only at this site include a species of Buprestidae, Carabidae, and Dermestidae, as well as *Necroses surinamensis*, and Nicrophorus (Table 5). Two types of butterflies were collected only at this site. These include Epargyreus, and Nymphalidae (Table 6).

More beetle taxa were collected from the embalmed surface pig site (McQuinn Surface) than the Kash site. Insects were captured from June 2, 2010, all the way to the termination date on June 30, 2010 (Table 8). Though flies did visit the embalmed pig and lay eggs, they never remained on or around the pig for very long. Beetles appeared in the early days of the study and generally were present throughout the duration of the surface study. Flies in the later days of the study were mostly captured on the vegetation in the area around the pig.

McQuinn Surface/ Embalmed Insect Succession Data

Flies associated only with these embalmed remains include an unidentified species of Syrphoidea, an unidentified species of Tabanidae, and *Lucilia sericata* (Meigen) (Table 4). Taxa of beetles collected exclusively at this site include Anobiidae, Scarabaeidae, *Nicrophorus tomentosus*, *Oiceoptoma noveboracense, Creophilus maxillosus* (Linnaeus), and *Platydracus comes*. Butterflies present exclusively at the embalmed pig are *Desmia funeralis* (Hübner), *Phyciodes tharos*, and Lycaenidae (Tables 5 and 6).

Table 8. Succession of Necrophagous Insects Collected at McQuinn Surface/Embalmed Site

Date Collected	Number	AM	PM	Taxonomy
06/02/2010	4		X	*Lucilia coeruleiviridis* (Macquart)
06/03/2010	2	X		*Lucilia coeruleiviridis* (Macquart)
	1		X	*Lucilia illustris* (Meigen)
	1		X	Silphidae *Silpha americana* *
06/04/2010	1	X		Muscidae
	6	X		*Phormia regina* (Meigen)
	1	X		*Creophilus maxillosus* (Linnaeus) *
	1	X		Coleoptera Scarabaeidae .
	1		X	*Lucilia coeruleiviridis* (Macquart)
06/05/2010	1	X		Sarcophagidae *Ravinia*
	2	X	X	*Phormia regina* (Meigen)
	1	X		Diptera Syrphoidea
	1	X		Hister
	1	X		Silphidae *Oiceoptoma* *
06/06/2010	1	X		Silphidae *Nicrophorus tomentosus* *
	2		X	Muscidae
	1		X	*Phormia regina* (Meigen)
06/07/2010	1	X		Coleoptera Carbide *
	1	X		Hister
	3	X	X	Muscidae
	1	X		*Phormia regina* (Meigen)
06/08/2010	2	X		*Phormia regina* (Meigen)
	1	X		Muscidae
	1		X	Silphidae *Silpha americana* *
06/09/2010	1	X		Silphidae *Oiceoptoma noveboracense* *
	1		X	Sarcophagidae *Ravinia*
06/10/2010	3	X		*Phormia regina* (Meigen)
	1	X		Sarcophagidae *Ravinia*
	1	X		Silphidae *Oiceoptoma noveboracense* *
	1		X	Muscidae
	1		X	Hister
06/11/2010	1	X		Lepidoptera Lycaenidae
	1	X		Staphylinidae *Platydracus comes* *
	2		X	Coleoptera Carbide *
06/12/2010	3	X	X	Muscidae
06/13/2010	4	X	X	Muscidae
	1	X		Hister
	1	X		Silphidae *Silpha americana* *
	1		X	Nymphalidae *Phyciodes tharos*
06/14/2010	1	X		Silphidae *Oiceoptoma noveboracense* *

(table continued)

	1	X		Nymphalidae *Phyciodes tharos*
	1	X		Muscidae
06/15/2010	1	X		Silphidae *Silpha americana* *
	1	X		Silphidae *Oiceoptoma noveboracense* *
	1		X	Muscidae
	1		X	Coleoptera Anobiidae *
	1		X	Nymphalidae *Phyciodes tharos*
06/16/2010	1	X		*Desmia funeralis* (Hübner)
	1	X		*Phormia regina* (Meigen)
	3	X	X	Muscidae
	2	X		Lepidoptera Lycaenidae
06/17/2010	1		X	Muscidae
06/18/2010	1	X		Nymphalidae *Phyciodes tharos*
	1		X	Diptera Tabanidae
06/19/2010	1	X		*Lucilia coeruleiviridis* (Macquart)
	1		X	Muscidae
	1		X	*Creophilus maxillosus* (Linnaeus) *
06/20/2010	1	X		Muscidae
	1		X	Coleoptera Carbide *
06/21/2010	2	X		Muscidae
06/22/2010	2	X		Muscidae
	1	X		*Desmia funeralis* (Hübner)
	1		X	Nymphalidae *Phyciodes tharos*
	1		X	*Lucilia sericata* (Meigen)
06/23/2010	1	X		*Phormia regina* (Meigen)
	3	X		Muscidae
06/25/2010	1		X	Silphidae *Silpha americana* *
06/26/2010	1		X	*Creophilus maxillosus* (Linnaeus) *
06/27/2010	2	X		Muscidae
	2	X		Sarcophagidae *Ravinia*
06/28/2010	1	X		Muscidae
	2	X	X	*Lucilia coeruleiviridis* (Macquart)
06/29/2010	1	X		Muscidae
	1		X	*Lucilia coeruleiviridis* (Macquart)
	1		X	*Phormia regina* (Meigen)
06/30/2010	1		X	*Lucilia coeruleiviridis* (Macquart)
	2		X	*Phormia regina* (Meigen)

Diptera identifications by Norman E. Woodley, Coleoptera and Lepidoptera identifications by Geoffrey White, Systematic Entomology Laboratory, Agriculture Research Service, US Department of Agriculture. A (*) sign denotes a tentative identification by Maria Allaire, Louisiana State University Forensic Anthropology and Computer Enhancement Services Lab. Purple denotes fly taxa, blue denotes beetle taxa, and orange denotes butterfly taxa.

Volatile Fatty Acids

Testing the soil samples collected yielded the following results. Though there were six fatty acids that comprised the original stock solution, only four acids could be detected in the standard run as well as the soil samples. Butyric, iso-butyric, valeric, and iso-valeric acids were detected. Propionic and acetic acids could not be detected by the GCMS instrument because they exit the injector at the same time the solvent does. There is a solvent delay time period of six and a half minutes between injection and when the instrument is turned on. This delay prevents damage to the GCMS instrument. Due to the inability to clearly detect propionic and acetic acids, these were disregarded and the remaining four acids were used to determine the VFA results for this study. Results from the soil extractions have been converted into parts per billion (Table 9 and Figure 13).

The specimens with the lower concentrations were the surface pigs. Between the two surface pigs, the McQuinn/embalmed pig had very low concentrations of VFAs. The Kash/unembalmed pig had slightly higher concentrations than the embalmed pig. This may be because this sample represented commingled soil, with this sample including the surface soil and soil ten centimeters vertically below the pig. The samples that represented buried pigs had higher concentrations of volatile fatty acids than the surface pigs.

Table 9. Soil Extraction Results

Site Designation	Iso-Butyric Acid	Butyric Acid	Iso-Valeric Acid	Valeric Acid
McQuinn2ftH10	0	0	52	69
McQuinnSV10	0	91	32	43
McQuinn4ftV10	5.1	44	40	51
McQuinn4ftH10	3.0	38	50	45
McQuinn4ftD	32	167	476	147
McQuinn2ftV10	24	131	71	36
Kash4ftV10	245	328	101	247
Kash2ftD	86	251	70	107
Kash4ftH10	290	316	87	88
Kash2ftH10	129	221	82	87

(table continued)

Kash4ftD	5.3	19	81	91
McQuinnSD	0	9.6	46	42
Kash2ftV10	57	117	65	44
KashSH10	0	15	46	69
McQuinn2ftD	181	254	481	727
McQuinnSH10	0	4.9	62	68
KashSD+KashSV10	0	0	372	507
KashSD+KashSV10DUP	0	0	396	477

Concentrations Reported in Parts Per Billion (µg/Kg)

H = Horizontal D = Directly Under Pig

10 = 10 Centimeters

V = Vertical S = Surface DUP = Duplicate

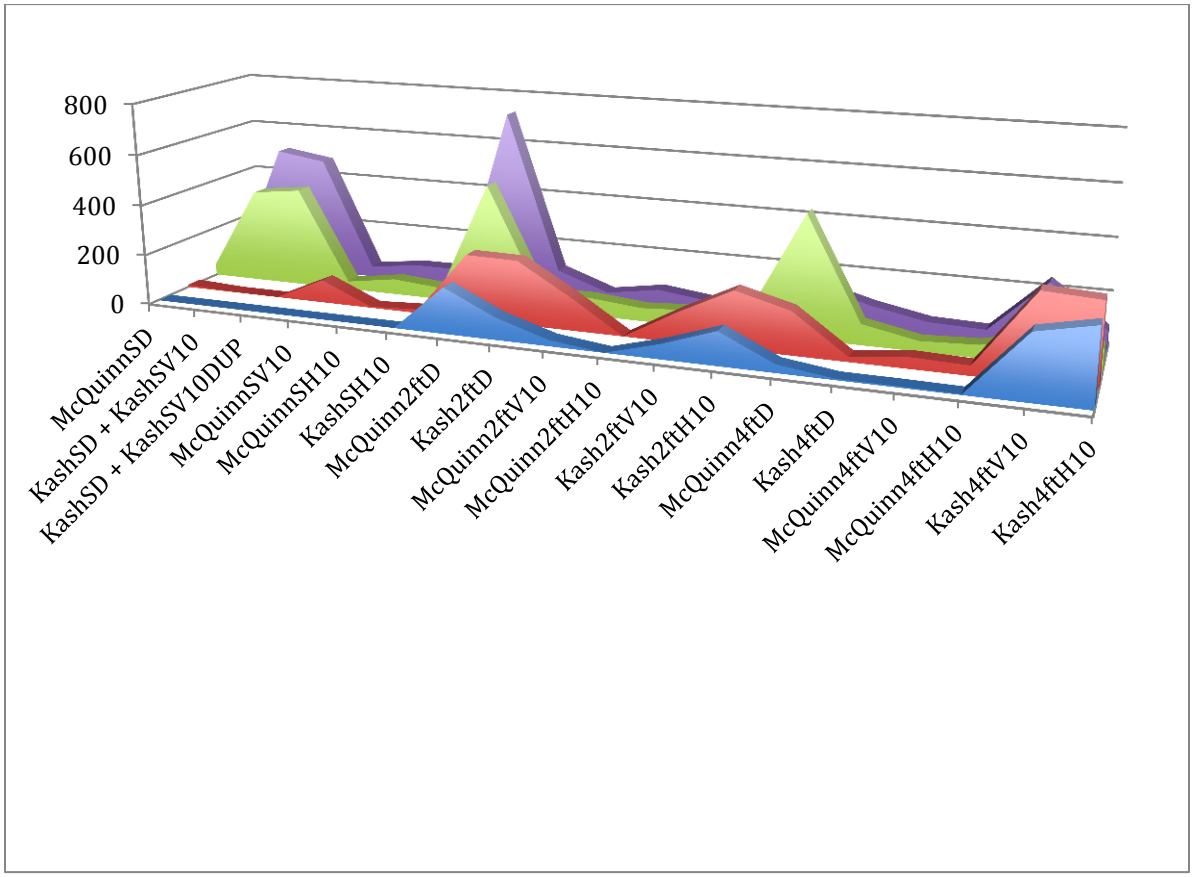


Figure 13. Soil Extraction Results for VFAs in Parts Per Billion

Blue denotes Iso-Butyric acid, red denotes Butyric acid, green represents Iso-Valeric acid, and purple represents Valeric acid.

H = Horizontal D = Directly Under Pig

10 = 10 Centimeters

V = Vertical S = Surface DUP = Duplicate

Chapter 5: Discussion

Embalming the dead results in differential decomposition and greatly delays the natural decomposition process. Both Bass (1988) and Meadows (1988) reached the same conclusion in their studies in Tennessee. With regard to the surface portion of the study, the non-embalmed pig reached the skeletal stage, while the embalmed pig had yet to fully decompose at the termination of the surface study thirty days later. Upon further comparison between the specimens, I noted that necrophagous insects were not equally attracted to embalmed versus non-embalmed remains. The non-embalmed control appeared to be a more attractive choice for insects. Additionally, a noticeable delay occurred in initial insect arrival between the two groups. It took only minutes for flies to arrive at the non-embalmed remains, while a minimum period of twenty-four hours elapsed before flies arrived at the embalmed remains.

Also, overall insect activity between the two surface pigs varied throughout the course of the study. While flies were present on the embalmed remains, they were fewer in number and did not remain long. In contrast, flies were always present and abundant in number on the non-embalmed pig until it reached the dry/skeletal stage. The rapid decomposition process of the unembalmed surface pig is consistent with Byrd and Castner's (2009) stages of decomposition.

Overall, more flies and maggots were observed and captured from the non-embalmed pig and fewer beetles and beetle larvae were captured, while the opposite was true for the embalmed pig. This can be attributed to the diet of both types of insects. Beetles possibly benefitted more from the embalmed pig since they tend to feed on hide and desiccated tissues. Since the embalming cavity fluid, coupled with high temperatures and exposure to sunlight, essentially mummified most of the remains, the beetles had a larger food source. The higher number of beetles captured from the embalmed pig can also be attributed to the length of the

study. Since the non-embalmed pig reached the skeletal stage in a period of four days, the food source was reduced for beetles and absent for flies and maggots. The embalmed pig had not completely reached the skeletal stage in thirty days, leaving a greater window of time for beetles to come and feed.

Perhaps this type of entomological information would be useful in instances where natural disasters (such as Hurricane Katrina, which occurred in New Orleans, Louisiana in 2005) not only resulted in mass casualties, but in disinterment of the dead as well. If those who had been disinterred had been embalmed, then perhaps they would appear mummified and attract similar arthropod succession as occurred in this study. Those who died during the disaster would theoretically decompose at a more rapid rate and attract larger numbers of flies. Additionally, the embalmed dead that had been disinterred may attract more beetles.

Perhaps a state of mummification would also yield evidence of embalming in exhumations as well. It is possible that the unembalmed dead may have higher rates of skeletonization than those who were embalmed. Future research may yield more information and answers.

In terms of specific insects present during this project, three taxa of flies and six taxa of beetles were captured at the embalmed surface site that were exclusive to that site alone. The reason for this is unclear. Perhaps, the pig's location, insect taxa commonality, or difference in decompositional odor may be factors; overall, it is unknown why these taxa of flies appeared at the embalmed specimen versus the unembalmed one.

The unembalmed surface site, too, had arthropod taxa that were exclusive to the unembalmed pig as well. Four fly species, five beetle taxa, and two butterfly taxa were site specific to the unembalmed pig. Again, the reason for this site specific insect taxa is unclear.

Perhaps the location of the pig, insect area commonality, or the traditional smell of decomposition may all be factors; yet, at this time, no definitive answer is available.

With regard to the buried specimens, embalming greatly extends the preservation of the dead. The two embalmed pigs still retained body hair and intact tissue. As with their embalmed surface level counterparts, decomposition appeared to occur in the same order, with the head and hindquarters becoming disarticulated from the rest of the body. Insects were not key players in any of the buried pigs due to inability to easily access these remains.

The embalming fluids had acted to retard decomposition, and, therefore, preservation was maintained. The decomposition was markedly different in the buried non-embalmed pigs. The unembalmed pigs had no preservative efforts applied to them, and decomposition was allowed to occur unhindered.

At the time of this study's termination, the unembalmed pig interred at two feet had been reduced to the skeletal stage, with a small amount of dehydrated tissue still present. The two-foot unembalmed pig was dry, perhaps because there was less clay accompanying the pig. The cage the two-foot pig was buried in also allowed a space for air to become trapped, and this may have caused decomposition fluids to evaporate.

The unembalmed pig buried at four feet was in a different state than any of its counterparts. Rather than a dry skeletal state, the soil immediately around the four-foot pig was saturated with fluids associated with decomposition. Bone was in place in the matrix of yellow fatty deposits and the red/pink decomposing tissue of the fetal pig.

Considering that the four-foot grave was placed on the top of a slope, and that the presence of moisture appeared to be only in the immediate area surrounding the pig, perhaps the moisture originated from the decomposing pig itself. Indeed, the profile revealed dry clay only

centimeters away from the pig. Since the soil is primarily clay and is not as easily penetrated by water as sandy or silty soil is, the decomposition fluids may have become trapped surrounding the pig.

Embalming greatly delays decomposition, and the cavity fluid used in the embalming process is a dehydrating agent that acts to mummify the majority of the remains. Cavity fluid effectively creates a mummified shell around mummified internal organs. Embalming is a deterrent for insects. The suture on the torso of the embalmed surface pig was avoided for the majority of the surface study. This is most likely due to the presence of cavity fluid that had been injected into the torso as well as the presence of artery fluid that had been injected at this site. Since the maggots tended to avoid the embalming fluid, the suture may have represented an area high in embalming fluid concentration.

Burial acts to discourage a majority of insect activity and slows decomposition. This is consistent with Byrd and Castner's (2009) findings dealing with entomological evidence associated with buried versus surface remains. Remains placed upon the surface of the earth tend to deteriorate much faster and involve exponentially more insects than a body interred in the earth. This slower rate of decay for buried remains is consistent with Haglund and Sorg's (2001) statement, that currently no clear stages of decomposition for a buried body exist. In general, the deeper a body is interred, the greater the preservation, regardless of whether or not a body has undergone the embalming process. Rodriguez and Bass (1985) reached the same conclusion that depth of burial is directly related to preservation in their study. Additional research could be done in order to begin to determine concise stages of decomposition for buried remains.

This study also influenced the embalming practices of the eastern Kentucky embalmer and funeral home associated with this research. Upon opening up the embalmed surface pig at

the termination of the surface study, a small number of large maggots were found in the stomach and intestines. This was an unexpected surprise since the cavity fluid works to dehydrate internal organs. The heart, lungs, liver, and other internal organs were completely mummified as was expected. The stomach and intestines, however, were still moist and contained a small number of maggots. Cavity fluid had been injected into the pig at more than adequate amounts, but there was still life present in a portion of the pig. Due to this, the embalmer now has decided to increase the amount of cavity fluid he injects into the deceased.

With regard to the volatile fatty acids (VFAs) study associated with this research project, if a body is buried, the preservation of VFAs is greater. The soil immediately below the surface pigs did not retain high concentrations of VFAs as did their buried counterparts. Vass (Vass et al. 1992) conducted VFA analysis on surface soils immediately below a body, and though his studied found VFAs, the current study demonstrates that concentrations are likely to be higher for buried individuals. Though the soil below the surface pigs at both sites did maintain some valeric and iso-valeric acids, they did not retain as much butyric and iso-butyric acids.

Volatile fatty acids are water soluble, and, therefore, travel with the water. Precipitation and moisture (such as morning dew) may explain why surface soil below the surface pigs had low concentrations of VFAs. The soil associated with the buried pigs, however, held more of the VFAs because it was protected from the rain by the two to four feet of dirt that lay above it. Soil type as well may possibly influence the amount of acid that is retained. The soils at the two-and four-foot depths had a higher clay concentration than the surface soils.

One exception to this is the unembalmed Kash four-foot burial site. This pig decomposed in a different manner than the others. It was the only pig that had an abundance of moisture in the soil immediately associated with the pig. Also, it was the only set of remains that

smelled of decomposition at the time of exhumation and still had decomposing tissue present. I suspected that this sample would retain the highest concentrations of VFAs; however, this was not the case. Uncertainty exists as to why this sample had lower VFA amounts than its buried counterparts. Perhaps, since VFAs are water soluble and the soil was very moist immediately around the pig, the acids had leached further down. This might explain the fact that the concentrations were higher in the sample ten centimeters below the pig.

The practice of embalming does not cause VFA concentrations to be lower. When the soil from the McQuinn sites /embalmed pigs were compared to soil from the Kash sites/unembalmed pigs, the concentrations were actually higher in the embalmed buried sites. VFAs are formed during the decomposition process, and fat seems to deteriorate in the same manner, whether or not a preservative chemical agent has been applied to a body.

This study also demonstrated that VFAs apparently do leach out on both a horizontal and a vertical plane. However, VFAs do seem to be in higher concentrations when they leach vertically, as compared to horizontally. As mentioned before, VFAs are water soluble and travel with water. Though water can and does often flow horizontally, the law of gravity exerts pressure for it to flow downward. Perhaps, this could be the reason that VFAs were generally seen in higher numbers ten centimeters below the pig than they were ten centimeters horizontally.

Though many samples were taken up to 50 centimeters away from the pigs in both directions, only the soil immediately around the pig, ten centimeters away horizontally, and ten centimeters away vertically, were actually prepped and tested on the GCMS instrument. This leaves possibilities for further testing at a later time.

Interestingly, it appears as though one cannot determine weight or size of remains based solely upon volatile fatty acid concentrations. Tuller's (2002) soil samples associated with mass graves in Croatia and a cemetery in Kosovo yielded surprisingly similar VFA concentrations. Tuller's soil represented graves of either mass casualties or a single individual, while my soil represented the decomposition of a still-born fetal pig approximately two pounds in weight. The methods used in the current study and Tuller's study were similar, and the analyses were conducted by the same scientist in both studies. Tuller used homogenized soil samples ten grams in weight, whereas I used homogenized samples fifteen grams in weight (Tuller, 2002). At this time, it does not appear that VFAs concentrations can clearly discern between an adult(s) and an infant decomposition. Tuller's (2002) study also used soils from mass graves that were at least six years old. Soils used in this study were less than one year old, and similar VFA concentrations were similar to Tuller's study. At this time, length of time interred cannot be determined.

It also does not appear that VFAs concentrations can denote human versus animal burials. Tuller's study focused on soil with human burials, while this study focused on swine. Soil VFA concentrations were similar in both studies. Possible testing for different VFAs in the future may yield information that would be useful in discerning between animal and human remains. Also, a different column could be used in the future. This study used a nonpolar Restek® Rxi - 5ms (5% biphenyl, 95% dimethyl polysiloxane) fused silica capillary column in the GCMS instrument. These columns can be interchangeable and certain types are used for different chemical compounds. Since VFAs are polar, perhaps a different column (such as a Restek® Rtx - 200 with a mid polarity or a Restek® stabiliwax column) may be better suited for future studies. Though the concentrations would not be have been different if this column has been

employed on this study, the chromatograph peaks may have been sharper and a bit more distinguishable with a different column.

Chapter 6: Conclusion

Embalmed remains placed upon the surface of the earth appear to attract fewer flies and more beetles than remains that are not embalmed. Flies are present in greater numbers for remains that have not been subjected to chemical preservation and reach the dry/skeletal stage more rapidly. Embalmed remains not placed in a closed container, such as a coffin, also tend to mummify regardless of whether or not they are placed upon the surface or buried. Even with the application of thorough embalming practices, decomposition does occur, though in a different manner and on a different time scale. More research needs to be done in the area of embalming in a forensic context and perhaps even a new decomposition time frame created for embalmed remains.

Volatile fatty acids are leached on both horizontal and vertical planes, though the concentrations tend to be higher vertically. The practice of embalming does not seem to prevent or lower the concentration of volatile fatty acids. In this study, embalming actually seems to increase VFA concentrations. In general, buried remains tend to retain higher VFA concentrations than surface remains due to the water solubility of VFAs. Additional research could be conducted in the future in this area as well. All soils samples from this study have been retained and may be tested in the future to determine if fatty acids leach out even further.

This study represents a baseline for comparison with future studies. This forensic snapshot serves as only one step in a sequence that can be followed by further and future research.

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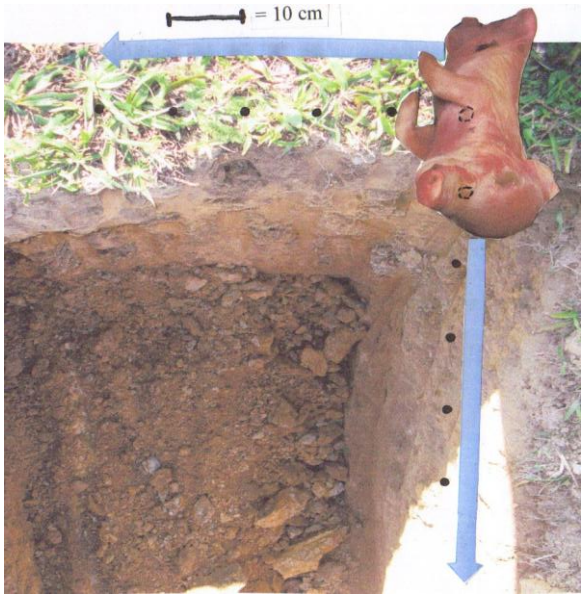
Appendix A. McQuinn/Embalmed Soil Chart

Site	Depth	Munsell Value	Munsell Color	Soil pH	Moisture Level	Soil Temp at Time of Interment (°F)
McQuinn 2 Foot	Under sod	2.5 Y 5/4	light olive brown	7	A	78
	1 foot	7.5 YR 4/6	strong brown	7	A	78
	2 feet	10 YR 5/8	yellowish brown	7	B	76
McQuinn 4 Feet	Under sod	2.5 Y 5/4	light olive brown	7	A	78
	1 foot	2.5 Y 5/4	light olive brown	6	B	75
	2 feet	10 YR 6/8	brownish yellow	7/6	B	76
	3 feet	10 YR 5/8	yellowish brown	7/6	A	74
	3 feet	GLE-Y 7/5BG	light greenish gray	7/6	B	74
	4 feet	10 YR 5/8	yellowish brown	7	A	62

Appendix B. Kash /Non-embalmed Soil Chart

Site	Depth	Munsell Value	Munsell Color	Soil pH	Moisture Level	Soil Temp at Time of Interment (°F)
Kash 2 Foot	Under sod	10 YR 4/4	dark yellow brown	7	A	78
	1 foot	7.5 YR 7/2	pinkish gray	6	C	78
	1 foot	7.5 YR 6/6	reddish yellow	6	C	78
	2 feet	7.5 YR 7/1	light gray	7	B	74
	2 feet	7.5 YR 6/6	reddish yellow	7	B	74
Kash 4 Feet	Under sod	10 YR 4/4	dark yellow brown	7	A	78
	1 foot	10 YR 6/6	brownish yellow	7	B	78
	2 feet	5 YR 7/1	light gray	6	C	67
	2 feet	5 YR 5/8	orange/ yellow red	6	C	67
	3 feet	2.5 Y 6/4	light yellow brown	7	A	58
	4 feet	2.5 Y 7/2	light gray	7/6	A	60

Appendix C. Soil Sampling Immediately Around Pig and 10 Centimeters Both Vertically and Horizontally from Pig Belly

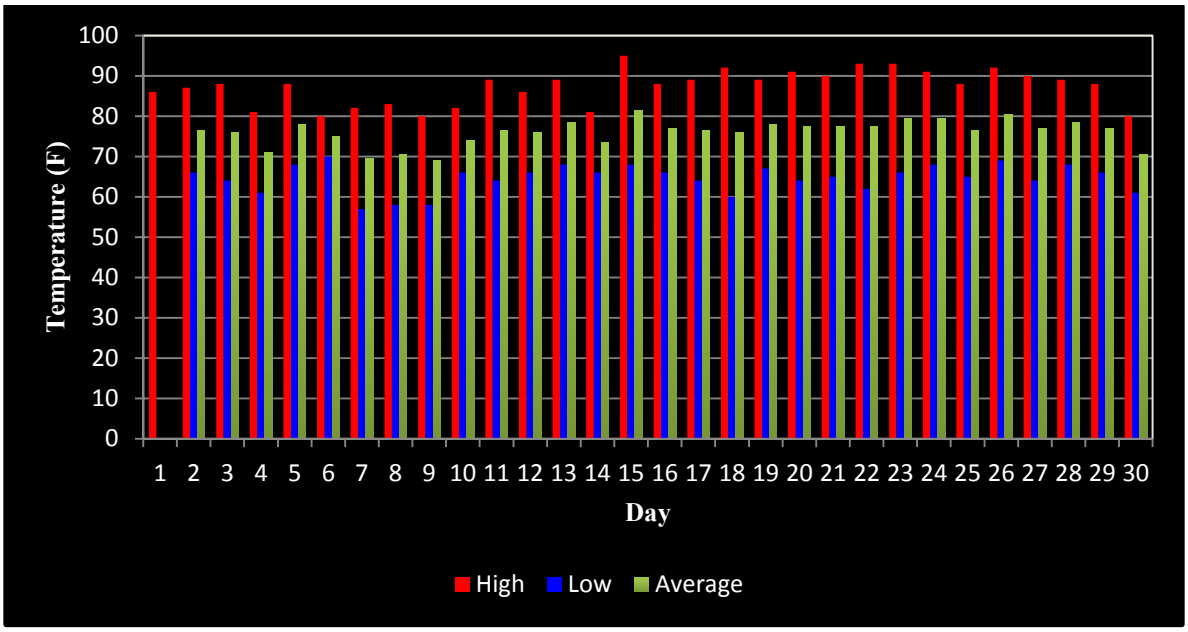


Black dots represent points at which soil samples were taken in 10 cm increments both vertically and horizontally from pig belly

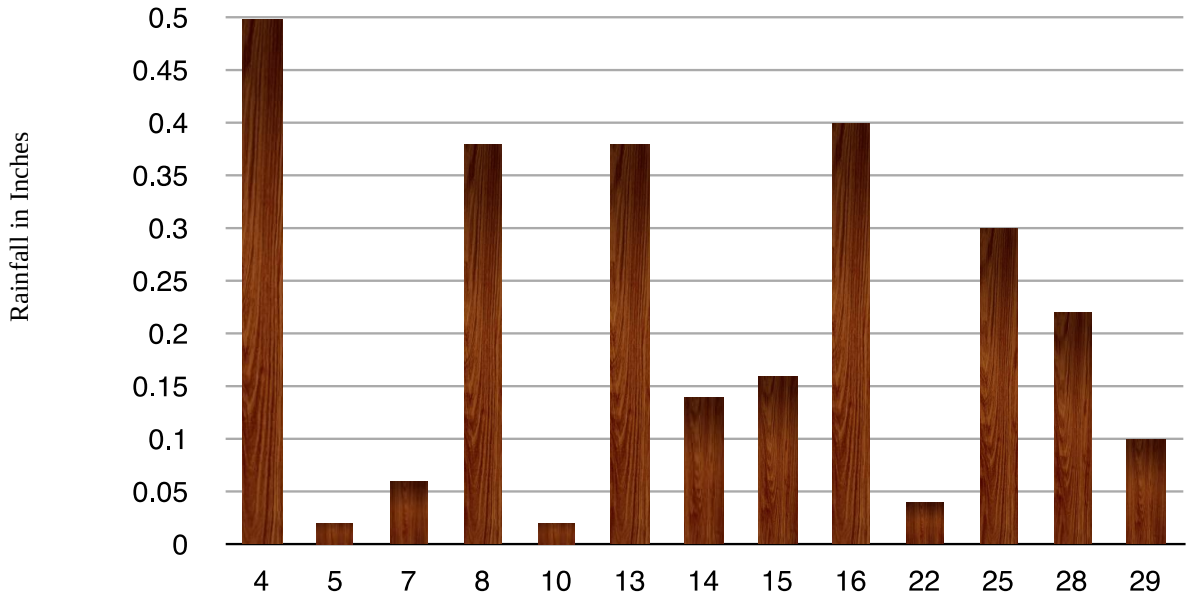
Appendix D. Soil Sample Weights

Sample	Soil Weight (g)	Bottle Weight Without Cap (g)
McQuinn Surface Directly around pig	15.09	72.91
McQuinn Surface Vertical 10 cm from pig	15.01	73.16
McQuinn Surface Horizontal 10 cm from pig	15.01	73.20
Kash Surface Directly around pig & Kash Surface Vertical 10 cm from pig	15.18	72.83
Kash Surface Directly around pig & Kash Surface Vertical 10 cm from pig - Duplicate Sample	15.08	73.32
Kash Surface Horizontal 10 cm from pig	15.00	73.34
McQuinn 2 Feet Burial Directly around pig	15.01	72.85
McQuinn 2 Feet Burial Vertical 10 cm from pig	15.17	73.16
McQuinn 2 Feet Horizontal 10 cm from pig	15.00	73.20
Kash 2 Feet Burial Directly from pig	15.04	72.64
Kash 2 Feet Burial Vertical 10 cm from pig	15.13	73.15
Kash 2 Feet Burial Horizontal 10 cm from pig	15.03	72.64
McQuinn 4 Feet Directly around pig	15.03	73.14
McQuinn 4 Feet Vertical 10 cm from pig	15.09	72.78
McQuinn 4 Feet Burial Horizontal 10 cm from pig	15.05	72.97
Kash 4 Feet Burial Directly around pig	15.00	72.76
Kash 4 Feet Vertical 10 cm from pig	15.04	72.72
Kash 4 Feet Horizontal 10 cm from pig	15.00	73.23

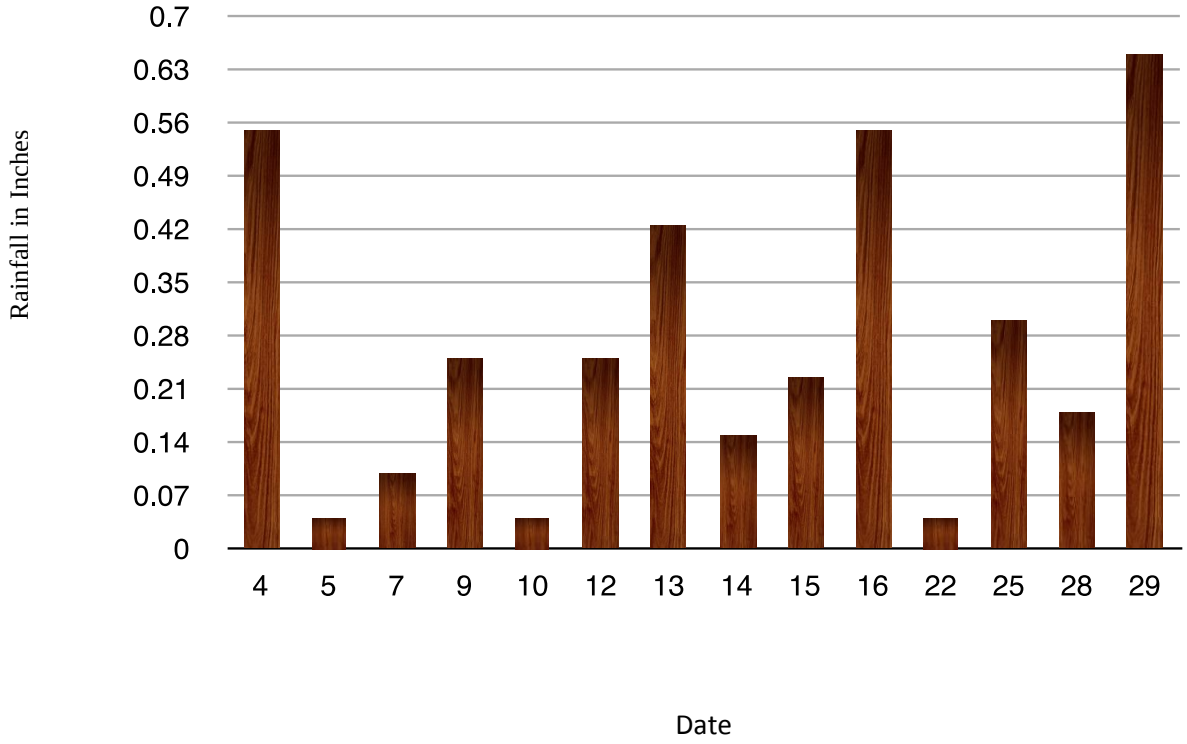
Appendix E. Daily High-Low and Average Temperatures for McQuinn Surface and Kash Surface Sites



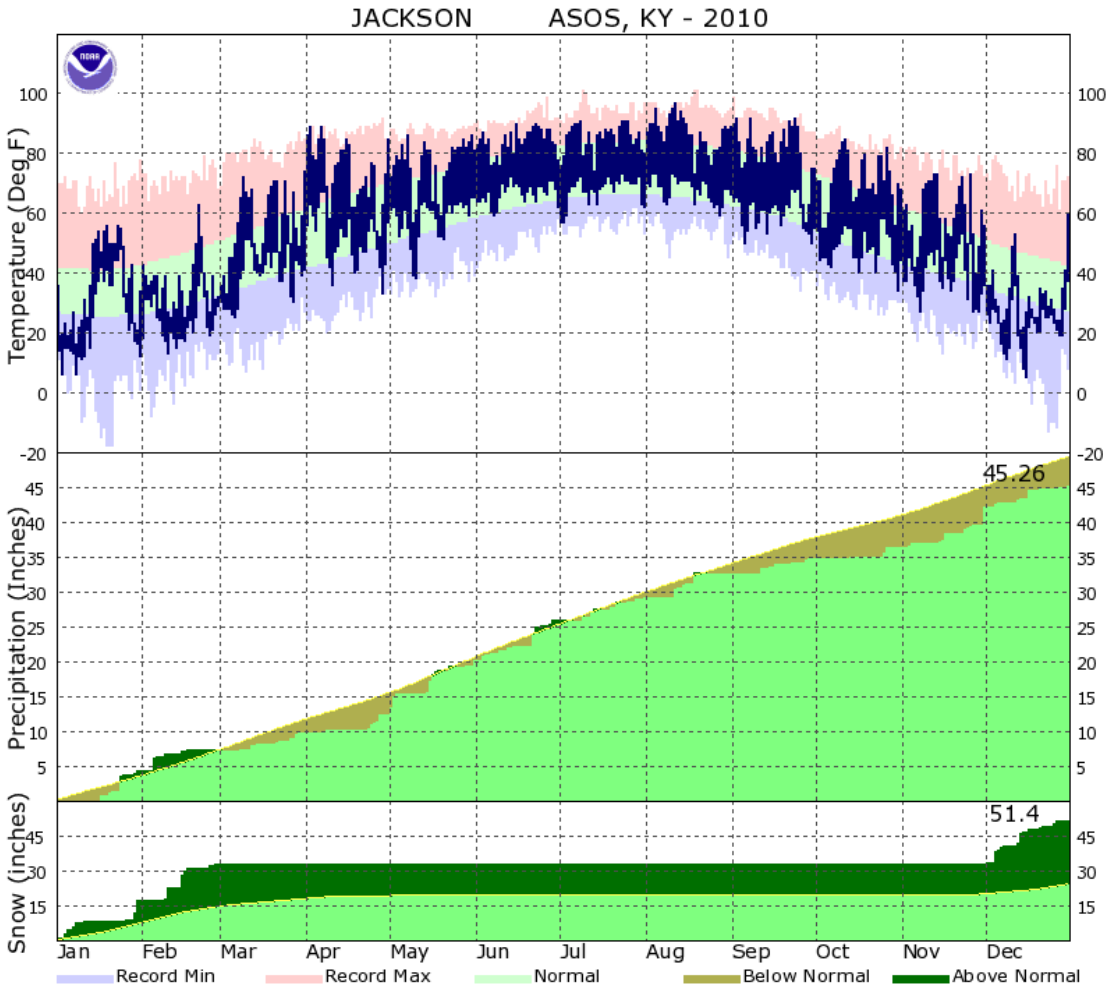
Appendix F. Rainfall Amounts for McQuinn Surface Site (June 2010)



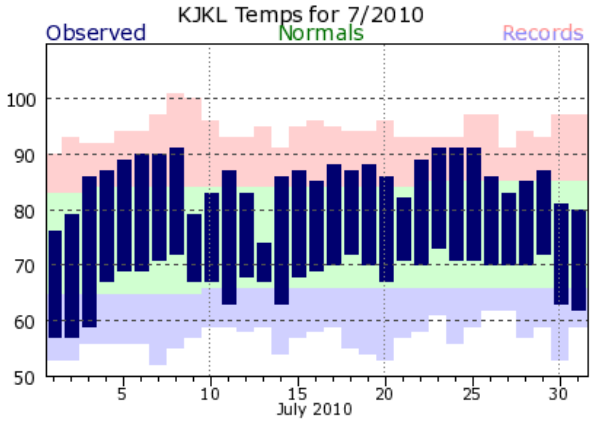
Appendix G. Rainfall Amounts for Kash Surface Site (June 2010)

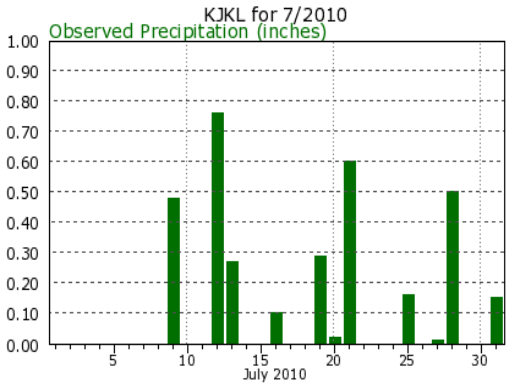


Appendix H. National Weather Service 2010 Temperature and Rainfall Data

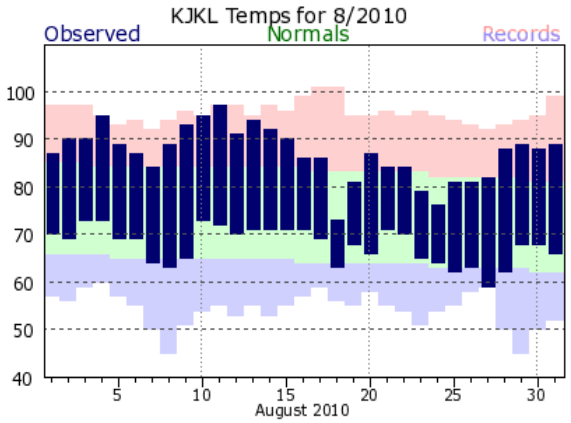


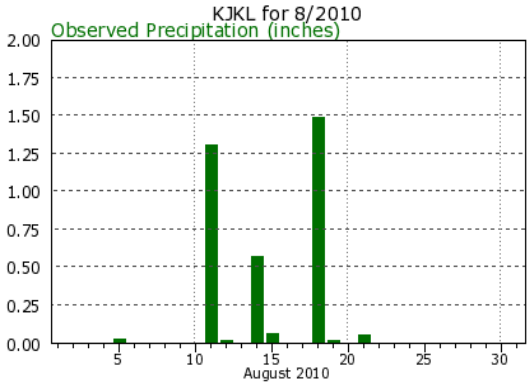
Appendices I and J. July 2010 National Weather Service Weather and Precipitation Data



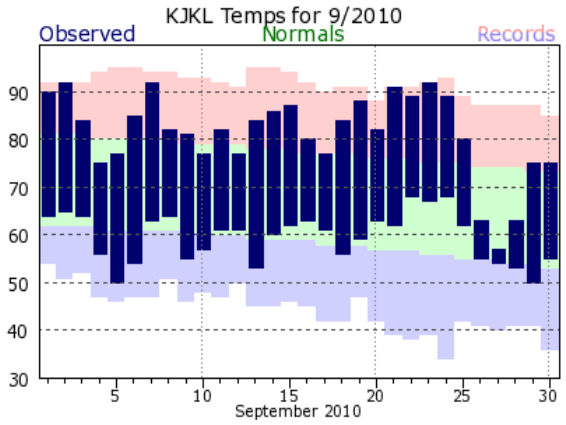


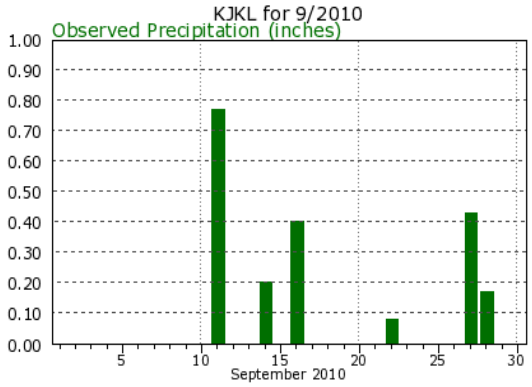
Appendices K and L. August 2010 National Weather Service Weather and Precipitation Data



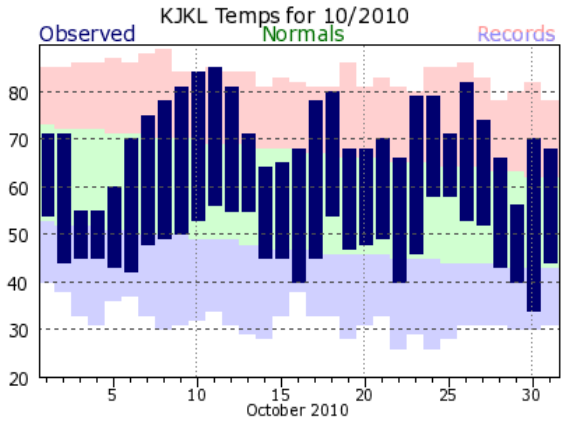


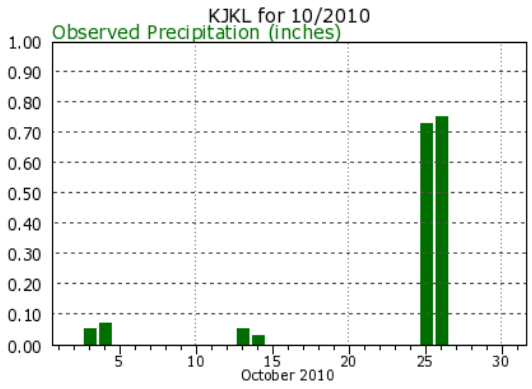
Appendices M and N. September 2010 National Weather Service Weather and Precipitation Data





Appendices O and P. October 2010 National Weather Service Weather and Precipitation Data





VITA

Charlana McQuinn was born in December 1981 in Lexington, Kentucky. Charlana grew up in the Appalachian mountains of eastern Kentucky and graduated from Wolfe County High School in 2000. In May, 2006, she graduated with her Bachelor of Arts in anthropology from Eastern Kentucky University. Charlana has participated in a number of archaeological excavations and surveys in Kentucky, both historic and prehistoric in nature. In 2005, she participated in a study abroad program in Ireland and in 2007 participated in an excavation on Mount Zion in Jerusalem, Israel.

In 2009, Charlana began her Master of Arts degree in anthropology at Louisiana State University. Under the direction of Ms. Mary Manhein, she has assisted in a number of active forensic cases, biological profiles, and on-site body recoveries. Her future plans include continuing her career in the medico-legal application of forensic anthropology.