TAPHONOMY OF CHILD-SIZED REMAINS IN SHALLOW GRAVE AND SURFACE DEPOSIT SCENARIOS

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TAPHONOMY OF CHILD-SIZED REMAINS IN SHALLOW GRAVE AND

SURFACE DEPOSIT SCENARIOS

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

ABSTRACT

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Forensic anthropologists occasionally encounter remains of children in various burial scenarios. These remains are often discovered in shallow grave or surface deposit environments, and are often covered with a blanket or sheet. This study examines these variables. The taphonomic processes in each of these settings occur at different rates; therefore, it is important to understand the effect on the estimation of the postmortem interval. This study involves a sample of child-size pig carcasses wrapped in baby blankets. Some of the pigs were buried in a shallow grave and periodically examined on-site to document stages in the

taphonomic processes. One pig carcass was deposited on the surface and it was also examined for taphonomic changes, including scavenger activity that occurred.

As expected, scavenger activity was present on the surface deposit carcass, but the depth of the shallow burials also permitted scavenger activity. Observations of the types of bones remaining and their distances from the graves, amount of commingling, and other taphonomic details were recorded and analyzed.

CHAPTER 1

BACKGROUND AND LITERATURE REVIEW

There have been few extensive studies into the epidemiology of child abduction and homicide, despite the increasing incidences of these crimes over the past couple of years (Gremillion 2005). Homicide is the only major cause of childhood death that has increased over the past three decades (Finkelhor and Ormrod 2001). In 2004, an estimated 1,490 children in the United States were victims of abduction and homicide (Anon. 2006). Research indicates that children 3 years old and younger are the most frequent victims of child homicide, mainly because of their dependency, small size, and inability to defend themselves (Anon. 2006). In homicide reports generated by the Federal Bureau of Investigation (FBI), victim age trends were catalogued for children 4 years or younger from 2002-2005. In this report, homicides of children 1 year old or younger made up approximately 63-65% of the 2357 reported cases (FBI Supplementary Homicide Reports 2006).

In 1996, the FBI sponsored research into homicides of children under 17 years old by their Violent Criminal Apprehension Program (VICAP) and National Center for the Analysis of Violent Crime (NCAVC). Their researchers looked at 550 cases from 47 states over a 10-year period. In 1997, the Washington State Attorney General's office released a study on missing children homicide cases from 577 cases from 44 states. Of 621 victims, 562 were under the age of 18. Both studies reported when, where and how remains were disposed of and the degree and type of concealment used by the offenders (Morton and Lord 2002). In the FBI study, remains were disposed of in different scenarios depending upon the motivation of the offender and age of the victim. In the Washington State Attorney General's office study, 52% of the victims were concealed to prevent discovery.

As a result of the likelihood of child homicide following abduction, research involving the investigation of child decomposition rates is vital for forensic investigators to understand the taphonomic processes child-sized remains go through. A better understanding of these processes may aid in locating remains and determining accurate postmortem intervals.

There have been few studies conducted regarding environmental and taphonomic effects on child-sized remains during decomposition. Of 112 articles between 1980 and 2005, utilizing the keywords "decomposition" and "children" from the *Journal of Forensic Sciences*, none dealt with specific decomposition rates of child-sized remains (Gremillion 2005). Children are often not used for taphonomic studies, mainly for ethical reasons and the lack of donated child bodies for such experiments. Melanie Archer, a forensic entomologist from Australia, has published several studies on stillborn neonate pig carcasses and the effects of rainfall and temperature on decomposition rates (Archer 2004; Gremillion 2005). Her research showed that newborns decomposed at faster rates than adults. However, her experiments were not representative of realistic forensic scenarios for the following reasons: her specimens were not accurately sized proxies for human newborns, and were frozen before they were deposited in the field, which may have skewed the postmortem interval and subsequently retarded the attraction of necrophagous insects.

There is a general consensus that child-sized remains decompose faster than adult-sized remains. Child remains undergo decomposition processes in a shorter time interval due to smaller size and greater surface-to-volume ratios (Morton and Lord 2002). However, there are a lack of experiments that take into account the differential ways that child victims of homicides are disposed of in the environment and how this affects decomposition rates. Criminals often go to great lengths to destroy and conceal evidence of their crimes, especially in child abduction- homicides. Depending on the motive of the offender, concealment of a child victim can range from no attempt to conceal to a complete burial. Oftentimes, offenders may choose to dispose of remains on the surface in outdoor environments. It is of particular interest to forensic anthropologists to understand how such methods of concealment affect the taphonomic processes of child-sized remains.

It is also important for forensic investigators to determine time since deposition and behavioral patterns of scavengers and arthropods. Major factors influencing taphonomic changes and decomposition rates are disposal site characteristics, environmental conditions, offender behavior, vertebrate scavengers, victim characteristics, and necrophagous insects (Morton and Lord 2002).

1.1 Physico-chemical Properties of Infant Bones

Child-sized remains are innately difficult to recover because of their smaller size and their tendency to decompose more quickly than adults. Their greater surface-to-volume ratios result in less flesh for arthropods to consume and easier disarticulation by scavengers (Morton and Lord 2002).

The physico-chemical composition of infant bones provides insight to their differential destruction and preservation rates. Guy et al. (1997) explored reasons for the scarcity of children's bones in cemeteries and their preservation in archaeological samples. Through analyses of various medieval and eighteenth century European cemeteries, they noticed that the proportion of infant remains found were less than the demographic expectations. The authors examined the bone mineral in infants to determine if this characteristic played a role. They found that bones of children under 2 years old were less dense than fetal (*in utero*) skeletons due to the regression of mineral content during the first year (Guy et al. 1997). Since compressive strength increases with the density of bone, very young children's bones are less resistant to indentation and scratching. The low mineralization of bone and the inherent qualities of bone composition in young children explain their poor preservation in burials. They concluded that these findings were strong enough to regard the expected representation of young children due to high infant mortality rates and the fatal effects of weaning and resultant diarrhea as "illegitimate *ipso facto*" (Guy et al. 1997).

1.2 Review of Human Decomposition Processes

Death is a process and not all cells die at once (Gill-King 1997). Decomposition of a corpse commences immediately after death and involves the consecutive processes of autolysis, putrefaction, and decay (Fiedler and Graw 2003; Dent et al. 2004). It begins with autolysis, or self-digestion of soft tissue and cells, which usually does not become visually apparent for a few days after death, manifesting as fluid-filled blisters on the skin and skin slippage (Vass 2001).

Following autolysis is the process of putrefaction, the destruction of soft tissues of the body by microorganisms already present or derived from in-soil microorganisms (Vass 2001; Dent et al. 2004). Aerobic organisms deplete body tissues of oxygen, which sets up favorable conditions for anaerobic microorganisms (Dent et al. 2004). This process is generally not observed until 48 to 72 hours after death. The intestines, stomach, accessory organs of digestion, blood, and heart muscle are the first tissues to decompose. Gas and fluid accumulation in intestines usually purge from the rectum, but can be severe enough to rip apart skin (Vass 2001). Air passages, lungs, kidneys, the bladder, brain and nervous tissue, skeletal muscles, connective tissues and integument are the next soft tissues, in that order, to decompose (Gill-King 1997).

After putrefaction, active decay begins. Proteins and fats decompose and electrolytes rapidly leach out of the body (Vass 2001). It is during this stage that aerobic and anaerobic bacteria are present in large numbers, and insect and scavenger activity begins. The body's tissues and organs soften during decomposition and degenerate to a mass of unrecognizable tissue that eventually becomes liquefied (Dent et al. 2004). Liquefaction and disintegration proceeds, leaving skeletonized remains articulated by ligaments. Skin, muscle, and internal organs are generally lost to the environment well before a skeleton becomes disarticulated. The insoluble fibrous protein found in skin and hair, keratin, resists degeneration by enzymes, hence hair often remains on corpses long after death (Dent et al. 2004).

1.3 Decomposition and Skeletonization Rates

Decomposition of soft tissue is completed within 15-25 years and leads to entire skeletonization of an interred corpse in a coffin (Fiedler and Graw 2003). Remains in direct contact with the soil decompose differently. The rate at which decomposition and subsequent skeletonization proceeds depends on a number of factors such as depth of burial, soil type, temperature, and surrounding environment. Schultz et al. (2006) monitored shallow burials of 0.5-0.6m in depth containing three large pig cadavers. After 12 months and 23 days, the cadavers exhibited variable degrees of skeletonization, with some retention of desiccated soft tissues. After 21.5 months, the cadavers were complete skeletonized. As a general rule, bodies that are buried decompose slower than bodies exposed on the surface (Rodriguez and Bass 1985). Research has shown that the burial of bodies retards the decomposition process and slows down bacterial putrefaction via cooler, more uniform temperatures and reduced oxygen availability (Morton and Lord 2002). The oxygenated environment increases the rate of decomposition for surface remains, as does the exposure to necrophagous insects, scavengers, human activity, and environmental stressors (Dent et al. 2004).

Temperature is an important factor in determining the rate of decomposition. In Tennessee and Virginia, the decomposition of human cadavers was found to be the most rapid during the spring and summer months, and the slowest in the fall and winter (Rodriguez and Bass 1983; Gremillion 2005). Tropical environments can result in skeletonization within two weeks because of the exposure to and prevalence of scavenging animals (Ubelaker 1997). In warm weather, total skeletonization has been observed to occur in as little as six days (Morton and Lord 2002). A buried body in a warm environment may skeletonize as rapidly as an exposed body in a mild environment (Gill-King 1997). In taphonomic studies done in the western United States, invertebrate colonization and subsequent scavenging were determined to be weather dependent (Morton and Lord 2006).

1.4 Insect Colonization and Decomposition

A human body is a valuable food resource for a large number of insects. Insects are primarily responsible for the removal of soft tissue, and do so by disseminating bacteria and secreting enzymes. Insects can be used to estimate time since death because they become attracted to corpses soon after death and have known developmental rates and predictable sequences of insect colonization (Rodriguez and Bass 1983; Anderson and Cervenka 2002; Anderson 2005). Oviposition, the laying of eggs, by blowflies occurs when the weather conditions include temperatures between 15 and 27°C (59 and 81°F), light winds, and sunny days (Gremillion 2005). Blowflies (*Calliphoridae*) arrive first, laying their eggs close to wounds or natural orifices so there is easier access to nutrients and protection from direct sunlight for the hatched larva and maggots. Maggots may form large masses on a corpse, generating heat and increasing the temperature of the body, which in turn increases the rate of decomposition.

Different groups of necrophagous insects are attracted to certain stages of the decomposition process. Some are attracted directly to the corpse, while others are attracted to the presence of other insects they use as a food resource (Anderson 2001). The odors emitted during each decomposition stage also aid in attracting different insects. Blowflies are not attracted to carcasses that have passed a certain stage of decomposition or become mummified or dry (Anderson 2001).

The placement of the corpse has an effect on the decomposition and insect colonization of the remains. Bodies in direct sunlight decompose faster, reducing the amount of flesh invertebrates are able to feed on. Buried remains may still be colonized by insects, but burial influences the time required for insects to reach the remains (Anderson 2001). There have been some studies on insect colonization of buried bodies. In 1968, Payne et al. published research on buried baby pig carcasses in South Carolina. Their results indicated that several insect species were attracted to buried pigs; however, these pigs were buried in small coffins and did not mimic scenarios often encountered in a forensic context. In Tennessee, researchers performed human burial experiments using six cadavers buried at different times of the year to study the effects of insect colonization on decomposition (Anderson 2001). Their results also highlighted the possibility for certain species to gain access to buried remains, especially in warmer weather.

Human remains are often found wrapped in some material, often to conceal the evidence of a crime (Morton and Lord 2002). The type and extent of the wrapping may affect the insect colonization pattern of the remains (Anderson 2001). In studies that utilized carpet, clothing, blankets, or bags as methods of concealment, insect colonization was still possible if there were gaps that allowed access for insects. Once insects gained access to the flesh, they proceeded with feeding as usual, though the barrier may have delayed access to the remains. In Hawaii, a female victim was found heavily wrapped in blankets in a rural, outdoor habitat. In order to determine the possible delay of insect colonization, Goff (1992) wrapped a freshly killed pig carcass in the same manner and concluded that there was a 2.5-day delay in colonization in this case.

1.5 Vertebrate Scavenging and Decomposition

Mammalian scavengers impact skeletonization by virtue of their chewing, disarticulation patterns, and dispersion of human remains (Haglund 2005). Vertebrates can produce a great amount of damage to the flesh and skeletal elements. Examination of the skeletal remains in Morton and Lord's experiment on the taphonomy of child-sized remains revealed postmortem damage caused by vertebrates, which included gnaw marks, chewed epipyhseal bone ends, teeth marks, and beak marks (Morton and Lord 2006). Characteristic v-shaped tooth marks are left by cats and dogs, as well as scratch marks from claws on the bone and flesh of remains. Under normal conditions, Haglund (2005) states that medium and large canids approach postmortem consumption of remains in a patterned sequence—removing soft tissue beginning at the head and finally working down to the lower limbs.

Like invertebrate scavengers, certain vertebrate scavengers are attracted to different stages of the decomposition process. Some scavengers prefer fresh corpses, while others wait for the corpse to enter more advanced stages of decomposition. Red foxes *(Vulpes vulpes)* started feeding on the desiccated surface-deposit pig remains six weeks after they had been deposited in Morton and Lord's (2006) experiment on child-sized remains. Turkey vultures *(Cathartes aura)* appeared within two days of another carcass placed on the surface, reducing this pig to skeletal elements within seven days (Morton and Lord 2006).

The extent of vertebrate scavenging is affected by the diurnal or nocturnal predilection of the scavengers. Vultures tend to feed primarily during the day, while raccoons, foxes, and coyotes prefer feeding after daylight hours. The different species of nocturnal animals visited the disposal sites of the Morton and Lord experiment at different times (Morton and Lord 2006), and from field studies conducted by Morton and Lord utilizing the FBI's NCAVC, it was found that the timing of vertebrate activity and invertebrate activity affects decomposition rates of surface-deposit and buried remains. Therefore, the time of day remains are deposited may have an effect on the rate of decomposition.

1.6 Taphonomic Studies on Child-Sized Remains

In 1998, the FBI's NCAVC conducted research examining the taphonomy of decompositional changes, predator scavenging, and the extent of remains scattering on pig carcasses (Morton and Lord 2006). This experiment took into account the various ways that child-sized homicide victims can be deposited in real-life scenarios. The pigs weighed around 13.61kg (30lbs) and were placed in a wooded area in Virginia in a variety of scenarios: surface deposit with no covering, surface deposit covered with tree branches and dead fall, surface deposit in rolled up carpet, shallow burial (less than 1ft), and suspended by rope from a tree. Each pig, except for the hanging pig, was reduced to skeletal components within 12 days, but each underwent very different taphonomic processes.

The pig deposited on the surface allowed easy access for a wide variety of necrophagous insects, had the least amount of scavenging activity, and least amount of scattering. The surface deposit covered with branches and the surface deposit wrapped in carpet also experienced some invertebrate activity. The shallow burial, unexpectedly, displayed the most prominent vertebrate scavenger activity and scattering (Morton and Lord 2002). Insect colonization was suppressed due to the soil covering, which in turn preserved the buried carcass for scavengers. The researchers found that scavengers would dig the carcass out, carry it a greater distance, disarticulate it more completely, and subsequently scatter the remains to a greater extent (Morton and Lord 2002). In conclusion, the research revealed that there was an accidental cooperative relationship between the vertebrates (coyotes, foxes, turkey vultures) and the insects. The vertebrates avoided feeding while invertebrates were active, but were able to gain access to deeper areas of the carcass that the invertebrates made accessible.

Burial type is a critical variable in this experiment, as it either facilitates or limits invertebrate and vertebrate scavenging activity. The introduction of another barrier, a blanket, simulates a realistic forensic scenario and also limits access to the remains. In the Morton and Lord experiment, it would have been expected that the surface remains with no covering would exhibit the greater amount of scavenging activity. The highly variable outcomes of their remains are prime examples of the complexity of taphonomic processes affecting child-sized remains.

The intent of this study is to document the taphonomy of child-sized pig (*Sus scrofa*) remains in burial and surface-deposit scenarios. The hypothesis is that there will be no difference in the decomposition rates of buried and surface-deposit remains. The primary goal of this research is to examine to what extent various factors such as surface-deposition, burial, and clothing affect child-sized remains during decomposition. All factors that affect the rate of decomposition for the remains will be noted and examined to aid in better understanding the specific factors involved in surface-deposit and buried scenarios.

CHAPTER 2

METHODS AND MATERIALS

2.1 Purpose

Child abduction homicide has been on the rise over the past decade and offender activity may include an attempt to conceal the victims (Gremillion 2005; Morton and Lord 2006). This research documents the taphonomy of shallow burials and surface deposits of child-sized remains wrapped in blankets. The purpose of this experiment is to compare the differential decomposition rates of child-sized pig carcasses placed in shallow graves versus those left as surface deposits. Additionally, the taphonomic processes that affect both scenarios are examined, with the expectation of scavenger activity occurring only on the surface deposited pigs.

2.2 Location

This research was conducted on a secluded plot of land in central Texas hill country on Dr. Grady Early's ranch near San Marcos. The soil contains many rocks of different sizes and had the consistency of clay, which was confirmed as the soil type in Texas hill country (Texas Department of Transportation: Soil and Bedrock Classification 2008).

2.3 Materials

<u>Shallow Graves</u>

On June 3, 2007, five shallow graves measuring 1.22m (4ft) in length, 0.61m (2ft) in width, and .30m (1ft) in depth were dug approximately 1.52m (5 ft) apart. The 5- foot distance between the graves was created to reduce the amount of interference from any taphonomic processes that might occur between each grave.

Figure 1. Photograph of Shallow Graves before Deposition.

Blankets

As is common in homicide cases involving young children blankets were utilized to conceal the carcasses (Morton and Lord 2002). A 7.32 x 5.50m (24 x 18ft) sheet of medium-weight lime-green cotton material was purchased at a local fabric store and cut into six smaller pieces of 1.22 x 0.91m (4 x 3ft) dimensions to serve as blankets for this experiment.

Photography Equipment

A Nikon® Coolpix L4 was used for all photographs taken during the experiment. The camera has a 4.0-megapixel resolution with 3x zoom, ensuring clear pictures of the pig carcasses, insects, and other features visible to the human eye.

2.4 Temperature Data

Since insect colonization and scavenging are often dependent on the weather, the temperature at the site was recorded from the San Marcos weather station via The Old Farmer's Almanac Weather Center website for each day until the end of the experiment (Table 1).

Table 1. Average Temperatures in San Marcos, TX (Celsius/Fahrenheit)

Day	Date	Low Temp	High Temp	Mean Temp
0	6/3/2007	21/69.8	33/91.4	26.7/80.1
1	6/4/2007	18/64.4	33/91.4	26.9/80.5
2	6/5/2007	18/64.4	33/91.4	22.5/72.5
3	6/6/2007	18/64.4	33/91.4	27.1/80.7
4	6/7/2007	24/75.2	30/86	26.2/79.1
5	6/8/2007	25.6/78.1	35/95	29.4/85
6	6/9/2007	24.4/75.9	34.4/93.9	28.8/83.9
7	6/10/2007	23.9/75	34.4/93.9	28.4/83.1
8	6/11/2007	22/71.6	33/91.4	29.2/84.5

2.5 General Subject Information

Although not a substitute for human remains, pigs (*Sus scrofa*) have been accepted as comparative models (Gremillion 2005). The use of pigs in taphonomy experiments has been shown to mimic the decompositional biogeochemistry of human beings (Dent et al. 2004), and pigs have been used in a number of decomposition studies (Goff 1992; Morton and Lord 2002, 2006; Archer 2004; Gremillion 2005; Schultz et al. 2006).

On June 4, 2007, six deceased domestic pigs were acquired from a nearby commercial farm. They weighed between 8 and 9kg (18 and 20lbs) each, to represent the average weight of a 6-12 month old child (CDC Growth Charts 2000). The pigs were received in individual plastic shopping bags, and were placed into a large tub filled with ice to prevent early decomposition and blowfly activity. Approximately 2 hours elapsed from the time of death to the time they were deposited at the ranch where the experiment took place. In a 1996 FBI study, Morton and Lord (2002) reported that murdered children in the weight range under observation, (i.e., 1-12 months of age) were typically killed and disposed of within 10 miles of their residence. The tub of ice served to simulate this short distance and potential postmortem interval.

2.6 Placement Location

On June 4, 2007, five of the six domestic pigs (Pigs 1-5) were buried in the shallow graves. As each pig was being buried, the rest remained in the ice-filled tub to retard their detection and modification by blowflies. Before deposition, the carcasses were tightly wrapped in the blankets.

Figure 2. Photograph of Pig 1 of Experimental Group in Shallow Grave.

Approximately six inches of dirt was packed on top of the pigs to represent shallow burials generally encountered in forensic scenarios (Anderson 2001). The rate at which skeletonization proceeds depends on the depth of the burial, soil type, and surrounding environment (Dent et al. 2004). All five pigs were buried in exactly the same geographical and environmental conditions to serve as the experimental group for shallow burial analysis, and to allow for observations of differential taphonomic processes in buried scenarios.

Figure 3. Photograph of a Shallow Burial.

One additional pig (Pig 6) was also wrapped in a blanket and deposited on the surface 5 feet away from the shallow graves to simulate the surface deposit scenario. Pig 6 served as the control group for observations of taphonomic processes that affect blanket-wrapped remains on the surface. It is general knowledge that surface remains decompose faster than buried remains (Rodriguez and Bass 1985); so only one pig was used to document surface taphonomy. Pig 6 was placed directly on the surface of an area of dry, long grass 5 feet away from Pig 5's grave.

Figure 4. Photograph of Surface-Deposit Pig 6.

2.7 Data Collection

After all of the carcasses were deposited, beginning with that evening and every day since the original date of deposition, the site was physically observed twice daily: in the morning hours and early evening. Pictures were taken first of the graves and the surface deposition, and then taphonomic changes such as soft tissue modification, insect activity, and scavenger activity were noted at each observation.

Scavenger activity by vultures on all six carcasses was observed and noted. Arthropod colonization on the surface deposit (Pig 6) was tracked and observed. The type of insects present and their level of colonization were also recorded.

To keep track of the extent of scattering due to scavenger activity, the number and type of skeletal remains left inside each grave, and removed from each grave was recorded daily and categorized accordingly. Scattered remains were flagged, and then measurements of the distances between the graves and remains were taken using a standard measuring tape.

Once all of the visible elements appeared skeletonized, i.e., there was minimal to no soft tissue adherence to the bone, the specimens were collected over a period of eight days. The remains were catalogued by pig number and location found, then placed in paper bags and labeled. For example, a left scapula found inside Pig 1's grave was labeled as "Pig 1-inside grave". A right scapula found in close proximity to Pig 1's grave was labeled as "Pig 1-scatter". All remains were boiled in a solution of water, trisodium phosphate minus phosphate, and chlorine to remove soft tissue residue so that any scavenger marks made on the bones could be visible to the naked eye. Missing skeletal components (those not found) were also noted.

After the remains were cleaned and air-dried in a secure shed, they were transported to the forensic anthropology lab at Texas State University-San Marcos for analysis, which included measurements, siding of elements, and analysis of damage. Skeletal elements found in graves that displayed evidence of commingling, i.e. if two or more elements of the same side were found in or around a grave, were marked lightly with a red marker to denote commingled remains. All pigs were too similar in size and age to visually or metrically discern one pig from another. Therefore, all graves were hierarchically categorized by the amount of commingling present: 0=no commingling, 1=commingling with minimum number of individuals (MNI) of 2, 2=commingling with MNI of 3, 3=commingling with MNI of 4, 4=commingling with MNI of 5, and 5=commingling with MNI of 6.

Since all graves were subject to scavenger activity, the extent of scattering, arthropod colonization, commingling, disarticulation, and rate of decomposition within, between, and among all burials were quantitatively and qualitatively analyzed. The data generated from this experiment show the extent to which deposition type affects the rate of decomposition and scavenging in child-sized remains, but also presents evidence of scavenging patterns specifically by vultures who are confronted with soil covering, blankets, and arthropod colonization as barriers to scavenging activity.

2.8 Variables Defined

Blowfly Activity – The flies observed in this study were blowflies (*Diptera calliphoridae*). In observation, the flies are described as present, active, and surrounding.

Distention – Distortion of soft tissues due to formation of various gases, especially in bowels. Gas and fluid accumulation in intestines usually purge from the rectum, but can be severe enough to perforate skin (Vass 2001).

Mummification – Dessication of soft tissue and skin. Tissue appears dry and leathery.

Maggot Activity – Maggot activity describes the presence of maggots on the carcasses. The maggots were observed as absent, present, or extensive.

Scavenger/Vulture Activity - Scavenger activity was observed in the form of vulture activity. Vulture activity was evident by sighting vultures in the vicinity of the graves, the scattering of remains, and presence of vulture feathers.

Scattering – Scattering refers to the removal of skeletal remains and scattering of them around the site.

Stage/Category of Decomposition – The categories and stages of decomposition referred to in this paper are in reference to Galloway (1997) and Vass's (2001) outline of human decomposition processes (Table 2).

Table 2. Human Decomposition Categories and Stages (Galloway 1997; Vass 2001)

Stage	Description
Fresh	1. Fresh, no discoloration or insect activity
Putrefaction	1. Destruction of soft tissues of the body by microorganisms 2. Bloating of body and distention of soft tissues
Active Decay	1. Protein and fat decomposes 2. Electrolytes rapidly leach out of body 3. Begin to see insect and carnivore activity
Skeletonization	1. Minimal adherence or absence of soft tissue to bone; desiccated tissue or mummified tissue covering less than one half the skeleton 2. May begin to see bleaching of bone in exposed environments

CHAPTER 3

OBSERVATIONS

Day 0

This experiment began on June 3, 2007 with the digging of the five graves and the deposition of the pigs on June 4, 2007. It officially ended with the collection of all visible remaining skeletal elements. The weather was very hot in the morning and afternoon while the graves were dug. However, it should be noted that at around 9pm of the night of June 3rd, an unexpected thunderstorm began with wind and rain strong enough to cause a power outage in San Marcos, Texas for the night. The graves were not covered during this storm; therefore, the clay became soaked and extremely difficult to bury the pigs the next day. Because the temperature served as a factor in determining the onset and extent of invertebrate colonization and scavenging activity, the average low and high temperatures were recorded (Table 1). The weather data corroborate that the conditions were warm enough to promote oviposition by blowflies during the experiment.

Day 1

On the first day of observation for this experiment, blowflies began approaching while the pigs were deposited and buried. The soil was still moist from the thunderstorm the previous night. Once all of the pig carcasses were deposited, any activity surrounding the pigs was observed and reported for a continuous 15 minutes from the time of the last deposition. As expected, it was observed that more blowflies surrounded the surface deposit carcass than the buried remains.

Day 2

On Day 2, the soil was dry and brittle. It was apparent that putrefaction had commenced in all pigs, due in part to the warm weather. The blankets in the graves of Pigs 2, 4, and 5 (Figures 5, 6, 7) became visible due to internal bloating of their bodies. Decomposition gas products like carbon dioxide diffuse upwards from remains in looser soils (Dent et al. 2004), which may also explain the displacement of the soil. The pigs were already emitting a slight odor, attracting blowflies to the area, but the soil and blankets prevented colonization.

Figure 5. Day 2; Pig 2; 10:50am June 5, 2007.
Note blanket protruding from soil covering.

Figure 6. Day 2; Pig 4; 10:50am June 5, 2007.
Note blanket protruding from soil covering.

Figure 7. Day 2; Pig 5; 10:50am June 5, 2007.
Note blanket protruding from soil covering.

Blowflies were attracted to the revealed areas of Pigs 4 and 5. Due to rigor mortis, the stiffening of the body after death, the surface deposit Pig 6's leg poked out of the blanket covering (Figure 8). Blowflies had also gathered around this exposed leg.

Figure 8. Day 2; Pig 6; 10:51am June 5, 2007.
Note leg revealed from blanket.

Day 3

On Day 3, ten turkey vultures were observed circling the burials in the air, and then gathering at the Pig 4 burial. The intestines of Pig 3 were now visible and numerous blowflies had settled on them and the exposed blanket (Figure 9).

Figure 9. Day 3; Pig 3; 2:07pm June 6, 2007.
Note intestines revealed through blanket and soil covering, and extensive blowfly presence.

Figure 10. Day 3; Pig 6; 2:07pm June 6, 2007.
Note blowflies gathering on blanket.

Evidence of blowflies gaining access to Pig 6's flesh is shown in Figure 10. The hind legs and caudal end of the torso were even more exposed than the previous day. The intestines were bloated and had extruded through the skin, appearing outside of the body.

Day 4

In the morning of Day 4, six vultures were observed flying overhead and two were perched on a nearby tree, but none were positioned directly at any of the burials. Pigs 1 and 3 exhibited extensive intestinal bloating outside of the body, with major blowfly activity. Pigs 2 and 5 were still bloated from putrefaction, but there was no evidence of intestinal distention. Pig 4's leg was completely exposed, and blowflies and butterflies had begun to gather (Figure 11).

Figure 11. Day 4; Pig 4; 10:35am June 7, 2007.
Note hind limb protruding from blanket and soil covering.

There was no visible evidence of eggs or maggot masses on the buried remains because the blankets and soil were still acting as barriers to insect colonization. However, the lack of soil covering on Pig 6 permitted the blanket to unravel and increased the potential areas for insect colonization. The blanket was also drenched in decomposition fluid, showing that Pig 6 had already moved into the active decay stage.

Figure 12. Day 4; Pig 6; 10:35am June 7, 2007.

Figure 13. Day 4; Pig 6; 10:35am June 7, 2007.
Note extensive maggot masses on head and anal region.

Blowflies lay eggs in natural orifices and open wounds, so as expected, maggot masses had formed underneath and on the blanket at Pig 6's head region, rear, and hind legs, as shown in Figures 12 and 13.

That evening, vultures were seen gathered around the burials, but flew away as they were approached. Upon first glance of the burial site, it was clear that there had been extensive vulture activity on the buried remains and surface-deposit. The buried remains (Pigs 1-5) were disturbed by scavengers to the point that the buried remains were brought to the surface and skeletal elements scattered. The number of vultures, their location in relation to the graves, and their activity were recorded on site. All remains found at the site were recorded by bone type, location found, and which pig they belonged to (Appendix A). The distance each skeletal element was scattered from the site of deposition was also measured and recorded (Appendix A).

Pig 1's mandible, palate, and hind legs had been removed from the grave (Figures 14, 15, 16). The mandible and cranial bones were disarticulated and completely skeletonized. One of the hind legs still had some tissue and hair adhering to the bone. The remaining interred remains were still exhibiting blowfly activity (Figure 17).

Figure 14. Day 4; Pig 1; 7:39pm June 7, 2007.
Note mandible-half outside of the grave.

Figure 15. Day 4; Pig 1; 7:39pm June 7, 2007.
Note cranial fragments and limb bone.

Figure 16. Day 4; Pig 1; 7:40pm June 7, 2007.

Figure 17. Day 4; Pig 1; 7:40pm June 7, 2007.
Note limb covered with blowflies.

Pig 2 and its blanket were not immediately visible inside the grave. The only remnants of Pig 2 noticeable were four leg bones, skin, and the blanket, located outside but very close to the grave (Figures 18, 19). These elements still exhibited blowfly activity. Upon further examination of the grave, numerous skeletal elements were discovered. The distance these artifacts were from the grave was also measured.

Figure 18. Day 4; Pig 2 grave;
7:44pm June 7, 2007.
Note skin of Pig 2 located outside of the grave.

Figure 19. Day 4; Pig 2 grave;
7:44pm June 7, 2007.
Note blanket located outside of the grave.

Pig 3's skeleton was not immediately visible, but the blanket was still firmly buried in the grave. It appeared that the scavengers had strategically removed the pig from the blanket covering (Figure 20). Numerous skeletal elements were found surrounding and inside the grave.

Pig 4's remains were found inside its grave, and feet and long bones were found around the grave (Figure 21).

Figure 20. Day 4; Pig 3;
7:45pm June 7, 2007.
Note blanket inside of grave.

Figure 21. Day 4; Pigs 3 and 4; 7:46pm June 7, 2007.
Note graves absent of pigs.

Pig 5's blanket was still inside the grave and appeared soaked in decomposition fluid. Blowflies were plentiful on the blanket and various skeletal elements were found inside the grave (Figure 22). A pair of intact mummified limbs was found associated with the grave, one hanging off the edge and the other laying flat outside of the grave (Figure 23). Vulture scavenging on the remains was evident by the feathers found inside the grave and underneath the blanket.

Figure 22. Day 4; Pig 5;
7:47pm June 7, 2007.
Note blanket and remains covered in blowflies.

Figure 23. Day 4; Pig 5; 7:47pm June 7, 2007.
Note limb bones halfway inside and outside of the grave.

The area that Pig 6 was deposited was void of the pig and stained with decomposition fluids (Figure 24). The blanket was located in close proximity to the deposit site, along with numerous skeletal elements. No maggots were visible, but there was still a presence of blowflies on the blanket itself.

Figure 24. Day 4; Pig 6; 7:48pm June 7, 2007.
Note grass stained with Pig 6's decomposition fluid.

CHAPTER 4

RESULTS

4.1 Control Results

The daily observations of Pig 6 illustrated the speed at which decomposition processes occur in a child-sized pig carcass wrapped in a blanket deposited on the surface in the summer in central Texas. The blanket covering retarded the onset of blowfly activity on Day 1, but once a portion of the leg was exposed on Day 2, blowflies were able to commence oviposition on top of and underneath the blanket. During the morning of Day 4, maggot masses had formed on Pig 6's head and anal region. The control had reached the active decay stage of decomposition in four days.

By that evening, Pig 6 was reduced to skeletal elements with some adherence of soft tissue and skin to the remains as a result of vulture activity. These elements were scattered around the spot Pig 6 was deposited, including the blanket that still exhibited a presence of blowflies.

It appeared that vultures had removed the pig from the blanket covering, consumed, and then scattered the pig in the vicinity of its deposition. The distance each element was scattered from the center of the deposit spot was measured and recorded (Appendix A). There was a general tendency for bones of the cranium and thorax to be found closer to the deposit spot and bones of the hind limbs to be found further away. This pattern resembled Haglund's (2005) model of carnivore scavenging, in which consumption of the head occurred first and proceeded downwards, with the lower limbs disarticulated last.

4.2 Experimental Group Results

The experimental group results exhibit the effects of shallow burial on decomposition processes of child-sized pig carcasses wrapped in blankets. Blowflies did not have full access to the buried remains due to the soil covering and blankets. However, once the intestines or limbs were exposed through the soil, as in the cases of Pigs 3 and 4, blowfly activity commenced but never reached the stage of creating maggot masses.

The soil covering on the burials was shallow enough for vultures to gain access to the pig carcasses and commence scavenging and scattering of the remains. Though the burials were constructed to be identical, each shallow grave exhibited slightly different taphonomic processes and rates of decomposition.

The Pig 1 burial had the most skeletal remains collected, and there was evidence of commingling, which will be discussed later in this section. As far as the general pattern of remains found associated with Pig 1, due to the extensive commingling it was difficult to discern a tendency for remains to be closer or further away from the grave. Nevertheless, it did appear that more vertebrae and cranial remains were located further away from the grave while thoracic elements were found inside the grave.

As for Pig 2, there was a general tendency for cranial elements and anterior leg bones to be found closer to the grave (under 1m from the grave), with hind leg and foot bones scattered up to 3.35m away. These bones were scattered the farthest among all of the skeletal elements recovered. The bones found inside Pig 2's grave were of the cranium and ribs, except for a left tibia.

Minus the cranial bones, Pig 3's grave followed a similar pattern. Ribs were found inside the grave and a couple of leg bones were present. Pig 3 also had the fewest remains found.

Pig 4 only had eight skeletal elements scattered from its grave. The closest to the grave were cranial and rib fragments, while the farthest were tibiae. The remains inside of the grave consisted of numerous ribs and cranial elements, with the presence of two leg bones: the femur and fibula, as was seen with Pig 3.

Pig 5 also exhibited a similar pattern as the previous four subjects. Cranial, thoracic, and anterior leg bones were found closer to the grave while hind legs and feet were scattered further away. The contents of the grave also contained cranial and rib elements. All remains were subject to vulture scavenging. The effects of this taphonomic process were analyzed. Once all of the remains from the control and experimental groups were collected and catalogued, the data for both were compiled (Table 3).

Table 3. Skeletal Remains Inventory: Whole and Fragmentary Bones

Pigs

Elements	**1**	**2**	**3**	**4**	**5**	**6**	**Total Per Element**
Cranial Bones	26	10		7	7	11	61
Mandible	3			1	1	1	6
R. scapula	1		2			1	4
R. humerus	2				1	2	5
R. ulna		1	1		1		3
R. radius		1	1		1		3
L. scapula	2		1			1	4
L. humerus	2			1	1	1	5
L. ulna		2	1		1		4
L. radius		1	1		1		3
Hand Bones		2	1				3
Sternum							0
Ribs	24	18	19	19	20	16	116
Cervical vertebrae	1						1
Thoracic vertebrae	4				2		6
Lumbar vertebrae							0
Sacral/Tail Bones							0
R. innominate		1			1	1	3
R. femur		1	2		1	1	5
R. tibia		2		1	2	1	6
R. fibula	1		1		1	1	4
L. innominate		1			1	1	3
L. femur	1	1	1	1	1	1	6
L. tibia		1	1	2	1	1	6
L. fibula	1	1	1	1	2		6
Foot Bones	5	2	2	4	10	3	26
Total Per Pig	**73**	**45**	**35**	**37**	**56**	**43**	**Total Recovered: 289**

Key

(yellow)	Bones recovered
# (yellow)	Number of recovered bones
(red)	Bones recovered with fragments
(white)	Bones not recovered

This inventory is not exhaustive; rather, it captures information considered to be most important in comparative analysis for this experiment (Ubelaker 2002). Note that pigs do not have clavicles like humans and have about 15 pairs of ribs (Appendix B). Also, a plethora of sesamoid bones, epiphyses, and possible sacral and tail ossification centers were found with the remains. Due to the immature nature and fragility of the remains, many elements could not be positively distinguished from one another. Given this circumstance, it was concluded that attempting to identify them would be a fruitless endeavor and therefore, they were excluded from the general population of remains for analysis. Pigs do not have hands, in the human sense of the term, but "Hand Bones" served as synonymous with metacarpal, carpal, and/or phalangeal bones of the anterior limbs. "Foot Bones" were synonymous with metatarsal, tarsal, and/or phalangeal bones of the hind limbs.

Cranial bones were either found disarticulated at the sutures or exhibiting fractures. Following Ubelaker's (2002) method of coding the presence of the bones of the skull, the cranial bones found from each grave were categorized as follows:

Table 4. Coding for Cranial Bones

Code	**Amount of Skull Present**
Complete	At least 75% present
Partially Complete	25-75% present
Poorly Preserved	Less than 25% present
Absent	Absent

The cranial elements recovered were coded as follows:

Table 5. Presence of Cranial Elements for each Pig

Pig	No. of Cranial Elements	Code/Number of Crania Present
1	26	2 complete 1 partially complete
2	10	1 partially complete 1 poorly preserved
3	0	Absent
4	7	1 poorly preserved
5	7	1 poorly preserved
6	11	1 partially complete

It should be noted that some crania were counted twice. For example, the partially complete cranium in Pig 1 and the partially complete cranium in Pig 2 equal one complete cranium. The presence and extent of commingling or absence of commingling was analyzed for each pig. All pigs were too similar in size to visually or metrically discern one pig from another; therefore, the presence of multiple bones of the same type and side was used to identify commingling (Ubelaker 2002). All graves were hierarchically categorized by the amount of commingling present: 0=no commingling, 1=commingling with MNI (minimum number of individuals) of 2, 2=commingling with MNI of 3, 3=commingling with MNI of 4, 4=commingling with MNI of 5, and 5=commingling with MNI of 6. Based on the presence of three left and three right mandible halves, Pig 1 scored a 2, MNI of 3 (Figure 25). Ribs were not used to determine MNI for Pig 1 because only 12 left and 12 right matching ribs were found, indicating the strong likelihood that the ribs belonged to one pig. No identical ribs were found in each of the rest of the graves or the surface deposit to warrant different MNI scoring.

Figure 25. 3 left and 3 right mandibles associated with Pig 1.

The skeletal elements collected from Pig 2 contained two left ulnae and two right tibiae. Pig 3 yielded two right scapulae and two right femora. Pig 4 yielded two left tibiae and Pig 5 yielded two right tibiae and two left fibulae. The skeletal remains collected from Pig 6 also exhibited commingling, with the presence of two right humerii. Pigs 2 through 6 all scored a 1, MNI of 2, based on these findings.

4.3 Post hoc Analyses

The total collection of skeletal remains was analyzed using Chi-square tests for independence. The null hypothesis was that there will be no difference in the number of elements recovered from each pig in the experimental group and the pig in the control group. The alternate hypothesis was that there will be a significant difference in the number of elements recovered from each pig. However, due to the presence of commingling in all of the graves and the deposit, it could not be statistically determined if there was a difference in the number of elements recovered from each pig solely belonging to that pig. The data showed that 73 skeletal elements, which include some cranial fragments, were found associated with Pig 1. But the data also showed that Pig 1 exhibited the greatest amount of commingling, with the possibility of at least two other pigs' skeletal remains present. It is apparent that of the pigs displaying an MNI of 2, Pig 3 had the least amount of skeletal elements recovered. This may be due to the complete absence of cranial remains.

All of the pigs' skeletal remains exhibited commingling, with Pig 1 exhibiting the greatest amount. The pigs were also subject to scattering by scavengers, which in this experiment, were observed to primarily be vultures. The locations of the skeletal elements recovered were categorized as either "Inside Grave" (remains found inside the grave) or "Scattered" (remains found outside of the grave, or for Pig 6, away from the site of deposition). The number of remains found inside the graves and scattered for each pig was analyzed using Chi-squared tests for independence. A critical value of .05 was used to determine significance. It should be noted that the statistical analyses performed were based on the assumption that the skeletal remains found associated with each burial belonged to the pig in that burial. It was assumed that if scavengers dragged the remains to another grave for consumption, scattering would be measured from the location the remains were probably consumed. Table 6 displays the frequency observed of remains found in both types of locations for each pig compared to the expected frequencies if no relationship existed between each pig and the location of their respective remains. The data revealed that over half of the skeletal remains found were located inside the graves. Pigs 1 and 2 had fewer remains found inside of their graves than was expected, while Pigs 3, 4, and 5 were observed to have less scattering of their remains than was expected.

Table 6. Frequency Table for Location of Remains Found for Experimental Group

		LOCATION		
		INSIDE GRAVE	SCATTERED	TOTAL
PIG 1	COUNT	26.0	47.0	73.0
	EXPECTED COUNT	38.9	34.1	73.0
PIG 2	COUNT	22.0	23.0	45.0
	EXPECTED COUNT	24.0	21.0	45.0
PIG 3	COUNT	21.0	14.0	35.0
	EXPECTED COUNT	18.6	16.4	35.0
PIG 4	COUNT	29.0	8.0	37.0
	EXPECTED COUNT	19.7	17.3	37.0
PIG 5	COUNT	33.0	23.0	56.0
	EXPECTED COUNT	29.8	26.2	56.0
TOTAL	COUNT	131.0	115.0	246.0
	EXPECTED COUNT	131.0	115.0	246.0

For the experimental group, Pigs 1-5, the null hypothesis was that there will be no difference in the distribution of skeletal remains found inside the grave and scattered. Conversely, the alternate hypothesis was that there will be a significant difference in the distribution of remains found inside the grave and scattered. Analyses of these data produced a Chi-square value of 20.213 which, at four degrees of freedom, resulted in a two-tailed significance value of .000. This implies that the difference in the distribution of skeletal remains is significantly different from what would be expected by chance. No cells had an expected value less than five, which could have artificially inflated the Chi-square value. Therefore, the null hypothesis that there will be no difference in the distribution of skeletal remains found inside the grave and scattered for the experimental group can be rejected.

Analysis of the extent of scattering was conducted for the experimental group first because it involved two possible locations: inside the grave and outside. The surface-deposit, Pig 6, exhibited scattering of all of its skeletal elements because there was no shallow grave present in this scenario to serve as a variable that would limit scattering by scavengers. Table 7 displays the frequencies of remains found for the control and experimental groups, along with the percentages of their remains found overall in each category.

Table 7. Frequency and Percentage Table of Pig Remains Found and Location of Remains

		LOCATION		
		INSIDE GRAVE	**SCATTERED**	**TOTAL**
PIG 1	COUNT	26.0	47.0	73.0
	% OF TOTAL	9.0%	16.3%	25.3%
PIG 2	COUNT	22.0	23.0	45.0
	% OF TOTAL	7.6%	8.0%	15.6%
PIG 3	COUNT	21.0	14.0	35.0
	% OF TOTAL	7.3%	4.8%	12.1%
PIG 4	COUNT	29.0	8.0	37.0
	% OF TOTAL	10.0%	2.8%	12.8%
PIG 5	COUNT	33.0	23.0	56.0
	% OF TOTAL	11.4%	8.0%	19.4%
PIG 6	COUNT	0.0	43.0	43.0
	% OF TOTAL	.0%	14.9%	14.9%
TOTAL	COUNT	131.0	158.0	289.0
	% OF TOTAL	45.3%	54.7%	100.0%

Including the control group, the number of remains scattered are now greater than the number of remains found inside of the graves. Because the "Inside Grave" category did not pertain to Pig 6, the "Scattered" category was analyzed to see which pig's remains were scattered the most compared to the total remains found. The null hypothesis was that there will be no difference in the extent of scattering of the remains among all of the pigs. The alternate hypothesis was that there will be a significant difference in the number of scattered remains. A total of 289 remains were found during this experiment. Of the 289 remains, 43 were of the control group, which only experienced scattering. Around a quarter of the remains found belonged to the Pig 1 collection. Statistical assessment of the data generated a Chi-square value of 62.188 with 5 degrees of freedom which produced a two-tailed significance value of .000. The null hypothesis can be rejected.

From the analysis of the percentages of scattered remains found (Table 8), Pig 1 exhibited the greatest amount of scattering with 64.4% of its remains found outside of its grave, accounting for 29.7% of scattered remains found (Table 6). It should be noted that these numbers could very well be inflated because of the greater extent of commingling associated with the Pig 1 burial. A positive correlation between commingling and scattering would be assumed from this finding. Because of the complications that may arise from including Pig 1, an assessment of the buried pigs exhibiting an MNI of 2 was conducted (Table 9). With the same amount of commingling present in each of these graves, the null hypothesis was that there will be no difference in the amount of remains found inside the graves versus scattered. The alternate hypothesis was that there will be a significant difference in the location of the remains.

Table 8. Frequency and Percentage Table of Scattered Remains

		LOCATION
		SCATTERED
PIG 1	COUNT	47.0
	% OF TOTAL	29.7%
PIG 2	COUNT	23.0
	% OF TOTAL	14.6%
PIG 3	COUNT	14.0
	% OF TOTAL	8.9%
PIG 4	COUNT	8.0
	% OF TOTAL	5.1%
PIG 5	COUNT	23.0
	% OF TOTAL	14.6%
PIG 6	COUNT	43.0
	% OF TOTAL	27.2%
TOTAL	COUNT	158.0
	% OF TOTAL	100.0%

Table 9. Frequency Table for Location of Remains of Buried Pigs Exhibiting MNI of 2

		LOCATION		
		INSIDE GRAVE	**SCATTERED**	**TOTAL**
PIG 2	COUNT	22.0	23.0	45.0
	EXPECTED COUNT	27.3	17.7	45.0
PIG 3	COUNT	21.0	14.0	35.0
	EXPECTED COUNT	21.2	13.8	35.0
PIG 4	COUNT	29.0	8.0	37.0
	EXPECTED COUNT	22.5	14.5	37.0
PIG 5	COUNT	33.0	23.0	56.0
	EXPECTED COUNT	34.0	22.0	56.0
TOTAL	COUNT	105.0	68.0	173.0
	% OF TOTAL	105.0	68.0	173.0

Observed and expected frequencies for the location of remains for Pigs 2 through 5 revealed that the observed number of scattered remains exceeded the expected count, except in Pig 4's case. Pig 4 exhibited a greater number of remains found inside its grave (78.4% of its remains) than was expected. Pig 3 and 5's observed counts were very close to their expected counts. Statistical assessment of these data generates a Chi-square value of 7.559 with three degrees of freedom which produces a two-tailed significance value of .056. Based on these findings, the null hypothesis was accepted and there was no significant difference in the location of remains for the buried pigs exhibiting an MNI of 2. From the foregoing, it is clear that all of the pig subjects exhibited commingling and scattering caused by vultures. There were significant differences in the number of elements found within graves and scattered, and a general pattern of what type of remains were located in relation to each grave (Appendix A).

CHAPTER 5

DISCUSSION

5.1 Overview

The major factors influencing taphonomic changes and decomposition rates of child-sized remains are disposal site characteristics, environmental conditions, offender behavior, vertebrate scavengers, victim characteristics, and necrophagous insects (Morton and Lord 2002). The extent each of these major factors affected child-sized pig carcasses during decomposition was tested and analyzed yielding some expected and unexpected results.

Disposal Site Characteristics

All six carcasses were deposited on a secure plot of land in central Texas. This rural setting excluded human interference with the remains, but allowed full access for scavengers indigenous to this geographical area.

Environmental Conditions

This study was conducted during the summer of 2007 in San Marcos, Texas. Over the course of the experiment, the lowest temperature in this area was recorded as 18°C (64.4°F) and the highest as 35°C (95°F). There was no rainfall or extreme weather such that occurred after the pigs were deposited that may have interfered with the decomposition rates or scattering of the remains. The relatively warm nights and extremely hot days would accelerate decomposition of any corpse at this disposal site, especially one that was exposed, because these temperatures promote oviposition by blowflies. Also, vultures (which were the only scavengers observed during this experiment) do not scavenge at night due to poor eyesight. They soar on thermals of warm, rising air during the day.

Offender Behavior

In the 1996 FBI-sponsored study into the epidemiology of child abduction and homicide, remains were disposed of in different scenarios depending upon the motivation of the offender (Morton and Lord 2002). Child homicide offenders often go to great lengths to conceal their victims (Gremillion 2005). In this experiment, the pig carcasses were wrapped in material simulating blankets. The blankets not only served to conceal the victim, they prevented immediate detection by blowflies and scavengers, influencing the postmortem interval.

Offenders also often bury their victims in shallow graves (Morton and Lord 2002). This added mode of concealment further delays attraction to remains by scavengers and insects. The carcasses in this experiment were not only wrapped in blankets, five of them were buried in shallow graves. This extra barrier should have either delayed or prevented scavengers and insects from gaining access to the remains for consumption, but did not.

Vertebrate Scavengers

Scavenging by vertebrates has recently received more attention in forensic literature as more incidences of scavenger activity on remains have been reported in forensic cases. Scavenging was also a factor in the decomposition of child-sized remains. Naturally exposed corpses are subject to scavenger modification, which in turn affects estimation of time since death by modifying the rate of decomposition and pattern of insect succession (Willey and Snyder 1989). Vertebrates can produce a great amount of damage to the flesh and skeletal elements.

In this experiment, vultures were observed scavenging on the surface-deposit and the buried pigs. Based on the percentages of scattered remains found, it appeared that vultures consumed and scattered the remains of Pigs 1 and 6 the most, and reduced their activity as they approached the middle graves (Pig 3 and 4) (see Table 8). In some of the cases, the pigs were removed from their blankets, which were still buried inside the graves. In a study by Gremillion (2005), the alpha bird selected a feeding site where vultures began feeding on a pig in a clockwise manner. The pigs were placed inside cages, yet vultures were able to mangle the carcasses by sticking their heads through the cages.

Victim Characteristics

The pigs used in this experiment weighed between 18 and 20 pounds (8-9kg) to represent an infant between the ages of 6 months to 12 months. Common knowledge is that child-sized remains decompose faster and their skeletal remains are hard to find because of their small size. Many of the remains in this experiment were not recovered. The sternum, lumbar vertebrae, and sacral/tail bones were not found from all pigs. Very few hand bones were recovered also. These remains were difficult to find among the grass and rocky soil. Because of the small size of these elements, it is also possible that the vultures could have swallowed them.

Necrophagous Insects

Blowflies are attracted to corpses within a matter of minutes. Oviposition occurs when weather conditions include temperatures between 15 and 27°C, light winds, sunny days, and no other direct continuous exposure of the corpse to the sun (Gremillion 2005). The weather conditions during this experiment were ideal for blowfly activity.

5.2 Control

As expected, the surface-deposit (Pig 6) exhibited the taphonomic processes associated with remains left on surfaces in outdoor settings. The carcass went through putrefaction, active decay, skeletonization, and sun-bleaching of skeletal elements. The blanket covering prevented immediate colonization by insects, but once portions of the carcass became exposed, blowflies were able to deposit eggs around natural orifices and wounds. The maggots also used the blanket as shelter from the sun.

Vulture scavenging was not expected on the surface deposit because of the presence of maggots. In Morton and Lord's (2006) experiment, the utilization of corpses as food sources by vertebrates was dependent upon insect colonization. Vultures avoided feeding on the pig carcasses in their experiment while insects were present. Between the time maggots were observed on Day 4 at 10:35am and the time Pig 6 was discovered skeletonized at 7:48pm in this experiment, either the maggots migrated from the remains (which in turn would allow vultures to begin feeding) or the vultures fed on the carcass while the maggots were still present. The latter scenario would not agree with what Morton and Lord observed and concluded.

Nevertheless, the child-sized carcass used in their experiment and in this experiment was consumed within 5 days and exhibited the least amount of scavenging when compared to distances of scattered elements of the buried remains. Of the remains scattered, there was a tendency for cranial and torso elements to be located closer to the spot of deposition than limbs.

5.3 Experimental Group

Unexpectedly, the experimental group of buried remains was subject to scavenging and subsequent scattering. In Morton and Lord's (2006) experiment, vultures were observed to visit the site every day and attempted to dislodge the buried remains from the shallow grave by grasping and pulling at the remains. The remains were not wrapped in any type of clothing or blanket. It took a number of different vultures several hours to eventually succeed in removing the intact remains from the burial. In their experiment, the soft tissues of the carcasses were completely consumed and scattered by the next day. In Schultz et al.'s (2006) experiment, it took 21.5 months for complete skeletonization of their shallow burial pigs. However, in this study, the digging, removal, consumption, and scattering of five pig carcasses wrapped in blankets occurred in only 9 hours. Complete consumption of the Morton and Lord buried remains occurred over a 10-day interval compared to the 4-day interval of this experiment. The size of the pigs may explain the difference in the time it took vultures to consume the remains. The pigs in their experiment weighed around 30lb (13.6kg), while the pigs in this experiment were only 8-9kg. These findings support the notion that smaller remains decompose faster because there is less flesh to feed on.

Vultures prefer fresher carcasses, and the shallow burials preserved the buried pigs, explaining their affinity to the experimental group during observations. The data show that in general, the remains of the buried carcasses were scattered to a greater extent. Statistical assessments of the number of remains found inside the graves versus scattered showed that there was a significant difference in where remains were found. There was not a significant difference in location of remains for Pigs 2-5 with MNI = 2, suggesting that the extent of commingling resulting from vulture scavenging influences the location of skeletal remains for buried child-sized carcasses wrapped in blankets. From the location where the remains were found, it appeared that consumption of the head and torso occurred primarily inside of the graves, while consumption and scattering of limbs occurred further away from the grave. It is still not understood why this pattern of consumption was observed but it can be speculated that consumption of the torso occurred *in situ* because it is the fleshiest part of the body in pigs. As explained earlier, Gremillion's (2005) study showed that vultures pick a feeding site to consume remains. The graves obviously served as a feeding site, and possibly upon consumption of the torso, separate vultures disarticulated limbs and dragged them to other locations to feed.

Because of the added covering of soil, it was expected that the buried remains would exhibit slower rates of decomposition because of the limited access for insect and scavenger activity. As far as internal decomposition processes such as putrefaction and active decay, through the exposure of the blankets and intestines in some cases, it was clear the remains were still undergoing these processes at a rate similar to the surface deposit. Blowflies were also observed on the exposed flesh of Pig 3, but unlike the surface deposit, there was no evidence of oviposition. This may have been because the flesh was directly exposed to the sun, which would not have been favorable for eggs and maggots to survive.

5.4 Limitations

The smaller size and weight of these remains and the steadily hot temperatures, coupled with the exposure to insect and scavenger activity, explains the accelerated rate of decomposition observed in this study. Few decomposition studies have been conducted on child-sized remains and only some on adult-sized or child-sized remains in central Texas. Texas holds a plethora of potential scavengers that may approach scavenging in different ways, depending on the size of the remains or type of deposition involved. More studies need to be conducted in this geographical area to provide data for comparisons of decomposition rates in various scenarios that simulate what forensic investigators may encounter.

There were, however, some limitations in this research. The use of pig carcasses versus the use of human cadavers was not ideal because of the introduction of commingling as a variable. For ethical reasons, it would not have been possible to use a human infant cadaver, but the use of six pig carcasses allowed greater room for observing differential taphonomic processes.

Commingling posed a problem in identifying the extent of scattering and rate of decomposition for both the buried and surface-deposit remains. Also, many of the remains were not successfully recovered. Multiple child burials are not common, also. It would have benefited analysis of the remains if there were fences between each grave to prevent commingling or for the remains to be buried further apart from each other. The use of GPS positioning could have been taken to locate remains and track how far elements were scattered. The difficulty in finding remains highlights the issues law enforcement face when dealing with child victims of homicide, especially those that are buried. Locating and identifying child skeletal remains through organized searches is often relatively unsuccessful (Morton and Lord 2006). Though it would have been ideal to fence off each grave to contain remains for more successful recovery of elements, it would not have been a realistic simulation and would have yielded skewed results.

A significant amount of scavenging occurred while the observer was not present. In a study on the effects of vulture scavenging on pig remains left on the surface in central Texas, turkey vultures were observed to practice a 24-hour waiting period before they started consuming the remains (Nicole Reeves, personal communication, May 8, 2008). It would have definitely benefited this study to have 24-hour surveillance by video technology. Questions such as why vultures fed in the pattern observed through recovery of the skeletal elements, how many vultures fed on the carcasses, and did any other scavengers partake in scattering are still unanswered and can only be speculated. If the remains were deposited at night, other scavengers such as coyotes would have first access to the remains, thus possibly producing different results.

The times of the year for decomposition studies such as this one should be alternated between the four seasons to observe taphonomic processes that can occur within each season in central Texas. A series of control scenarios should be conducted as a means of comparison against the decomposition rates to determine how significant the delays in decomposition are within the context of the decomposition rates of children.

Nevertheless, the findings from this experiment yielded interesting observations of vulture scavenging behavior. The consumption of the surface-deposit that exhibited maggot colonization does not support previous findings that concluded an accidental cooperative relationship between insects and scavengers. Vultures did feed on this carcass even though insect colonization was very much active. Also, this study has presented the aggressiveness of vultures when it comes to scavenging buried remains. They visited the site daily and eventually were able to remove the soil covering, and in some cases, the blankets of the buried pigs to commence feeding. The vultures fed during the daytime hours and early evening as expected. The extent vultures scatter remains are of importance to forensic investigators searching for remains of smaller victims. It is unsure if commingling significantly affected the distance remains were removed from the graves, but the data collected show how far vultures are capable of scattering elements and in what pattern.

CHAPTER 6

CONCLUSION

The rate of decomposition was slightly faster by several hours for the surface deposit than that observed in the experimental group of five buried remains, mainly due to the presence of insect colonization on the control. The depth of the shallow burials was also not significant enough to create a greater difference in decomposition rates between the experimental group and control. The blanket on the surface deposit delayed insect colonization by one day, but by the fourth day of the study, extensive maggot activity had commenced. The buried remains exhibited no maggot activity due to the soil covering and blanket barrier, as well as the direct exposure to sunlight on exposed flesh of some of the buried pigs.

Both the control and the experimental group were subject to scavenger activity by vultures. Within nine hours on the fourth day of this study, vultures reduced all carcasses to skeletal elements. As a result of vulture scavenging, the six carcasses' remains were commingled and scattered. Pig 1's grave exhibited the greatest extent of commingling, but it is unknown why this occurred. The buried pigs exhibited less scattering of remains than the surface-deposit, except for Pigs 1 and 2, based on the number of their respective remains found scattered. This does not support findings of Morton and Lord's research in which buried remains exhibited greater scattering than the surface-deposits. For all of the pigs, there was a general tendency for cranial and thorax bones to be located closer to the grave/deposit site and limb bones to be located further away, with the exception of Pig 1.

Over half of the skeletal remains found associated with the experimental group were located inside of the graves. There was a significant difference in the distribution of remains found inside the graves and scattered. There was also a significant difference among the number of scattered remains for all buried pigs. However, excluding Pig 1 because of its higher commingling rate, the difference in the location of remains was found not to be significant. Pig 1 exhibited the greatest amount of scattering also, suggesting a positive correlation between commingling and scattering.

This study was executed in an attempt to determine the effect shallow burials and blankets have on the rate of decomposition and taphonomic processes of child-sized remains. Analysis of the results revealed that the major difference between the control and experimental subjects was the insect activity, but both groups were skeletonized at the same rate by vultures.

A major limitation of this study was not having 24-hr surveillance at the site. The scavenging patterns of the vultures, as well as the presence of any other possible scavengers could have been observed and analyzed. Future research should entail the utilization of technology for such surveillance and GPS positioning to locate and recover scattered remains.

The findings from this experiment can assist investigators in understanding the rate of decomposition for child-sized remains deposited or buried in central Texas. This information shows that buried victims can exhibit as much as scattering of their remains as victims deposited on the surface. Therefore, investigators should expect scattering of buried remains. Investigators should also expect to find cranial and torso elements closer to burials or deposit sites, and missing limbs further away.

APPENDIX A

Skeletal Remains Inventory, Location Found, and Distance from Burial

Bone(s)	Side	Location	Distance from Burial (cm)
Pig 1			
Vomer/Rostral Bone		Outside Grave	3.8
Fibula	Right	Outside Grave	5.8
Mandible	Right	Outside Grave	6.9
Rib	Right	Outside Grave	7.1
Cervical vertebra		Outside Grave	7.4
Humerus	Left	Outside Grave	9.4
Humerus	Left	Outside Grave	9.7
Fibula	Left	Outside Grave	9.7
Tarsal		Outside Grave	9.7
Tarsal		Outside Grave	9.7
Maxilla fragment with teeth	Right	Outside Grave	9.7
Humerus	Right	Outside Grave	10.2
Mandible	Left	Outside Grave	10.7
Femur	Left	Outside Grave	11.4
Tarsal		Outside Grave	13.5
Maxilla fragment with teeth	Right	Outside Grave	14.7
Maxilla fragment with teeth	Left	Outside Grave	14.7
Tarsal		Outside Grave	14.7
Maxilla fragment with teeth	Left	Outside Grave	15.0
Tarsal		Outside Grave	15.0
Mandible	Right	Outside Grave	15.7
Occipital, parietals, temporal	Right	Outside Grave	16.0
Mandible	Left	Outside Grave	16.5
Rib	Left	Outside Grave	16.5
Vomer/Rostral Bone		Outside Grave	16.8
Rib	Left	Outside Grave	17.9
Thoracic vertebra		Outside Grave	18.0
Scapula	Left	Outside Grave	19.1
Thoracic vertebra		Outside Grave	19.1
Thoracic vertebra		Outside Grave	19.1
Mandible	Right	Outside Grave	19.4
Maxilla/Palate with teeth	Complete	Outside Grave	20.1

Appendix A continued

Temporal	Left	Outside Grave	24.4
Humerus	Left	Outside Grave	28.4
Scapula	Right	Inside Grave	
Scapula	Left	Inside Grave	
Mandible	Left	Inside Grave	
Thoracic vertebra		Inside Grave	
Temporal	Right	Inside Grave	
21 Ribs	11R;10L	Inside Grave	
Pig 2			
Occipital		Outside Grave	1.3
Occipital/cranial fragments		Outside Grave	1.9
Ulna	Right	Outside Grave	4.3
Temporal	Left	Outside Grave	4.6
Metacarpal		Outside Grave	4.8
Rib	Left	Outside Grave	5.6
Entire leg (femur, tibia, foot)	Right	Outside Grave	13.2
Ulna	Left	Outside Grave	13.3
Tibia	Right	Outside Grave	14.4
Ulna	Left	Outside Grave	15.7
Radius	Right	Outside Grave	16.0
Metacarpal		Outside Grave	16.9
Radius	Left	Outside Grave	17.0
Femur	Left	Outside Grave	335.0
Innominate		Outside Grave	335.0
Tarsals		Outside Grave	335.0
Metatarsals		Outside Grave	335.0
Parietals/occipital		Inside Grave	
Tibia	Left	Inside Grave	
Temporal	Right	Inside Grave	
17 Ribs	8R; 9L	Inside Grave	
Pig 3			
Rib	Right	Outside Grave	0.8
Fibula	Right	Outside Grave	1.8
Scapula	Right	Outside Grave	3.0
Ulna	Right	Outside Grave	3.3

Appendix A continued

Radius	Right	Outside Grave	3.3
Radius	Left	Outside Grave	3.3
Rib	Right	Outside Grave	3.8
Tibia	Left	Outside Grave	4.1
Ulna	Left	Outside Grave	6.4
Scapula	Right	Outside Grave	6.6
Femur	Left	Outside Grave	6.6
Tarsals		Outside Grave	6.6
Femur	Right	Outside Grave	6.9
17 Ribs	7R; 10L	Inside Grave	
Scapula	Left	Inside Grave	
Femur	Right	Inside Grave	
Fibula	Left	Inside Grave	
Metacarpal		Inside Grave	
Pig 4			
Temporal	Right	Outside Grave	1.0
Rib	Right	Outside Grave	1.3
Rib	Right	Outside Grave	1.4
Humerus	Left	Outside Grave	1.5
Rib	Right	Outside Grave	1.5
Tibia	Left	Outside Grave	4.7
Tibia	Left	Outside Grave	3.8
Tibia	Right	Outside Grave	4.8
16 Ribs	8R; 8R	Inside Grave	
Mandible	Complete	Inside Grave	
Occipital		Inside Grave	
Zygomatic/maxilla with teeth		Inside Grave	
Palate with teeth	Left	Inside Grave	
Small foot bones		Inside Grave	
Cranial fragments		Inside Grave	
Femur	Left	Inside Grave	
Fibula	Left	Inside Grave	
Pig 5			
Cranial fragments		Outside Grave	1.0
Ulna	Left	Outside Grave	1.5

Appendix A continued

Thoracic vertebra		Outside Grave	2.0
5 Ribs	3R; 2L	Outside Grave	2.5
Radius	Right	Outside Grave	3.0
Radius	Left	Outside Grave	3.2
Tibia	Right	Outside Grave	3.7
Innominate		Outside Grave	5.1
Femur	Right	Outside Grave	6.4
Femur	Left	Outside Grave	6.5
Fibula	Left	Outside Grave	8.1
10 Foot Bones		Outside Grave	8.9
Fibula	Left	Outside Grave	10.7
Fibula	Right	Outside Grave	10.7
Tibia	Left	Outside Grave	10.7
Tibia	Right	Outside Grave	10.9
Mandible	Complete	Inside Grave	
Cranial fragments		Inside Grave	
15 Ribs	7R; 8L	Inside Grave	
Thoracic vertebra		Inside Grave	
Maxilla fragment with teeth	Left	Inside Grave	
Pig 6			
Mandible	Complete	Outside Grave	1.8
6 Ribs		Outside Grave	2.2
Cranial fragments		Outside Grave	2.4
10 Ribs		Outside Grave	3.0
Scapula	Right	Outside Grave	3.6
Innominate		Outside Grave	4.3
Humerus	Right	Outside Grave	4.6
Scapula	Left	Outside Grave	5.8
Humerus	Left	Outside Grave	6.1
Foot Bones		Outside Grave	6.6
Humerus	Right	Outside Grave	7.7
Femur	Right	Outside Grave	10.7
Tibia	Right	Outside Grave	10.7
Fibula	Right	Outside Grave	10.7
Femur	Left	Outside Grave	11.9
Tibia	Left	Outside Grave	11.9

APPENDIX B

Skeletal Anatomy of Pig (*Sus scrofa*)

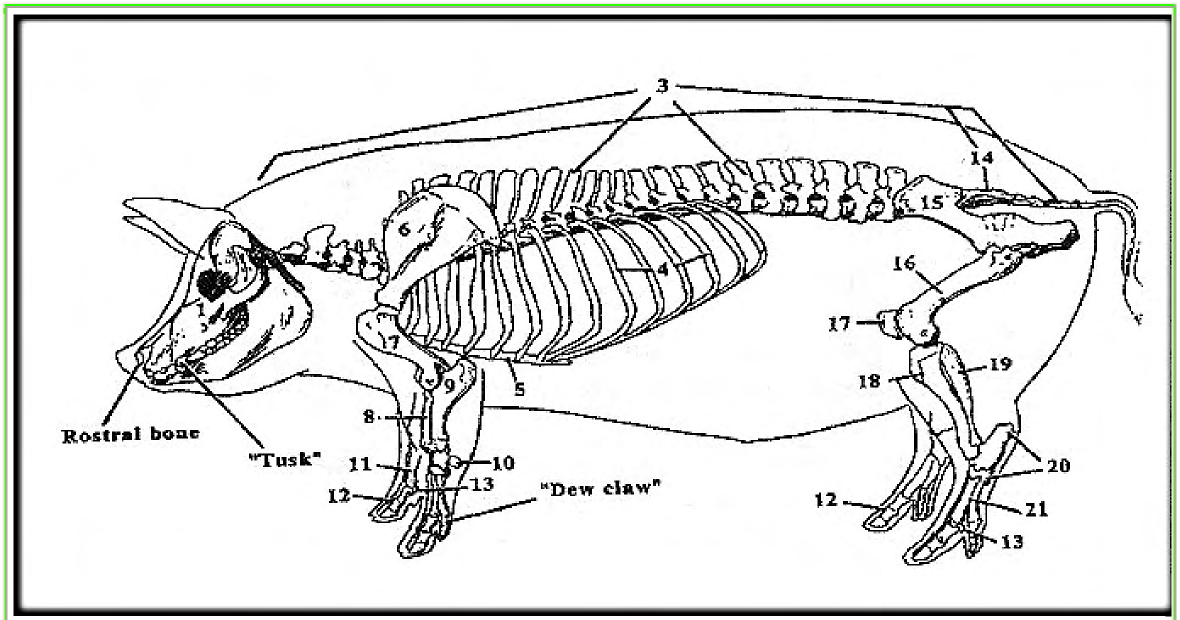

Image from: http://www.upprs.com/health/skeleton.htm

1. Skull	8. Radius	15. Os Coxae
3. Vertebral Column	9. Ulna	(Innominate)
4. Ribs	10. Carpal Bones	16. Femur
5. Sternum	11. Metacarpal Bones	17. Patella
6. Scapula	12. Phalanges	18. Tibia
7. Humerus	13. Sesamoid Bones	19. Fibula
	14. Sacrum	20. Tarsal Bones
		21. Metatarsal

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