A STUDY ON THE RATE OF DECOMPOSITION OF CARRION IN CLOSED CONTAINERS PLACED IN A SHADED AREA OUTDOORS IN CENTRAL TEXAS

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A STUDY ON THE RATE OF DECOMPOSITION OF CARRION

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CHAPTER 1

INTRODUCTION

Initially, forensic anthropology was interested in skeletal identification (Krogman and Isçan 1986). Determining age, sex, race and stature of unidentified human skeletal remains was the major contribution made by forensic anthropologists (Stewart 1979). Though forensic anthropology has grown, skeletal identification is still one of the most important aspects of anthropological investigation. Nevertheless, the momentous accomplishments made by forensic anthropologists have broadened the scope of the discipline to include related phenomena such as decomposition, arson, entomology and effects of all types of trauma. In the field of forensic anthropology, the decomposition process has inspired many studies over the years (Bass 1997, Cahoon 1992, Clark et al. 1997, Galloway et al. 1989, Mann et al. 1990, Ritchie 2005, Rodriguez and Bass 1983). This study is concerned with the decomposition process.

The rate of decomposition has proven significant in determining postmortem interval (PMI). The PMI is essential to investigators when attempting to determine time of death. By conducting studies to determine specific stages in the process of decomposition, forensic anthropologists have made provisional timelines of PMI based on their findings. Continuing research into the decomposition process provides specific rates of decomposition for an increasing number of varied environments.

In cases of homicide, the location and condition of the area where the body is disposed is key to the rate of decomposition. Many studies have been performed at the Anthropological Research Facility (ARF) in Knoxville, Tennessee, on the effects outdoor, indoor, aquatic and burial conditions have on the decomposition process (O'Brien 1994, Ritchie 2005, Rodriguez and Bass 1983, Tomlinson 2003). Each of these studies simulates scenarios of suspicious death. This closed container research is intended to add to the existing knowledge of decomposition studies. The choice of closed container research was made due to personal interest in real homicide cases involving victim's bodies stored in closed containers.

In order to determine a standard rate of decomposition for the outdoor central Texas environment, one control was used and nine experimental conditions. Nine Rubbermaid® containers were purchased and modified by the addition of airlocks. A temperature sensor was installed into one of the containers to record fluctuations in temperature both inside and outside the container. Cages were built in order to protect the container subjects from scavengers. All subjects were placed outdoors in naturally shaded areas. The purpose of this study is to determine the consequence of a closed container on the decomposition process.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Forensic anthropology is a subdiscipline of physical anthropology. In the beginning, forensic anthropologists were concerned with identifying age, sex, race and stature of unidentified human remains (Stewart 1979). While skeletal identification remains in the upper echelon of the grand scheme, forensic anthropologists have expanded their field of inquiry.

The development of forensic anthropology may be attributed to increased involvement with the process of law and law enforcement. The postmortem interval (PMI) is essential for developing a timeline of events leading up to and following death (Wells and LaMotte 2001). By determining PMI, forensic anthropologists can provide investigators with a tentative time of death. In addition, in cases of homicide the PMI can assist investigators in determining possible suspects associated with the death (Geberth 1996). The techniques of excavation are another crucial contribution made by forensic anthropologists to investigation of human remains. Proper excavation assists with prevention of trauma to the postmortem remains, evidence collection and positioning at burial (Haglund and Sorg 1997a). Advances in forensic anthropology involving taphonomy have substantially increased techniques for determining PMI.

2.2 Forensic Taphonomy

Forensic taphonomy includes a multitude of contributions from researchers (Bass 1997). Forensic taphonomy assists in establishing PMI and also concentrates on ante-, peri- and postmortem trauma (Sauer 1997); data collection and analysis from the area where remains were found (Haglund and Sorg 1997b); and the legal issues involving evidence and chain of custody (Melbye and Jimenez 1997). Determining the timing of occurrences of trauma helps distinguish between trauma indicative of manner of death and trauma indicative of events leading up to death and the actual deposition of remains (Sauer 1997). To aid with identification of types of trauma, instruments used to inflict trauma, and the resulting skeletal trauma, several studies involving sharp force, blunt force and projectile force trauma have been conducted (Berryman and Symes 1997, Houck 1997, Reichs 1997, Symes et al. 1997).

The information gained by researchers is a combination of retrospective and prospective studies. Retrospective studies involve the collection of previously acquired data, while prospective studies involve execution of an experiment to acquire data. Both types of study have limitations, but each provides an abundance of knowledge and a crucial reference for researchers.

Forensic taphonomists have researched the effects varied conditions have on soft tissue and bone (Haglund and Sorg 1997a). Several retrospective studies have examined rates, stages and the processes of decomposition (Clark et al. 1997, Galloway et al. 1989, Galloway 1997, Komar 1998, Rhine 1984, Sledzik 1997). These studies have formed classifications of decomposition stages (Clark et al. 1997, Galloway 1997, Rhine and Dawson 1998). Although there are limitations involving subject similarities, the

application of the aforementioned stages must address environmental variance. The benefits derived from these studies are immeasurable.

Many researchers have pursued prospective studies to overcome the limitations inherent to retrospective ones. Because there is currently only one research facility with access to human cadaver study subjects (the Anthropological Research Facility at The University of Tennessee Knoxville), many prospective decomposition studies have used animals in place of humans (Anderson and VanLaerhoven 1996, Hewadikaram and Goff 1991, Micozzi 1986, Shean et al. 1993). There are, however, several prospective decomposition studies using human subjects (Bass 1997, Cahoon 1992, Mann et al. 1990, Ritchie 2005, Rodriguez and Bass 1983, Srnka 2003). These studies of the decomposition process have yielded valuable information on rates and stages of decomposition under numerous environmental variables. Although the continuity that results from the controlled environment of a study may seem ideal, it has been suggested that such an environment may produce biased results. This is because elimination of possible variables may result in artificiality (Haglund and Sorg 1997b).

2.3 Pig (*Sus scrofa* L.) Substitution

The use of animals in place of human subjects is a common practice in forensic anthropological research (Anderson and VanLaerhoven 1996, Hewadikaram and Goff 1991, Micozzi 1991, Shean et al. 1993). Micozzi (1991) performed a significant study of decomposition involving animals in place of humans. In the study, Micozzi (1991) compared the decay rates of several animals with the decay rates of human remains. The study suggests that the pig (*Sus scrofa* L.) is the most suitable substitute test replacement

for the human because of similarities in the intestinal flora, skin and decomposition rates (Campobasso et al. 2001).

2.4 Internal Decomposition

Decomposition is characterized by the chemical and organic breakdown of remains. Internal decomposition is initiated at the time of death when the process of autolysis occurs (Gill-King 1997). Autolysis is an irreversible process resulting in the death of tissue. Observable products of autolysis are skin slippage, lighter skin tone, stiffening of muscles (rigor mortis), pooling of blood (livor mortis) and core body temperature equalizing to ambient temperature (algor mortis) (Love and Marks 2003).

Following autolysis is putrefaction. The putrefaction stage of internal decomposition is caused by a significant increase in bacteria (Gill-King 1997). Bacteria thrive in the anaerobic environment created by the body's cells when autolysis ends. These bacteria convert proteins, carbohydrates, lipids and acids into gases and result in bloating, putrid odor and color changes in the tissue such as "marbling" (Love and Marks 2003).

Two alternatives to putrefaction are adipocere formation and mummification; they are both reliant on specific environments (Campobasso et al. 2001). The rates of all decomposition processes vary with climate and with the size, weight and unique body chemistry of the individual (Hewadikaram and Goff 1991). As previously stated, several studies have produced stages and rates of decomposition based on the gross morphological changes that occur (Bass 1997, Clark et al. 1997, Galloway 1997, Rhine and Dawson 1997, Rodriguez and Bass 1983). The variance of classifications of categories and stages of decomposition are considerably useful references, though

external and internal variables hinder absolute PMI determination via use of these stages (Micozzi 1991). Due to climatic differences in the studies, application of the resulting stages from the studies to new studies should caution towards the climate most similar to the one in question.

2.5 Effects of External Variables on Decomposition

The two most important external variables affecting decomposition are climate and insect activity (Mann et al. 1990, Rodriguez and Bass 1983). Climate, especially ambient temperature, is most significant due to its effect on insects and bacteria (Mann et al. 1990). The presence and survival of insects can be determined by temperature alone (Rodriguez and Bass 1983, Wells and LaMotte 2001).

Climate

Variables included with the discussion of climate are ambient temperature and aridity versus humidity. The ambient temperature directly affects internal decomposition and insect activity. With regard to internal decomposition, bacterial reproduction is greatest at temperatures between 15 and 37ºC (Micozzi 1997). Temperatures below 15ºC and above 37ºC can significantly retard and even stop bacterial growth (Love and Marks 2003).

Aridity has been a subject of a few decomposition studies (Galloway et al. 1989, Rhine and Dawson 1997). The acceleration of the decomposition process followed by the preservation of remains through mummification is commonly observed in arid environments (Galloway et al. 1989, Galloway 1997, Rhine and Dawson 1997). Studies on humid environments illustrate significant fly and maggot activity (Mann et al. 1990).

This has been attributed to the ability of a humid environment to maintain soft accessible tissue for insects (Galloway et al. 1989).

Insect Activity

Insect development and activity is significantly affected by temperature (Higley and Haskell 2001). An attempt has been made to determine temperature increments associated with insect development and thresholds (Higley and Haskell 2001). However, researchers have advised to expect variations because more studies must be performed (Campobasso et al. 2001, Higley and Haskell 2001). Though development increases at a certain range of temperatures, extreme high and low temperatures may result in the death of all insects (Wells and LaMotte 2001).

Flies (*Diptera*) and beetles (*Dermestes*) are two insects commonly found on decomposing bodies. Several researchers have emphasized the destruction these insects are capable of inflicting (Byrd and Castner 2001, Campobasso et al. 2001, Rodriguez and Bass 1983). The remains are initially colonized by blowflies (*Diptera calliphoridae*), which results in remarkable maggot masses concentrating on exposed areas of the body (Byrd and Castner 2001). Following extensive maggot activity, the remains of the decaying body become surrounded and inhabited by beetles (Bass 1997). Blowflies are one of the first insects to colonize on human remains, while beetles are one of the last (Haskell et al. 1997). The beetles will continue the process of decay until all soft tissue has been removed and the remains are fully skeletonized (Haskell et al. 1997).

2.6 Decomposition in Insect Restricted Environments

The study of decomposition in insect restricted environments has been scarce (Ritchie 2005, Tomlinson 2003). Studies of this nature may require control of several

variables including, but not limited to, climate, insect activity and carnivorous scavengers. The control of these variables may result in significant differences in decomposition rates in specific forensic cases. However, researchers will never know the impact of each variable until they hold most at a constant, and then allow the variables to change one at a time. In this study, I attempt to restrict insect activity and scavengers to investigate decomposition in a restricted environment.

CHAPTER 3

MATERIALS AND METHODS

3.1 Location

This research experiment took place outdoors in central Texas, at the Early Ranch, located off Ranch Road 12 in San Marcos, Texas. Trees indigenous to this area are the live oak, Spanish oak and cedar elm. These trees provided a canopy to shade the area where the subjects were placed. San Marcos (longitude -98°W latitude 29°E) has outside high temperatures over thirty-eight degrees Celsius and lows in the teens during the summer months in which the study took place.

3.2 Equipment

Containers

In order to simulate makeshift coffins, nine Rubbermaid® Roughneck 11.36 decaliter storage containers, with the measurements of 82.55 x 50.8 x 42.7 centimeters, were used. The lids of this specific type of container are “snap on stay tight.” Once each lid was snapped securely shut, each was reinforced shut with several layers of duct tape in attempt to ensure limited insect activity. Each container was given a specific number with regard to the order in which they would be opened. The number was written with permanent marker on the lid of each container (see Figure 1).

Prevention of container deformation caused by gases was achieved by use of three-piece airlocks. A three-piece airlock was placed in a drilled hole in each container lid and sealed with Nail Power® Liquid Nail. Once the containers were placed at the study location, each airlock was filled half way with water. The three-piece airlock compares pressure of gas within the container to outside air pressure. If the pressure inside the container is greater than atmospheric pressure, the excess gas vents through the airlock.

Figure 1: Photograph of Container 9. This photograph is illustrating the number system on the lids and the airlock in the bottom right corner of the lid.

Temperature Data

The temperatures inside and outside Container 9 were recorded using a HOBO® H8 Pro Temperature Logger (see Figure 2). The HOBO® was attached to the outside of

Container 9 with a sealed screw and Velcro®. The sensor for measuring internal temperature was placed through a drilled hole directly above the HOBO®. The exterior of the container involving the sensor was sealed with Nail Power® Liquid Nail. The interior of the container was sealed around the sensor with a 1 oz. pill bottle in order to record interior temperature while preventing sensor exposure to gases and chemical breakdown, which may have affected the sensor over the prolonged period. The accuracy of the HOBO® is ± 0.2°C.

Figure 2: Photograph of the HOBO® H8 Pro Temperature Logger. The Logger is attached to Container 9.

The HOBO® was programmed to begin logging temperature data on June 6, 2006 at 18:00:00 hours. The logger was programmed to save data obtained every hour. Data

logging ended on October 3, 2006 at 21:00:00, at which time 2860 temperature points had been saved.

BoxCar Pro® 4 software was used to download temperature data from the HOBO®. It was also used to program the HOBO®. In addition, BoxCar Pro® has the capabilities to analyze data in tabular and graphic formats as well as export the data into Excel® spreadsheets.

Weather Underground, Incorporated provided outside temperature, humidity and rainfall information taken each day from San Marcos, Texas. The temperature data were compared to the HOBO® outdoor temperature via Excel® spreadsheets to determine the variability between temperatures.

Photography Equipment

A Canon® Powershot SD450 was used for all photographs taken during the study. The camera has 5.0-megapixel resolution resulting in clear pictures of the carrion as well as individual insects. The camera has a 6.35 centimeter LCD display insuring quality pictures at the time of data collection.

Cages

Three cages were built in order to prevent scavenging and container destruction by rodents, coyotes and birds. One cage measured 1.22 x 0.91 meters and the other two cages measured 3.66 x 0.91 meters. The cages were framed with pine lumber and each side except the bottom was lined with poultry fencing. Eyebolts were attached to the four corners of the top of each container. Nylon rope was threaded through two of the eyebolts on one side of each cage and attached to nearby trees then rope was attached the same way to the opposite side of the cage. This was done to prevent scavengers from

removing the cages to gain access to the containers. The small cage was used to cover the Control and the two large cages were used to protect the experimental containers. Cage one protected the Control (see Figure 3). Cage two protected Containers 1 through 5 (see Figure 4) and cage three protected Containers 6 through 9 (see Figure 5).

Figure 3: Cage One. Photograph of cage one covering the Control.

Figure 4: Cage Two. Photograph of cage two protecting Containers 1 through 5.

Figure 5: Cage Three. Photograph of cage three protecting Containers 6 through 9.

3.3 General Subject Information

The subjects used for this study were feral hogs (*Sus scrofa* L.) in place of human cadavers. Texas has the highest population of feral hogs in the United States; they are a nuisance to land owners because they destroy crops, pastures, property and livestock. Thus, feral hogs are easy to acquire for studies such as this one. Each hog weighed between twenty-five and twenty-seven kilograms. Ten hogs were used for this study, one control and nine experiments. Freshly killed hogs were acquired from a local rancher on June 6, 2006. Nine were placed in individual containers and sealed shut. The tenth hog was placed directly into the control cage without a container.

3.4 Placement Location

All subjects were placed in naturally shaded areas outdoors. The Control was placed under a cage in an area that constantly remained in partial to full shade. The individual containers were placed approximately ten meters from the Control, and were similarly shaded at all times. Sun exposure was minimal due to efficiency of foliage coverage; thus, the Control and containers were never in full direct sunlight during the study.

3.5 Data Collection

The Control was observed twice a day from day zero until day eleven when insect activity had significantly decreased. The Control continued to be observed once a day until skeletonization occurred. Prior to each observation, the time, date and visual weather condition of the sky were logged. The visual weather conditions were described as sunny, partly cloudy, or overcast. In addition, humidity and temperature data for the times of observation were recorded in the observation logs (Appendix A).

Upon observation, the cage was lifted, granting clear visual exposure for photography and descriptions. First, photographs were taken, and then changes in tissue and insect activity were recorded. Later, photos were inspected and any additional observations were incorporated into the daily logs. In addition, the photographs were useful in determining most insects present. All daily records were transferred to Word® documents and can be found in Appendix A. Photographs are saved on compact disc and can be found in Appendix E.

Daily observations of containers were limited to exterior observations. The shape of the containers was observed as well as the sides of the containers and water in the airlocks. One container was opened at each weekly interval. Container 1 was opened one week after placement. Container 2 was opened two weeks after placement and so on until Container 8, which was opened on day fifty-six. Because the Container 8 subject had begun to skeletonize, the opening of Container 9 was postponed until day 119, a little over twice the time of the Container 8 subject.

On container opening days, the container was moved away from the study area to prevent cross contamination with the Control. The initial odor of the closed container was recorded. Then the tape was removed from the lid and the lid was pried off the container. Immediately after opening, photographs were taken of the state of the carrion while still in the container, and the observations were logged. Once everything was logged, the carrion was removed from the container and photographs were taken again. Additional data observed from the carrion outside of the container were logged. In all data, variables mainly observed were fly activity, beetle activity, marbling, presence of maggots and stage of decomposition.

3.6 Variables Defined

Fly Activity- The flies observed in this study were blowflies (*Diptera calliphoridae*) and fleshflies (*Diptera sarcophagidae*). Because both blowflies and fleshflies were present, they were combined for discussion. However, there were many more blowflies than fleshflies. In observation, the flies are described as present, active, decreased and surrounding. The Control produced a second set of flies, which remained on surrounding vegetation.

Beetles- The beetles observed in this study were flesh-eating beetles (*Dermestes lardarius* L.). The beetles were observed as present, increase in activity, larvae and decrease in activity. Beetles were only observed on the control.

Marbling (intravascular hemolysis)- Marbling refers to the color of the soft tissue when veins and arteries become visible due to bacterial action.

Mummification- Soft tissue dries considerably and becomes brittle. Tissue is usually darker in appearance with a leathery consistency.

Presence of Maggots- Maggot activity was referred to in notes with regard to eggs (see Figure 6), pupae and maggots present. The maggots present were observed as scattered, present and extensive (see Figure 7).

Stage of Decomposition- The Control was the only subject observed through all stages of decomposition (see Figure 8). The stages of decomposition referred to in this paper are in reference to the "Categories and Stages of Decomposition" (Galloway 1997:141). This information has been replicated in Table 1.

Table 1: Categories and Stages of Decomposition. (From Galloway 1997:141)

A. Fresh
   1. Fresh, no discoloration or insect activity
   2. Fresh burned

B. Early Decomposition
   1. Pink-white appearance with skin slippage and some hair loss
   2. Gray to green discoloration, some flesh relatively fresh
   3. Discoloration to brownish shades particularly at fingers, nose and ears; some flesh still relatively fresh
   4. Bloating with green discoloration
   5. Post bloating following rupture of the abdominal gases with discoloration going from green to dark
   6. Brown to black discoloration of arms and legs, skin having leathery appearance

C. Advanced Decomposition
   1. Decomposition of tissues producing sagging of the flesh, caving in of the abdominal cavity, often accompanied by extensive maggot activity
   2. Moist decomposition in which there is bone exposure
   3. Mummification with some retention of internal structures
   4. Mummification of outer tissues only with internal organs lost through autolysis or insect activity
   5. Mummification with bone exposure of less than one half the skeleton
   6. Adipocere development

D. Skeletonization
   1. Bones with greasy substances and decomposed tissue, sometimes with body fluids still present
   2. Bones with desiccated tissue or mummified tissue covering less than one half the skeleton
   3. Bones largely dry but still retaining some grease
   4. Dry bone

E. Extreme Decomposition
   1. Skeletonization with bleaching
   2. Skeletonization with exfoliation
   3. Skeletonization with metaphyseal loss with long bones and cancellous exposure of the vertebrae

Figure 6: Maggot Eggs. Photograph of Control on June 7, 2006 (day one after placement).

Figure 7: Extensive Maggot Activity. Photograph of Control on June 9, 2006 (day three after placement).

Figure 8: Bloat Stage. Photograph of Control on June 8, 2006 (day two after placement).

CHAPTER 4

RESULTS

4.1 Control Results

The Control results illustrate the speed at which the decomposition process occurs in the summer in central Texas. The Control results table (Table 2) is a compilation of the significant observations noted in the full daily logs that are included in Appendix A. The significant observations included in the table were insects, maggots and the stage of decomposition. Every time a significant change was documented, it was listed on the results table. The observations are charted in reference to the day they occurred in order to ease comparison with the experiment observations.

4.2 Container Subject Results

The container results include any changes to the container prior to opening and all observations made once opened. The container result tables (Tables 3-11) are condensed from daily logs and container logs found in Appendices A and B. The variables observed include the outside of the container, the physical condition of the container, the water inside the airlock, insects, maggots and the stage of decomposition. The physical condition of the container is noted in four of the container result tables as “slight deformation.” Slight deformation means that the sides of the container were convex, indicating internal pressure greater than atmospheric pressure. In the instances where the

containers were convex, they did not open. The convexity was caused by the airlocks not releasing gaseous pressure as quickly as it was accumulating, because within 24 hours the containers had returned to initial state.

The result tables were created to ease comparison among the containers and with the Control. Specific variables noted demonstrate the impediment the container has on the decomposition process. When compared to the Control table, the container results illustrate a four times slower rate of decomposition.

Table 2: Control Results. Observations emphasizing insects, maggots and tissue.

Day	Significant observations
1	Flies Present Foaming at the mouth, pink in color and bubbling Maggot eggs on anal cavity, ventral/posterior portion of thorax and dorsal area Beginning bloat stage
2	Marbling from mouth to midline of posterior aspect of thorax Maggot activity at nose and mouth: structured breakdown Maggot activity along the spinal column-structured breakdown Eye orbits completely eviscerated Discoloration under right anterior limb
3	Skin slippage present at spinal column Right front leg detaching Extensive maggot activity throughout torso, concentration hind quarters Marbling at the shoulder area Maggot destruction of anterior aspect of torso Major maggot concentration on ventral surface Hair sloughed off along dorsal surface
4	Body deflated, bloat stage has passed Maggots darker in color Mummification present right hind quarter, posterior region and shoulder area
5	Decrease in fly activity Bone visible of front left leg Mummification occurring at both hind quarters and spinal column Bone visible in back left leg
6	Second set of flies present
7	Mold on nose
8	Mold on posterior/anal region Pupa casings visible within a hole in the shoulder region Maggots are gone
9	Beetles present Skin eroding very slowly
11	Many more beetles present on most surfaces of carcass Left front bone exposed
13	Bottom of mouth deteriorating Bones visible on all quarters
16	Beetle larvae
17	Exposed bone at shoulder Posterior bones exposed Features of skull visible and distinct
18	Ribs becoming exposed and vertebral column Bones being cleaned as they are becoming exposed
22	Skull completely clean Posterior aspect of vertebral column completely exposed
29	Fully skeletonized

Table 3: Significant Observations of Container 1. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
1	Slight deformation of container
2	Fly activity noted around container
3	Dark fluid with maggot egg casings noted on the sides of container
5	Maggots present in water of airlock Foaming decomposition fluids with maggots around the edges
7	Hair missing on various visible areas exposing extremely light colored skin Soup-like decomposition light brown and pinkish in color Skull is exposed Mass quantity of dead maggots on carcass and in decomposition fluids Few live maggots present Carcass is generally intact Decomposition to skeleton is only visible at the skull Internal organs intact Bloat stage has not occurred

Table 4: Significant Observations of Container 2. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
2	Fly activity noted around container
5	Foaming decomposition fluid with maggots around the edges of the container
13	Rain washed away decomposition fluid that was on the sides of the container
14	Flies swarmed immediately when opened Head smashed down, skull skeletonized Carcass intact Lack of decomposition when compared to control and container one Bloat stage has not occurred Hair mainly still intact, sloughing starting on posterior, dorsal and ventral surface No maggots present Extremely putrid odor

Table 5: Significant Observations of Container 3. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
2	Fly activity noted around container
21	No maggots present White flesh exposed at posterior, this color is similar to that noted in Container 1 Back limbs are bare of hair and flesh Sloughed off hair at ventral portion, thorax and most of the carcass Marbling noted Head almost completely eviscerated, more intact than others Chunky consistency of decomposition fluids Flies swarmed shortly after opening Organs intact

Table 6: Significant Observations of Container 4. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
1	Slight deformation of container
2	Fly activity noted around the container Fire ants present on container
3	Dark substance and egg casings on sides of container
4	Gold colored substance along the lid of the container and the handles and edges
5	Maggots on the ground around the container Foaming decomposition fluid with maggots around the edges
13	Rain washed away the decomposition fluid stained on the edges
16	Several flies present around the container
28	Severe storm (lightning) opening had to be postponed
29	Flies immediately appeared Skull skeletonized and broken apart (broken from gunshot trauma) Limbs skeletonized Marbling on torso Decomposition is grayish in color No maggots present Red chunky decomposition material Organs intact Partial pelvic area skeletonized

Table 7: Significant Observations of Container 5. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
2	Fly activity noted around container
3	Dark substance and egg casings on the sides of the container White mass of maggot eggs hanging from the area next to handle of the container
4	White mass has fallen to the ground and dispersed
5	Maggots on the ground area around the container
9	Maggots present in the water of the airlock
13	Rain washed decomposition fluids off the sides of the container
35	Decomposition is more of a green color Femurs are still articulated Skull is skeletonized Lots of hair still present Chunky substance present Maggots in airlock only one maggot noted on carcass Adipocere present Fire ants on the container Carcass is held in rectangular form because of congealed decomposition No other maggots visible

Table 8: Significant Observations of Container 6. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
1	Slight deformation of container
2	Fly activity noted around container
5	Maggots on the ground area around the container
42	No maggots visible Odor has taken on more of a fecal matter scent than the previous container scents Decomposition is a greenish brown in color Some flies but not as quick concentration upon opening as prior containers Limbs and skull are skeletonized Chunky decomposition material present Adipocere present Solid decomposition containing bony elements holding the form of the container

Table 9: Significant Observations of Container 7. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
2	Fly activity noted around container
49	Flies immediately swarmed when the container was opened Dead maggots around the edge of the container Clumpy/Chunky material present Decomposition in shape/form of the container Skull was skeletonized Dark coloration of skin Hair present and still attached to skin Grey color decomposition

Table 10: Significant Observations of Container 8. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
2	Fly activity noted around container
56	Right before opening the flies were already present Decomposition is thinner than the decomposition in previous container Organs have liquefied Still some tissue on bones Adipocere is present Possible pupa casings present No formation of decomposition to the shape of the container No maggots

Table 11: Significant Observations of Container 9. The main areas of interest were the decomposition process having occurred upon opening as well as the condition of container prior to opening.

Day	Significant observations
1	Slight deformation of the container
2	Fly activity noted around container
3	Dark substance and egg casings on the sides of the container
4	Container has a concentration of maggot activity around the handle areas
5	Maggots on the ground area around the container Container has foaming decomposition fluid with maggots around the edges
13	Rain washed away decomposition fluid that was on the sides of the container
119	Odor was contained in the container until opening Bones reddish in color and clean of tissue Maggots present in decomposition material Darker portion of decomposition by the skull Hair and adipocere in decomposition material Flies arrive as soon as opened Decomposition is not consistent (opaque) Basically liquefied Odor seems less pungent than previous containers Thick adipocere

4.3 Climate Data Analysis

All temperature data from the HOBO® H8 Pro Temperature Logger and San Marcos, TX are included in Appendices C and D. The HOBO® was programmed to record the temperature inside the container and outside the container on the hour every hour every from June 6, 2006 to October 3, 2006. All temperatures recorded by the HOBO® were logged in Celsius.

The high and low outdoor temperatures recorded daily by the HOBO® varied by a maximum of 4°C when compared to the daily high and low temperatures recorded for San Marcos, TX (see Figure 9). The average temperature variation was less than 1°C for the duration of the study.

The high and low temperature inside the container taken by the HOBO® compared to the high and low outside temperature taken by the HOBO® varied by a

maximum of 5°C (±0.2°C) (see Figure 10). When the temperature inside the container taken by the HOBO® was compared to the outside temperatures recorded for San Marcos, TX the temperatures varied by a maximum of 8°C (±0.2°C) (see Figure 11).

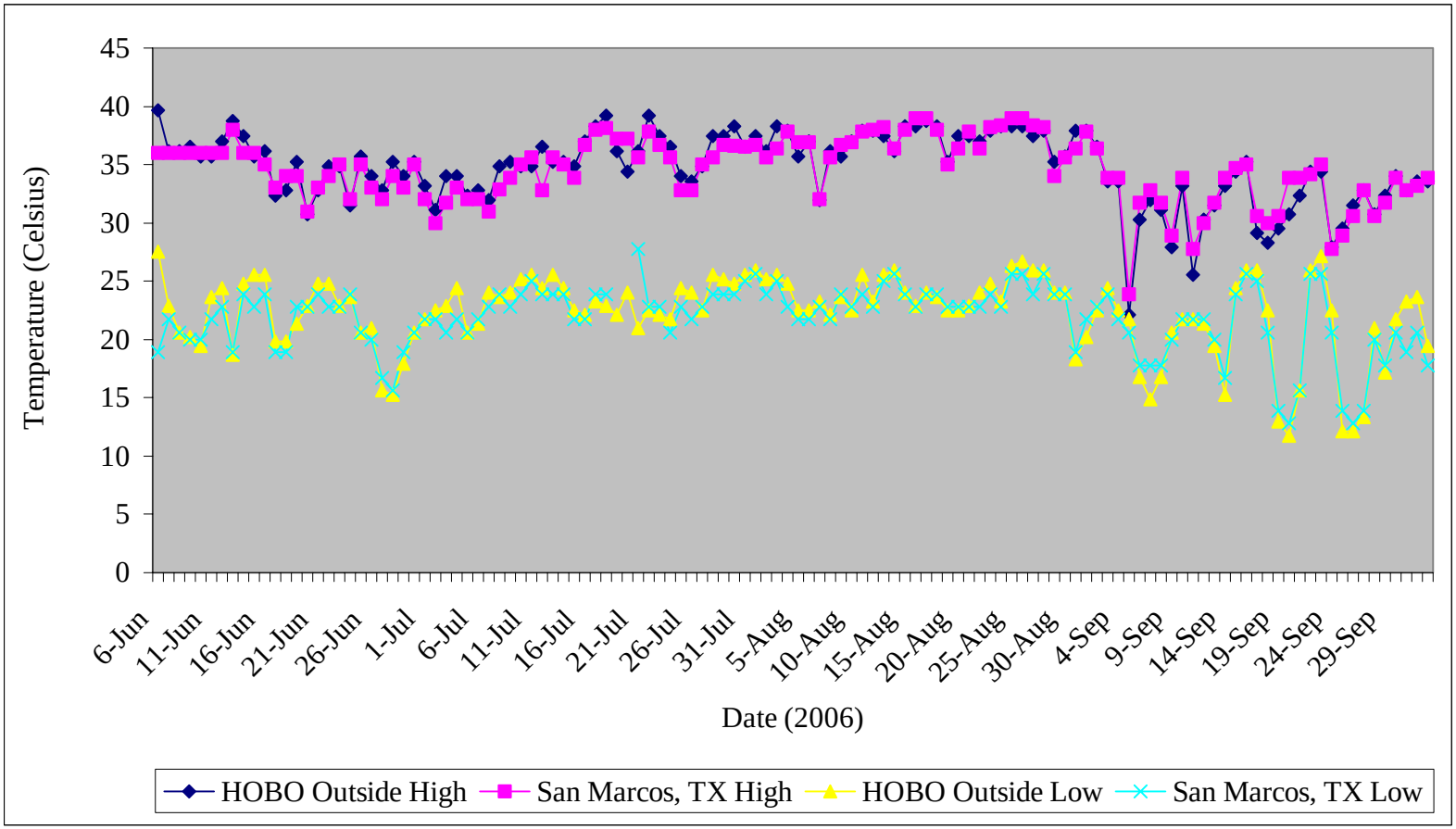

Figure 9. Combined High and Low Temperatures. Comparison of outside high and low temperatures taken by the HOBO® and San Marcos, TX.

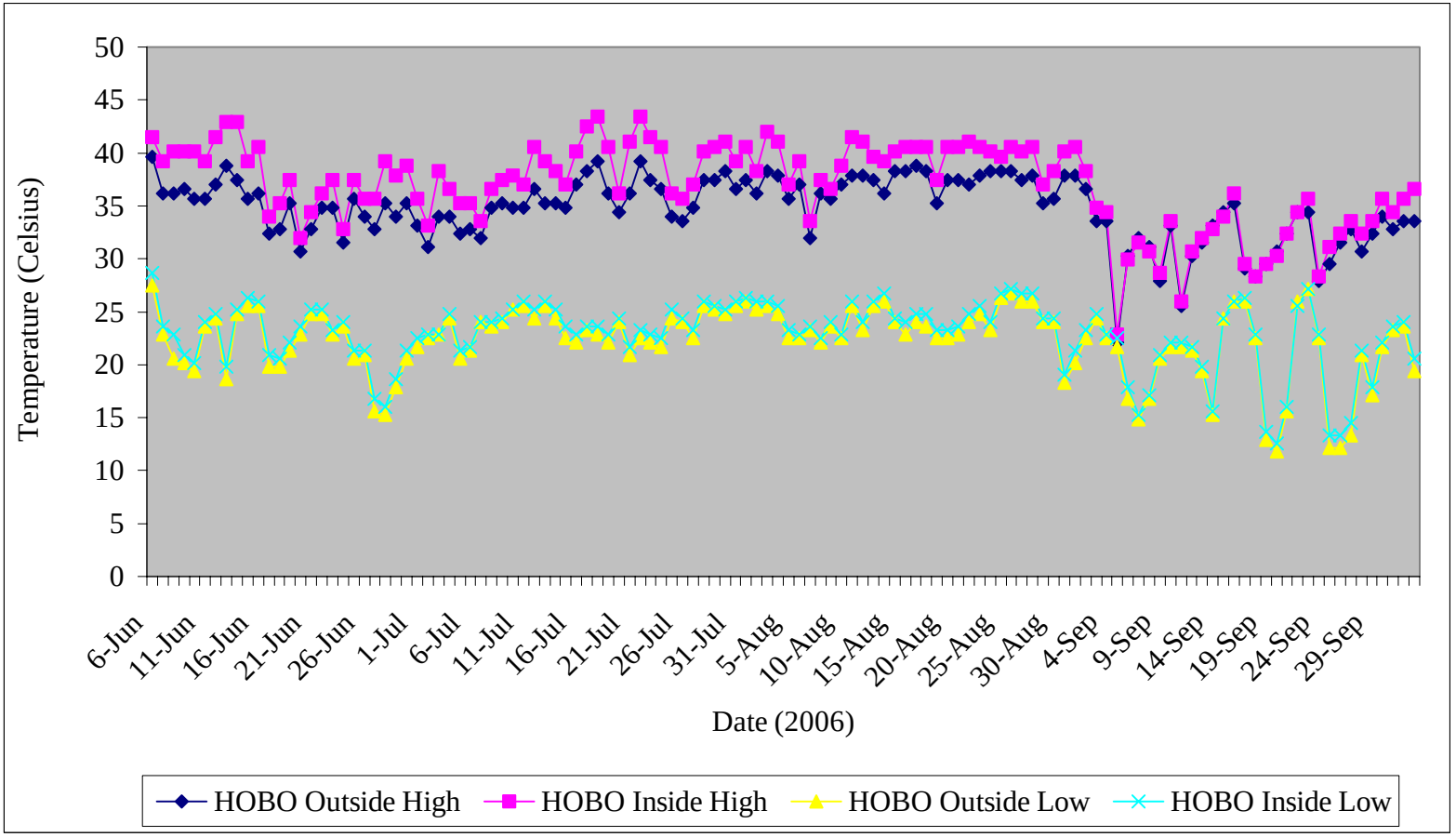

Figure 10. Combined HOBO® Temperatures. Comparison of outside high and low temperatures taken by the HOBO ® and indoor high and low temperatures taken by the HOBO®.

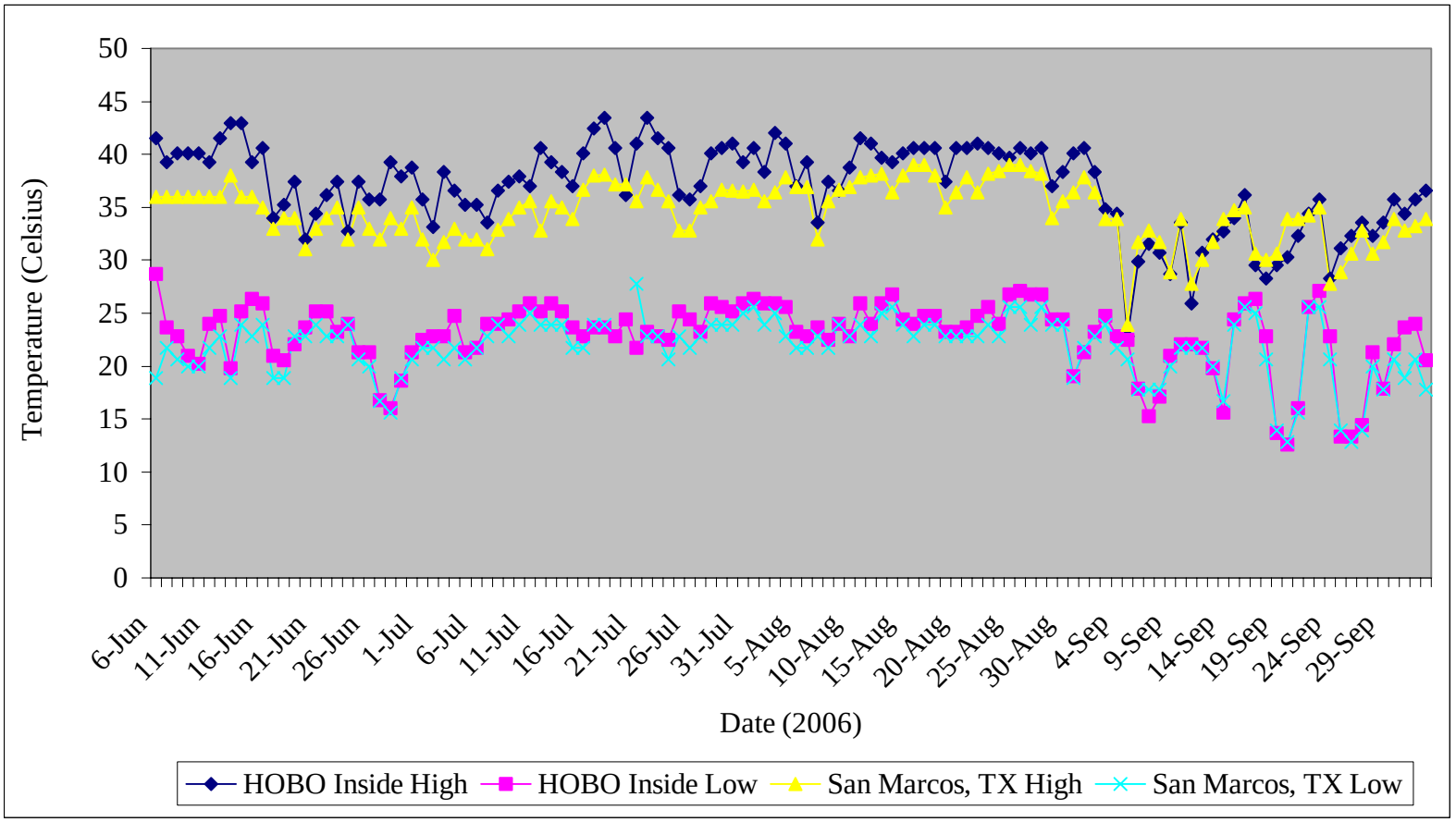

Figure 11. Combined HOBO® and San Marcos, TX Temperatures. Comparison of indoor high and low temperatures taken by the HOBO ® and high and low temperatures taken for San Marcos, TX.

Throughout the experiment the outside HOBO® temperatures and the San Marcos, TX temperatures showed little variance. The variation of indoor HOBO® temperatures and all outdoor temperatures maintained a steady difference through the summer months. The fall months illustrated little variance between the indoor HOBO® temperatures and all outdoor temperatures.

4.4 Analysis of Variables

Blowfly (*Diptera calliphoridae*) and Fleshfly (*Diptera sarcophagidae*) Activity

Fly activity was most commonly observed on the Control. The fly activity began on day one, increased and stabilized over the next three days, then decreased significantly by day five. On day six a second set of flies was observed on the vegetation surrounding cage one (see Figure 12). Flies were last noted on or around the Control on day sixteen.

As expected, the flies were unable to penetrate the containers (with a few noted exceptions). The limited access to the container subjects drastically reduced the amount of flies present around the containers. Upon opening of the containers, flies swarmed immediately to all containers except Container 9. Because Container 9 remained closed for 119 days, there were no longer any extreme odors released from the airlocks, no other containers and the control had completely skeletonized, there was nothing left to attract fly activity.

Figure 12: Second Set of Flies. Photograph of vegetation surrounding Control.

Beetle (*Dermestes*) Activity

Flesh-eating beetles (*Dermestes lardarius* L.) were only present on the Control. Beetles were first observed on day nine. By day eleven there was a significant increase in the amount of beetles on the carcass as well as the cage. Beetle larvae were present on day sixteen and the beetles continued cleaning the bones until complete skeletonization occurred.

Presence of Maggots

Maggot eggs were present on the Control by day one. Maggot activity continued on the Control until day seven. Initially the maggots caused a structured breakdown of the soft tissue on the skull and vertebral column. Over the next five days, the maggots continued to breakdown the carcass. Maggots were no longer present on the Control after day seven. Pupa casings were visible in the shoulder region on day eight.

Maggot eggs were observed clustered on the side of Container 5 (see Figure 13). Maggots were observed in decomposition fluids on the sides Containers 1, 4, 5 and 9 (see Figure 14). Maggots were observed in the water of the airlocks of Containers 1 and 5. However, maggots were only observed inside Containers 1, 5 and 9 (see Figure 15). Upon opening of Container 1, there was not significant tissue breakdown of the body and there were a large number of dead maggots inside. Container 4 was observed with maggots on the sides of the container though the opening of the container revealed no maggots or maggot activity. Containers 5 and 9 did not appear to have any maggots upon opening but after prolonged observations a very limited number were spotted, only one on Container 5.

Figure 13: Cluster of Maggot Eggs. Cluster hanging from the lid of Container 5.

Figure 14: Maggots in the Decomposition Fluids. Photograph of the side of Container 4 from aerial view.

Figure 15: Maggots in Container 1. Photograph taken upon opening, the majority are dead.

Marbling

Marbling was present on the Control and two of the container subjects. The duration of the marbling was only observed on day three for the Control (Table 2). Out of the nine container subjects, marbling was only observed on Container 3, which was opened twenty-one days after placement and Container 4, which was opened twenty-nine days after placement. Because marbling was observed after an interval of one week between Containers 3 and 4, an inference of the length of time marbling occurred can be made. Considering there was one week prior to opening of Container 3 when marbling may have begun and lasted through the week following the opening of Container 4, the marbling may have lasted anywhere between seven and twenty one days. Consideration of the container opening days alone demonstrates that the closed container slowed the rate of decomposition by twenty-one to twenty-nine days, assuming Containers 1-9 were decomposing at a similar rate.

4.5 Decomposition Analysis

Refer to Table 1 for Categories and Stages of Decomposition.

Early Decomposition

Five of the ten subjects were observed in the early decomposition stage, which includes changes in skin color, maggot activity and bloating (Table 1). The Control was in early decomposition for three days after placement then began to mummify by day four (Table 2). When Container 1 was opened on day seven it was observed prior to bloating with pink skin and the body intact (Table 3). Container 2 was opened on day fourteen and was observed prior to bloat, soaking in decomposition fluids (Table 4). When Container 3 was opened on day twenty-one it had a white appearance similar to

Container 1 (Table 5). Container 4 was opened on day 29 and was relatively fresh and organs were still intact (Table 6).

The rate of decomposition was accelerated so significantly with the Control that observations made on Containers 1, 2, 3 and 4 can only be compared to day one of the Control. Maggot activity became so extensive during the Control's early decomposition that the breakdown was at least seven times faster than the breakdown of Containers 1, 2, 3 and 4.

Advanced Decomposition

The Control entered advanced decomposition (Table 1) on day four. Though the Control reached advanced decomposition quickly, it lasted nineteen days due to mummification (Table 2). When opened on day thirty-five, Container 5 revealed advanced decomposition involving bone exposure of the hindquarters and skull and adipocere development (Table 7). Container 6 had slightly more bone exposure involving all the limbs and adipocere development when it was opened on day forty-two (Table 8). When Container 7 was opened on day forty-nine it had slightly more bone exposure than Container 6, though less than half of the skeleton was exposed (Table 9). None of the container subjects mummified due to the moisture in the container caused by decomposition fluids. Because Container 7 was opened on day forty-nine, this indicates advanced decomposition lasted at least thirty days longer than the Control.

Skeletonization

The Control reached skeletonization (Table 1) on day twenty-two (Table 2). Containers 8 and 9 were the only two containers to reach skeletonization (Table 10,11). The skeleton of Container 8 was visible with decomposed tissue still attached. Container

9 had progressed to greasy bone upon opening of the container. Therefore, Container 8 started skeletonization thirty-four days after the Control and Container 9 was still in skeletonization stage ninety-seven days after the Control. This suggests the containers slowed the rate of decomposition by four times.

Extreme Decomposition

The Control was the only carrion to reach extreme decomposition (Table 1,2). Bleaching of the skeleton was observed on day forty-nine. On the last day of the study, day 119, the Control was observed skeletonized with cancellous exposure of the vertebrae, metaphyseal loss and complete bleaching.

CHAPTER 5

DISCUSSION

5.1 Overview

As expected, the rate of decomposition of the container subjects is significantly slower than the Control. The key variable slowing the rate of decomposition in the container subjects is the lack of insects. The containers are efficient for simulating a makeshift coffin and restricting insect access. Since each container is only opened once and then discarded, exposing the container subjects to insects via human interference for observation is avoided. In this study, it is crucial that possible contamination of the study from exposure does not occur. If a container is opened daily to make observations and then closed again, the subjects would inevitably encounter exposure to far more insects, which will drastically affect the decomposition process.

Marbling was significant in offering insight to the extent of time the container subjects maintained the early decomposition stage. Marbling was observed on day three of the Control, but was no longer visible by day four. Marbling was observed on Container 3 on day twenty-one, which was seventeen days after it had passed on the Control. Marbling was observed again on Container 4, on day twenty-nine.

Because maggot activity was limited and in some cases prevented, it was critical to the slowed decomposition of the container subjects. Out of the nine containers, maggots were only observed in three. The container with an abundant amount of maggots was Container 1. However, the majority of those maggots were dead, likely from a lack of air and increased heat inside the container.

The humid environment of the inside of the containers prevented any mummification process. Mummification did not occur in any of the container subjects. Mummification of the Control caused the prolonged advanced decomposition. As suggested by Galloway et al. (1989) the closed environment created by the containers slowed the rate of early decomposition and then accelerated skeletonization. In other words, the humidity in the containers kept the decomposition moist until the entire skeleton could be seen.

This research took place in central Texas during the hot summer months. The most applicable study to this research is that of Galloway et al. (1989) focusing on decomposition in arid environments in which data was gathered in order to determine a rate of decomposition in Arizona. The humidity in central Texas is notable, but not enough to prevent mummification. Few decomposition studies have been performed in central Texas, leaving little reference to the possible rates and stages of decomposition. Due to the size of Texas and unique climate, many more studies need to be done in order to determine rates of the decomposition process.

5.2 Limitations

There were several limitations in this research. First, the use of hogs as a substitute for human cadavers was not the ideal choice for the subjects of this study. However, the time frame between death and placement was better for determining a reliable rate between the Control and all container subjects than if human cadavers were used that had varied dates of death and preservation.

Second, though ten subjects seem a sufficient number, the design of the research would have benefited from a larger sample. As each container was opened, a steady rate of decomposition was revealed, but a stronger case could be made if two or three subjects were observed at each opening to determine if the rate was relatively the same for each subject.

Third, time was also a limitation with regard to the container subjects. Due to the length of time the container subjects took to decompose, there was not enough time to repeat the study. The summer season is the only time frame that a repeat could take place. If the study were conducted a second time during the cooler months, the results would be skewed significantly from the original experiment.

Fourth, another limitation was the inability of the containers to totally restrict insect access. Due to the heat and gases inside the containers, decomposition fluid seeped out of some of the lids, which gave the flies a place to lay their eggs and maggots a small chance to enter the container. Flies laid their eggs on top of airlocks and in clusters hanging off the edges of the containers. In most cases, the container with maggot eggs and clusters would later be observed with maggots on the ground surrounding the

container, likely because they could not penetrate the container. However, in some instances maggot activity did occur inside the container.

The final limitation of this decomposition study is that it was performed in the climate of central Texas. If this study were performed anywhere else the time frame of the decomposition process may vary significantly. In all climates, it is likely the container would slow the rate of decomposition.

CHAPTER 6

CONCLUSIONS

The rate of decomposition was longer for the experimental subjects than the Control. While the experimental subjects were in early decomposition, the Control had skeletonized. Analysis of the results revealed that the major differences between the Control and experimental subjects were caused by the containers. Therefore, early and advanced decomposition stages were inhibited by the use of containers.

Restriction of insect activity was sufficiently achieved, with the exception of a few noted occurrences. Five of the containers revealed total insect restriction upon opening. In the cases where maggots were able to penetrate the container lids, the interior environment was uninhabitable. Insect restriction by the containers played an important role in the rate of the decomposition process.

Analysis of temperature data illustrated remarkable variation. Temperatures inside the containers were higher than ambient temperatures until the skeletonization stage. The high temperatures inside the container combined with the air quality, contributed drastically to the death of the maggots that were able to penetrate the containers.

The slowest stage of decomposition for the Control was the advanced decomposition stage. Due to mummification, the skeletonization of the Control was delayed for weeks. Because the experimental subjects were placed in containers, moisture from the decomposing carrion provided a humid environment inside the containers. The humid environment prevented the mummification process from occurring in the containers.

This study was executed in an attempt to determine the effect a closed container has on the rate of decomposition. A major limitation of this study was the sample size. The opening of each container revealed a steady rate of decomposition between experimental subjects. However, a larger sample size would allow multiple containers to be opened at the same times, which would allow the accuracy of stages to be determined. More research must be done in order to strengthen all conclusions.

CHAPTER 7

SUMMARY

In the field of forensic anthropology, the decomposition process has sparked the interest of several researchers over the years (Micozzi 1986, Rodriguez and Bass 1983, Shean et al. 1993). Determining the rate of decomposition in various environments has proven significant to law enforcement officials in investigations of suspicious death (Geberth 1996). The knowledge gained in determining decomposition rates and categories can be used to determine time lines, which help estimate the postmortem interval (Wells and LaMotte 2001).

In June through October of 2006, this study took place on the rate of decomposition in closed containers. Ten feral hogs were used for the study. One hog was placed in a cage as a control to determine the rate of decomposition without a closed container. The other nine hogs were each placed in Rubbermaid® containers, sealed shut and placed in cages. The cages were to protect the experiment from corruption by animals.

Notes, photographs and temperature data were taken for all observations. Notes were taken twice daily of the Control and the outside of the containers until the Control stopped changing significantly at which time the notes were reduced to once daily.

Photographs were taken every time notes were taken. Temperature data for the containers were taken every hour, while daily highs and lows were recorded separately.

This experiment was executed to determine the rate of decomposition of carrion in closed containers placed outdoors in central Texas. The design of the experiment involved simulation of a homicide scenario in which a makeshift coffin was used for storage of the remains. Rubbermaid® containers were used due to ready availability to the public and for their sealed storage capabilities. All variables were concerned with regard to isolation and discretion of the placement area of the container and prevention of contamination caused by the opening of the containers. Concern for the variables resulted in a wooded area with limited visibility and sun exposure for the location of placement and the disposal of each container subject upon opening. One container was opened each week and then discarded after observations were made.

The results of this experiment revealed the significant impediment a closed container has on the decomposition process. A Control subject was used to determine the decomposition process with exposure to all elements. All observations recorded from the control were used for comparison with the decomposition process of the container subjects. The comparison between Control and containers revealed that the rate of decomposition in the containers was four times longer than that of the Control.

This study is a valuable addition to existing decomposition studies. The categories and rates of decomposition were significantly different between the control and containers. Several limitations existed in this research, however they will be addressed in later dissertation research.

APPENDIX A

DAILY OBSERVATION LOG

DAY 0 (6-6-06) Temperature High 36ºC Low 18.9ºC
Each hog shot in the head with 223 Rifle.
Ten hogs total
Nine of the hogs were each placed in their own Rubbermaid ®Roughneck Container, sealed shut with Duck® Tape and placed under protective cages. The lid of each container is suited with a plastic air-lock which allows gases to be released but prevents oxygen and insects from entering.
The tenth hog was placed approximately ten meters away from the containers, in it's own cage.
Placed in partially shaded area.
Humidity
Max: 88%
Min: 30%

DAY 1 (6-7-06) Temperature High 36ºC Low 21.7ºC
11:30 A.M.
Clear Sky and Sunny
Outdoor Temperature 31ºC Humidity 55%
Beginning bloat stage
Black Soldier Flies
Blow Flies
There is a concentration of flies present at mouth, nostrils and eye orbits.
There is foaming at the mouth, steam and bubbling.
Maggot egg casings present were surrounding the anal cavity.
Cigarette butts placed around the control cage as well as the two cages surrounding the containers in order to deter predators/raccoons.

DAY 1 (6-7-06)
8:08 P.M.
Clear Sky and Sunset
Outdoor Temperature 33ºC Humidity 41%
There was a turkey buzzard on top of the control cage.
Control:
The largest concentration of flies were on the mouth, anal cavity and in-between the shoulder blades.
*The increase in flies was notable.
Increase area of maggot egg casings.
Eggs visible on anal cavity and ventral/posterior portion of thorax.
A cluster of eggs visible on dorsal/anterior side, in-between shoulder blades.
No visible egg casings in eye orbits or mouth.
Slight deformation of Containers 1, 4, 6 and 9
Fire ants traveling along the floor portion of the cage.

DAY 2 (6-8-06) Temperature High 36ºC Low 20.6ºC
12:00 P.M.
Clear Skies and Sunny
Outdoor Temperature 33.1ºC Humidity 43%
Turkey buzzard on cage 1.
Maggots present in mouth and eye orbits.
Marbling of exposed surface from mouth extending to midline of posterior aspect of thorax.
Eggs present at anal cavity.
Swarm of flies.
Flies concentrating on handles of containers.
Heavy concentration on Container 9.

DAY 2 (6-8-06)
7:45 P.M.
Clear skies and beginning dusk.
Outdoor Temperature 33.1ºC Humidity 38%
Increased fly activity over containers
Fire ants present on Container 4
Increased maggot activity at nose and mouth-structured breakdown
Maggot activity along the spinal column-structured breakdown
Eye orbits structure completely eviscerated & expansion of hole
Discoloration under right anterior limb.

DAY 3 (6-9-06) Temperature High 36ºC Low 20ºC
11:15 A.M.
Clear sky and sunny.
Outdoor Temperature 31.9ºC Humidity 43%
Control:
Skin slippage present at spinal column
Right front leg detaching
Extensive maggot activity throughout torso, concentrating at rear hind quarters.
Marbling present at the shoulder area
Back left hoof completely detached

DAY 3 (6-9-06)
8:00 P.M.
Clear Sky and sun setting.
Outdoor Temperature 33ºC Humidity 36%
Containers:
White mass hanging from Container 5 (handle area), cluster of maggot eggs
Dark substance (likely decomposition fluids) and egg casings on the sides of Containers 1, 4, 5 and 9
Turkey vulture observed
Control:
Maggot destruction of anterior aspect of torso
Continuation of skin slippage
Hair sloughed off all along the dorsal surface
Major maggot concentration on ventral surface

DAY 4 (6-10-06) Temperature High 36ºC Low 20ºC
11:40 A.M.
Clear sky and sunny
Outdoor Temperature 32ºC Humidity 43%
Containers:
Container 9 has a concentration of maggot activity around the handle areas
Container 5 the white cluster of maggot eggs has fallen and dispersed
Container 4 goldish colored substance along top of container, handles and edges
Container 2, 6, 7 and 8 show no change since placement
Control:
Putrefaction stage
Body deflated, bloat stage has passed
Maggots concentrating most specifically to ventral and dorsal surface

DAY 4 (6-10-06)
7:50 P.M.
Clear sky and sun setting
Outdoor Temperature 32ºC Humidity 33%
Turkey Vulture observed
Maggots darker in color
Decomposition is staining around the carcass enlarged
Mummification present hind right leg, posterior region and shoulder area
More maggots present since morning check
Top of cage shows impression on the poultry fencing, likely from turkey vulture

DAY 5 (6-11-06) Temperature High 36ºC Low 21.7ºC
12:05 P.M.
Clear sky and sunny
Outdoor Temperature 31.1ºC Humidity 66.2%
Containers:
Turkey vulture observed
Maggots present in airlock water of Container 1
Maggots on the ground area around Containers 4, 5, 6 and 9
Control:
Bone visible of front left leg
Decrease in fly activity
Mummification beginning to occur at hindquarters and spinal column

DAY 5 (6-11-06)
7:46 P.M.
Clear sky and sun setting
Outdoor Temperature 32ºC Humidity 40%
Containers:
Containers 1, 2, 4 and 9 have foaming decomposition fluid with maggots around the edges
Control:
Bone visible in back left leg
Still no pupa casings visible

DAY 6 (6-12-06) Temperature High 36ºC Low 22.8ºC
12:00 P.M.
Clear sky and sunny
Outdoor Temperature 30.9ºC Humidity 49%
Containers:
Containers number 3 and 7 have decomposition fluids pouring down the side
Control:
Mummification continues
Still no visible pupa casings
Second set of flies present

DAY 6 (6-12-06)
6:50 P.M.
Clear sky and sun beginning to set
Outdoor Temperature 34ºC Humidity 34%
Control:
Wasps present around control
No pupa casings visible
Turkey vulture observed

DAY 7 (6-13-06) Temperature High 38ºC Low 18.9ºC
12:07 P.M.
Clear sky and sunny
Outdoor Temperature 34ºC Humidity 30%
Control:
Decrease in maggots/maggot activity
Still no visible pupa casings
Mummification

DAY 7 (6-13-06)
6:00 P.M.
Clear sky and sunny
Outdoor Temperature 37ºC Humidity 27%
Control:
No change
Turkey vulture present
Mold on nose.
Still no pupa casings visible

DAY 8 (6-14-06) Temperature High 36ºC Low 23.9ºC
12:00 P.M.
Clear sky and sunny
Outdoor Temperature 32.1ºC Humidity 43%
Control:
Pupa casings visible within a hole in the shoulder region, it is possible all pupa casings are internal
Mold on posterior/anal region

DAY 8 (6-14-06)
7:00 P.M.
Clear sky and sun setting
Outdoor Temperature 34ºC Humidity 30%
Control:
Raccoon present
Maggots are gone
Beetles present
Mold on posterior/anal section
Skin is leathery in appearance and brown in color

DAY 9 (6-15-06) Temperature High 36ºC Low 22.8ºC
12:00 P.M.
Clear sky and sunny
Outdoor Temperature 32ºC Humidity 49%
Container:
Maggots present in the water of the airlock of Container 5
Turkey Vulture present
Beetles present
Skin is slowly eroding, very slowly
Holes that are present in the skin get slightly larger daily
Flesh flies and blow flies still present

DAY 9 (6-15-06)
7:00P.M.
Clear Sky and sun setting
Outdoor Temperature 33.1ºC Humidity 41%
No change
Beetles and flies still present

DAY 10 (6-16-06) Temperature High 35ºC Low 23.9ºC
12:15 P.M.
Cloudy and partly sunny
Outdoor Temperature 33ºC Humidity 43%
Dried skin is beginning to peel off stomach
No significant change
Decrease in fly activity

***On Day 11 the observations of Control were reduced to once daily.

DAY 11 (6-17-06) Temperature High 33ºC Low 18.9ºC
3:05 P.M.
Overcast (Rained hard last night)
Outdoor Temperature 33.1ºC Humidity 52%
Some moisture returned to carcass due to rain
Left front bone exposed
Beetles present on stomach, sides, posterior region, legs and cage

DAY 12 (6-18-06) Temperature High 34ºC Low 18.9ºC
3:14 P.M.
Overcast (Rained hard again last night)
Outdoor Temperature 33ºC Humidity 46%
Flies covering the plants near the cage
Beetles eating more mummified tissue
Lots of flies and beetle activity

DAY 13 (6-19-06) Temperature High 34ºC Low 22.8ºC
3:15 P.M.
Sunny and partly cloudy
Outdoor Temperature 34.1ºC Humidity 44%
Container:
All containers still intact, rain washed away some of decomposition fluids on the sides
Control:
Bottom of mouth deteriorating
Flies still present on surrounding flora
Bones visible on all quarters
Eating away tissue and muscle around skull
Beetles mainly concentrated on posterior region, legs and head

DAY 14 (6-20-06) Temperature High 31ºC Low 22.8ºC
4:47 P.M.
Clear skies and sunny
Outdoor Temperature 30ºC Humidity 51%
Flies pretty much gone from the surrounding flora
Beetles continuing to eat tissue/mummified skin
Mold at nose

DAY 15 (6-21-06) Temperature High 33ºC Low 23.9ºC
3:30 P.M.
Clear skies and sunny
Outdoor Temperature 33ºC Humidity 41%
Beetles eating away posterior
Maggots noted
Areas of lighter colored mummified tissue along thorax and posterior

DAY 16 (6-22-06) Temperature High 34ºC Low 22.8ºC
1:00 P.M.
Cloudy and Overcast
Outdoor Temperature 32.1ºC Humidity 52%
Container:
Several flies present around all containers
Control:
Turkey Vulture observed
Maggots present
Very few flies
Beetle larvae
More breakdown of skin/tissue at posterior

DAY 17 (6-23-06) Temperature High 35ºC Low 22.8ºC
1:45 P.M.
Sunny and Cloudy
Outdoor Temperature 33.2ºC Humidity 49%
Beetle larvae all over the cage covering control
Nose is completely gone
Bones of legs fully exposed
Exposed bone at shoulder
Posterior bones exposed
More features of skull visible and distinct
Lots more beetle larvae type bugs present

DAY 18 (6-24-06) Temperature High 32ºC Low 23.9ºC
1:55 P.M.
Overcast
Outdoor Temperature 31.1ºC Humidity 55%
Posterior bones exposed
"Sandy" appearance
Beetle larva throughout carcass
Ribs becoming exposed & vertebral column
Bones being cleaned as they are becoming exposed

DAY 19 (6-25-06) Temperature High 35ºC Low 20.6ºC
3:10 P.M.
Overcast and Partly sunny
Outdoor Temperature 33.1ºC Humidity 49%
Skull is visible
Limbs (bone) fully exposed
Ribs visible and vertebrae and vertebral bodies exposed
Pelvis and part of scapula visible
Sandy insect residue all over carcass

DAY 20 (6-26-06) Temperature High 33ºC Low 20ºC
2:40 P.M.
Clear skies and Sunny
Outdoor Temperature 33.2ºC Humidity 36%
Skull fully exposed
Beetle larva present
Ribs more visible
Hind limb fully exposed

DAY 21 (6-27-06) Temperature High 32ºC Low 16.7ºC
7:05 P.M.
Clear skies and Sunny
Outdoor Temperature 30ºC Humidity 31%
More of Vertebral column visible
Concentration of larva at neck
Ribs visible
Posterior visible

DAY 22 (6-28-06) Temperature High 34ºC Low 15.6ºC
2:15 P.M.
Clear and Sunny
Outdoor Temperature 33.1ºC Humidity 28%
Skull completely clean
2 maggots noted
Beetle larva still present
Posterior aspect of vertebral column completely exposed
Ribs continue to show cleaning

DAY 23 (6-29-06) Temperature High 33ºC Low 18.9ºC
3:00 P.M.
Clear and Sunny
Outdoor Temperature 33ºC Humidity 36%
Progressively cleaned
Front and hind legs skeletonized fully
(About the same.)

DAY 24 (6-30-06) Temperature High 35ºC Low 20.6ºC
2:15 P.M.
Clear Skies and Sunny
Outdoor Temperature 33.1ºC Humidity 41%
More rib and shoulder skeletonized
Shoulder blade visible
Beetle refuse

DAY 25 (7-1-06) Temperature High 32ºC Low 21.7ºC
2:50 P.M.
Overcast
Outdoor Temperature 31.9ºC Humidity 43%
No Change

DAY 26 (7-2-06) Temperature High 30ºC Low 21.7ºC
2:15 P.M.
Overcast
Outdoor Temperature 30ºC Humidity 58%
Posterior aspect of vertebral column visible (spinous process)
More of ribs visible
Lack of flies

DAY 27 (7-3-06) Temperature High 31.7ºC Low 20.6ºC
3:00 P.M.
Overcast
Outdoor Temperature 32ºC Humidity 52%
Entire scapula visible
Superior ribs visible

DAY 28 (7-4-06) Temperature High 33ºC Low 21.7 Rainfall 3.25”
RAIN DELAY ON CONTROL CHECK AND CONTAINER OPENING
THUNDERSTORM

DAY 29 (7-5-06) Temperature High 32ºC Low 20.6ºC
2:55 P.M.
Overcast
Outdoor Temperature 30.9ºC Humidity 58%
Fully Skeletonized
Beetle larva still present
Neck area of vertebral column visible (fully)
Decomposition and Hair mass detached from skeleton
Sacrum fully visible

DAY 30 (7-6-06) Temperature High 32ºC Low 21.7ºC
2:43 P.M.
Partly Cloudy
Outdoor Temperature 31ºC Humidity 58%
Daily Observations of Control End due to Skeletonization

APPENDIX B

CONTAINER OBSERVATION LOGS

CONTAINER 1
DAY 7 (6-13-06) Opening of Container 1
6:50 P.M. Temperature High 38ºC Low 18.9ºC
Clear sky and sunny
Outdoor Temperature 36.1ºC Humidity 30%
Hair missing on various visible areas showing white skin
Soupy decomposition, light brown and pinkish in color
Skull is visible
Dead Maggots and live ones
Pig generally intact, decomposition to skeleton is only visible at the skull
Internal organs intact
Bloat stage not reached

CONTAINER 2
DAY 14 (6-20-06) Opening of Container 2
5:00 P.M. Temperature High 31ºC Low 22.8ºC
Clear sky and sunny
Outdoor Temperature 31ºC Humidity 49%
Flies swarmed immediately when opened
Head smashed down, skull skeletonized
Carcass intact
Lack of decomposition when compared to control and Container 1
Bloat stage has not yet occurred
Hair mainly still intact, sloughing starting on posterior, dorsal and ventral surface
No maggots present
Extremely foul odor.

*It is apparent that insect involvement was strongly limited in this container due to lack of maggots.

CONTAINER 3
DAY 21 (6-27-06) Opening of Container 3
7:18 P.M. Temperature High 32ºC Low 16.7ºC
Clear sky and sunny
Outdoor Temperature 19ºC Humidity 64%
No maggots present
White flesh exposed at posterior
Back limbs bare
Sloughed off hair at ventral portion, thorax and all over
Marbling on body
Head almost completely eviscerated-more in tact than others
Chunky consistency of decomposition fluids
Flies swarmed shortly after opening
Organs intact

CONTAINER 4
DAY 29 (7-5-06) Opening of Container 4
3:15 P.M. Temperature High 32ºC Low 20.6ºC
Overcast
Outdoor Temperature 32.1ºC Humidity 55%
Flies immediately appeared
Skull skeletonized and broken apart
Forelimbs and hind limbs were also skeletonized
Marbling on torso
Decomposition fluids grayish in color
No maggots present
Red chunky decomp material
Organs intact
Partial pelvic area skeletonized

CONTAINER 5
DAY 35 (7-11-06) Opening of Container 5
7:15 P.M. Temperature High 35.6ºC Low 25ºC
Sunny and Clear
Outdoor Temperature 33.1ºC Humidity 43%
Decomposition more green
Femur still articulated
Skull Visible
Lots of hair still present
Chunky substance present
Maggots in Airlock only one maggot seen on carcass
Adipocere present
Fire ants on containers
Carcass looks that form is b/c of congealed decomposition
No other maggots visible

CONTAINER 6
DAY 42 (7-18-06) Opening of Container 6
7:30 P.M. Temperature High 38.1ºC Low 23.9ºC
Sunny and Clear
Outdoor Temperature 35ºC Humidity 45%
No Maggots
More of a fecal scent
Greenish decomposition
Some flies but not as quick concentration upon opening as prior containers
Limbs and skull and skeletonized
Chunky decomposition material present
Solid decomp containing bony elements holding the form/shape of the container

CONTAINER 7
DAY 49 (7-25-06) Opening of Container 7
7:30 P.M. Temperature High 32.8ºC Low 22.8ºC
Sunny and Clear (Dusk is starting)
Outdoor Temperature 30ºC Humidity 42%
Flies present- they immediately swarmed when the container was opened
Dead maggots around the edge of the container
Clumpy/Chunky material present
Decomposition in shape/form of container
Skull decomposed
Dark coloration of skin
Hair present and still attached to skin
Grey color decomposition fluids

CONTAINER 8
DAY 56 (8-1-06) Opening of Container 8
7:45 P.M. Temperature High 36.7ºC Low 25.6ºC
Dusk and Clear
Outdoor Temperature 34.4ºC Humidity 44%
Right before opening, flies already present
Decomposition is thinner than precious containers
Organs and tissue liquefied
Adipocere
Possible pupa casings
No formation of decomp to shape of container
No maggots

CONTAINER 9

DAY 119 (10-3-06) Opening of Container 9
4:45 P.M. Temperature High 33.9ºC Low 17.8ºC
Sunny and Clear
Outdoor Temperature 32.1ºC Humidity 38%
Smell contained to container until tape was ripped off
Bones reddish in color (on surface) and clean of tissue
Maggots present in decomp material
Darker portion of decomp by head
Hair and adipocere in decomp material
Flies arrive as soon as opened
Decomposition is not consistent (not opaque)
Basically liquefied (not holding form/shape of container)
Odor seems less pungent than previous containers
Thick Adipocere

APPENDIX C

HOBO TEMPERATURE DATA

CELSIUS

Date	HOBO Outside High	HOBO Inside High	HOBO Outside Low	HOBO Inside Low
06-Jun	39.67	41.52	27.52	28.70
07-Jun	36.13	39.22	22.86	23.63
08-Jun	36.13	40.13	20.57	22.86
09-Jun	36.57	40.13	20.19	20.95
10-Jun	35.70	40.13	19.42	20.19
11-Jun	35.70	39.22	23.63	24.01
12-Jun	37.00	41.52	24.40	24.79
13-Jun	38.77	42.94	18.66	19.81
14-Jun	37.44	42.94	24.79	25.17
15-Jun	35.70	39.22	25.56	26.34
16-Jun	36.13	40.59	25.56	25.95
17-Jun	32.34	34.01	19.81	20.95
18-Jun	32.76	35.27	19.81	20.57
19-Jun	35.27	37.44	21.33	22.09
20-Jun	30.71	31.93	22.86	23.63
21-Jun	32.76	34.43	24.79	25.17
22-Jun	34.85	36.13	24.79	25.17
23-Jun	34.85	37.44	22.86	23.24
24-Jun	31.52	32.76	23.63	24.01
25-Jun	35.70	37.44	20.57	21.33
26-Jun	34.01	35.70	20.95	21.33
27-Jun	32.76	35.70	15.62	16.76
28-Jun	35.27	39.22	15.23	16.00
29-Jun	34.01	37.88	17.90	18.66
30-Jun	35.27	38.77	20.57	21.33
01-Jul	33.17	35.70	21.71	22.48
02-Jul	31.12	33.17	22.48	22.86
03-Jul	34.01	38.32	22.86	22.86
04-Jul	34.01	36.57	24.40	24.79
05-Jul	32.34	35.27	20.57	21.33
06-Jul	32.76	35.27	21.33	21.71
07-Jul	31.93	33.59	24.01	24.01
08-Jul	34.85	36.57	23.63	24.01
09-Jul	35.27	37.44	24.01	24.40
10-Jul	34.85	37.88	25.17	25.17
11-Jul	34.85	37.00	25.56	25.95
12-Jul	36.57	40.59	24.40	25.17
13-Jul	35.27	39.22	25.56	25.95
14-Jul	35.27	38.32	24.40	25.17
15-Jul	34.85	37.00	22.48	23.63
16-Jul	37.00	40.13	22.09	22.86
17-Jul	38.32	42.46	23.24	23.63
18-Jul	39.22	43.42	22.86	23.63
19-Jul	36.13	40.59	22.09	22.86

Date	HOBO Outside High	HOBO Inside High	HOBO Outside Low	HOBO Inside Low
20-Jul	34.43	36.13	24.01	24.40
21-Jul	36.13	41.05	20.95	21.71
22-Jul	39.22	43.42	22.48	23.24
23-Jul	37.44	41.52	22.09	22.86
24-Jul	36.57	40.59	21.71	22.48
25-Jul	34.01	36.13	24.4	25.17
26-Jul	33.59	35.70	24.01	24.40
27-Jul	34.85	37.00	22.48	23.24
28-Jul	37.44	40.13	25.56	25.95
29-Jul	37.44	40.59	25.17	25.56
30-Jul	38.32	41.05	24.79	25.17
31-Jul	36.57	39.22	25.56	25.95
01-Aug	37.44	40.59	25.95	26.34
02-Aug	36.13	38.32	25.17	25.95
03-Aug	38.32	41.99	25.56	25.95
04-Aug	37.88	41.05	24.79	25.56
05-Aug	35.70	37.00	22.48	23.24
06-Aug	37.00	39.22	22.48	22.86
07-Aug	31.93	33.59	23.24	23.63
08-Aug	36.13	37.44	22.09	22.48
09-Aug	35.70	36.57	23.63	24.01
10-Aug	37.00	38.77	22.48	22.86
11-Aug	37.88	41.52	25.56	25.95
12-Aug	37.88	41.05	23.24	24.01
13-Aug	37.44	39.67	25.56	25.95
14-Aug	36.13	39.22	25.95	26.73
15-Aug	38.32	40.13	24.01	24.40
16-Aug	38.32	40.59	22.86	24.01
17-Aug	38.77	40.59	24.01	24.79
18-Aug	38.32	40.59	23.63	24.79
19-Aug	35.27	37.44	22.48	23.24
20-Aug	37.44	40.59	22.48	23.24
21-Aug	37.44	40.59	22.86	23.63
22-Aug	37.00	41.05	24.01	24.79
23-Aug	37.88	40.59	24.79	25.56
24-Aug	38.32	40.13	23.24	24.01
25-Aug	38.32	39.67	26.34	26.73
26-Aug	38.32	40.59	26.73	27.12
27-Aug	37.44	40.13	25.95	26.73
28-Aug	37.88	40.59	25.95	26.73
29-Aug	35.27	37.00	24.01	24.40
30-Aug	35.70	38.32	24.01	24.40
31-Aug	37.88	40.13	18.28	19.04
01-Sep	37.88	40.59	20.19	21.33
02-Sep	36.57	38.32	22.48	23.24

Date	HOBO Outside High	HOBO Inside High	HOBO Outside Low	HOBO Inside Low
03-Sep	33.59	34.85	24.40	24.79
04-Sep	33.59	34.43	22.48	22.86
05-Sep	22.09	22.86	21.71	22.48
06-Sep	30.31	29.90	16.76	17.90
07-Sep	31.93	31.52	14.85	15.23
08-Sep	31.12	30.71	16.76	17.14
09-Sep	27.91	28.70	20.57	20.95
10-Sep	33.17	33.59	21.71	22.09
11-Sep	25.56	25.95	21.71	22.09
12-Sep	30.31	30.71	21.33	21.71
13-Sep	31.52	31.93	19.42	19.81
14-Sep	33.17	32.76	15.23	15.62
15-Sep	34.43	34.01	24.40	24.40
16-Sep	35.27	36.13	25.95	25.95
17-Sep	29.10	29.50	25.95	26.34
18-Sep	28.31	28.31	22.48	22.86
19-Sep	29.50	29.50	12.93	13.70
20-Sep	30.71	30.31	11.77	12.55
21-Sep	32.34	32.34	15.62	16.00
22-Sep	34.43	34.43	25.95	25.56
23-Sep	34.43	35.70	27.12	27.12
24-Sep	27.91	28.31	22.48	22.86
25-Sep	29.50	31.12	12.16	13.32
26-Sep	31.52	32.34	12.16	13.32
27-Sep	32.76	33.59	13.32	14.47
28-Sep	30.71	32.34	20.95	21.33
29-Sep	32.34	33.59	17.14	17.90
30-Sep	34.01	35.70	21.71	22.09
01-Oct	32.76	34.43	23.24	23.63
02-Oct	33.59	35.70	23.63	24.01
03-Oct	33.59	36.57	19.42	20.57

APPENDIX D

SAN MARCOS, TX TEMPERATURE DATA

CELSIUS

Date	San Marcos, TX High	San Marcos, TX Low
06-Jun	36.0	18.9
07-Jun	36.0	21.7
08-Jun	36.0	20.6
09-Jun	36.0	20.0
10-Jun	36.0	20.0
11-Jun	36.0	21.7
12-Jun	36.0	22.8
13-Jun	38.0	18.9
14-Jun	36.0	23.9
15-Jun	36.0	22.8
16-Jun	35.0	23.9
17-Jun	33.0	18.9
18-Jun	34.0	18.9
19-Jun	34.0	22.8
20-Jun	31.0	22.8
21-Jun	33.0	23.9
22-Jun	34.0	22.8
23-Jun	35.0	22.8
24-Jun	32.0	23.9
25-Jun	35.0	20.6
26-Jun	33.0	20.0
27-Jun	32.0	16.7
28-Jun	34.0	15.6
29-Jun	33.0	18.9
30-Jun	35.0	20.6
01-Jul	32.0	21.7
02-Jul	30.0	21.7
03-Jul	31.7	20.6
04-Jul	33.0	21.7
05-Jul	32.0	20.6
06-Jul	32.0	21.7
07-Jul	31.0	22.8
08-Jul	32.9	23.9
09-Jul	33.9	22.8
10-Jul	35.0	23.9
11-Jul	35.6	25.0
12-Jul	32.8	23.9
13-Jul	35.6	23.9
14-Jul	35.0	23.9
15-Jul	33.9	21.7
16-Jul	36.7	21.7
17-Jul	38.0	23.9
18-Jul	38.1	23.9
19-Jul	37.2	24.1

Date	San Marcos, TX High	San Marcos, TX Low
20-Jul	37.2	25.8
21-Jul	35.6	27.8
22-Jul	37.8	22.8
23-Jul	36.7	22.8
24-Jul	35.6	20.6
25-Jul	32.8	22.8
26-Jul	32.8	21.7
27-Jul	35.0	22.8
28-Jul	35.6	23.9
29-Jul	36.7	23.9
30-Jul	36.6	23.9
31-Jul	36.5	25.0
01-Aug	36.7	25.6
02-Aug	35.6	23.9
03-Aug	36.4	25.0
04-Aug	37.8	22.8
05-Aug	36.9	21.7
06-Aug	36.9	21.7
07-Aug	32.0	22.8
08-Aug	35.6	21.7
09-Aug	36.7	23.9
10-Aug	36.9	22.8
11-Aug	37.8	23.9
12-Aug	38.0	22.8
13-Aug	38.2	25.0
14-Aug	36.4	25.6
15-Aug	38.0	23.9
16-Aug	39.0	22.8
17-Aug	39.0	23.9
18-Aug	38.0	23.9
19-Aug	35.0	22.8
20-Aug	36.4	22.8
21-Aug	37.8	22.8
22-Aug	36.4	22.8
23-Aug	38.2	23.9
24-Aug	38.4	22.8
25-Aug	39.0	25.6
26-Aug	39.0	25.6
27-Aug	38.4	23.9
28-Aug	38.2	25.6
29-Aug	34.0	23.9
30-Aug	35.6	23.9
31-Aug	36.4	18.9
01-Sep	37.8	21.7
02-Sep	36.4	22.8

Date	San Marcos, TX High	San Marcos, TX Low
03-Sep	33.9	23.9
04-Sep	33.9	21.7
05-Sep	23.9	20.6
06-Sep	31.7	17.8
07-Sep	32.8	17.8
08-Sep	31.7	17.8
09-Sep	28.9	20.0
10-Sep	33.9	21.7
11-Sep	27.8	21.7
12-Sep	30.0	21.7
13-Sep	31.7	20.0
14-Sep	33.9	16.7
15-Sep	34.7	23.9
16-Sep	35.0	25.6
17-Sep	30.6	25.0
18-Sep	30.0	20.6
19-Sep	30.6	13.9
20-Sep	33.9	12.8
21-Sep	33.9	15.6
22-Sep	34.2	25.6
23-Sep	35.0	25.6
24-Sep	27.8	20.6
25-Sep	28.9	13.9
26-Sep	30.6	12.8
27-Sep	32.8	13.9
28-Sep	30.6	20.0
29-Sep	31.7	17.8
30-Sep	33.9	20.6
01-Oct	32.8	18.9
02-Oct	33.2	20.6
03-Oct	33.9	17.8

APPENDIX E

PHOTOGRAPHS ATTACHED ON COMPACT DISC

Compact Disc and plastic sleeve will be attached here.

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VITA

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