To the Graduate Council:

I am submitting herewith a thesis written by Kimberly Dawn Tomlinson entitled "Death as a Process: Human Decomposition in an Insect-Restricted Environment." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

Murray K. Marks, Major Professor

We have read this thesis and recommend its acceptance:

Acceptance for the Council:

Vice Provost and Dean of Graduate Studies

Death as a Process:
Human Decomposition in an Insect-Restricted Environment

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Kimberly Dawn Tomlinson
December 2003

Insect-Restricted Environment for Human Decomposition 5-31-02

Dedication

To those who give so graciously of themselves--even in death

Acknowledgements

I would like to take this opportunity to thank those who contributed to this endeavor. Thanks to Dr. Murray Marks is in order for giving me the confidence to take my research to the next level. Also, I would like to thank Dr. Lee Meadows Jantz for contributing to my determination to "make it work," and Dr. Walter Klippel for his patient ear and entomological advice. Special thanks are attributed to Dr. William M. Bass for his sincere faith, enthusiasm, and support for my research from beginning to end.

In addition to faculty mentors, I would also like to recognize a few "student" mentors. Special thanks goes to Angi Christensen, Michelle Hamilton, and Jennifer Synstelien for their academic advice and to Nancy Anderson for her professional advice, as well as emotional support.

I would also like to acknowledge the support I received while affiliated with the Facility. The William M. Bass Endowment provided funding for the construction of the insect-restricted environment. Graduate students involved with the transport and handling of donations included: Jaime Stuart, Jennifer Synstelien, Beth Bassett, Kate Spradley, Jamie McCuiston, Michelle Miller, and Mariateresa Tersigni. Thanks for treating my "guys" with such gentleness. I would also like to recognize Erin Eldridge for her botanical expertise and thank Carrie Smka for keeping me company while I worked. Further acknowledgments are in order for the morgue staff. Thanks for enduring the 4:30 wake-up calls! Also, I would like to recognize the UT Medical Center Police for making sure I was okay in the dark.

Last, but certainly not least, I would like to extend my greatest appreciation to my family: Thanks Mother for always believing in me, even when my goals seemed unobtainable. Thanks Daddy for showing your love for "your little girl" by helping me make my blue-prints a reality. And to my beloved Jay Sikes, thanks for never doubting me and for inspiring me to "adapt and overcome."

Abstract

Many view death as an event; however, the death investigator must perceive death as a process that is catalyzed by cellular breakdown and ultimately results in skeletal remains. Yet, a gap persists in the understanding of the causal events inherent to the human decomposition process. In order to gain a clearer understanding of these causal events, research must focus on internal factors of decomposition, specifically autolysis and putrefaction. However, in order to observe the contribution of autolysis and putrefaction to the process of human decomposition, external factors proven to grossly manipulate these effects, as perceived by the senses, must be limited. One such external factor is insect activity.

While gathering data for successional analysis of insects affiliated with the decomposition of the baby pig, *Sus scrofa* Linnaeus, Payne (1965) denied insect access to a separate group of pigs. Observing that the decomposition of this group differed from the group exposed to insects, Payne designated an alternative nomenclature for the stages of decomposition specific to the unexposed pigs.

To determine if this nomenclature could be applied to humans in a similar setting, an insect-restricted environment was constructed at the Anthropology Research Facility in Knoxville, Tennessee. Four unembalmed, unautopsied human donations were involved in the study. As two members of the control group were allowed full exposure to the elements, two members of the experimental group were placed inside the structure specifically to monitor autolysis and putrefaction influenced only by environmental conditions and insects that crossed the barrier. Data collection involved observations of

the visual and olfactory cues of human decomposition and notations of insects attracted to each subject, including those attempting to cross the constructed barrier. Environmental data (i.e., temperature, humidity, rainfall, sky conditions) was collected in the vicinity of each donation, with special attention attributed to temperature and humidity data collection methods. In order to contemplate each progression, all data specific to each subject was articulated within the context of the circumstances surrounding each donation. Hence, Bass's (1997) nomenclature representative of decomposition in a natural and uncontrolled environment served as the default for all subjects, while Payne's (1965) nomenclature specific to insect-free pigs was considered when addressing the progression of the experimental group.

While the interpretations of the decomposition and insect activity data and the environmental data collection methods were supported by the literature, the ultimate goal was to access the causal events affiliated with internal decomposition. Although the results of this study indicated that the control group members followed Bass's (1997) nomenclature while the experimental group progressed according to Payne's (1965) nomenclature, both progressions revealed generalized sequential patterns of causal events attributed to autolysis and putrefaction. Such events involving initial indications of generalized skin discoloration, marbling, skin slippage, hair slippage, the purging of fluids, and odor occurred prior to and continued throughout bloating, while dehydration and skeletonization were noted upon deflation and beyond. Adipocere formation, desiccation, and the proliferation of fungi and/or mold were variable. In addition, these patterned events were influenced by temperature, humidity, rainfall, and sky conditions, which consequently affected the rate of decomposition.

Research contributions inherent to this study include support for regional models based on patterns of causal events. Contributions to the death scene investigation involve the recognition of both the visual/olfactory signatures attributed to decomposition and natural versus disrupted insect successional patterns, coupled with suggestions for proper environmental data collection methods.

Table of Contents

List of Tables

List of Figures

Chapter 1:
Introduction

Many view death as an event—the point in time in which life ceases to exist. However, to the death investigator, it is much more than an event in time; it is a process that begins with cellular breakdown and ultimately results in human skeletal remains. Based on this understanding, forensic pathologists and forensic anthropologists have offered their expertise in such matters concerning identification of human remains, as well as the postmortem interval.

Traditionally, the individual expertise of the forensic pathologist and forensic anthropologist has co-existed on opposite ends of this spectral process. The forensic pathologist typically observes the consequences of earlier postmortem events, including the independent, yet concomitant, effects attributed to rigor mortis, livor mortis, and algor mortis. Rigor mortis can be defined as stiffening or hardening of muscle tissue due to the increase of lactic acid and the absence of ATP. Yet as gravity causes stagnant blood to pool within the capillaries, livor mortis manifests as time-dependent discoloration of the skin ranging from pink to red to purple. In addition, algor mortis describes the cooling of the body as it approaches ambient temperature (Fisher 1980, Dang 1996, Gill-King 1997, Marieb 1998, www.ut.med.com, Dix and Graham 2000, Clark et al. 1997).

Yet, while the forensic pathologist considers such events in the estimation of the postmortem interval (i.e., the elapsed time since death), the forensic anthropologist applies physical anthropological techniques of determining age, ancestry, sex, and stature (Krogman and Iscan 1986) to the identification of human skeletal remains. As a result, a

tremendous gap has formed in the understanding of the causal events affiliated with the death process from earlier postmortem events to skeletal remains. In response, forensic anthropologists have been attempting to bridge this gap via studies involving human decomposition in the hopes of offering insight as to what occurs at the cessation of life and beyond.

Internal Factors of Human Decomposition: Autolysis and Putrefaction

The study of human decomposition involves distinct, yet somewhat overlapping occurrences attributed to the effects of two internal factors: autolysis and putrefaction (Fisher 1980, Gill-King 1997, Dix and Graham 2000, Clark et al. 1997, Vass et al. 2002, Love 2001, Teather 1994, Dang 1996). Autolysis is triggered by an increase of carbon dioxide and a decrease of oxygen in the blood due to the elimination of respiratory function. This initiates a positive feedback loop, creating a highly acidic environment that is detrimental to cellular survival. As a result, enzymatic proteases and lipases normally held in check begin to digest the cells (Vass et al. 2002, Teather 1994, Clark et al. 1997), and ultimately hydrolytic enzymes break down proteins and carbohydrates into simpler derivates (Clark et al. 1997, Dang 1996, Fisher 1980). According to Gill-King (1997), autolysis occurs initially in cells containing their own supply of hydrolytic enzymes and those most affected by the lack of oxygen. Included are cells found in the intestines and the heart muscle, as well as the respiratory passages.

Fluids that support bacterial proliferation released from the disintegrated cells into a completely anaerobic environment allow for the onset of events affiliated with the second internal factor. Bacteria released from cellular lysis occurring in the gut and

lungs feed on these fluids and act to assist in the conversion of soft tissue into liquids and gases (Vass et al. 2002, Teather 1994, Fisher 1980). This effect is evident on the parts of the body where livor mortis is prominent (Clark et al. 1997), yet it proceeds throughout until all tissues take on a "fluid consistency" (Fisher 1980:20). Hence, autolysis and putrefaction could ultimately "reduce the body to the skeleton" (Love 2001:2), provided that ideal environmental circumstances coincided within a realistic time frame.

Visual and Olfactory Cues Indicative of Human Decomposition

Beyond the effects of rigor mortis, livor mortis, and algor mortis, certain visual and olfactory cues exist that accompany autolysis and putrefaction (Fisher 1980, Gill-King 1997, Dix and Graham 2000, Clark et al. 1997, Galloway 1997, Vass et al. 2002, Bass 1997, Love 2001). Color changes appear throughout the body due to the spread of bile pigments resulting from the chemical breakdown of hemoglobin coupled with solidities of hydrogen sulfide found in the tissues and within the vascular system (Gill-King 1997).

Initially, the energy (Marieb 1998) state of the bile pigments determines the color as perceived from the tissues (Gill-King 1997). The source of the green discoloration is biliverdin, which is derived from the destruction of biliary structures. If biliverdin gains electrons, it can be reduced to bilirubin, a red pigment. Additionally, the continuous drop in pH due to the increasingly anaerobic environment causes bilirubin to receive more electrons, thus gaining more energy. Hence, bilirubin is reduced to urobilin, which is perceived as brown within the tissues. Yet, if oxygen is available in the outer tissue layers, oxidation occurs resulting in blue and yellow discoloration (Gill-King 1997).

Consequently, these oxidation-reduction reactions involving the bile pigments, along with the presence of hydrogen sulfide within the vessels of the outer tissue layers, produce color changes due to intravascular hemolysis and are commonly referred to as marbling (Gill-King 1997, Dix and Graham 2000, Clark et al. 1997). According to Gill-King (1997:101), there is a continuum ranging from "green to purple to black." However, Clark et al. (1997) includes blue in reference to deoxyhemoglobin.

As discoloration proceeds throughout the body tissues and vascular system the body itself will begin to bloat due to gases released by the microorganisms no longer in check by the body's defenses (Dix and Graham 2000, Clark et al. 1997, Fisher 1980, Gill-King 1997, Vass et al. 2002, Love 2001). Initially, bloating occurs as these volatile gases become trapped in the large intestine and as bacteria further contributes to enzymatic reactions within the circulatory system (Gill-King 1997, Vass et al. 2002, Love 2001). However, as hydrogen, hydrogen sulfide, carbon dioxide, ammonia, and methane become confined within other body tissues, all parts may potentially balloon to "two to three times [the] normal size" (Fisher 1980:20). Hence, the abdomen expands, the head enlarges (Clark et al. 1997, Fisher 1980), and in males, gases are driven through the inguinal canals, ultimately causing distention of the scrotum (Clark et al. 1997).

Other by-products of bacterial action include odoriferous compounds such as putrescine and cadaverine (Gill-King 1997, Love 2001), which can be detected in certain concentrations via an "electronic nose" (Love 2001:v-vi). Odor can also be recognized in the beginning stages of putrefaction as fluid flows freely from the nose, mouth, and rectum (Clark et al. 1997, Fisher 1980, Vass et al. 2002). According to Clark et al.

(1997), this purge fluid is propelled through the digestive tract by gases produced during putrefaction.

Visual cues due to autolysis are layered onto the mentioned putrefactive effects. Hydrolytic enzymes released by body cells at the division between the skin's epidermal and dermal layers causes the epidermis to become detached. Commonly referred to as skin slippage (Fisher 1980, Clark et al. 1997, Dix and Graham 2000, Galloway 1997, Vass et al. 2002, Bass 1997, Love 2001), this phenomenon is easily recognized in the hands due to its glove-like appearance. Also, bullae, derivatives of skin slippage, are formed by the development of fluid at this "dermal-epidermal junction" (Clark et al. 1997:154). Similarly, hair slippage (Dix and Graham 2000, Bass 1997) occurs as the epidermis begins to slip in the scalp region.

In addition to the visual and olfactory cues caused by the symbiotic effects of autolysis and putrefaction, certain environmental conditions may determine whether the body will be the target of mold and/or fungi or eventually become desiccated. For example, molds occurring in a wide range of colors (Bass 1997) may appear if wet, moist, or humid conditions are sustained throughout the decomposition process. Yet, if dry conditions persist, dependent portions of the body may take on a leathery texture (Clark et al. 1997, Dang 1996, Bass 1997, Galloway 1997, Galloway et al. 1989, Rhine and Dawson 1998).

However, the progression towards skeletonization continues with the gradual expiration of gases from the body cavity and surrounding tissues (Clark et al. 1997, Galloway 1997). This causes the distended abdomen to deflate and the pooled internal organs to expel from the body (Clark et al. 1997). Meanwhile, skeletonization

commences with widespread tissue loss and may result in the disarticulation of the skeletal elements (Rodriguez and Bass 1985). Although insects and carnivores are largely responsible (Dix and Graham 2000), skeletonization can occur merely as a consequence of autolysis and putrefaction (Clark et al. 1997, Love 2001).

Progressive Alternatives to Putrefaction

According to Love (2001), autolysis maintains a somewhat constant progression. However, putrefaction demonstrates greater flux due to environmental circumstances. As a result, alternative forms of decomposition have been noted in various regions (Galloway et al. 1989, Galloway 1997, Bass 1997, Rhine and Dawson 1998). For example, adipocere tends to form in a wet, anaerobic environment (Dix and Graham 2000, Teather 1994, Dang 1996, www.utmed.com, Gill-King 1997, Clark et al. 1997) due to the "hydrolysis and hydrogenation of fats to fatty acids" (Clark et al. 1997:158). This odoriferous substance can appear "crumbly" or "paste-like" (Gill-King 1997:102) depending on whether sodium or potassium is part of the formative reaction. Hence, the resulting decline in pH discourages bacterial proliferation, which slows the putrefactive process.

Alternately, mummification is a result of prolonged exposure to hot, dry conditions (Galloway et al. 1989, Galloway 1997, Dix and Graham 2000). Similar to desiccation, mummification is considered to be an alternative to putrefaction as long as sufficient drying of the body takes place as to inhibit putrefactive effects. As a result, the skin becomes dry and leathery (Galloway et al. 1989, Galloway 1997).

However, it is possible to observe both alternatives to putrefaction if the body is not exposed to some type of outside water source and yet maintains adequate internal hydration (Clark et al. 1997). Adipocere will form in response to this internal water supply, yet mummification is eminent as long as hot and dry conditions remain constant.

Stages of Human Decomposition

Those familiar with the visual cues, as well as progressive alternatives of putrefaction, have designated benchmarks (Goff 2000) along the continuum that divide the progression into stages of human decomposition (Williams 1997, Love 2001, Marks et al. 2000, Galloway et al. 1989, Galloway 1997, Rodriguez 1982, Bass 1997, Clark et al. 1997). The most commonly recognized benchmark is bloating. From this angle, observations can be divided as to what effects lead to bloating, what occurs in conjunction with bloating and what happens after the gases are released from the body.

Typically, events that occur prior to bloating are classified into one stage (Williams 1997, Galloway et al. 1989, Galloway 1997, Rodriguez 1982, Bass 1997, Clark et al. 1997). Although the nomenclature varies with Williams (1997) and Clark et al. (1997) utilizing the term putrid and Galloway (1997) and Bass (1997) preferring fresh, similar observations are highlighted such as: the effects of rigor mortis, livor mortis, and algor mortis; little or no discoloration; and in some cases, skin slippage. However, Love (2001) and Marks et al. (2000) consider a further division among events leading to bloating. They nominate a separate category for discoloration involving skin slippage, which leaves fresh to refer to observations affiliated with the effects of rigor mortis, livor mortis, and algor mortis (Love 2001).

Next, observations are noted as the body distends due to bacterial action. The overall consensus recognizes this stage as bloating and includes such indicators as: swelling of the abdominal region and other areas, marbling, the formation of bullae, and odor detection. However, once gases are released from the gut, further benchmarks must be assigned that distinguish the dissolution of soft tissues from partial or complete skeletonization.

Purging from the nose and mouth is a consequence of the release of gases produced by bacterial action. However, once putrefaction wanes, adipocere formation and mummification may become evident. Williams (1997) and Clark et al. (1997) categorize these events in the destruction stage, while Galloway (1997) prefers advanced decomposition and Bass (1997) decay. Yet, according to Marks et al. (2000) and Love (2001), skeletonization begins once all the gases have been released and ends when all of the volatile fatty acids have leached out of the body. They include these processes in the skeletalization stage. To others, skeletonization, skeleton, or dry, denotes partial or complete skeletonization (Williams 1997, Galloway 1997, Clark et al. 1997, Rodriguez 1982, Bass 1997) and extreme decomposition (Galloway 1997) along with bone breakdown (Bass 1997) and bone decomposition (Marks et al. 2000, Love 2001), relay observations concerning events beyond skeletonization such as bleaching and exfoliation of skeletal remains.

External Factors that Affect the Rate of Human Decomposition

External factors including environmental variables and situational factors exist that influence the rate at which putrefaction progresses along the decomposition

continuum (Williams 1997, Mann et al. 1990, Galloway 1997, Bass 1997). Examples of environmental variables include: temperature, humidity/aridity, and rainfall (Mann et al. 1990, Galloway 1997, Bass 1997). According to Mann et al. (1990), temperature has the greatest impact on the rate of human decomposition. A direct correlation is demonstrated by increased in the summer and decreased in the winter. In terms of humidity/aridity, both conditions affect the rate of decomposition by creating environments that support progressive alternatives to putrefaction (Dix and Graham 2000, Gill-King 1997, Clark et al. 1997, Galloway et al. 1989, Galloway 1997). However, rainfall does not enhance the detachment of decayed tissue, so therefore, does not visibly affect the process (Mann et al. 1990).

Situational factors also affect the progression of putrefaction. Bodies that have been buried take longer to decompose compared to those left on the ground, while those left on the ground tend to decompose more quickly than others placed on man-made surfaces. Also, deeper burials demonstrate less decay than shallow burials. The condition of the body also affects the progression of decomposition. While size and weight of the body is questionable, those wearing clothes or having received some type of trauma tend to decay more quickly than those without clothes or evidence of trauma. Interestingly, embalming proves to hinder decomposition due to the change in the pattern of decomposition itself (Mann et al. 1990).

Insects provide an added dimension to the decomposition continuum by aiding putrefaction in the form of soft tissue disintegration, thereby increasing the rate of decomposition (Mann et al. 1990, Haskell et al. 1997). Whether insects contribute to the rate as an environmental variable or a situational factor is dependent upon context.

Insects as an environmental variable refers to insect activity, which describes the insects' relationship to the body (Goff 2000, Goff 1993, Merritt n.d.) in terms of developmental rates (Merritt n.d., Anderson 2000, Introna et al. 1991, Wells and LaMotte 1995, Haskell et al. 1997, Goff 1993, Castner 2001, Wells and LaMotte 2001, Goff 2000) and patterns of succession (Goff 2000, Merritt n.d., Krogman and Iscan 1986, Haskell et al. 1997, Anderson 2001, Wells and LaMotte 1995). Alternatively, insects as a situational factor describes insect access or defines barriers (Merritt n.d.) that affect developmental rates or distorts successional patterns (Richer n.d., Shahid et al. 2000, Introna et al. 1991, Goff 1991, Avila and Goff 1998, Shalaby et al. 2000, Davis and Goff 2000, Haskell et al. 1997, Goff 1993, Anderson 2001, Wells and LaMotte 2001, Goff and Lord 2001).

Insects as an Environmental Variable

From an ecological perspective, humans and insects are elements within the natural environment, interacting with it and with one another. According to Goff (2000:9), "Insects are major players in nature's recycling effort, and in nature a corpse is simply organic matter to be recycled." Hence, various types of arthropods interact directly with human remains, thereby "reducing the body to its basic components" (Goff 2000:9). As a result, entomologists (Goff 2000, Goff 1993, Merritt n.d.) recognize four specific types of direct interactions between the body and carrion-related insects. For example, the necrophages are insects that feed on the body itself and include flies (Order Diptera) and beetles (Order Coleoptera). As these numbers increase, they attract predatory/parasitic species, consisting of ants, wasps, and bees (Order Hymenoptera). This second group of carrion-related insects feed on the necrophage immatures, rather

than the body's tissues. However, the third group of insects affiliated with the remains is considered to be omnivorous since they feed on both the body and surrounding arthropods. Ants, along with certain wasps and beetles, are responsible for the severe decline in necrophage species frequenting the remains. Finally, members of the fourth classification simply include the remains as part of their habitat. These adventive (Goff 1993) or incidental (Merritt n.d.) species include springtails, spiders, mites, and centipedes (Goff 2000, Goff 1993, Merritt n.d.). (Tables 1.1 and 1.2.)

With this understanding of how insects interact with human remains, forensic entomologists can estimate the postmortem interval (PMI) from developmental rate and successional pattern data. The developmental rates of carrion-related species found on the body during earlier stages of decomposition are considered when estimating the minimum PMI (Goff 1993, Higley and Haskell 2001, Merritt n.d., Goff and Flynn 1991, Wells and LaMotte 1995). Although most species of forensic distinction undergo complete metamorphosis (egg→larva→pupa→adult) (Merritt n.d., Castner 2001), the flies from the order Diptera provide the most accurate minimum PMI (Haskell et al. 1997, Goff 2000). With the exception of the flesh fly (Sarcophagidae), which deposits 1st instars onto the body, most flies will lay eggs in natural openings (mouth, nose, eyes, genital areas) and sites of trauma. Once the eggs hatch, the flies will pass through three stages (instars) in the larval period before pupation. Based on the understanding that the postmortem interval cannot be narrower than represented by the later stages of development, these instar maggots along with the puparium are commonly used for the minimum PMI estimation (Goff 2000, Haskell et al. 1997, Castner 2001).

Table 1.1. Insects Significant to Forensic Entomology*

Flies (Order Diptera)	Beetles (Order Coleoptera)
Blow Flies (Family Calliphoridae)	Carrion Beetles (Family Silphidae)
Flesh Flies (Family Sarcophagidae)	Skin Beetles, Leather Beetles, Hide Beetles, Carpet Beetles, and Larder Beetles (Family Dermestidae)
Muscid Flies (Family Muscidae)	
Skipper Flies (Family Piophilidae)	
Dung Flies (Family Scathophagidae)	
Black Scavenger Flies (Family Sepsidae)	Rove Beetles (Family Staphylinidae)
Small Dung Flies, Minute Scavenger Flies (Family Sphaeroceridae)	Clown Beetles (Family Histeridae)
	Checkered Beetles (Family Cleridae)
Soldier Flies (Family Stratiomyidae)	Hide Beetles (Family Trogidae)
Humpbacked Flies or Scuttle Flies (Family Phoridae)	Scarab Beetles (Family Scarabaeidae)
Moth Flies, Sand Flies, and Owl Midges (Family Psychodidae)	Sap Beetles (Family Nitidulidae)

*adapted from "Insects of Forensic Importance"
Byrd and Castner (2001:43)

Table 1.2. Insects Observed at the Anthropology Research Facility*

Flies (Order Diptera)	Beetles (Order Coleoptera)
Blow Flies (Family Calliphoridae)	Carrion Beetles (Family Silphidae)
Flesh Flies (Family Sarcophagidae)	Clown Beetles (Family Histeridae)
Muscid Flies (Family Muscidae)	Rove Beetles (Family Staphylinidae)
	Sap Beetles (Family Nitidulidae)
	Checkered Beetles (Family Cleridae)
	Dermestid Beetles (Family Dermestidae)
	Scarab Beetles (Family Scarabaeidae)

*adapted from "Figure 2. The Ten Major Insect Families Observed and Their Approximate Spring/Summer Distribution During the Stages of Decay"
Rodriguez (1982:37)

The length and weight of the oldest maggots are key measurements when using instars to estimate the minimum PMI (Tantawi and Greenberg 1993, Goff 2000). According to Wells and LaMotte (2001), age can be determined by plotting the length or weight of the maggot onto a growth curve. However, Higley and Haskell (2001:288) state that "[a]ll growth depends on temperature because the biochemical reactions that are the ultimate basis for growth are themselves temperature-dependent." Since the maggot growth rate is dependent upon the temperature (Anderson 2000, Introna et al. 1991, Haskell et al. 1997, Goff 2000), age is related in terms of degree-days or degree-hours, with the developmental process itself expressed as an accumulation of these units (ADD or ADH) (Higley and Haskell 2001, Wells and LaMotte 2001, Goff 2000, Goff 1993, Hall 2001, Anderson 2000, Haskell et al. 1997).

Yet, once human decomposition progresses to the later stages on the continuum, successional pattern analysis must be applied (Goff 1993, Goff and Flynn 1991) in order to estimate both the minimum and maximum PMI (Wells and Lamotte 1995, Wells and LaMotte 2001). This concept of succession is based on the understanding that each group of carrion-related arthropods alters the remains or makes the body more attractive to the succeeding group of arthropods. As a result, a predictable and sequential pattern of human remains/carrion-related insect interactions evolves along the human decomposition continuum (Payne 1965, Anderson 2001, Merritt n.d., Goff 2000, Rodriguez 1982, Krogman and Iscan 1986).

Although Goff (2000:42) advises that "[d]ecomposition is a continuous process not amenable to division into discrete stages," he and others (Payne 1965, Rodriguez 1982) have superimposed this pattern onto the decomposition continuum. Despite the

fact that Payne's (1965) ground-breaking publication involved successional analysis on pigs, the sequential pattern itself proves consistent when compared to human studies (Goff 2000, Rodriguez 1982). For example, during the Fresh Stage, flies (Calliphoridae, Sarcophagidae) deposit eggs or instars onto the remains, while wasps feed on the adults and ants prey on the eggs. By the time the body reaches Bloated Stage, high numbers of fly eggs and maggots are present, along with beetles that are predaceous to the maggots (Silphidae, Staphylinidae, Cleridae, Histeridae). The Decay Stage initially supports maggots, along with predaceous and necrophagous beetles. However, towards the end of the stage, fly larvae migrate away from the remains in order to pupate, and the predaceous beetles follow. Beetles that prefer dry remains (Dermestidae, Nitidulidae, Cleridae) are present during the Dry Stage with little evidence of carrion-related species thereafter (Goff 2000, Goff 1993, Payne 1965, Rodriguez 1982).

In order to maximize PMI estimation potential, the knowledge of the life cycles and behavior of carrion-related insects has been coupled with modern technology (Schoenly 1992, Schoenly et al. 1992, Byrd and Allen 2001). For example, Schoenly et al. (1992) created a computer simulation in BASIC language that can estimate PMI from successional pattern data. The needed input involves information on the successional patterns of geographically specific carrion-related arthropods along with the identity of those recovered at the scene of death (Schoenly et al. 1992, Byrd and Allen 2001). The program compares the list of geographically specific carrion-related arthropods to those found at the scene and offers a minimum and maximum PMI estimation as the output (Schoenly et al. 1992). This BASIC language program can also be adapted to incorporate developmental data, such as larval length or weight of flies and beetles. In this case, the

required input should include information concerning larval stages at known temperatures. The output can then be used to narrow the PMI estimate or support the successional pattern output (Schoenly et al. 1992).

Another example demonstrating the use of modern technology in maximizing PMI estimation involves the utilization of Simulink flow diagram software (Byrd and Allen 2001). This program forms a model by distributed delay (Byrd and Allen 2001), a methodology commonly employed by engineers to account for delay processes. However, in the case of insect development, this methodology uses a "linear chain of differential equations" (Byrd and Allen 2001:305) in order to model the development of insect life stages. According to Byrd and Allen (2001:306), "Thus by simply measuring the mean and standard deviation of the time to complete a stage, one can obtain the data needed to construct a stage model using a distributed delay."

Insects as a Situational Factor

The need to use ADH and other linear models to estimate PMI implies that there are underlying variables that affect development and succession. These variables can be considered situational factors in the sense that they define barriers (Merritt n.d.) that affect the developmental rate or distort successional patterns. Although certain climatic/seasonal factors are regarded as environmental variables when referring to decomposition, they become situational within the context of insect development and succession. Hence, the "microclimatic conditions" (Introna et al. 1991:238) surrounding the remains has a direct impact on larval growth rate, as well as insect invasion potential (Goff 1993, Anderson 2001). For example, increasing temperatures generally enhance

larval developmental rates (Wells and LaMotte 2001). However, larvae exposed to direct sunlight tend to be underdeveloped and often migrate early in search of other food due to the rapid depletion of the original remains (Anderson 2001). Yet, the amount of sunlight that reaches the remains also affects invasion potential (Anderson 2001, Richer n.d.). According to Goff (1993), cloud cover along with low temperatures and rainfall can retard or even terminate fly invasions. As a result, the number of insects and the timing of succession are often correlated with the season of death (Anderson 2001).

However, the geographical region and its habitat characteristics determine the type of carrion-related species associated with the remains along with their arrival time and colonization (Introna et al. 1991, Anderson 2001, Wells and LaMotte 2001). Accordingly, insect colonization of a body found in water will differ somewhat from those affiliated with terrestrial remains (Anderson 2001, Davis and Goff 2000). For example, when comparing carrion-related species on pig remains in terrestrial and intertidal habitats, Davis and Goff (2000) noted that water restricted the succession of carrion-related species on the intertidal remains, while the terrestrial pigs demonstrated predictable development and succession. Additionally, certain characteristics of the intertidal habitat involving depth, wave action, and currents yielded low levels of insect activity (Davis and Goff 2000).

Yet, inhabitants of the geographical region itself can impact insect development and succession. Animal scavengers are attracted to remains as well and are especially responsible for massive tissue removal. This loss of tissue greatly enhances the decomposition rate in general and disrupts insect succession by denying later arrivals an adequate food source (Anderson 2001).

Although the microclimate, geographical region, and inhabitants of the region contribute to the variation in insect development and succession, in cases of homicide or suicide, the condition of the body, as well as its disposition, also determines developmental rates and/or successional patterns. While the presence of drugs, such as cocaine and heroin, can either increase or decrease larval development (Goff and Lord 2001, Wells and LaMotte 2001), the amount and timing of insect activity can be influenced by trauma. In cases involving trauma, any type of break in the skin can be just as attractive to flies as the "nine natural body orifices" (Haskell et al. 1997:420). Hence, flies are attracted to cracks in burnt remains (Avila and Goff 1998). However, with burnt remains, the level of insect activity is determined by the remaining tissue (Anderson 2001).

Conversely, circumstances involving the disposition of the remains can be relayed in terms of insect access and succession. While hanging disrupts successional patterns by denying certain soil-inhabiting insects access to the body (Anderson 2001, Shalaby et al. 2000), efforts to conceal the remains can either disrupt succession or delay, if not prevent, the onset of insect activity (Haskell et al. 1997, Goff 1993, Anderson 2001, Richer n.d., Rodriguez and Bass 1985). For example, insect invasion of wrapped remains could depend on the material used and how well it is sealed (Anderson 2001). Similarly, buried bodies can be invaded, with burial depth influencing the colonization time and successional pattern (Anderson 2001, Rodriguez and Bass 1985, Richer n.d.). However, enclosed spaces can serve as barriers (Merritt n.d.) for insect activity as well. Insects affiliated with remains discovered in vehicles or inside buildings are restricted to those

that manage to make their way across these barriers (Goff 1991, Anderson 2001, Richer n.d.).

Human Decomposition in an Insect-Restricted Environment

Despite whether insects act as an environmental variable or a situational factor, observations support that, in general, they greatly accelerate the process of human decomposition (Mann et al. 1990). However, in order to gain a clearer understanding of how internal decomposition involving autolysis and putrefaction progresses along the continuum, the insect dimension must be eliminated. Payne (1965) inadvertently explored this aspect by denying insect access to baby pigs *Sus scrofa* Linnaeus. Hence, "[t]he decomposition and disintegration of pigs free from insects was very different from that of pigs exposed to insects" (Payne 1965:598). As a result, Payne (1965) designated benchmarks along the decomposition continuum and defined stages of decomposition applicable to remains free from insects: Fresh Stage, Bloating and Decomposition, Flaccidity and Dehydration, Mummy Stage, and Desiccation and Disintegration.

Although Payne's study is considered to be insect-free, ants were discovered inside the cage during the Fresh Stage (Payne 1965). This demonstrates that even though insect activity can be limited, no environment will stay insect-free indefinitely (Anderson 2001). However, if insects that significantly affect the rate of decomposition (i.e., flies, beetles) were limited, one can proceed as if the environment were insect-free. Hence, the question remains as to how human decomposition progresses in an insect-restricted environment. Will human remains follow the same progression designated by Payne (1965), yielding similar benchmarks that divide the human decomposition continuum into

Payne's (1965) stages of decomposition for insect-free carrion? If so, this better understanding of death as a process can ultimately bridge the gap between the causal events affiliated with earlier postmortem events and those resulting in human skeletal remains.

Fulfilling the Role of Death Investigator in a Legal Setting

Traditionally, the forensic anthropologist assumes the role of death investigator when applying physical anthropological techniques designed to determine age, ancestry, sex, and stature specifically to the identification of human skeletal remains. However, as rigidity wanes, lividity becomes fixed, and the body temperature matches ambient temperature, the pathologist consequently loses information vital to the estimation of the postmortem interval. As a result, "[t]he forensic anthropologist is ... [prematurely] pulled into the information vacuum created by the loss of soft tissue" (Rhine and Dawson 1998:145). Hence, the forensic anthropologist must find a way to fulfill this added responsibility of estimating the postmortem interval from decomposing remains.

Yet, estimating the postmortem interval becomes somewhat of a challenge in geographical areas with condensed populations due to the increased likelihood of the discovery of remains in various stages of decomposition (Bass 1997). As a result, studies designed to determine the rate of decomposition, specifically in terms of the correlation between the decomposition process and certain interrelated variables (Mann et al. 1990), have been conducted at the Anthropology Research Facility (ARF) in Knoxville, Tennessee. However, "...correct interpretation of the events surrounding a death is dependent on knowing both the sequence and character of the taphonomic processes"

(Sorg and Haglund 2002:6). Hence, it is important that a basic understanding of the decomposition process itself in terms of causal events resulting from autolysis and putrefaction is acknowledged prior to the appreciation of how external factors affect the rate of progression. Ultimately, if the death investigator can recognize the visual and/or olfactory cues affiliated with internal decomposition, as well as understand how external factors affect the rate of decomposition, estimation of the postmortem interval can be successfully applied in a variety of death scene scenarios.

Chapter 2:
Materials and Methods

To observe the process of human decomposition in conjunction with environmental variables and situational factors (Mann et al. 1990), one must have access to a research laboratory that is not only open to the elements, but also serves as a "barrier" to invading animal (including human) activity. Such a research laboratory exists in the vicinity of the University of Tennessee Medical Center in Knoxville, Tennessee. Consisting of mostly maple and oak trees situated on a hillside and surrounded by a chain-linked and wooden privacy fence, the Anthropology Research Facility (ARF) meets the laboratory criteria for research involving human decomposition (Figure 2.1). However, in order to study the progression of human decomposition with limited insect activity, an additional element must be introduced to ARF—an insect-restricted environment.

Insect-Restricted Environment

The insect-restricted environment was added to ARF in the form of an 8x10 ft. wooden-framed structure designed to house two human subjects within the confines of military-issued netting, chicken wire, and hardware cloth. Located at the top of the hill, this unique construction was engineered in such a way as to allow the subjects full exposure to the surrounding environment (with the exception of insects and animals), while suspended platforms were included in order to maximize experimental documentation efficiency (Figure 2.2 and Table 2.1).

Figure 2.1. The Anthropology Research Facility

Figure 2.2. Insect-Restricted Environment

Table 2.1. Structural Design of the Insect-Restricted Environment*

Outer Frame:
--4x4 standing posts cemented into the ground

Top:
--2x6s and 1x4s running perpendicular to one another to allow for suspension of platforms, as well as sunlight and rainfall→1x4s nailed onto the 2x6s
--2x6s attached to 4x4s with joist hangers and screws

Sides:
--2x4s attached to 4x4s with joist hangers and screws

Door:
--constructed from 1x4s
--1 padlock latch and hook latch on outside
--2 hook latches on inside→2 drawer handles to hold door tight while using latches to seal door

Netting and Wire Screen:
--military-issued netting attached to inside of 2x6s (top) and 2x4s (sides) with staples and duct tape→ 3/8x4 in. plywood strips nailed on top of duct tape
--wire screen (hard cloth and chicken wire) stapled to outside of 2x6s (top) and 2x4s (sides)

Floor:
--hard cloth stapled to bottom 2x4 (side)→tucked underneath and attached to a middle piece of hard cloth with rebar wire
--netting attached to inside of bottom 2x4 (side)→drapes on top of hard cloth
--tarp placed on top of netting

Platforms:
--(2) 6'4"x3 plywood sheets reinforced by 2x4s
--eyebolts screwed into 2x6/1x4 perpendicular junctions (top) for chain and come-along
--5 ft. chain suspended from eyebolts and hooked to 4 corners of each platform

*Dimensions: 8x10ft (length and width); 6-8 ft (height) depending on the slope of the hill

Yet, upon the establishment of this new environment, it seemed imperative to "test" the structure before permitting human subjects to occupy it. In order to discern the solidarity of the design, a Styrofoam plate containing chunks of raw beef was placed on one of the platforms and allowed to remain within the structure until the arrival of the first donation. As a result, careful inspections spanning an eleven-day time frame (6-05-02→6-16-02) indicated that the beef remained undisturbed, hence satisfying the criteria for the study of human decomposition in an insect-restricted environment.

Human Donations

The focus of the study surrounded four unautopsied, unembalmed humans that were donated to the Department of Anthropology at the University of Tennessee for purposes of scientific research. Following the methodology common to scientific experimentation, insect activity as a situational factor was isolated in order to determine how human decomposition progresses in an insect-restricted environment. Hence, two subjects placed inside the structure were nominated the "experimental" group, while two located outside of the structure were designated the "control" group. However, due to the uncertainty as to the arrival time of donations, it is important to note that the members of the experimental group were used specifically for this study, while the members of the control group were simultaneously affiliated with another research project focusing on human decomposition in the sun vs. the shade (see Srnka 2003).

Group assignments alternated with the arrival of each donation. The first body (A) was placed inside the structure in a supine position on the platform farther from the door. In order to avoid causing postmortem trauma to the neck and arms, the trachea tube

and IV were left in place. Clothing was removed and initial photographs were taken using an Olympus Camedia C-3020 Zoom digital camera. Finally, information concerning age (D.O.B.), sex, ancestry, time (date) of death (day 0), and cause of death were noted for the William M. Bass Donated Skeletal Collection database, while the condition of the body was considered for decomposition documentation purposes (Table 2.2).

The second arrival became the first member of the control group (B) and was promptly located in a shaded area at the bottom of the hill. Similar to A, B was placed nude in a supine position, and initial photographs were taken. Information required for the Bass Donated Skeletal Collection database was noted, along with the present condition of the body. In addition, a previously constructed 5'6"x 2'10.5" x 2' cage consisting of 2x4s and hardware cloth was placed over the body on 7-08-02 (day 10) as an extra precaution against animal activity.

Extra precautions against insect contamination were initiated in preparation for the arrival of the second experimental subject (C). For example, a 6'4"x 3' x 2' frame was assembled from PVC pipe and placed on A's platform. The same type of netting used in the structure design was draped over the frame in order to temporarily isolate A while moving C onto the second platform. Similarly, C was isolated as well, having been secured with black plastic and duct tape prior to transport to ARF.

Following the establishment of C within the structure, it was decided that the subjects should remain in their respective isolated environments at least overnight. Although the protective frame and netting was left on A's platform for a few extra days as an added precaution, the black plastic was removed from C the following morning

Table 2.2. Human Donations Used in the Study

ID	Group Assignment	Age (D.O.B.)	Sex/ Ancestry	Time (Date) of Death *	Cause of Death	Condition of the body at arrival
A	Experimental	62 (10-16-39)	Male/ White	7:53 (6-16-02)	Lung cancer, non-small cell carcinoma	bruises on arms, along clavicles, right shoulder: red, purple, and black; bedsores on ankles: red underneath; scrotum, tip of penis, abdomen, knees, feet, upper thighs: purple; skin: dry and flaky trachea tube and IV on left arm
B	Control	50 (5-27-52)	Female/ White	(6-28-02→ 7-01-02 ?) exact D.O.D. unknown	Cardiovascular and pulmonary disease	green skin discoloration on abdomen/pelvis; blackened drying of fingertips: red; black marbling on right upper leg; livor mortis/bullae formation on lower legs; ankles: red; feet: purple; skin slippage: left, distal to knee
C	Experimental	65 (6-14-37)	Male/ White	(7-14-02)	Brain cancer	blue bruises on anterior forearms near elbows; cuts on face ante/perimortem midfacial and forehead are pink: beginning of livor mortis
D	Control	85	Female/ White	(7-10-02)	Brain cancer	purple bruises along mid-thigh left and right and along anterior right bicep; green discoloration of abdomen/pelvis, thorax (left side up to breast), and posterior forearm right; red lividity on sides of thorax, abdomen/pelvis, and upper left arm medial; brown and red bruises on chest

*Time (Date) of Death = day 0. In the case of B, the date last seen (6-28-02) = day 0

(7-16-02) (day 2). At this time, the clothing and pulse monitor were discarded. The subject was arranged in a supine position, and proper photographic and written documentation were conducted.

The final addition to the study (D) became the second member of the control group. Similar to the first member (B), D was located at the bottom of the hill, but in a separate shady area. The subject was placed nude and in a supine position while photographic and written documentation commenced. Also, the cage that was previously used with B was eventually transferred to D (7-24-02) (day 14) as an added precaution against animal activity.

Documentation of Decomposition

Written documentation of decomposition included notations of visual and olfactory cues as they occurred in each region of the body. Recognition of a particular cue in a specific region was determined by the perceptions of the observer at the time of observation. Hence, the condition of the body was determined at each encounter in order to eliminate potential bias from preceding observations. Similarly, care was taken not to disturb the environment during documentation so as to eliminate potential bias at each encounter.

Yet, not only were observation biases a concern, but also the standardization and replication potential of the documentation methods, as well as the defining characteristics of the data (Sorg and Haglund 2002, Wells and LaMotte 2001). As a result, the "adoption of a standardized recordkeeping method" similar to "an occurrence matrix" (Wells and LaMotte 2001:270) was deemed appropriate for this study. However, in order

to focus on the presence or absence of a certain cue within more than one region on separate occasions, the time dimension was considered as a constant to be introduced at the termination of observations. Hence, the decomposition data sheet used at each observation consisted of a table designed to record the presence or absence of each characteristic of human decomposition in each anatomical region. The column headings represented anatomical regions analogous to regions defined in anatomical texts (Netter 2001, Agur and Lee 1999). However, for the purpose of this study, the head and neck (Netter 2001) and abdomen and pelvis regions were combined. Also the upper and lower limbs (Netter 2001, Agur and Lee 1999) were labeled arms and legs respectively. In addition, the row headings represented the visual and olfactory cues indicative of human decomposition and progressive alternatives to putrefaction discussed in the first chapter of this thesis, along with insect and animal activity (Figure 2.3).

However, due to the inherently subjective nature of the observer's perceptions, the standardization of the defining characteristics of the visual and olfactory cues must be addressed. In reference to color changes, the designation of specific categories was based on the colors defined in the literature as pertaining to human decomposition (Gill-King 1997, Clark et al. 1997, Fisher 1980, Dang 1996, Teather 1994) with variations or shades included in their definitive color categories (i.e., tan = brown). Yet, the labeling of pink/red simply recognizes defined variations caused by factors other than decomposition (i.e., carbon monoxide poisoning [Clark et al. 1997] vs. hemolysis). In addition to generalized skin discoloration, the presence of marbling was noted as described by Gill-King (1997), Dix and Graham (2000), and Clark et al. (1997) with the coloration noted in their respective categories.

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Color changes: Pink/Red					
Blue					
Green					
Purple					
Brown					
Black					
Marbling					
Bloating					
Odor					
Skin slippage					
Liquids running from orifices					
Hair slippage					
Adipocere					
Fungus/mold					
Desiccation					
Deflation (Post-bloating)					
Insect activity					
Carnivore/rodent activity					
Skeletonization					

Figure 2.3. Decomposition Data Sheet. The column headings represent boundaries analogous to regions defined in anatomical texts (Netter 2001, Auger and Lee 1999). The row headings include the visual and olfactory cues indicative of human decomposition, progressive alternatives to putrefaction, and insect and animal activity.

Indications of bloating occurred with noticeable swelling of each region (Dix and Graham 2000, Clark et al. 1997, Fisher 1980, Gill-King 1997, Vass et al. 2002, Love 2001). Although odoriferous compounds have been previously detected and identified (Love 2001, Vass et al. 2002, Gill-King 1997), odor in general was recorded as perceived by the observer. Skin slippage (whether in progress or arrested) was noted if the epidermis appeared to be detaching from the dermis (Fisher 1980, Clark et al. 1997, Dix and Graham 2000, Galloway 1997, Vass et al. 2002, Bass 1997, Love 2001). While the liquids running from orifices category applied only to the head/neck and abdomen/pelvis regions (Clark et al. 1997, Fisher 1980, Vass et al. 2002), the color of the fluid was not recorded. Hair slippage was noted if the hair was detaching from the scalp (Dix and Graham 2000, Bass 1997).

Adipocere was observed in both "crumbly" and "paste-like" (Gill-King 1997:102) forms (Dix and Graham 2000, Teather 1994, Dang 1996, Clark et al. 1997). The recognition of fungus or mold was based on visual observations (i.e., no samples were taken for analysis) and various colors were noted in the color categories (Bass 1997). Desiccation was recorded in the presence of completely dry tissue with little or no evidence of hydration (Dix and Graham 2000, Galloway 1997, Galloway et al. 1989). Indications of deflation (Clark et al. 1997) were noted as the body began to lose its bloated appearance, while the presence of skeletonization was based on visual observations of bone (Rodriguez and Bass 1985, Williams 1997, Galloway 1997, Clark et al. 1997, Rodriguez 1982). However, since the same data sheet was used for all subjects, insect and animal activity categories were also included.

With the exception of C, written and photographic documentation of the decomposition process began immediately upon the arrival of each donation. Initially, the documentation of all four subjects occurred on a daily basis between 15:00 and 16:00. However, it is important to note that accumulating insect activity outside of the structure made it impossible to enter without risk of contamination. Since most adult flies (Order Diptera) are typically inactive at night, it was determined on 7-21-02 (A: day 35, C: day 7) that the decomposition data collection and photographic documentation for the experimental group could be best performed an hour before sunrise (5:00), while the control group observations remained an afternoon endeavor. Hence, sufficient lighting, including a head lamp, lantern, and flashlight, was required for support during these morning observations, while rubber wading boots were eventually added to the existing safety precautions (i.e., nitrile gloves, long-sleeved shirt and pants, and a hair scarf) in response to the build-up of purged fluids mixed with occasional rain water puddled inside the structure.

At the termination of observations, the time dimension was recognized in order to discern the initial occurrence of each visual and olfactory cue within each anatomical region, along with the total occurrences in each region as compared to the corresponding number of total observations.

Documentation of Insect Activity

In the documentation of insect activity, great care was taken to record data from both the experimental and control groups. Initially, all data collection concerning insect activity occurred in conjunction with decomposition data collection and photographic

documentation. Insect activity on and around the members of the control group were noted, while, in reference to the experimental group, a distinction was made between insects attracted to the outside of the structure and those discovered on or near the remains inside the structure. However, when it became too difficult to enter the structure without risk of contamination, it was decided that insect activity inside would coincide with morning observations, while notations of activity outside would continue to be an afternoon activity, along with the observations concerning the control group. Due to the limited insect activity inside the structure, recognition of the insects affiliated with the members of the experimental group coincided with specific days, while initial and final notations of insect activity were emphasized in reference to insects surrounding the structure and those affiliated with the members of the control group.

The identification of the insects affiliated with the experimental and control groups were based on visual observations of the physical characteristics of each stage of development (i.e., egg, larva, pupa, adult), along with their patterns of behavior. However, due to the limited entomological expertise of the observer, the nomenclature of the identified insects reflected the common names as presented in Byrd and Castner (2001).

Documentation of Environmental Variables

While the documentation of human decomposition in conjunction with limited insect activity was the focus of the study, other environmental variables known to influence this event (i.e., temperature, humidity, rainfall, and sky conditions) were considered as well. Although ARF maintains a self-contained weather station at the

bottom of the hill, the station's success in detecting environmental conditions at the top of the hill has never come into question. As a result, environmental data was recorded in the vicinity of each donation as site-specific data and was later converted to subject-specific data for final comparisons. Subject-specific data concerning temperature and humidity was then compared to weather station readings (see Srnka 2003) to determine if the weather station could be used in future studies conducted at the top of the hill.

Temperature and Humidity

The decision to record site-specific temperature and humidity data created a dilemma. The ideal procedure would involve using digital thermometers and hygrometers to record daily "highs" and "lows" for both temperature (degrees Centigrade) and humidity (%). While digital thermometers were available at a reasonable cost, none possessed the ability to record high and low humidity. Furthermore, neither digital thermometer/hygrometer combinations nor individual digital hygrometers proved to be cost effective.

Instead, a non-digital Springfield brand thermometer/hygrometer combination instrument was placed at each site. However, due to the instrument's inability to record high and low data, estimated high and low temperature and humidity readings (based on personal familiarity of local weather patterns) were recorded daily. "Low" temperature readings were taken an hour before sunrise, at approximately 5:00, while due to fluctuations in summer temperatures, "high" temperature readings were carefully monitored between 14:30 and 16:00. Also, for matters of convenience, humidity readings were recorded in conjunction with temperature data, even though "high"

humidity data seemed to correspond with "low" temperature readings and vice versa. However, it is important to note that due to constant exposure to the elements, the reliability of the instrumental readings eventually became a concern. Hence, an identical thermometer/hygrometer was added to each site on 9-08-02, with further documentation resulting from the average readings between the two instruments.

Upon completion of observations, the temperature and humidity data collected at site-specific locations was organized into subject-specific data, hence relating the influences of temperature and humidity to the observation time frame of each subject. In regards to comparisons to the weather station, sixteen independent population t-tests were conducted using SPSS 11.0 to test for significant differences between subject-specific high/low temperature and humidity readings and corresponding weather station data previously collected by Srnka (2003).

Rainfall and Sky Conditions

Similar to temperature and humidity, rainfall data was also collected at site-specific locations. Springfield brand rain gauges were placed near the subjects, and rainfall amounts (in.) were recorded in conjunction with temperature and humidity readings. At the same time, visual observations of the sky were conducted and noted as clear, partly cloudy, or mostly cloudy conditions. Upon the termination of observations, total rainfall amounts and notations of sky conditions were organized into subject-specific data in order to relate the influences of rainfall and cloud cover to the individual donations.

Observation Time Frames

Due to the observation overlap caused by the donation arrival schedule, the observation time frames for the documentation of decomposition, insect activity, and environmental variables relative to each subject must be clarified. To situate this study within the proper "seasonal" context, the overall observation time frame for each subject was represented by dates (i.e., A: 6-16-02→10-14-02; B: 7-05-02→10-02-02; C: 7-16-02→10-14-02; D: 7-19-02→10-14-02). However, in order to allow for comparisons among subjects, all data was considered in terms of "days" (i.e., day 0 = day or date of death).

The documentation of decomposition and insect activity involving the members of the control group adhered to a consistent afternoon observation schedule. As a result, the decomposition and insect activity time frames for B and D were defined as days 7→96 and days 9→96 respectively. Yet the decomposition and insect activity time frames for the members of the experimental group were adjusted to account for the rescheduling of observations from the afternoon to the morning. Hence, these time frames were days 0→119.5 for A and days 2→91.5 for C.

Similar to the documentation of insect activity affiliated with the members of the control group, the notations of insects attracted to the outside of the structure also followed an afternoon observation schedule. However due to the invasion potential of these insects, separate observation time frames were defined for A (days 0→120) and C (days 2→92). In addition, the subject-specific observation time frames involving environmental variables (i.e., A: days 0→120; B: days 7→96; C: days 2→92; D: days 9→96) were representative of daily high and low temperature and humidity data

collection, along with accumulated rainfall and recorded sky conditions (Tables 2.3 and 2.4).

Decomposition Progression of Each Donation

The decomposition progression of each subject was contemplated by articulating the collected data and photographic documentation within the context of the individual circumstances surrounding each donation. Hence, these circumstantial articulations were used to highlight certain benchmarks that would ultimately divide the continuum into stages of decomposition appropriate to the progression of each subject, while considering how insects and environmental conditions may or may not have affected the rate of each progression.

As discussed in the first chapter of this thesis, the literature maintains a plethora of possible nomenclatures representing stages of human decomposition. Yet, the question remains as to which decomposition nomenclature most accurately describes the individual progression of each donation. Bass's (1997) rendition proves to be the most appropriate, based on its successful application to previous observations at ARF (Table 2.5). However, the fact that ARF is designated as an encircled outdoor setting suggests that caution should be observed when applying this nomenclature to remains located in an insect-restricted environment. Consequently, as Bass's (1997) nomenclature concurrently served as the default for all subjects, an alternative nomenclature, specifically Payne's (1965) illustration of the decomposition of the baby pig, *Sus scrofa* Linnaeus, in an insect-free environment, was considered when addressing the members of the experimental group (Table 2.6).

Table 2.3. Seasonal Observation Time Frame for Each Subject

ID	Dates
A	6-16-02→10-14-02
B	7-05-02→10-02-02
C	7-16-02→10-14-02
D	7-19-02→10-14-02

Table 2.4. Observation Time Frames for Decomposition, Insect Activity, and Environmental Variables*

ID	Decomposition and Insect Activity (Days)	Insect Activity Outside The Structure (Days)	Environmental Variables (Days)
A	0→119.5	0→120	0→120
B	7→96	N/A	7→96
C	2→91.5	2→92	2→92
D	9→96	N/A	9→96

*day 0 = day of death

Table 2.5. Human Decomposition at the Anthropology Research Facility*

Fresh:

--blowflies attracted to body
--flies lay eggs in natural orifices and wounds→eggs are white, resemble sawdust
--blue and green marbling
--purging fluids: nose and mouth

Fresh to Bloated:

--eggs have hatched→maggots on face
--lips distended
--bone visible around eyes and nose
--beetles present
--skin slippage
--hair slippage
--blue and green marbling
--odor
--purging fluids: nose, mouth, rectum
--abdomen bloating
--molds are present
--animal activity: ingesting tissue and bone
--volatile fatty acids kill the vegetation around the body

Bloated to Decay:

--decline in maggot activity→beetles are present
--bloating passes
--if covered body: most bones exposed
--if not covered: remaining skin→ dry and leathery
--animal activity: transporting limbs and skull
--molds on tissue and bone
--volatile fatty acids have turned area around body black→body appears burned
--adipocere present

Dry:

--sunlight has bleached the bones
--parts in the shade: moss or algae
--animal activity: rodent gnawing, mice and/or wasps using skull as nest

Bone Breakdown:

--exfoliation of bone
--longitudinal cracks in bone in sunlight
--roots have grown into/through bones
--animal activity: rodent gnawing

*adapted from "Summer Decay Rates (Bodies on Surface)"
Bass (1997:183-185)

Table 2.6. Decomposition of Pigs in an Insect-Free Environment*

Fresh Stage:
--ended with the first indications of bloating

Bloating and Decomposition:
--indications of bloating
--blood and other fluids bubbling→propelled through mouth, nose, anus
--oily and greasy consistency
--odor
--constant fluid flow: mouth and anus
--bubbles under skin
--skin appears black

Flaccidity and Dehydration:
--losing fluids and bloated appearance
--tissue consistency: soft and flabby
--odor
--last region to deflate: abdomen/pelvis
--tissue becoming leathery
--fungi present
--all fluids escaped by end of the stage

Mummy Stage:
--slow dehydration
--carcass dry and flat
--fungi→speckled appearance
--outline of bones visible through the remaining tissue
--odor

Desiccation and Disintegration:
--exposure of tissue and bone due to rupture of skin
--skull visible

---

*adapted from "Carrion free from insects"
Payne (1965:598-599)

Chapter 3:
Results

As introduced in Chapter 2, insect activity as a situational factor was isolated in order to observe the process of human decomposition in an insect-restricted environment. Human donations were assigned to experimental and control groups with data collection focusing on daily notations of decomposition, insect activity, and environmental conditions. However, in order to remain true to the methodology of scientific experimentation, the results of the study must be organized in such a way as to allow for direct comparisons among the subjects. Hence, the following is a parallel representation of the collected data, specific to the observation time frame for each donation.

Decomposition

Successful documentation yielded occurrences within the visual and olfactory cue categories illustrated by the decomposition data sheet. In addition to the coloration of livor mortis ranging from pink to red to purple, color changes involving red, blue, green, purple, brown, and black reflected the oxidized or reduced state of bile pigments released into the tissues as an indication of the destruction of biliary structures fueled by an increasingly anaerobic environment. Yet, color changes due to hemolysis and the presence of hydrogen sulfide and bile pigments within the vascular system resulted in blue, green, purple, and black marbling (Gill-King 1997, Clark et al. 1997, Dix and Graham 2000). Gases produced as a by-product of bacterial action initiated odor detection prior to or in conjunction with bloating and purging from the gastrointestinal

tract (Dix and Graham 2000, Clark et al. 1997, Gill-King 1997, Vass et al. 2002, Love 2001, Fisher 1980). Concomitantly, skin slippage occurred as a result of autolysis at the junction of the skin's epidermal and dermal layers, with hair slippage maintained within the scalp region (Fisher 1980, Clark et al. 1997, Dix and Graham 2000, Galloway 1997, Vass et al. 2002, Bass 1997, Love 2001). Internal hydration and the occasional rainfall provided water for adipocere formation resulting in "paste-like" (A and C) and "crumbly" (all subjects) forms (Gill-King 1997:102). While fungus and/or mold appeared following each rainfall, hence thriving during humid conditions, desiccation resulted from prolonged exposure to dry conditions (Gill-King 1997, Clark et al. 1997, Dix and Graham 2000, Bass 1997, Galloway 1997, Galloway et al. 1989, Rhine and Dawson 1998). Deflation (or in the case of A and C, implosion) occurred as putrefactive gases escaped from the body (Clark et al. 1997, Galloway 1997) and skeletonization was evident with recognition of bone (B and D) (Rodriguez and Bass 1985). Insect activity reflected interactions with the remains, while carnivore and rodent activity were absent.

However, not all encounters yielded successful documentation. For example, no observations were conducted for A on day 29 due to the risk of insect contamination upon the arrival of C. Similarly, observations were postponed on day 35 for A and day 7 for C as a result of the increase in insect activity outside of the structure. Documentation was also unsuccessful on day 101.5 for A and day 73.5 for C during morning rainfall, while due to continuous rainfall observations for all subjects were cancelled on 9-21-02 and 9-22-02 (A: days 96.5, 97.5; B: days 85, 86; C: days 68.5, 69.5; D: days 73, 74). Finally, in response to the increase in university-related activities near the vicinity of ARF, encounters for B and D were cancelled on 9-07-02 and 9-28-02 (B: days 71, 92; D:

days 59, 80). Hence, the total number of successful observations was as follows: A = 116 observations; B = 86 observations; C = 87 observations; and D = 84 observations (Table 3.1 and Appendix A).

Color Changes: Pink/Red

Pink/red was present on the thorax, arms, and legs upon the arrival of A (day 0). However, pink/red was not noted on the thorax seven times in July (days 17→20, 23→24, 30), two times in September (days 102.5→103.5), and three times in October (days 115.5→117.5). Yet, the total number of occurrences was 104 out of 116 observations. Similarly, pink/red was not noted on the arms two times in September (days 102.5→103.5) and three times in October (days 115.5→117.5). Total notations of pink/red on the arms were 111. Pink/red on the legs did not occur during three observations in October (days 115.5→117.5), yielding a total of 113 occurrences out of a possible 116.

Pink/red appeared on the abdomen/pelvis and head/neck of A four days (day 4) and 13 days (day 13) respectively after arrival. It was not noted on the abdomen/pelvis two times in July (days 23→24) and four times in October (days 115.5→118.5). Hence, the total number of occurrences was 106. In reference to the head/neck region, pink/red was not noted eight times in July (days 21→27, 30), five times in September (days 89.5→90.5, 98.5, 102.5→103.5), and three times in October (days 115.5→117.5). Total occurrences were 87 out of a possible 116.

Pink/red was present on the thorax, abdomen/pelvis, arms, and legs of B upon arrival to ARF (day 7). This cue occurred on the thorax 13 times in July and August

Table 3.1. Successful vs. Unsuccessful Observations

ID	No observations (Days*)	Total number of observations
A	29, 35, 96.5, 97.5, 101.5	116
B	71, 85, 86, 92	86
C	7, 68.5, 69.5, 73.5	87
D	59, 73, 74, 80	84

*day 0 = day of death

(days 7, 10→18, 22, 60→61). No evidence existed in September and October. Pink/red appeared on the abdomen/pelvis five times in July (days 7, 12→14, 17), with no further evidence after 7-15 (day 17). The arms yielded pink/red 20 times in July (days 7→14, 16→27) and one time in August (day 60). Ten occurrences were noted on the legs in July (days 7→14, 16→17), with no evidence recorded in August, September, and October.

Pink/red occurred initially on the head/neck region of B nine days after arrival (day 16) and was noted four times in July (days 16→18, 22).

Yet, pink/red was already present on the head/neck region of C at initial observations (day 2). However, it was not noted five times in July (days 4→6, 9.5, 16.5), six times in August (days 18.5→20.5, 23.5→25.5), three times in September (days 70.5, 74.5→75.5), and October (days 87.5→89.5). Total occurrences were 70.

Pink/red occurred on the arms initially 7.5 days after initial observations (day 9.5) and was recorded 74 times. No evidence existed on two occasions in September (days 70.5, 75.5) and four times in October (days 87.5→90.5).

Pink/red occurred on the abdomen/pelvis and legs 9.5 days after initial observations (day 11.5) and was noted 57 times and 71 times respectively. It was not noted on the abdomen/pelvis three times in July (days 14.5→16.5), eight times in August (days 19.5→26.5), six times in September (days 65.5→67.5, 70.5, 74.5→75.5), and four times in October (days 87.5→90.5). In reference to the legs, no occurrences were noted three times at the end of July (days 12.5, 14.5, 16.5), one time in August (day 18.5), and three times in October (days 87.5→89.5).

Pink/red appeared on the thorax of C 10.5 days after initial observations (day 12.5). However, no evidence existed two times in July (days 13.5, 16.5), ten times in August (days 17.5→26.5), 12 times in September (days 61.5→67.5, 70.5→71.5, 74.5→76.5), and four times in October (days 87.5→90.5). Out of a possible 87 occurrences, 49 were recorded.

Pink/red was present on the thorax, abdomen/pelvis, and arms at the time of D's arrival (day 9) (Figure 3.1). In reference to the thorax, no evidence was recorded two times in July (days 11, 21) and throughout the month of August. Similarly no notations were made 22 times in September (days 53→58, 60→72, 75→76, 78). Occurrences ceased after day 86, yielding a total of 19 occurrences out of a possible 84. As with the thorax, no notations of pink/red were recorded on the abdomen/pelvis for the month of August, while no evidence was recorded 22 times in September (days 53→58, 60→72, 75→76, 78). The total number of occurrences of pink/red on the abdomen/pelvis was 21. In reference to the arms, no notations were made of occurrence five times in July (days 11, 18→21), and throughout August. Similar to the thorax and abdomen/pelvis, no evidence existed on the arms 22 times in September (days 53→58, 60→72, 75→76, 78), with occurrences ceasing after day 86. The total number of occurrences for this region was 16.

Pink/red occurred on the head/neck and legs of D two days after arrival (day 11). In reference to the head/neck region, there were no notations on four occasions in July (days 18→21) and none in August. Twenty-three occasions yielded no occurrences in September (days 53→58, 60→72, 75→78), while no evidence was noted three times in October (days 87→89). Occurrences ceased after day 90, yielding a total of 15 out

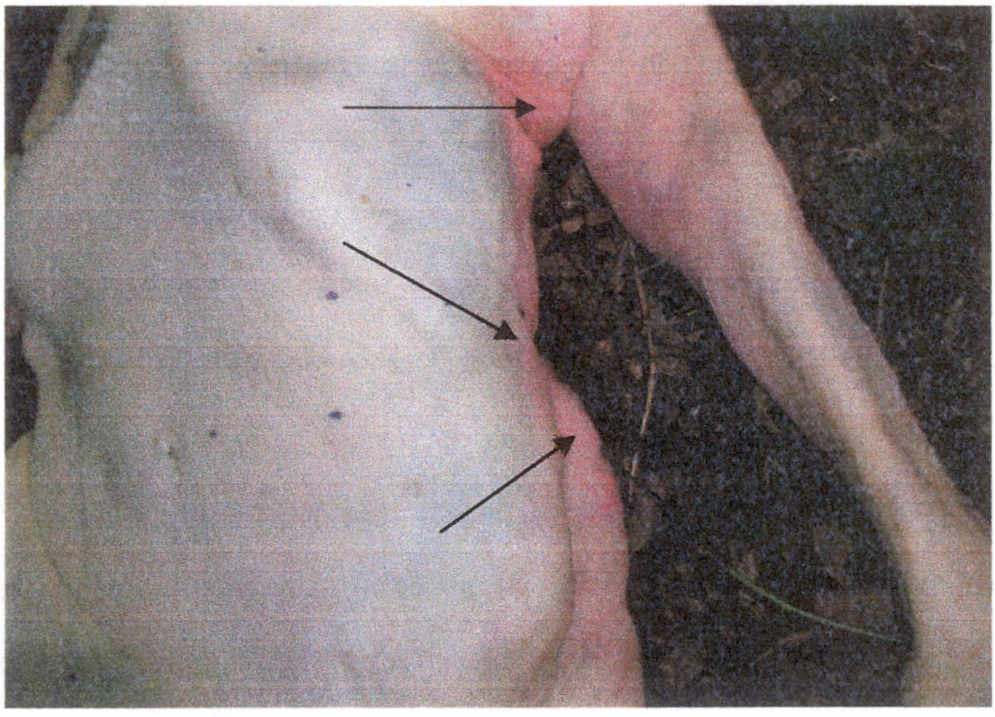

Figure 3.1. Pink/Red (D). Lividity was fixed upon arrival to ARF as indicated by the black arrows. The pink coloration is due to exposure to a cool environment before placement.

of a possible 84 for the head/neck region. Similarly, pink/red occurred on the legs 20 times out of a possible 84. No evidence was noted 29 times in August (days 24→52) and 23 times in September (days 53→58, 60→72, 75→78). Occurrences ceased following day 86.

Color Changes: Blue

On A, blue appeared only on the thorax and abdomen/pelvis regions. Initial occurrence of blue on the thorax was seven days after arrival to ARF (day 7) and persisted on nine occasions in June and July (days 7→14, 20). Blue did not appear on the abdomen/pelvis until 14 days after initial observations (day 14). However, it only occurred on two occasions at the end of June and the beginning of July (days 14→15).

Blue did not occur on B.

In reference to C, blue was present on the arms at initial observations (day 2), and occurred on the legs ten days later. Blue was not noted on the arms on two occasions in July (days 12.5→13.5), but only persisted through day 14.5. Hence, blue was noted on the arms a total of 11 out of a possible 87 times (Figure 3.2). However, blue was noted on the legs seven times at the end of July and the beginning of August (days 11.5→17.5).

Blue only occurred on the legs and the abdomen/pelvis region on D. Occurrences were noted three times on the abdomen/pelvis (days 10→12) and on one occasion on the legs (day 12).

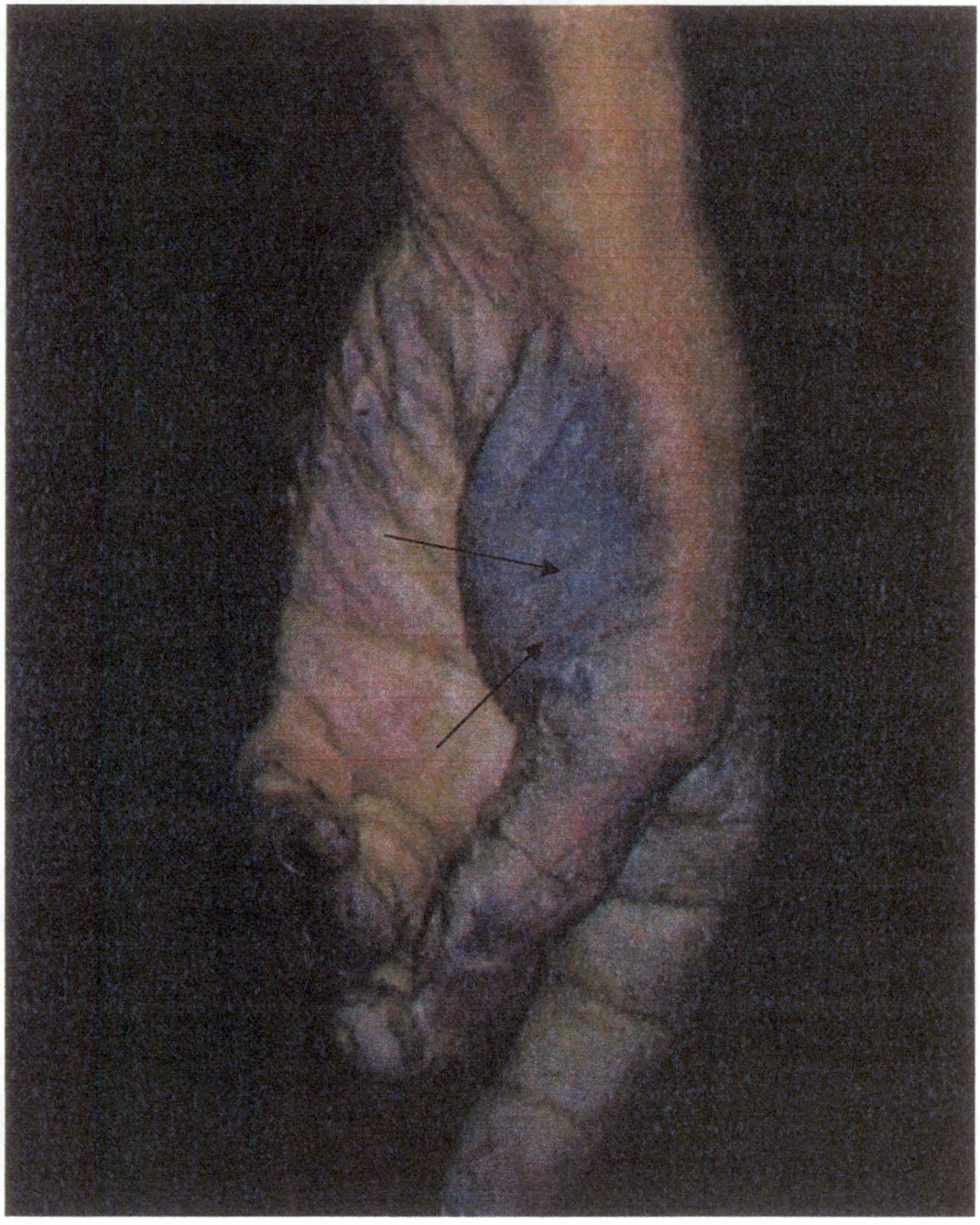

Figure 3.2. Blue (C). Although previously noted on the fingertips, blue eventually became distinct on other areas of the left hand, especially within the thenar region, as demonstrated by the black arrows.

Color Changes: Green

Green appeared on A's arms ten days after arrival (day 10). Occurrences were not noted 6 times in October (days 106.5→108.5, 115.5→117.5), yielding a total of 100 occurrences out of a possible 116.

Green occurred on the head/neck region of A 12 days after arrival (day 12). One time was not noted in July (day 27). Also, five times were not noted in September (days 89.5→90.5, 98.5, 102.5→103.5), along with four times in October (days 111.5, 115.5→117.5). Total occurrences were 94 out of a possible 116.

Green appeared on the thorax of A 14 days after arrival to ARF (day 14). Occurrences were consistent, ending on day 88.5. A total of 74 out of a possible 116 was accumulated.

Green occurred on the abdomen/pelvis and legs 15 days after arrival (day 15). In reference to the abdomen/pelvis, no occurrences were noted twice in September (days 89.5→90.5), yielding a total of 81 occurrences out of a possible 116. Green was not noted on the legs six times in October (days 106.5→108.5, 115.5→117.5) resulting in a total of 95 occurrences.

In reference to B, green was present on the abdomen/pelvis region upon arrival to ARF (day 7). It occurred six times in July (days 7→11, 13) and once in August (day 39). Total occurrence of green was seven times out of a possible 86.

Green appeared on the thorax of B two days after arrival (day 9). It occurred on five occasions total in July (days 9, 11→12, 15, 22).

Green was found on the arms five days after the arrival to ARF (day 12), but only occurred on two occasions in July (days 12, 22).

Following the arms, green appeared on the legs 6 days after arrival (day 13). Occurrences were noted four times in July (days 13→16), once in August (day 53), and five times in September (days 79→83), for a total of ten occurrences out of a possible 86.

However, green did not appear on the head/neck region of B until 15 days after initial observations (day 22). Notations of occurrences were made at one time in July (day 22), six times in August (days 59→64), and on two occasions in September (days 82→83). The total number of occasions yielding green on the head/neck was nine out of a total of 86 times.

Green appeared on the abdomen/pelvis of C one day after initial observations (day 3) (Figure 3.3). The occurrences were consistent through day 60.5, accumulating a total of 58 out of a possible 87.

The thorax of C reflected green three days after initial observations (day 5), and similar to the abdomen/pelvis, persisted through day 60.5 but with an additional three times in October (days 82.5, 86.5, 91.5). Total occurrences were 59.

Following the thorax, green appeared on the head/neck region and arms four days after initial observations (day 6). Five occurrences were not noted on the head/neck in August (days 19.5→23.5), four occasions in September (days 70.5, 74.5, 76.5→77.5), and ten times in October (days 78.5→83.5, 87.5→90.5). Total occurrences for the head/neck region were 64 out of a possible 87. Green located on the arms was consistent through day 67.5, with the exception of one occasion in August (day 18.5). Total occurrences for green on the arms were 61 out of 87.

Green occurred on the legs 7.5 days after initial observations. No notations were made eight times in September (days 61.5→66.5, 70.5→71.5) and three times in

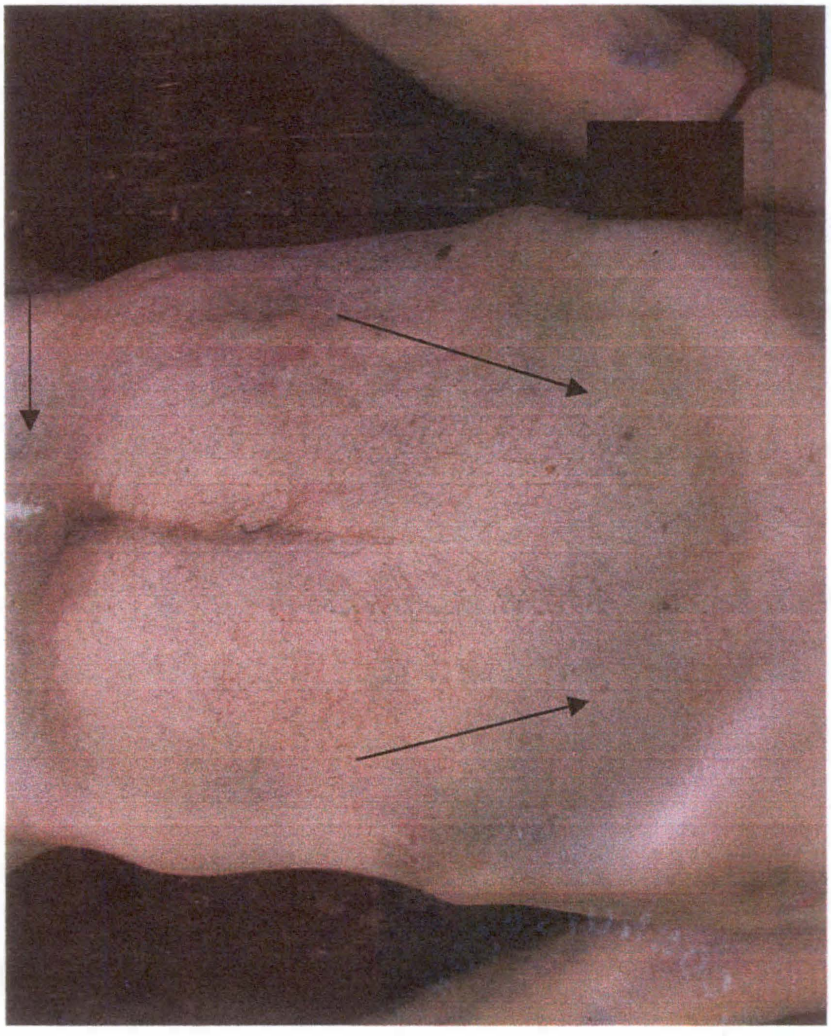

Figure 3.3. Green (C). While green was initially noted along the abdomen/ pelvis boundary (single left arrow), it was later apparent along the thorax/ abdomen boundary (two right arrows).

October (days 87.5→89.5). Total occurrences equal 69 out of a possible 87.

In reference to D, green was present on the thorax, abdomen/pelvis, and arms upon arrival (day 9). Green on the thorax occurred nine times in July (days 9→17). One time was not noted on the abdomen/pelvis (day 12), but persisted through day 16, yielding a total of seven occurrences. The arms reflected the same numbers as the thorax.

Green appeared on the legs four days after initial observations (day 13). Total occurrences were seven in July (days 13→19).

Following the legs, green occurred on the head/neck five days after arrival to ARF (day 14), but was observed on two occasions in July (days 14→15).

Color Changes: Purple

Evidence of purple was present on the thorax, abdomen/pelvis, arms, and legs of A upon introduction to ARF (day 0). No occurrences were noted on the thorax on three occasions in July (days 26→27, 30), on four occasions in September (days 91.5, 98.5, 102.5→103.5), and on nine occasions in October (days 106.5→109.5, 113.5, 115.5→118.5). Total occurrences of purple on the thorax were 100 out of a possible 116. Purple did not appear on the abdomen/pelvis seven times in September (days 92.5, 98.5→100.5, 102.5, 104.5→105.5), and ten times in October (days 106.5→110.5, 113.5→117.5). The total number of occurrences was 99. Purple remained consistent on the arms with the exception of three occasions in October (days 115.5→117.5). Total occurrences equaled 113 occasions. Occurrences were not noted on the legs three times in July (days 17→19), five times in September (days 99.5, 102.5→105.5), and five times

in October (days 113.5, 115.5→118.5). Purple occurred on the legs a total of 103 times out of a possible 116.

Purple did not occur on the head/neck region until seven days after initial observations (day 7). No occurrences were noted on ten occasions in July (days 18→20, 22→28), on two occasions in September (days 98.5, 102.5), and on three occasions in October (days 115.5→117.5). Total occurrences of purple on the head/neck of A were 94 out of a possible 116.

In reference to B, purple was present on the legs at the time of arrival (day 7). It occurred a total of seven times in July (days 7→10, 12→14).

Purple appeared on the thorax and abdomen/pelvis of B one day after initial observations (day 8). It was present on the thorax a total of seven times in July (days 8→13, 22), and on the abdomen/pelvis a total of six times in July (days 8→13).

Following the thorax and abdomen/pelvis, purple on the head/neck region and the arms appeared two days after arrival to ARF (day 9). Purple was noted a total of five times on the head/neck region in July (days 9→10, 12→14), and a total of four times on the arms in July (days 9→10, 12, 22), compared to a possible 86 occurrences.

Purple appeared on the abdomen/pelvis of C one day after initial observations (day 3). No occurrences were noted on 15 occasions in August (days 31.5, 33.5→36.5, 38.5→47.5), on 13 occasions in September (days 48.5→60.5), and on three occasions in October (days 87.5→89.5). Total occurrences equaled 55 out of a possible 87.

Purple occurred on the head/neck region two days after initial observations (day 4). No occurrence was noted once in July (day 16.5), 24 times in August (days 18.5,

20.5→42.5), two times in September (days 63.5, 74.5), and four times in October (days 87.5→90.5). Total occurrences were 54 (Figure 3.4).

Initial occurrence of purple on the thorax and arms of C was 5.5 days after initial observations (day 7.5). No notations occurred on the thorax three times in August (days 30.5→32.5), four times in September (days 66.5→67.5, 74.5, 76.5), and four days in October (days 87.5→90.5). Total occurrences of purple on the thorax were 71 out of a possible 87 observations. No occurrences were noted on the arms ten times in August (days 18.5, 20.5, 22.5, 27.5→28.5, 32.5→36.5), and four times in October (days 87.5→90.5). A total of 68 out of a possible 87 were noted for C.

Following the thorax and arms, purple appeared on the legs of C 6.5 days after initial observations (day 8.5), with no notations on one occasion in August (day 34.5), on one occasion in September (day 72.5), and on three occasions in October (days 87.5→89.5). Total occurrences for purple on the legs were 76.

Purple was present on the arms and legs of D upon arrival to ARF (day 9). It was present on the arms ten times in July (days 9→17, 19), and on the legs, a total of 11 times in July (days 9→19).

Purple appeared on the abdomen/pelvis one day after initial observations (day 10), and was present six times in July (days 10→11, 13, 15→16, 18).

Following the abdomen/pelvis, purple occurred on the thorax two days after initial observations of D (day 11). It was noted a total of five times in July (days 11→13, 17→18).

Following the thorax, purple appeared on the head/neck of D three days after arrival (day 12) and occurred on four occasions in July (days 12, 14→15, 17).

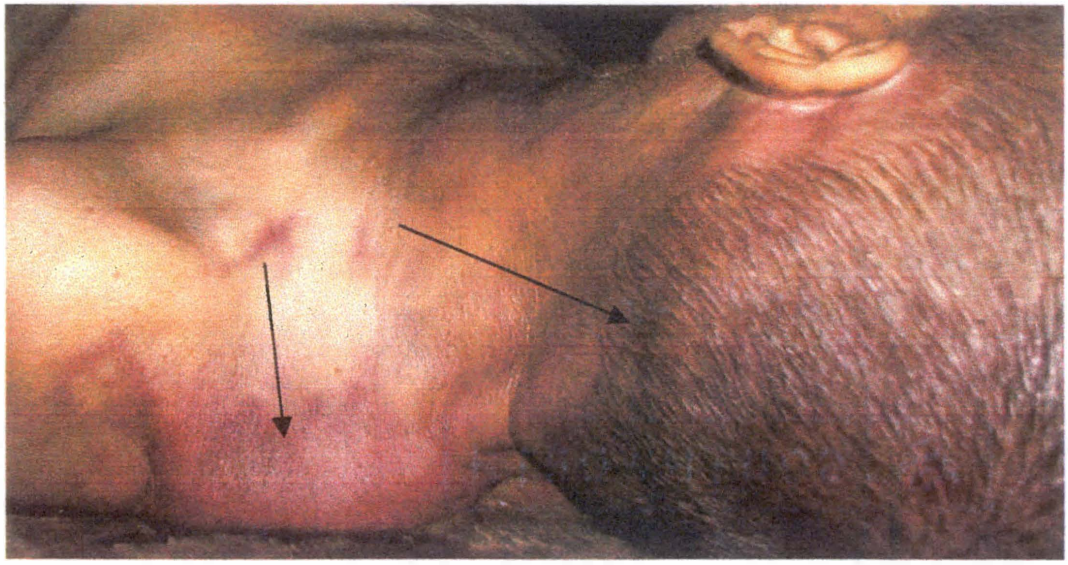

Figure 3.4. Purple (C). The purple discoloration on the head/neck region and along the neck/arm boundary, as indicated by the black arrows, is due to the progression from red to purple lividity.

Color Changes: Brown

In reference to A, brown occurred on the thorax, abdomen/pelvis, and arms two days after introduction to ARF (day 2) (Figure 3.5). All regions demonstrated consistency throughout, yielding a total of 114 occurrences per region.

Following the thorax, abdomen/pelvis, and arms, brown appeared on the legs and head/neck region three days after initial observations (day 3). These regions remained consistent throughout, accumulating a total of 113 occurrences each.

Brown appeared on the head/neck and legs of B one day after arrival (day 8). Despite the notation of no occurrences four times in July (days 15→18), it was consistent on the head/neck through day 91, yielding a total of 77 occurrences out of a possible 86. Brown was present nine times on the legs in July (days 8, 11→14, 16→18, 22).

The thorax and the arms of B yielded brown initially three days after arrival (day 10). No notations were made on both regions on two occasions in July (days 15, 17). Total occurrences of brown on the thorax and arms were 77 each out of a possible 86.

Brown appeared on the abdomen/pelvis region of B five days after initial observations (day 12). No occurrences were noted three days in July (days 14→15, 17), and once in August (day 39). Total occurrences yielded 73 out of a possible 86.

In reference to C, brown occurred on the head/neck, abdomen/pelvis, and arms one day after initial observations (day 3). Occurrences were consistent in these regions throughout, yielding 86 occurrences each out of a possible 87.

Following the head/neck, abdomen/pelvis, and arms, brown occurred on the thorax and legs two days after initial observations (day 4). Similarly, occurrences were constant, yielding 85 occurrences each out of a possible 87.

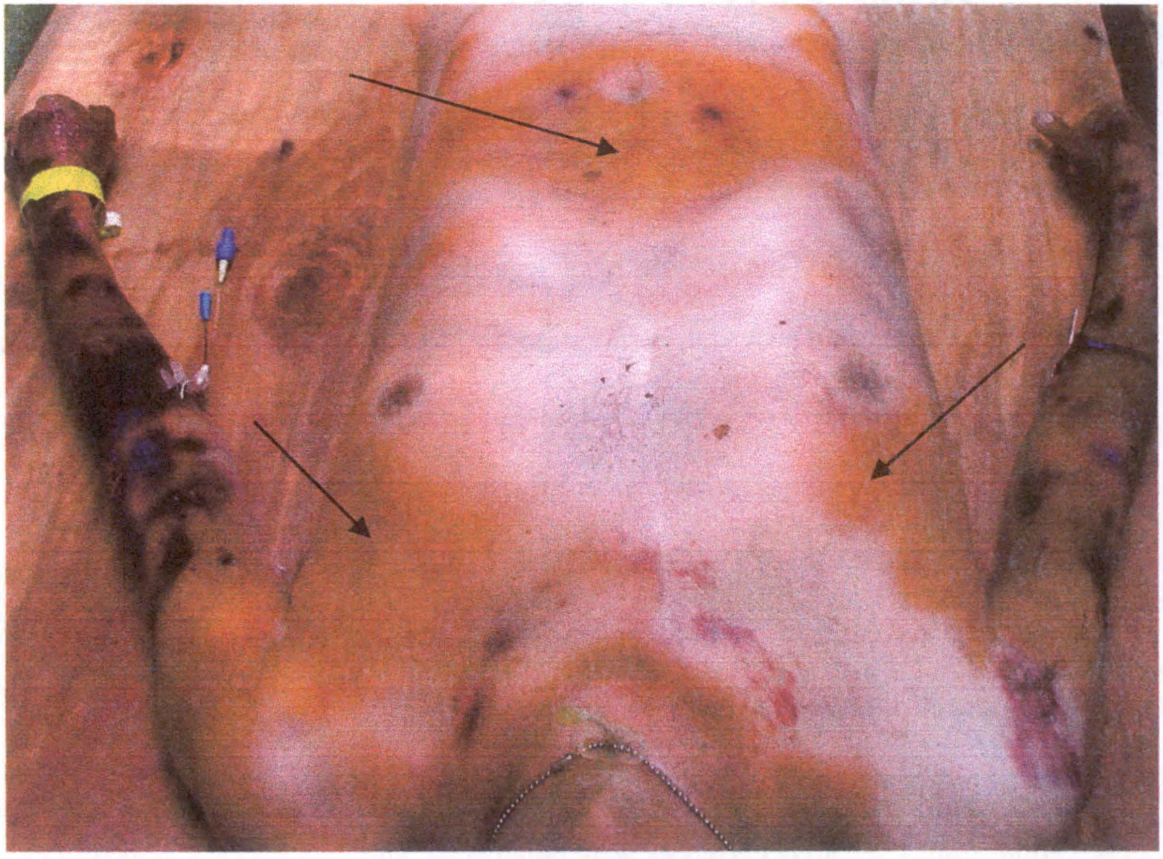

Figure 3.5. Brown (A). Following the initial appearance of brown discoloration in the lower right quadrant of the abdomen/pelvis region, brown eventually appeared along the entire abdominal area (single arrow) and upper body, including the thorax (two arrows), arms, and head/neck regions.

Brown was present on the thorax of D upon arrival to ARF (day 9). Occurrences were consistent, accumulating a total of 84.

Following the thorax, brown occurred on the head/neck and abdomen/pelvis one day after arrival (day 10). Consistency in occurrences yielded a total of 83 in each region out of a possible 84.

Brown appeared on the arms and legs three days after initial observations (day 12). Consistency in occurrences in each region yielded a total of 81 out of a possible total of 84 occurrences.

Color Changes: Black

Black was present on the arms of A upon arrival to ARF (day 0). Despite the absence of notation three times in October (days 115.5→117.5), occurrence was consistent, yielding a total of 113 out of a possible 116 occurrences.

However, black did not appear on the head/neck and abdomen/pelvis until seven days after initial observations (day 7). Black did not occur on the head/neck on one occasion in July (day 30), and on four occasions in October (days 115.5→118.5). Total occurrences of black in the head/neck region were 104. Yet, the occurrences of black on the abdomen/pelvis were consistent, yielding a total of 109.

Black appeared on the legs of A nine days after arrival to ARF (day 9) (Figure 3.6). Other than three occasions in October (days 115.5→117.5) it was consistent, yielding a total of 104 occurrences.

Yet, black was not noted on the thorax until 14 days after arrival. No occurrences were noted seven times in July (days 20→24, 28, 30) and three times in October (days

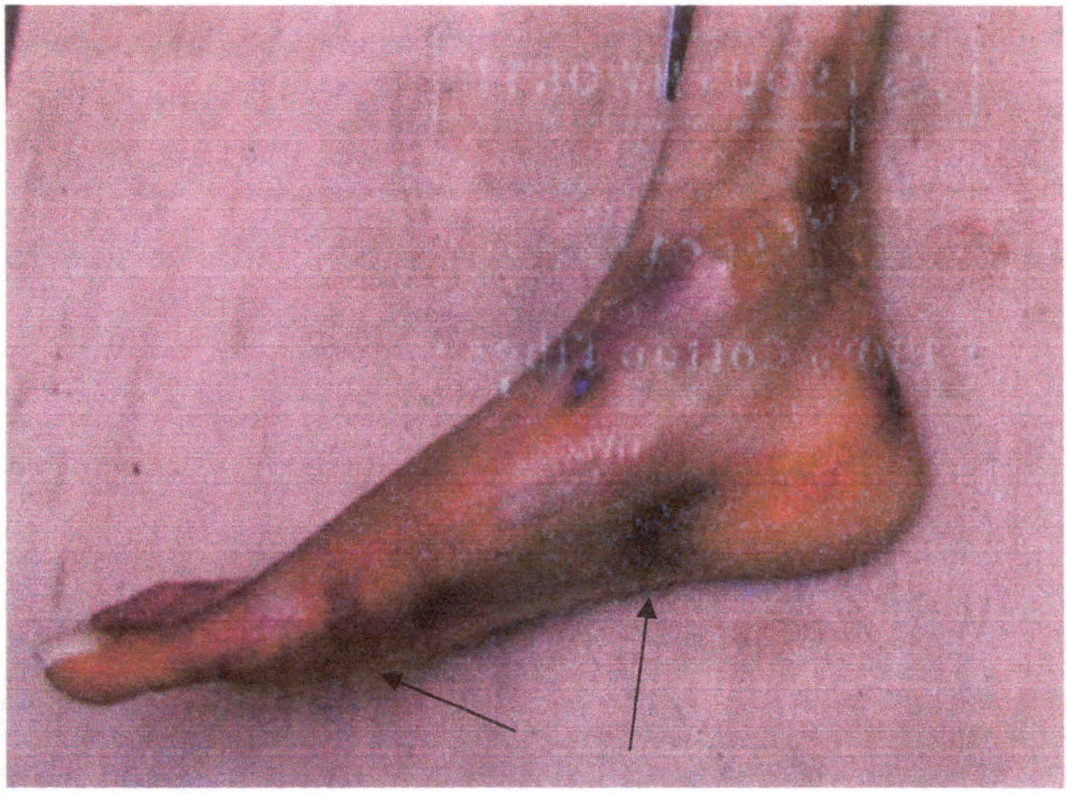

Figure 3.6. Black (A). Among other colors, black can be observed on the ankle and both the dorsum and sole (two arrows) of the right foot.

115.5→117.5). The total number of occurrences for the thorax was 92.

In reference to B, black was present on the arms and legs at the time of arrival to ARF (day 7). No occurrences were noted on both the arms and legs on one occasion in July (day 15) and three times in August (days 50→52). Total occurrences for black on both regions were 82 each out of a possible 86.

The initial occurrence of black on the head/neck region of B was noted four days after arrival to ARF (day 11). No occurrences were noted four times in July (days 15, 19→21) and three times in August (days 50→52). Total occurrences equaled 75 out of a possible total of 86 occurrences.

Black occurred on the thorax and abdomen/pelvis five days after initial observations (day 12). No occurrences were noted on the thorax ten times in July (days 14→15, 26→23), as well as August. Also no occurrences were noted 20 times in September (days 65→70, 72→84, 87). Total occurrences equaled 20 out of a possible 86. No occurrences were noted on the abdomen/pelvis five times in July (days 15, 18→20, 22) and three times in August (days 50→52). Total occurrences of black in the abdomen/pelvis region were 73.

In reference to C, black appeared on the thorax and arms 5.5 days after initial observations (day 7.5). No occurrences were noted on the thorax four times in July (days 13.5→16.5), two times in August (days 17.5, 19.5), five times in September (days 70.5→72.5, 74.5→75.5) and one time in October (day 82.5). Total occurrences of black on the thorax were 62 out of a possible 87 occurrences. With the exception of one occasion in July (day 13.5), black was consistent on the arms, yielding a total of 76 occurrences out of a possible 87.

Black appeared on the head/neck region on day 9.5. No occurrences were noted four times in July (days 12.5→14.5, 16.5), two times in September (days 70.5, 74.5), and two times in October (days 87.5→88.5). Total occurrences equaled 72.

Following the head/neck, black appeared on the legs of C 8.5 days after initial observations (day 10.5). No occurrences were noted five times in July (days 11.5, 13.5→16.5), one time in August (day 17.5), five times in September (days 70.5→72.5, 74.5→75.5), and five times in October (days 85.5, 87.5→90.5). Total occurrences of black on the legs were 63 out of a total 87.

Black occurred on the abdomen/pelvis of C 11.5 days after initial observations (day 13.5). No occurrences were noted two times in July (days 14.5→15.5) and four times in September (days 70.5→71.5, 74.5→75.5). Total occurrences of black in the abdomen/pelvis region were 70.

Black was present on all regions of D four days after arrival to ARF (day 13). No occurrences were noted on the head/neck one time in July (day 14) and two times in August (days 38→39), yielding a total of 77 occurrences out of a possible 84. No occurrences were noted on the thorax three times in July (days 18, 20→21), and in August. Also, five times were not recorded in September (days 53→57), yielding a total number of 41 occurrences out of a possible 84. No occurrences were noted on the abdomen/pelvis three times in July (days 18→20) and two times in August (days 38→39), yielding a total number of 75 occurrences. No occurrences were noted on the arms on two occasions in July (days 18→19) and on two occasions in August (days 38→39). Hence, total occurrences were 76 out of a possible 84. No occurrences were

noted on the legs on one occasion in July (day 15) and on two occasions in August (days 38→39). Total occurrences for black on the legs were 77.

Marbling

Marbling appeared on the abdomen/pelvis of A four days after arrival to ARF (day 4). It was consistently noted through day 98.5, occurring a total of 92 times.

Marbling occurred on the arms six days after initial observations (day 6). Similar to the abdomen/pelvis, occurrences were consistent throughout, yielding a total of 92 out of a possible 116 observations.

Following the arms, marbling appeared on the legs seven days after arrival (day 7). As with the arms, occurrences were consistently noted through day 100.5. Total occurrences were 91 out of a possible 116.

Marbling appeared on the head/neck region nine days after initial observations (day 9), but was visible only through day 35.5. Hence, total occurrences were 26 out of a possible 116 observations.

Initial occurrence of marbling on the thorax of A was noted ten days after arrival to ARF (day 10). Occurrences were recorded through day 95.5, yielding a total of 85.

In reference to B, marbling was present on the legs upon the arrival to ARF (day 7), and was noted eight times in July (days 7→14).

Marbling occurred on the thorax two days after initial observations (day 9), and was present a total of 13 times in July (days 9, 12→13, 16→25).

Initial notations of marbling on the head/neck region occurred five days after arrival (day 12) and was noted as present six times in July (days 12→14, 16→18).

Yet, marbling was not recorded on the arms of B until ten days after initial observations (day 17), yet it was recorded on two occasions in July (days 17→18).

Marbling was not recorded on the abdomen/pelvis region of B.

Referring to C, marbling was initially noted on the arms, head/neck, and thorax regions 5.5 days after initial observations (day 7.5). It was noted on the head/neck region five times in July (days 7.5→11.5). Marbling was not noted on the thorax on one occasion in August (day 18.5), but was otherwise consistent through day 26.5, yielding a total of 19 occurrences out of a possible 87 observations (Figure 3.7). Marbling was not noted on the arms on two occasions in August (days 18.5→19.5). However it was consistent through day 28.5, with a total of 20 total occurrences recorded.

Marbling occurred on the abdomen/pelvis region of C 6.5 days after initial observations (day 8.5), and was recorded as present 29 times out of a possible 87.

Following the abdomen/pelvis, marbling occurred on the legs of C 7.5 days after initial observations (day 9.5). Occurrence was not recorded on one occasion in August (day 19.5), but was still consistent through day 32.5, yielding a total of 23 occurrences.

In reference to D, marbling initially occurred in the head/neck region two days after arrival to ARF (day 11). It was noted as present on six occasions in July (days 11→12, 14→17).

Following the head/neck, marbling appeared on the thorax, arms, and legs three days after initial observations (day 12). It was noted on the thorax and arms on five occasions in July (days 12, 14, 16→18 and days 12→13, 15→17 respectively). Marbling also occurred on the legs eight times in July (days 12→19).

Marbling appeared on the abdomen/pelvis four days after initial observations, and

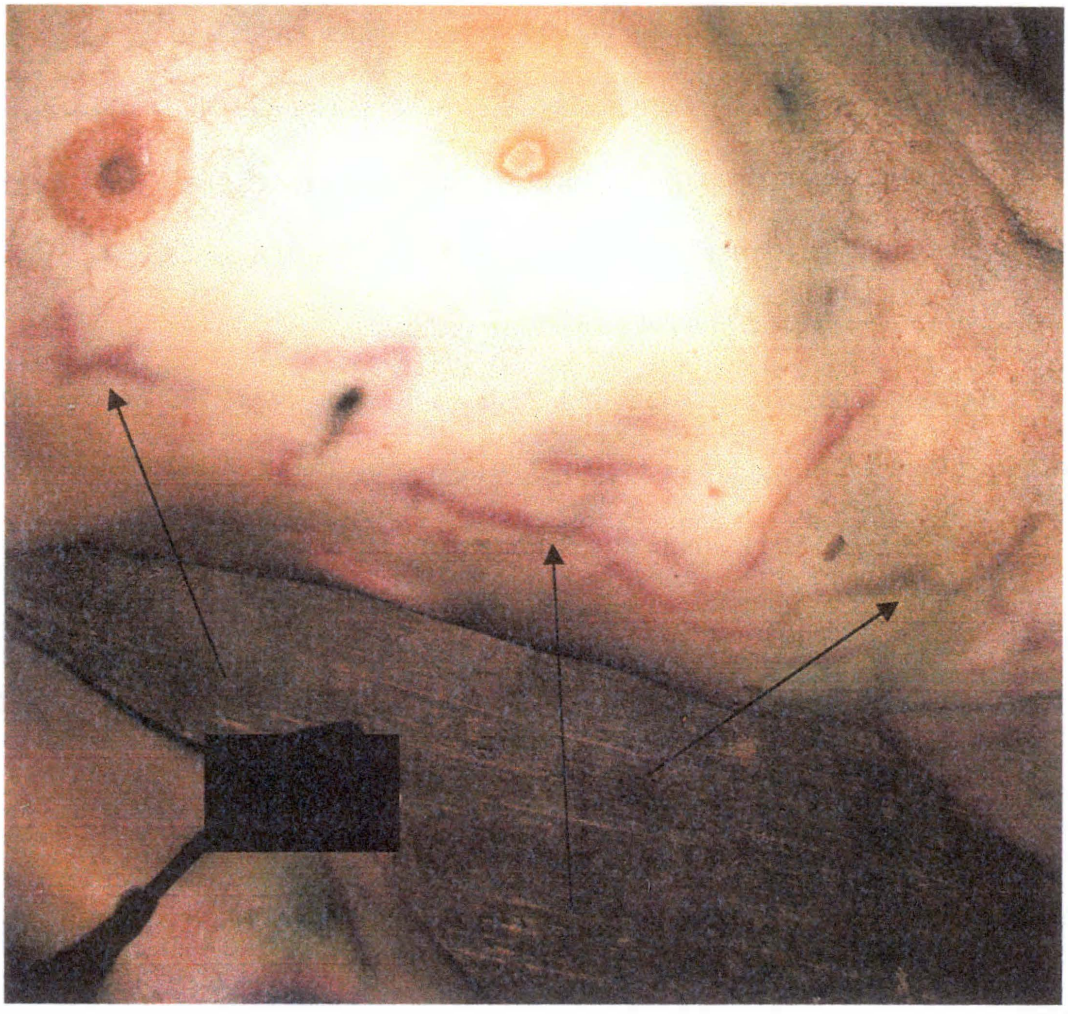

Figure 3.7. Marbling (C). Prior to bloating, marbling appeared on the sides (black arrows) of the thorax and abdomen/pelvis regions.

occurred five times in July (days 13→16, 18).

Bloating

Bloating initially occurred in the abdomen/pelvis region of A 16 days after arrival to ARF (day 16). It was noted through day 74.5, yielding a total of 58 occurrences.

Following the abdomen/pelvis, bloating was initially noted on the head/neck, thorax, and arms 17 days after initial observations (day 17). Occurrences were consistent throughout, yielding a total of 44, 42, and 35 respectively.

Bloating appeared on the legs of A 20 days after arrival (day 20), and was consistently noted through day 54.5, yielding a total of 34 occurrences.

In reference to B, bloating did not occur on the head/neck, arms, and legs. However, it occurred initially in the thorax and abdomen/pelvis regions four days after arrival to ARF (day 11). It was noted in the thorax region on five occasions in July (days 11→15) and in the abdomen/pelvis region on two occasions in July (days 11→12).

Bloating was affiliated with C initially in the head/neck, thorax, and abdomen/pelvis regions 7.5 days after initial observations (day 9.5). It was consistently noted in the head/neck region through day 25.5, yielding a total of 17 occurrences. Notations of bloating in the thorax region occurred through day 23.5, accumulating a total of 15 occurrences. Occurrences continued on the abdomen/pelvis through day 27.5, yielding a total of 19 occurrences from 87 observations (Figure 3.8).

Bloating was noticed on the arms of C 8.5 days after initial observations (day 10.5) and persisted through day 24.5, for a total of 15 occurrences.

Following the arms, bloating was noted on the legs 9.5 days after initial

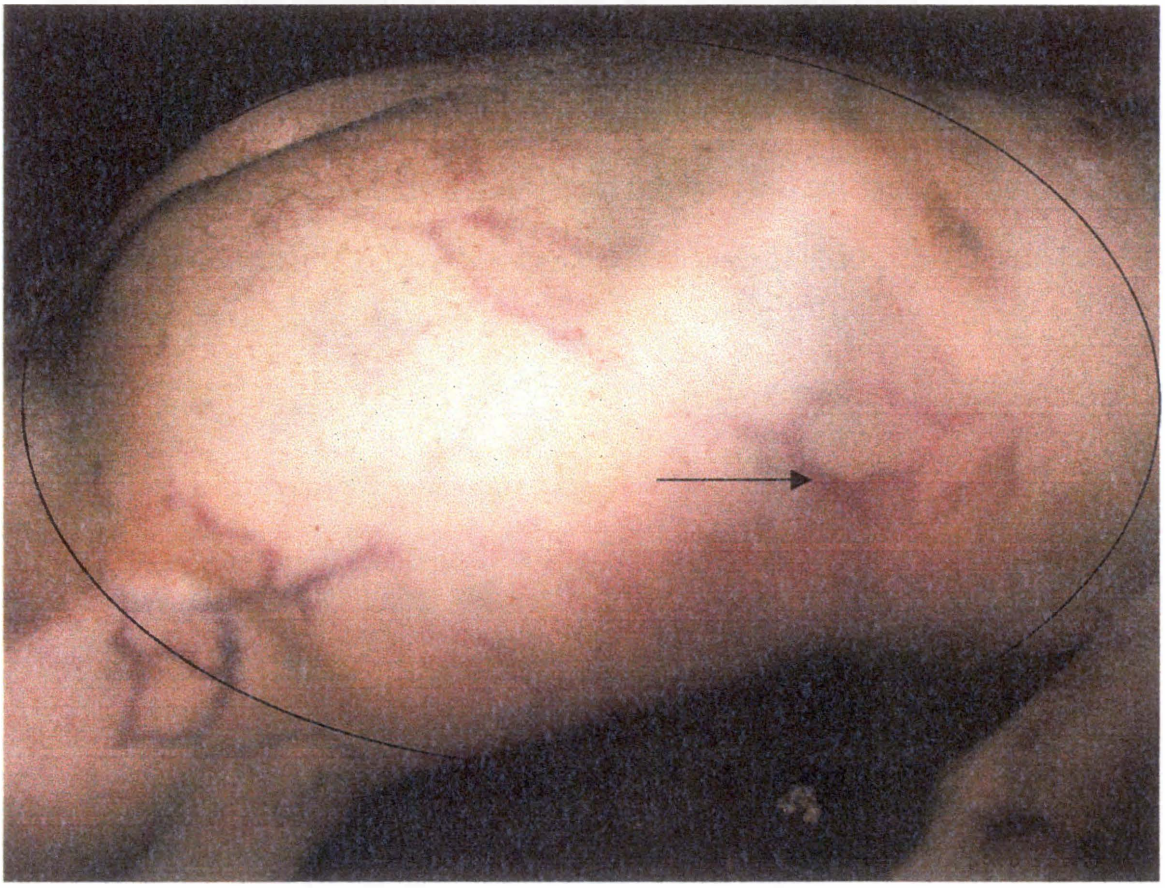

Figure 3.8. Bloating (C). Following the establishment of marbling (black arrow), bloating was noted as swelling occurred in the abdomen/pelvis and thorax regions as emphasized by the circle.

observations (day 11.5) and was consistently recorded through day 24.5, yielding a total of 14 occurrences.

In reference to D, bloating was initially noted in the abdomen/pelvis region two days after arrival to ARF (day 11). It was recorded four times in July (day 11→14).

Following the abdomen/pelvis, bloating was noticed on the thorax three days after initial observations (day 12), and was recorded on three occasions in July (day 12→14).

Similarly, bloating was recorded on the head/neck, arms, and legs four days after arrival (day 13), with occurrence noted in these regions twice in July (days 13→14).

Odor

Odor was detected near A ten days after arrival to ARF (day 10), and persisted through final observations, yielding a total of 106 occurrences from 116 observations.

Odor was initially detected near B two days after arrival to ARF (day 9) and persisted through day 40, yielding a total of 32 occurrences out of a possible 86.

In reference to C, odor was detected 5.5 days after initial observations (day 7.5) and persisted through final observations, yielding a total of 82 occurrences.

Odor was detected near D three days after arrival to ARF (day 12). It was consistently recorded through day 42, yielding a total of 31 occurrences.

Skin Slippage

Skin slippage was initially observed on the arms of A 12 days after arrival to ARF (day 12). Evidence of skin slippage persisted throughout, yielding a total number of 104 occurrences.

Following the arms, skin slippage was noted in the head/neck region 13 days after initial observations (day 13), and was noted consistently throughout for a total of 103 occurrences out of a possible 116.

Following the head/neck, skin slippage occurred on the thorax 14 days after arrival (day 14), with evidence persisting consistently throughout. Hence, total occurrences out of a possible 116 were 102.

Skin slippage was noted on the abdomen/pelvis region of A 17 days after arrival to ARF (day 17). Evidence persisted consistently throughout this region, yielding 99 occurrences out of a possible 116.

Skin slippage was noted on the legs 19 days after initial observations (day 19). Despite a brief absence on two occasions in July (days 21→22), evidence indicated that occurrence equaled 95.

Regarding B, skin slippage was present on the thorax and legs upon arrival to ARF (day 7). It was noted on the thorax on seven occasions in July (days 7→13) and on the legs on eight occasions in July (days 7→14).

Skin slippage occurred on the head/neck and abdomen/pelvis regions two days after initial observations (day 9). It was noted on the head/neck on five occasions in July (days 9→13) and on the abdomen/pelvis on four occasions in July (days 9→12).

Following the head/neck and abdomen/pelvis, skin slippage occurred on the arms of B three days after arrival (day 10). It was noted three times in July (days 10→12).

In reference to C, skin slippage occurred in the head/neck region 5.5 days after initial observations (day 7.5). Evidence persisted throughout for a total of 82 noted occurrences.

Following the head/neck, skin slippage appeared on the arms 6.5 days after initial observations (day 8.5). Notations were consistent throughout, yielding a total of 81 occurrences out of a possible 87.

Similarly, skin slippage occurred on the legs 7.5 days after initial observations (day 9.5), with evidence persisting throughout. Hence, total occurrences were 80 out of the possible 87 observations.

Finally, skin slippage occurred on the thorax and abdomen/pelvis regions of C 8.5 days after initial observations (day 10.5). Evidence was consistently noted, with total occurrences equaling 79 each.

Skin slippage was noted on the head/neck, thorax, and arms of D one day after introduction to ARF (day 10). It was noted on the head/neck region on two occasions in July (days 10→11), on the thorax on four occasions in July (days 10→13), and on the arms on three occasions in July (days 10→12) (Figure 3.9).

Following the head/neck, thorax, and arms, skin slippage was indicated on the abdomen/pelvis and legs two days after initial observations (day 11). Three occasions were noted in July for each (days 11→13).

Liquids Running From Orifices

Liquids draining from the head/neck region of A were indicated ten days after introduction to ARF (day 10). No occurrences were recorded on two occasions in June (days 11→12), on 14 occasions in August (days 60.5→65.5, 67.5→70.5, 72.5→75.5), and on four occasions in September (days 76.5→79.5). Occurrences ceased after day 90.5, yielding a total of 60 occurrences.

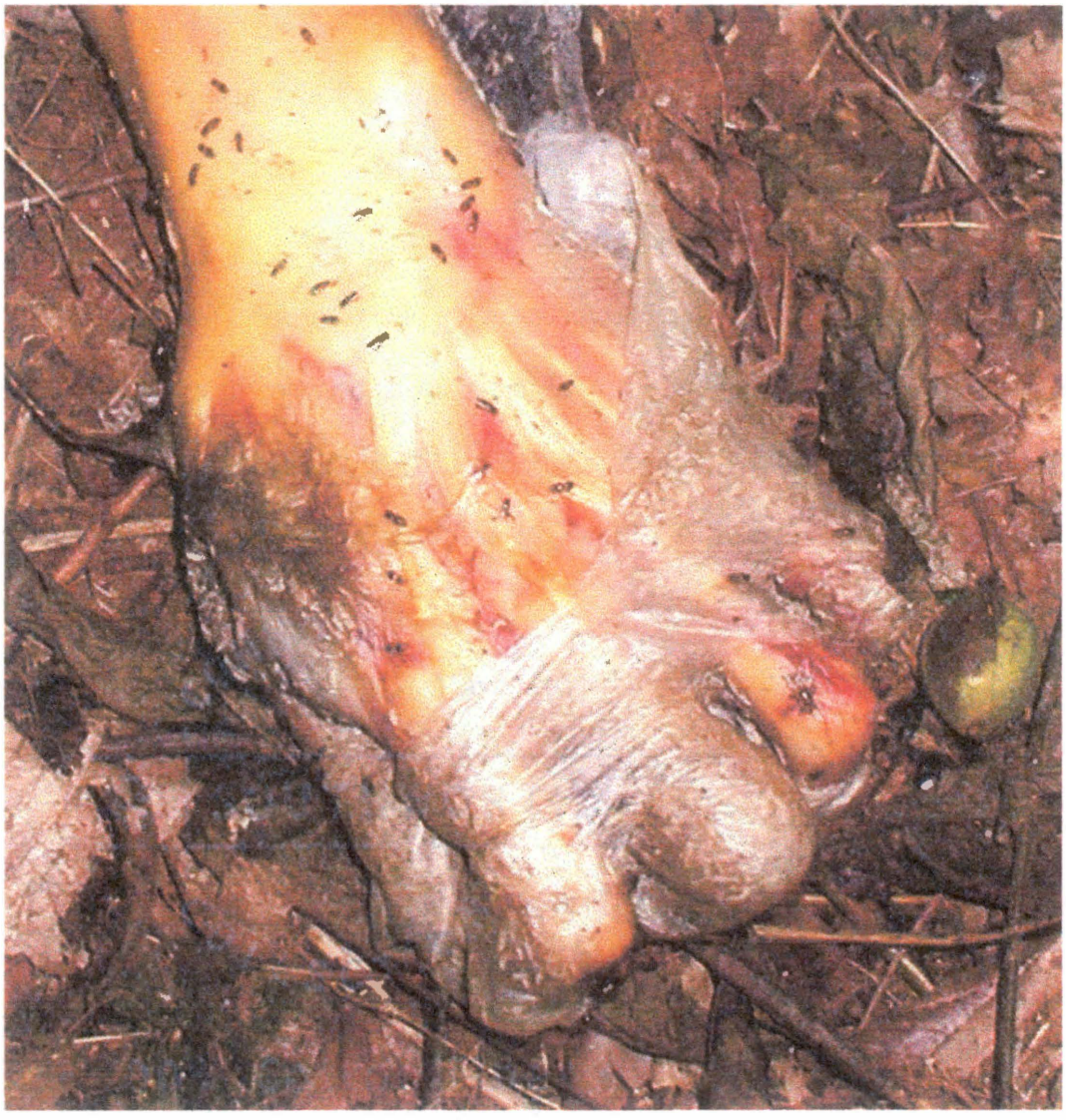

Figure 3.9. Skin Slippage (D). Sloughing of the epidermal layer on the left hand occurred as a result of cellular breakdown between the epidermal and dermal layers of the skin.

Liquids draining from the abdomen/pelvis region occurred 16 days after initial observations (day 16). No occurrences were recorded five times in July (days 25→28, 30), eight times in August (days 56.5→60.5, 73.5→75.5) and four times in September (days 76.5→79.5). Occurrences were terminated after day 93.5, also yielding a total of 60 occurrences.

The thorax, arms, and legs were not applicable.

Liquids draining from the head/neck region of C occurred 5.5 days after initial observations (day 7.5). No notations were made on one occasion in July (day 8.5), on 21 occasions in August (days 20.5, 24.5→28.5, 30.5→41.5, 45.5→47.5), and on seven occasions in September (days 48.5→54.5). Hence, total occurrences were 28 out of a possible 87 (Figure 3.10).

Liquids draining from the abdomen/pelvis region occurred 8.5 days after initial observations (day 10.5). No occurrences were noted five times in July (days 12.5→16.5), 14 times in August (days 21.5→28.5, 42.5→47.5), 25 times in September (days 48.5→62.5, 65.5→67.5, 70.5→72.5, 74.5→77.5), and 12 times in October (days 78.5→89.5). Total occurrences were 23 out of a possible total of 87.

The thorax, arms, and legs were not applicable.

This visual cue did not apply to B and D.

Hair Slippage

No evidence of hair slippage in the head/neck region was apparent on A until 73 days after arrival to ARF (day 73). This evidence persisted throughout, yielding a total of 45 occurrences.

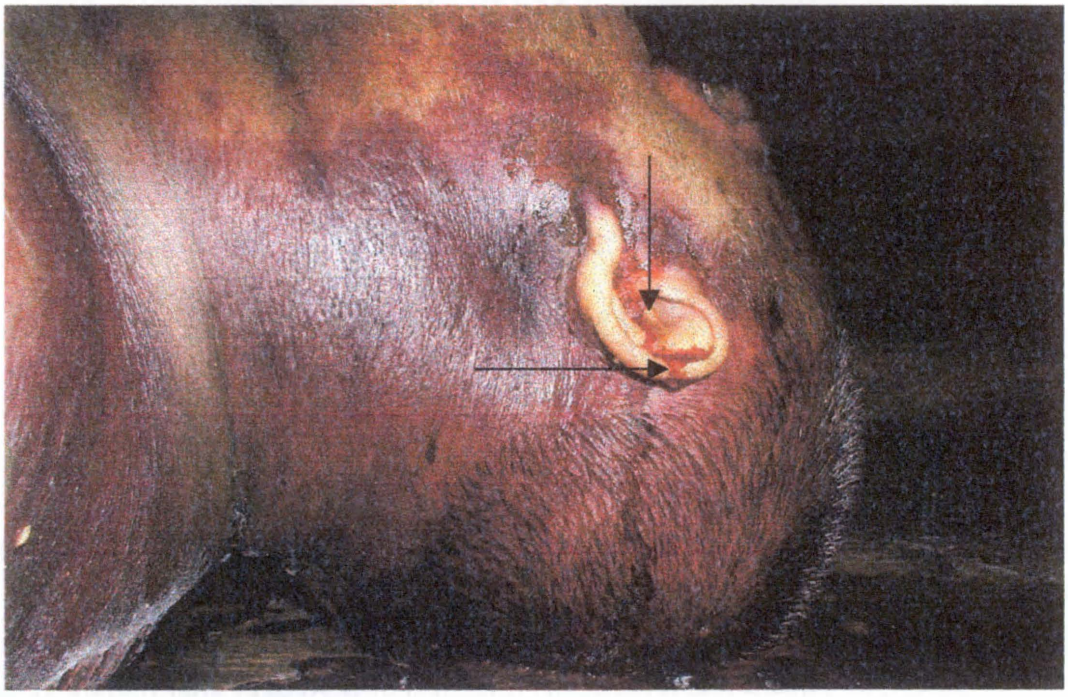

Figure 3.10. Liquids Running From Orifices (C). As emphasized by the black arrows, red fluid can be observed draining from the left ear, while the head/neck region is at full bloat.

The other four regions were not applicable.

Hair slippage occurred in the head/neck region of B nine days after introduction to ARF (day 16). It was unclear as to when this process ceased.

The other four regions did not apply.

Hair slippage occurred on C 17.5 days after initial observations (day 19.5), with evidence present throughout, yielding a total of 70 recorded occurrences (Figure 3.11).

The other four regions did not apply.

Hair slippage was initiated on D three days after arrival to ARF (day 12). The duration for this visual cue is uncertain.

The other four regions were not applicable.

Adipocere

Adipocere was noted on all regions of A 28 days after initial observations (day 28). It occurred throughout, yielding a total of 88 occurrences each (Figure 3.12).

Similarly, adipocere was formed on all regions of B 16 days after introduction to ARF (day 23). Total occurrences in each region equaled 70 out of a possible 86.

Regarding C, adipocere initially occurred on the abdomen/pelvis and arms 8.5 days after initial observations (day 10.5). No occurrences were noted on the abdomen/pelvis two times in July (days 14.5, 16.5) and 24 times in August (days 18.5→41.5). Total observations were 53. No notations were made on the arms on 11 occasions in August (days 19.5, 24.5→31.5, 35.5, 41.5) and on seven occasions in September (days 54.5→60.5). Total occurrences were 61 out of a possible 87.

Adipocere formed on the head/neck, thorax, and legs 9.5 days after initial

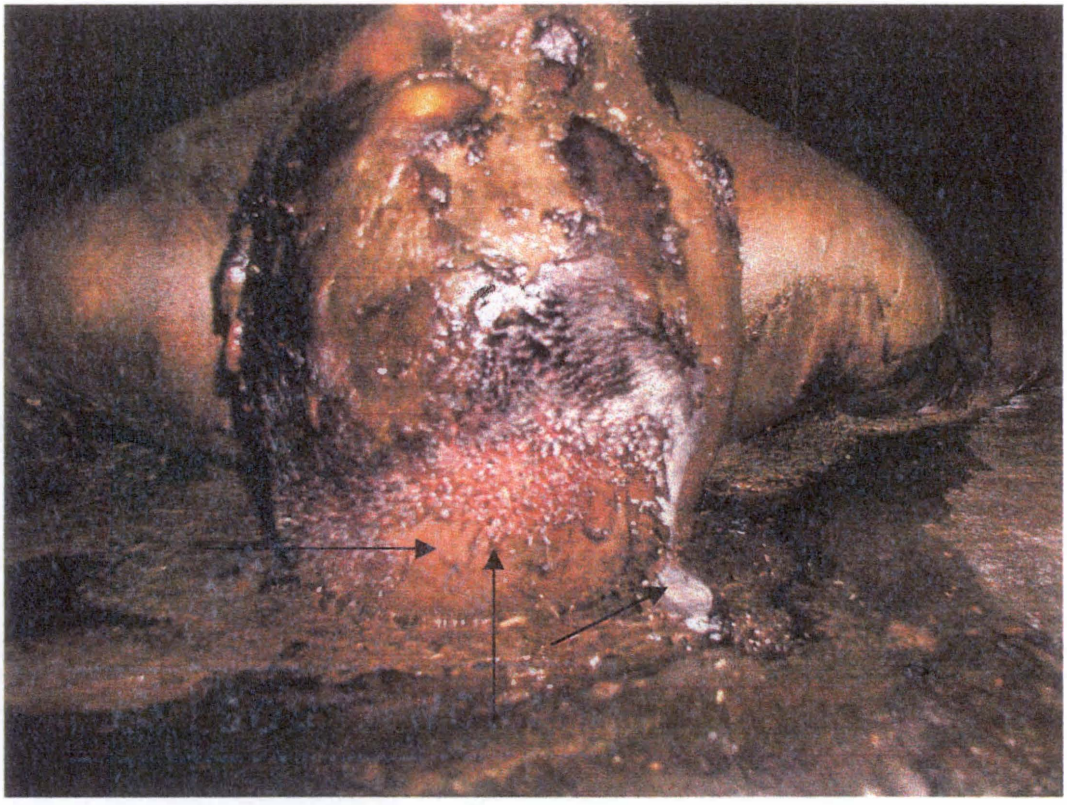

Figure 3.11. Hair Slippage (C). Hair slippage in the vicinity of the black arrows followed the notations of maggot activity in the head/neck region.

Figure 3.12. Adipocere (A). Adipocere appeared on the legs and feet following the first heavy rainfall (day 28) and persisted as a white, crumbly substance (black arrows), while black fungus or mold reoccurred with each rainfall.

observations (day 11.5). No occurrences were noted on the head/neck three times in July (days 14.5→16.5), 21 times in August (days 19.5→20.5, 23.5→41.5), and nine times in September (days 52.5→60.5). Total occurrences of adipocere in the head/neck region were 45 out of a possible 87. No notations were made on the thorax on two occasions in July (days 14.5→15.5), on 22 occasions in August (days 17.5→32.5, 35.5, 37.5→41.5), and on ten occasions in September (days 52.5→60.5, 67.5). Total occurrences were 44. No occurrences were recorded on the legs of C on three occasions in July (days 14.5→16.5) and 15 times in August (days 18.5→32.5). Total occurrences were 60 out of a possible 87.

In reference to D, adipocere formed initially on the arms and legs ten days after introduction to ARF (day 19). No notations of occurrence were recorded on the arms on 27 occasions in August (days 22, 27→52), and on 12 occasions in September (days 53→58, 60→65). Total occurrences equaled 35 out of a possible 84. Despite one absence in August (day 39), adipocere was consistent throughout on the legs, yielding a total of 73 occurrences.

Adipocere formed on the thorax 12 days after initial observations (day 21). No occurrences were noted 30 times in August (days 23→52), and 12 times in September (days 53→58, 60→65). The total number of occurrences was 30 out of a possible 84.

Adipocere appeared on the head/neck region 14 days after introduction to ARF (day 23). No occurrences were noted on 29 occasions in August (days 24→52) and on 12 occasions in September (days 53→58, 60→65). Total occurrences were 29.

Following the head/neck, adipocere appeared on the abdomen/pelvis of D 15 days after initial observations. No occurrences were noted on 25 occasions in August (days

27→40) and on 12 occasions in September (days 53→58, 60→65). Total occurrences equaled 32 out of a possible 84.

Fungus/Mold

Fungus/mold occurred initially on the head/neck of A four days after initial observations (day 4). Despite the absence on one occasion in July (day 27), occurrences were consistent throughout, yielding a total of 111 occurrences.

Fungus/mold appeared on the arms and legs ten days after arrival to ARF (day 10). Notations were consistent throughout, yielding a total of 106 occurrences each out of a possible 116 (Figure 3.13).

Next, fungus/mold appeared on the thorax 13 days after introduction to ARF (day 13). No occurrences were noted six times in July (days 22→27). Total occurrences equaled 97 out of a possible 116.

Finally, fungus/mold was noted on the abdomen/pelvis region 19 days after arrival (day 19). No notations were made on eight occasions in July (days 20→27). Total occurrences were 89.

Regarding B, fungus/mold became apparent on the head/neck, thorax, abdomen/pelvis, and arms 46 days after initial observations (day 53). No occurrences were noted on the head/neck 13 times in September (days 65→70, 72→78). Hence, total occurrences equaled 20 out of a possible 86. Fungus/mold occurred on the thorax on three occasions in August (days 53→55) and on two occasions in September (days 87→88), yielding a total of five occurrences. It was apparent on the abdomen/pelvis three times in August (days 53→55) and three times in September (days 80, 87→88) for

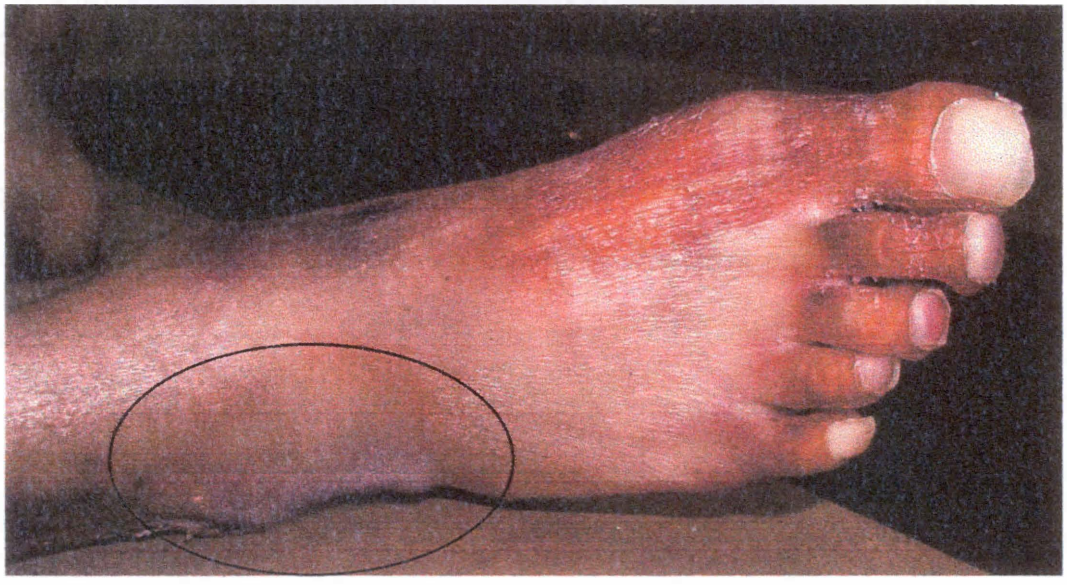

Figure 3.13. Fungus/Mold (A). The circled area on the ankle of the right foot indicates the presence of a white/fuzzy fungus or mold.

a total of six occurrences. Similarly, fungus/mold was noted on the arms of B on six occasions, including three in August (days 53→55) and three in September (days 87→88, 93).

Fungus/mold became apparent on the legs 72 days after initial observations (day 79). It was noted on seven occasions in September (days 79→83, 87→88).

In reference to C, fungus/mold appeared on the head/neck and arms on day 7.5. No occurrences were noted on the head/neck seven times in July (days 10.5→16.5), 24 times in August (days 17.5→36.5, 44.5→47.5), and 21 times in September (days 48.5→62.5, 65.5, 70.5→72.5, 74.5→75.5). Total occurrences were 22 out of a possible 87. Notations were made on the arms on five occasions in July (days 7.5→9.5, 12.5→13.5), on one occasion in September (day 63.5), and on five occasions in October (days 79.5→83.5). The total number of occurrences for the arms on C was 11.

Following the head/neck and arms, fungus/mold appeared on the thorax, abdomen/pelvis, and legs 6.5 days after initial observations (day 8.5). It was noted on the thorax on two occasions in July (days 8.5→9.5) and on one occasion in September (day 63.5), for a total of three occurrences. It occurred on the abdomen/pelvis on two occasions in July (days 8.5→9.5) and on two occasions in September (days 63.5→64.5), for a total of four occurrences. Fungus/mold was not noted on the legs five times in July (days 10.5→11.5, 13.5→14.5, 16.5), 27 times in August (days 19.5, 21.5→36.5, 38.5→47.5), and 21 times in September (days 48.5→62.5, 67.5, 70.5→72.5, 74.5→75.5). Total occurrences noted were 20 out of a possible 87.

Fungus/mold occurred on the head/neck, abdomen/pelvis, arms, and legs of D 59 days after introduction to ARF (day 68). It was noted on the head/neck region on nine

occasions in September (days 68→72, 75→78). Fungus/mold was apparent on the abdomen/pelvis nine times in September (days 68→72, 75→77, 82) and four times in October (days 83→86), for a total of 13 occurrences. It was present on the arms and legs on ten occasions in September (days 68→72, 75→77, 81→82) and on four occasions in October (days 83→86), for a total of 14 occurrences each.

Finally, fungus/mold was detected on the thorax 66 days after initial observations (day 75) and persisted on three occasions in September (days 75→77).

Desiccation

Desiccation occurred on the legs of A 23 days after initial observations (day 23), and was constant for 93 occurrences.

Desiccation occurred on the arms 26 days after introduction to ARF (day 26), and persisted for a total of 90 occurrences.

However, desiccation did not apply to the head/neck, thorax, and abdomen/pelvis regions of A.

In reference to B, desiccation was present on the arms upon arrival to ARF (day 7). Occurrences were consistent, yielding a total of 86.

Desiccation was apparent on the head/neck 11 days after initial observations (day 18). Occurrences were consistent, with the total equaling 75 (Figure 3.14).

Following the head/neck, desiccation occurred on the legs 12 days after arrival to ARF (day 19). Consistent occurrences yielded a total of 74.

Desiccation appeared on the abdomen/pelvis region 14 days after initial observations (day 21), with total occurrences equaling 72.

Figure 3.14. Desiccation (B). The tissue on the skeletonized remains of the head/ neck region has become dry and leathery.

Finally, desiccation occurred on the thorax 19 days after arrival (day 26), with total occurrences yielding 67.

Desiccation did not occur on C.

In reference to D, desiccation appeared on the arms six days after introduction to ARF (day 15). Despite an absence on one occasion in July (day 18), occurrences were consistent, yielding a total of 77.

Desiccation occurred on the legs of D ten days after initial observations (day 19), with consistent recordings throughout. Total occurrences were 74.

Finally, desiccation appeared on the head/neck, thorax, and abdomen/pelvis regions 14 days after arrival to ARF (day 23). Consistent occurrences yielded a total of 70 for each.

Deflation (Post-bloating)

Deflation was initially detected in the head/neck and abdomen/pelvis regions of A 45.5 days after introduction to ARF (day 45.5). Total occurrences were 72 each.

Detection of deflation was then noted in the arms 53.5 days after initial observations (day 53.5). Total occurrences equaled 64.

Following the arms closely, the legs began deflating 55.5 days after introduction to ARF (day 55.5). Total occurrences were 62.

Finally, deflation was noted in the thorax 60.5 days after initial observations (day 60.5). The total number of occurrences was 57.

In reference to B, detection of deflation of the abdomen/pelvis was noted six days after initial observations (day 13) for a total of 80 occurrences, while deflation of the

thorax occurred nine days after arrival (day 16), yielding a total of 77. The head/neck, arms, and legs were not applicable.

Deflation initially occurred in the abdomen/pelvis region of C 18.5 days after initial observations (day 20.5), accumulating a total of 69 occurrences out of 87.

Following the abdomen/pelvis, deflation was detected in the head/neck region 19.5 days after initial observations (day 21.5), yielding a total of 68 occurrences.

Deflation occurred in the thorax of C on day 24.5 and in the arms and legs on day 25.5. In reference to the thorax, total observations were 65, while the arms and legs yielded a total of 64 each (Figure 3.15).

Referring to D, deflation was recorded in all regions six days after introduction to ARF (day 15), yielding a total of 78 occurrences in each region out of a possible 84.

Insect Activity

Insect activity was first detected in the head/neck region of A 19 days after introduction to ARF (day 19). No occurrences were noted on 12 occasions in July (days 20, 26, 35.5→ 44.5). Total number of occurrences was 85.

Insects were discovered on the legs of A 51.5 days after initial observations (day 51.5). Occurrences were consistent, yielding a total of 66.

Insect activity occurred on the thorax 54.5 days after introduction to ARF (day 54.5). Despite the absence on one occasion in August (day 63.5), occurrences were consistent, yielding a total of 62.

Insects were detected on the abdomen/pelvis of A 64.5 days after initial observations (day 64.5), and persisted for a total of 53 occurrences.

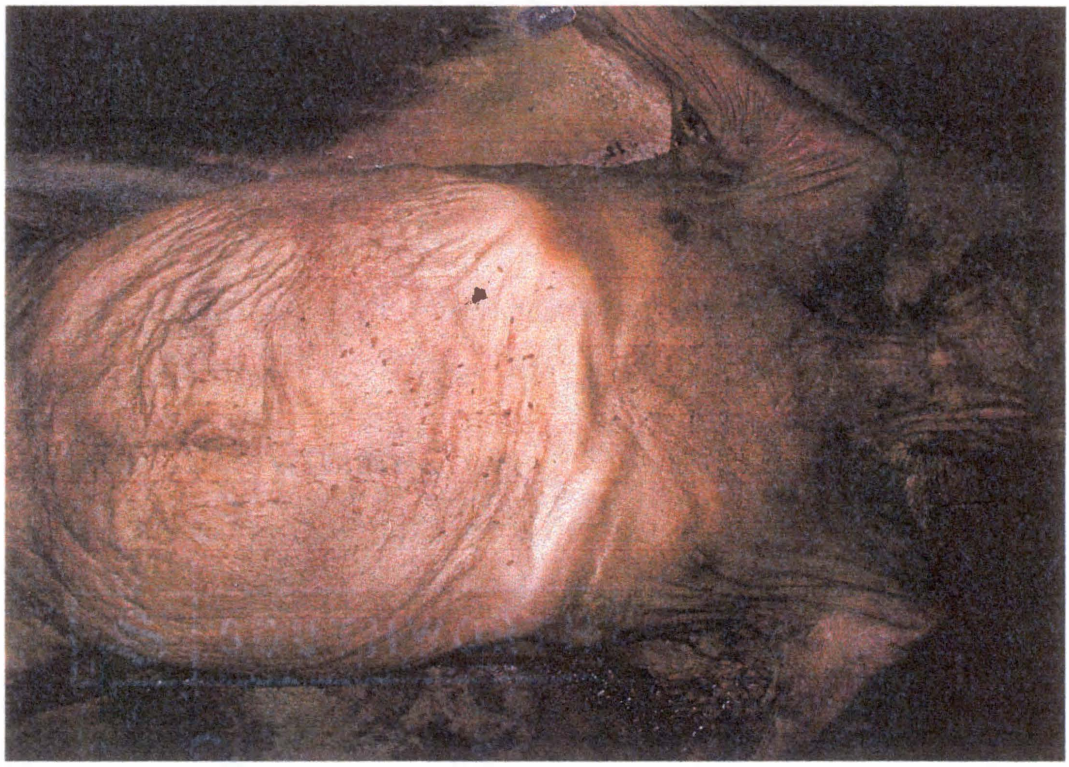

Figure 3.15. Deflation (Post-bloating) (C). As the body deflates, the skin maintains a wrinkled and soft/flabby consistency.

Finally, insects were present on the arms 65.5 days after initial observations (day 65.5), and persisted for a total of 52 occurrences.

In reference to B, all regions experienced insect activity upon arrival to ARF (day 7). Despite the absence of notation on one occasion in July (day 20), occurrences were consistent on the head/neck and abdomen/pelvis, yielding a total of 85 each out of a possible 86. No notations were recorded on the thorax on three occasions in July (days 18, 20, 22). Total occurrences were 83. No occurrences were noted on the arms on four occasions in July (days 19→20, 22→23). Total occurrences equaled 82. Notations were not made on the legs on two occasions in July (days 22→23), yielding a total of 84 occurrences (Figure 3.16).

Insect activity affiliated with C was initially noted on the legs 7.5 days after arrival to ARF (day 9.5). No occurrences were noted on seven occasions in July (days 10.5→16.5) and on 12 occasions in August (days 23.5→31.5, 34.5→36.5). Total occurrences were 61 out of a possible total of 87.

Insects were then noted on the head/neck region 8.5 days after initial observations (day 10.5). Two occasions were not noted in August (days 26.5, 28.5), with total occurrences equaling 77.

Following the head/neck, insects were discovered on the arms on day 11.5. No occurrences were noted on one occasion in July (day 12.5) and on ten occasions in August (days 23.5→31.5, 34.5). Total occurrences were 67.

Following the arms, insects were present on the thorax 10.5 days after initial observations (day 12.5). Five occasions yielded absence data in August (days 26.5, 28.5, 30.5→31.5, 34.5). Otherwise, total occurrences were 72 out of a possible 87.

Figure 3.16. Insect Activity (B). The formation of a maggot mass on the abdomen/ pelvis and leg regions has resulted in skeletonization, allowing the right femur to become visible.

Insects found on the abdomen/pelvis of C were present on day 15.5. Despite the absence on one occasion (day 28.5), occurrences totaled 73.

In reference to D, insects were noted on the head/neck region upon arrival to ARF (day 9). Occurrences were consistent throughout, yielding a total of 84.

Following the head/neck, insects were discovered on the abdomen/pelvis one day after introduction to ARF (day 10). No occurrences were noted on three occasions in August (days 22, 24→25), yielding a total of 80 occurrences out of a possible 84.

Following the abdomen/pelvis, insects were observed on the thorax, arms, and legs two days after arrival (day 11). No notations were made on the thorax on one occasion in July (day 21) and on two occasions in August (days 24→25). Total occurrences were 79. No occurrences were noted on the arms on two occasions in July (days 20→21) and on four occasions in August (days 22, 27→29), yielding a total of 76 occurrences. No occurrences were noted on the legs on two occasions in July (days 20→21) and on eight occasions in August (days 22→29). Total occurrences equaled 72.

Carnivore/Rodent Activity

The structure and cage successfully prevented carnivore and rodent activity.

Skeletonization

Skeletonization did not occur on A.

Skeletonization initially occurred on the arms and legs of B four days after introduction to ARF (day 11). Noted occurrences equaled 82 each (Figure 3.17).

Following the arms and legs, skeletonization was noted on the head/neck region

Figure 3.17. Skeletonization (B). Skeletonization has occurred based on visual assessment of the tibia and fibula of the right and left legs.

five days after initial observations (day 12), yielding a total of 81 occurrences.

Skeletonization was then noted on the abdomen/pelvis region of B nine days after introduction (day 16), accumulating a total of 77 occurrences.

Finally, skeletonization was recognized on the thorax 37 days after arrival (day 44), yielding a total of 49 occurrences.

Skeletonization did not occur on C.

Skeletonization occurred initially on the head/neck and arms of D six days after introduction to ARF (day 15), yielding a total of 78 occurrences each.

Following the head/neck and arms, skeletonization occurred on the abdomen/pelvis on day 16, yielding a total of 77 occurrences.

Following the abdomen/pelvis, skeletonization occurred on the thorax and legs eight days after arrival (day 17), accumulating a total of 76 occurrences each.

Insect Activity

The initial and final notations of the insects affiliated with the members of the control group (B and D) demonstrated a generalized successional pattern initiated by blow fly activity followed by an overlap due to the introduction of other types of flies and beetles (Goff 1993, Goff 2000, Merritt n.d.). Yet despite the gap that persisted between the blow fly's delayed arrival and the introduction of other flies and beetles, the initial and final notations of the insects attracted to the outside of the structure illustrated a successional pattern similar to the control group insects.

Insects that managed to cross the constructed barrier included scuttle flies (A and C) and at least one blow fly that resulted in one blow fly life cycle (C) (Appendix B).

Control Group: B

Adult blow flies were attracted to B upon arrival to ARF (day 7) and were last noted in the vicinity on day 16. Blow fly eggs were observed on day 8, with maggots appearing on day 9. Hence, evidence of a maggot mass was initially recorded on day 9 and was maintained through day 15. As a result, two maggot migrations were witnessed thereafter (days 15.5, 18).

Initial and final notations of other flies involved black soldier flies (days 14, 73), flesh flies (days 14, 83), minute scavenger flies (days 60, 73), black scavenger flies (days 67, 75), and house flies (day 76).

Initial and final notations of beetles observed on or near B included the American carrion beetle (days 9,11) and red-legged ham beetles (days 14, 96).

Other insects affiliated with B involved ants (days 8, 96), which caused postmortem artifacts on days 8 and 9, wasps (days 14, 84), brown moths (days 14, 31), pillbugs (days 33, 91), and orange flies (?) (days 33, 93).

Control Group: D

Adult blow flies were attracted to D upon arrival to ARF (day 9) and were last recorded on day 94. Blow fly eggs were noticed the same day as arrival (day 9), thereby producing maggots on day 10. Although a maggot migration took place on day 18, notations continued until day 21.

Initial and final documentation of other flies included flesh flies (days 9, 79), black scavenger flies (days 10, 55), black soldier flies (days 13, 72), minute scavenger flies (days 42, 63), and house flies (days 52, 87).

Initial and final notations of beetles included American carrion beetles (days 11, 14), hairy rove beetles (days 13, 14), red-legged ham beetles (days 13, 96), and clown beetles (day 16).

Other insects noted in the vicinity of D were ants (days 10, 96), wasps (days 9, 76), brown moths (day 13), orange flies (?) (days 19, 91), and pillbugs (days 25, 90).

Experimental Group: Outside of the Structure

Initial and final notations of flies outside of the structure involved flesh flies (A: days 3, 114; C: N/A, day 86), blow flies (A: days 11, 120; C: N/A, day 92), black soldier flies (A: days 49, 100; C: days 21, 72), house flies (A: days 58, 96; C: days 30, 68), black scavenger flies (A: days 72, 79; C: days 44, 51), and minute scavenger flies (A: days 81, 87; C: days 53, 59).

Initial and final notations of beetles included American carrion beetles (A: days 13, 18; C: N/A, N/A), clown beetles (A: days 45, 114; C: days 17, 86), hairy rove beetles (A: day 49; C: day 21), red-legged ham beetles (A: days 66, 112; C: days 38, 84), and burying beetles (A: day 73; C: day 45).

Other insects documented outside of the structure involved wasps (A: days 26, 120; C: N/A, day 92), pillbugs (A: day 67; C: day 39), brown moths (A: day 71; C: day 43), and ants (A: days 75, 107; C: days 47, 79).

Experimental Group: A

Scuttle fly larvae were initially observed on A on day 19, with scuttle fly puparia appearing on day 22. However, scuttle fly adults were not apparent until day 65.5. All

three mentioned stages were consistently noted throughout, from the initial date of notation to the end of observations.

Other insects recorded in affiliation with A included one burying beetle (day 31), one blow fly (days 56.5, 57.5, 67.5), and one red-legged ham beetle (day 57.5).

Experimental Group: C

The first indication of insect activity in relation to C involved the siting of a burying beetle near the left foot on day 9.5. The next day (day 10.5), one scuttle fly larva was noticed, with puparia and adults appearing on days 14.5 and 37.5 respectively. All three mentioned stages of the scuttle fly were consistently noted until the termination of observations.

One hairy rove beetle was observed (day 16.5) in the vicinity of C prior to the initial documentation of blow fly activity. Blow fly maggots were discovered near the mouth on day 19.5, with indications of a maggot mass forming in the nostrils on day 20.5. Hence, a corresponding maggot migration was witnessed the following morning (day 21.5). Adult blow flies were initially noted inside the structure on day 27.5, with a recorded count of over 50 residing on the ceiling above C's head the next day (day 28.5). None of the members of the new generation were able to produce eggs, and the existing blow flies eventually died within the structure (days 30.5→39.5).

Other insects included a pillbug noted in the vicinity of C on day 34.5.

Environmental Variables

Environmental conditions during the seasonal observation time frame of each subject were representative of a hot and humid summer, punctuated by an occasional afternoon rainfall.

The results of the temperature t-test supported the use of the weather station for both the bottom and top of the hill in future studies, while the humidity t-test results suggested the use of readings recorded in the vicinity of each donation (Appendix C).

Temperature

Seven out of the eight independent population t-tests for temperature reflected no significant differences ($p = .05$) between subject-specific and weather station readings. As a result, the temperature data for this study is presented as average weekly high and low temperatures (degrees Centigrade) as recorded by the observer at the location of each subject, with the understanding that the weather station could be used to record temperature data in future studies conducted at both the top and bottom of the hill.

The average high and low temperatures for A's first week (days 0→6) were 29 and 19, while the average high and low temperatures for B (days 7→13) were 30 and 23. C's high and low temperatures for the first week (days 2→8) were 30 and 22, and D's (days 9→15) were 29 and 21.

The average high and low temperatures of the second week for A (days 7→13) were 30 and 22, while the average high and low temperatures of the second week for B (days 14→20) were 26 and 21. Coincidently, the average high and low temperatures of the second week for C (days 9→15) and D (days 16→22) equaled 30 and 23.

The average high and low temperatures of the third week for A (days 14→20) and C (days 16→22) were 32 and 22, while third week averages equaled 29 and 21 for B (days 21→27) and 30 and 21 for D (days 23→29).

The average high and low temperatures of the fourth week for A (days 21→27) were 30 and 22. Average temperatures for B (days 28→34) were 30 and 23; yet, the average high and low temperatures of the fourth week for C (days 23→29) and D (days 30→36) equaled 32 and 21.

High and low temperature averages of the fifth week for A (days 28→34) were 28 and 22, while B's fifth week (days 35→41) averages equaled 30 and 21. The average high and low temperatures of the fifth week for C (days 30→36) were 33 and 21, and D's fifth week (days 37→43) averages equaled 31 and 21.

High and low temperature averages of the sixth week for A (days 35→41) were 30 and 23, while the sixth week averages for B (days 42→48) equaled 32 and 21. The sixth week average high and low temperatures for C (days 37→43) were 33 and 22, and D's sixth week (days 44→50) averages equaled 31 and 21.

A's seventh week (days 42→48) high and low temperatures were 32 and 22, while B's seventh week (days 49→55) temperatures equaled 31 and 21. C's seventh week (days 44→50) high and low temperature averages were 31 and 20, and D's seventh week (days 51→57) averages equaled 32 and 21.

The eighth week high and low temperature averages for A (days 49→55) were 32 and 21, while the eighth week averages for B (days 56→62) equaled 31 and 21. C's eighth week (days 51→57) high and low temperature averages were 35 and 21, and D's eighth week (days 58→64) averages equaled 32 and 20.

A's ninth week (days 56→62) high and low temperature averages equaled 33 and 22, and B's ninth week (days 63→69) averages were 32 and 21. The ninth week high and low temperatures for C (days 58→64) were 30 and 20, while D's ninth week (days 65→71) averages were 27 and 21.

The tenth week high and low temperature averages for A (days 63→69) equaled 34 and 22, while the tenth week averages for B (days 70→76) were 32 and 20. The tenth week averages for C (days 65→71) were 28 and 20, and the tenth week averages for D (days 72→78) equaled 23 and 18.

The eleventh week high and low averages for A (days 70→76) were 30 and 21, while the eleventh week high and low temperature averages for B (days 77→83) were 27 and 21. The eleventh week averages for C (days 72→78) were 23 and 18, and the eleventh week averages for D (days 79→85) equaled 27 and 19.

The twelfth week high and low temperature averages for A (days 77→83) equaled 35 and 21, while the twelfth week averages for B (days 84→90) and D (days 86→92) were 23 and 18. The twelfth week high and low averages for C (days 79→85) equaled 25 and 19.

The thirteenth week high and low temperature averages for A (days 84→90) were 32 and 20, while the final week averages for B (days 91→96) equaled 27 and 19. The final week temperature averages for C (days 86→92) were 21 and 16, and the final week averages for D (days 93→96) equaled 22 and 16.

A's fourteenth week (days 91→97) high and low temperature averages were 28 and 21, while the fifteenth week (days 98→104) averages equaled 21 and 18. The sixteenth week temperature averages for A (days 105→111) were 27 and 20, and the

seventeenth week (days 112→118) averages equaled 22 and 16. The final week high and low temperature averages for A (days 119→120) were 19 and 16.

Humidity

Five out of the eight independent population t-tests for humidity did not reflect significant differences ($p = .05$) between subject-specific and weather station readings. However, the p-values were lower in comparison to the results of the temperature t-tests, indicating that caution should be used when applying weather station humidity readings to future studies conducted at both the top and bottom of the hill.

In response to the results of the humidity t-tests, the subject-specific and corresponding weather station data were converted to categorical data, maintaining the divisions as indicated on the Springfield brand hygrometer: Very Dry = 10-40%; Normal = 41-70%; and Humid = 71-100%. With the understanding that these categories represent benchmarks along a continuum, the daily high and low humidity readings determined whether humidity levels reached very dry and normal, normal and humid, or very dry, normal, and humid each day. Hence, the total number of days in which humidity reached very dry, normal, and humid were calculated for both the subject and weather station within each observation time frame. As a result, the humidity data for this study is presented as a comparison between subject-specific and corresponding weather station categorical data.

Subject-specific humidity data for A indicates that conditions met the criteria for Very Dry on 28 days, Normal on 79 days, and Humid on 87 days. The weather station

data for the corresponding observation time frame suggests that conditions matched Very Dry on 24 days, Normal on 67 days, and Humid on 86 days.

Subject-specific humidity data for B suggests that conditions never matched Very Dry. However, the weather station readings indicate that conditions met the criteria on 24 days. B's data implies that conditions fell within the Normal category on 60 days and within the Humid category on 86 days. Corresponding weather station data suggests that conditions reached Normal on 64 days and Humid on 82 days.

The subject-specific humidity conditions for C indicate that Very Dry was reached on 28 days, while readings matched conditions within the Normal and Humid categories on 73 and 78 days respectively. The corresponding weather station readings indicate that Very Dry conditions were met on 20 days, while Normal and Humid conditions were recorded on 60 and 76 days.

Subject-specific humidity data for D implies that conditions never matched Very Dry. However, the corresponding weather station data indicates that conditions met the criteria on 20 days. D's data suggests that conditions fell within the Normal category on 57 days, and the Humid category on 81 days. The weather station readings imply that Normal and Humid conditions were reached on 58 and 73 days respectively.

Rainfall and Sky Conditions

Rainfall amounts were recorded (in.) at site-specific locations, with totals calculated at the end of observations. Hence, the rainfall data is organized and presented as total rainfall amounts specific to the observation time frame of each subject.

Total rainfall (in.) for the time frame of A was 6 9/10; 13 9/10 for B; 6 2/10 for C;

and 12 6/10 for D.

Notations of sky conditions were categorized as Clear, Partly Cloudy, or Mostly Cloudy. Five days were noted as Clear, 81 days as Partly Cloudy, and 35 days as Mostly Cloudy during the observation time frame of A. Four days were recorded as Clear, 66 days as Partly Cloudy, and 20 days as Mostly Cloudy for B. Three days were nominated as Clear and 61 days as Partly Cloudy for C and D, while C's time frame included 27 Mostly Cloudy days and D's time frame contained 24.

Decomposition Progression of Each Donation

While the members of the control group (B and D) followed the typical progression as represented by Bass's (1997) nomenclature for decomposition in a natural and uncontrolled environment, the members of the experimental group (A and C) progressed according to stages of decomposition designated by Payne (1965) for pigs in an insect-free environment.

Control Group: B

The condition of B clearly reflected the circumstances surrounding the events prior to placement at ARF. With whereabouts unaccounted for within an approximate four-day time frame (6-28-02→7-01-02), B was eventually discovered sitting in a chair inside her place of residence. Consequently, livor mortis manifested on this apparent casualty of C.O.P.D. as red and purple discoloration on the ankles and feet respectively, while skin slippage occurred as a result of bullae formation on the lower legs. In addition to livor mortis and skin slippage, putrefaction had commenced at some point prior to

arrival to ARF. Hence, during the elapsed time frame including the missing period prior to discovery and time spent at the morgue (days 0→7), green discoloration appeared on the abdomen/pelvis region, along with black marbling located specifically on the right upper leg.

Blow flies were attracted to B within minutes after placement in a shady area at ARF. As a result, blow fly eggs were observed the following day (day 8), specifically in the pelvic area, the mouth, and around the eyes. Concomitantly, ants were noticed on all parts of the body, producing postmortem artifacts that facilitated additional environments for blow fly eggs and potential skin slippage.

Although maggot activity was initially noted in the eyes, nose, and mouth on day 9, blow fly eggs located in areas of skin slippage yielded maggots as well. By day 10, B's skin had slipped consistently in all regions, with maggots feeding on the tissue underneath the epidermal layer. Further evidence supporting the passage from the Fresh stage to the Bloated stage included swelling in the thorax and abdomen/pelvis regions (day 11), with indications of skeletonization in the head/neck region (day 12). Interestingly, the arms and legs seemed to accelerate towards the Decay stage via skeletonization on day 11.

While the Decay stage typically becomes apparent after the body has deflated and maggot activity has declined, in the case of B, maggot activity appeared to increase upon deflation of the abdomen/pelvis (day 13). Hence, maggots located inside the body exited via the pelvic region and proceeded to feed on the remaining tissue on all regions. This maggot mass was sustained through day 15, seemingly unaffected by the heavy rainfall that occurred that afternoon. However, a maggot migration was witnessed during

a temperature reading (5:00) the next morning (day 15.5), with indications of skeletonization in the abdomen/pelvis region noted that afternoon (day 16).

The progression towards the Dry stage commenced after a lingering maggot migration on day 18. Although adipocere formation was recorded on day 23, the remaining tissue in all regions began to show signs of desiccation by day 26. By day 78, all exposed bones were dry and the remaining tissue was completely desiccated.

Despite the unique circumstances prior to placement at ARF, B demonstrated a decomposition progression typical of stages outlined in Bass (1997), excluding Bone Breakdown (i.e., Fresh, Bloated, Decay, Dry). However, the rate of progression may or may not have been manipulated by specific environmental variables. Average low and high temperature readings ranging from 21 to 30 (degrees Centigrade) during the first two weeks greatly encouraged insect activity, which in this case is considered as an environmental variable as well. Maggot activity continued until the first heavy rainfall, which averaged about 1 7/10 inches in one afternoon. Whether this particular rainfall stimulated the initial maggot migration is uncertain. As for the consistency of the tissue remains, humid and humid to normal conditions may have delayed complete desiccation. Yet in regards to sky conditions, cloud cover may not have been a factor since B was located in a shady area.

Control Group: D

The information provided concerning the circumstances prior to the arrival of D was not as detailed as in the case of B; yet, it is certain that D developed brain cancer at some point and had been deceased since 7-10-02. Indications of a type of pink/red, rather

than purple, lividity may suggest that D was placed in a cold environment not long after death (Clark et al. 1997). Yet, in reference to the green discoloration located on the thorax and abdomen/pelvis regions, it is questionable as to whether it is due to the destruction of the biliary structures (Gill-King 1997) or is the reflection of exposure to an inconsistent environment, thus supporting bacterial proliferation.

Due to the blow fly's initial attraction to the body, blow fly eggs were noted in the nose approximately one hour after introduction to ARF. However, maggot activity recorded in and around the nose, mouth, and eyes the following day (day 10) supported the rapid progression towards the Bloated stage. At the same time, eggs were noted in the pelvic region and within some areas of skin slippage. On day 11, maggots were active in the pelvic area, while bloating was noted in the abdomen/pelvis region. By day 12, skin slippage had commenced on all regions, with maggots feeding underneath the epidermal layer. Hence, bloating was recorded in all regions on day 13, along with the formation of a maggot mass in the pelvic area. Yet, compared to B, a smaller number of maggots moved beyond this area, allowing marbling and continuing discoloration to remain visible.

Progression from the Bloated to the Decay stage became evident upon deflation of all parts on day 15, with maggots exiting the body via the pelvic region. While skeletonization was initially noted on the head/neck at this time, all regions showed signs by day 17. A maggot migration was witnessed the next day (day 18) following an afternoon rainfall (3/10 in.). As a result, adipocere was noticed on the arms and legs on day 19, with all parts affected by day 24. Also desiccation had commenced on all regions by day 23, with fungus/mold noted on most regions by day 68. However, complete

establishment within the Dry stage did not occur until day 86.

As in the case of B, D demonstrated a decomposition progression typical of stages outlined in Bass (1997), with the exception of Bone Breakdown. Similarly, the rate of progression may or may not have been manipulated by environmental conditions. For example, as with B, average low and high temperature readings ranging from 21 to 30 (degrees Centigrade) during the first two weeks of observations greatly encouraged insect activity, while it is uncertain as to whether the rainfall occurring on day 18 affected the witnessed maggot migration. In regards to the tissue remains, similar humidity conditions, as experienced by B, may have also delayed the complete desiccation of D. Also, due to the placement within a shaded area, it is uncertain as to the role cloud cover played in the decomposition of D.

Experimental Group: A

A's circumstances prior to placement at ARF revolved around the medical history provided at the time of donation. While single heart by-pass surgery was conducted approximately seven years prior to death, at some point a drug regiment aimed at lowering high cholesterol and triglyceride levels was introduced. More recent information included diagnosed Diabetes and Lung Cancer. Yet, whether or not the medical history had any relationship to the condition of the body and/or the visual cues affiliated with the decomposition process remains uncertain.

Red, purple, and black bruises were noted along the arms of A upon the arrival to ARF (day 0); yet by day 2, a small patch of yellow-brown discoloration had appeared in the lower right quadrant of the abdominal region. While the feet began to show signs of

pink/red and purple discoloration, by day 3 purple and brown were added to the knees. At this time, brown discoloration appeared to be spreading along the head/neck, thorax, and arms. Some type of fungus/mold was observed in the mouth on day 4, along with the first indications of marbling resembling varicose veins originating from the original patch of brown discoloration. By day 7, brown had continued to spread along the abdomen/pelvis region and thighs, while blue appeared on the thorax. Black was noted on the head/neck, abdomen/pelvis, and legs by day 9.

On day 10, odor was detected as red liquid was observed bubbling in the mouth. By this time, marbling was established in all regions. Skin slippage due to bullae formation was noted on the arms on day 12, while green discoloration had occurred on both the arms and the head/neck region. Yet by day 13 red fluid was observed draining from the back of the head, while simultaneously filling the mouth. Hence, the same fluid was witnessed flowing from underneath the thorax region the following day. Meanwhile, thick purple marbling had become quite distinct in the thorax region, specifically on the right pectoral area.

Although bubbling fluids flowing from the nose and mouth were noted in conjunction with bloating in Payne's (1965) description of insect-free pigs, in the case of A, the initial observation of this bubbling fluid, along with other indicators including green discoloration in the inguinal regions and the purple and black coloration of the genitals (day 15), was considered as a precursor to the Bloating and Decomposition stage. Hence, bloating was initially observed along the abdomen on day 16, followed by the scrotum, neck, thorax, arms (day 17), head (day 19), and legs (day 20).

On day 19, purge fluid was witnessed overflowing from the mouth, while

continuing to drain from the back of the head. By day 20, the same fluid could be seen flowing from the ears as well. When the tongue had sealed the mouth (day 21), the fluid continued to propel through the nose and ears. While the build-up of purge fluid continued to make the face unrecognizable (day 24), the skin, beginning with the upper thorax and arms (day 21), became "oily and greasy" (Payne 1965:598). However, by day 26, the feet and hands began to show signs of desiccation. Also by this time, the coloration of the body, including the marbling, had darkened with red spreading across the abdomen.

While maintaining the steady progression through the Bloating and Decomposition stage, A experienced some physical changes as a result of the rainfall that occurred on day 27. Hence, adipocere and fungus/mold were noted on all regions the following day (day 28). In addition, periodic rainfall seemed to facilitate skin slippage over the right pectoral area and along the inguinal regions (day 34), while preserving the appearance of marbling. As fluids continued to flow through the nose and ears (day 35.5), a darker brown began to spread on all regions with the abdomen reflecting red and black (day 36.5).

Evidence of deflation in the head/neck and abdomen/pelvis regions initiated the passage into the Flaccidity and Dehydration stage. On day 45.5, the tongue began showing signs of retraction, while the scrotum appeared wrinkly. The same wrinkled appearance eventually occurred on the arms (day 53.5), legs (day 55.5), thorax (day 60.5), and neck (day 62.5). Although the scrotum was greatly imploded by day 61.5, the abdomen did not show signs of deflation until day 75.5. Fluid loss continued, while the body remained "soft and flabby" (Payne 1965:598). Adipocere formation continued in

conjunction with each rainfall until the end of observations (day 119.5).

Despite the individual status described in the medical history, A proceeded to follow Payne's (1965) progression of decomposition (i.e., Fresh Stage, Bloating and Decomposition, Flaccidity and Dehydration), with the exception of the Mummy Stage and Desiccation and Disintegration. Although it was clear that A was progressing towards the Mummy Stage at the termination of observations, complete establishment within this stage did not occur within the observation time frame. Reasons for this determination included notations of lingering fluid drainage from the head/neck, thorax, and abdomen/pelvis regions; constant odor detection; and the maintenance of tissue consistency. However, as A was evacuated from the structure (11-04), it was noted that fluid drainage had ceased, and at some point the remaining fluids had dried onto the platform.

Specific factors, including limited insect activity and environmental conditions, may or may not have affected the rate of progression. In the case of A, isolation of insect activity as a situational factor is defined in terms of the relationship of scuttle fly activity to the remains. Although several generations of the larval stage were witnessed feeding on the body, the extent of these events in terms of rate of decomposition is difficult to ascertain. Similarly, the effects of temperature can only be relayed in terms of scuttle fly activity and bacterial growth. In this case, average weekly high temperatures ranging mostly in the upper-20s to mid-30s and average weekly low temperatures falling mostly within the lower-20s (degrees Centigrade) encouraged scuttle fly activity and bacterial proliferation. As for the influence on the rate of progression, winter data must be collected in order to make a proper comparison.

Even though dry conditions were noted in the vicinity of the structure, the mostly humid and humid to normal conditions may have delayed desiccation of some regions. The rainfall occurring on day 27, followed by periodic episodes totaling 6 9/10 inches, increased adipocere formation and seemed to enhance skin slippage. Yet, due to the absence of vegetation directly above the structure, sunlight allowed the remains to dry and the colors to revert to their previous state.

Experimental Group: C

Similar to A, C's individual circumstances prior to placement at ARF revolved around the medical history available at the time of donation. Earlier information mentioned the occurrence of a heart attack approximately twenty years prior to death, followed by a stroke one year later. Also, the development of high blood pressure was noted at some point; yet, treatments for this condition were not listed. More recent information included diagnosed Lung Cancer, followed by diagnosed Brain Cancer approximately one month prior to death. However, as with A, it is uncertain as to whether or not the medical history had any effect on the condition of the body and/or the visual cues affiliated with the decomposition process.

While pink lividity was noted during initial observations (day 2), evidence of putrefaction was observed as green and purple discoloration formed in the abdomen/pelvis region the following day (day 3). Yet, after the pink lividity had progressed to purple (day 4), green discoloration began to spread along the boundary between the thorax and abdomen (day 5). Marbling appeared as purple on the thorax, green and purple on the arms, and purple on the head/neck region by day 7.5; however,

marbling was not recorded on the abdomen/pelvis region until the next day. Also on day 7.5, odor was detected as blood drained from the back of the head.

In the case of C, odor detection served as the precursor to the Bloating and Decomposition stage. Hence, initial indications of bloating were observed in the abdomen/pelvis, thorax, and head/neck regions on day 9.5, as marbling and skin slippage were noted on the legs. However, by day 10.5 the face and eyelids were obviously swollen with blood draining from the eyes and ears, while the tongue appeared to protrude as green purge fluid propelled through the nose and mouth. Also at this time, brown discoloration was noted in the inguinal regions as a possible contributor to the scrotum's bloated condition, while the presence of bullae compounded the arms' bloated appearance. Hence, the continuing separation of the epidermal layer eventually resulted in skin slippage on the left hand.

By day 11.5, all regions were bloated. As a result, the arms abducted away from the body midline, while the knees pulled towards the chest (day 12.5). As noted on the arms, bullae extended over the thighs and along the sides of the abdomen/pelvis region. Green and purple discoloration was noted along the inguinal regions on day 13.5, as purple reflected from the inner thighs adjacent to the scrotum. However, by day 17.5 black had appeared in the inguinal regions, and green was added to the inner thighs. Also at this point, purging from the nose and mouth began to decline, while red and brown sludge continued to drain from the ears.

The initial indication that C had entered the Flaccidity and Dehydration stage in Payne's (1965) progression was the slightly wrinkled appearance of the scrotum noticed on day 20.5. Deflation continued on day 21.5 with the slow retraction of the tongue,

followed by the wrinkling of the thorax (day 24.5), the arms and legs (day 25.5), the neck (day 26.5), and the abdomen (day 28.5). As all regions continued to implode, the discolorations and marbling appeared darker (day 33.5), ultimately causing the remaining tissue to reflect red, brown, and black (day 43.5).

Similar to A, C followed the decomposition progression outlined in Payne (1965), with the exception of the Mummy Stage and Desiccation and Disintegration. Hence, at the termination of observations (day 91.5), it was clear that C was steadily proceeding through the Flaccidity and Dehydration stage. Although fluid loss remained constant, the tissues demonstrated no signs of desiccation. As a result, C maintained a "soft and flabby" (Payne 1965:598) appearance, while reflecting evidence of continuing skin slippage.

However, specific environmental and situational factors may or may not have affected the rate of progression along the decomposition continuum. In the case of C, limited insect activity involved continuous scuttle fly activity along with one recorded blow fly invasion. While it is uncertain as to the insects' contribution to the rate of decomposition, careful examination of C during the blow fly invasion yielded interesting observations.

On day 19.5, a maggot unlike the previously noted scuttle fly larva was sighted near the mouth of C; hence, the evidence of a maggot mass was present in the nostrils the following morning (day 20.5). Yet, it became clear after the witnessed maggot migration (day 21.5) that the larvae had been the source of postmortem artifacts on the head/neck, thorax, and arms. Feeding on the surface of these regions, the maggots facilitated hair slippage (day 19.5) and caused the tissues to take on a liquid consistency. Evidence of

this was found on the platform and in the fluid surrounding these regions. The maggots also left trails in this fluid as they fed and later migrated onto the tarp.

Yet, there were also indications of feeding inside the body, especially within the head/neck region. Support for this included notations of flared nostrils and distended lips, despite the protruding tongue. Also, one must question whether or not this maggot activity facilitated deflation. In any case, the next generation of blow flies were not attracted to the remains (day 28.5). Unable to escape to the outside, they eventually died inside the structure (days 30.5→39.5).

Environmental conditions involving temperature, humidity, rainfall, and sky conditions may or may not have influenced the rate of progression. As in the case of A, the effect of temperature on the decomposition of C can only be considered in terms of insect activity and bacterial growth. Hence, similar average weekly high and low temperatures (degrees Centigrade) as recorded with A supported both scuttle fly and blow fly activity, as well as bacterial proliferation. Yet in terms of the rate of decomposition, winter data must be collected for a proper comparison.

The mostly humid and humid to normal conditions, as well as periodic rainfall totaling 6 2/10 inches, discouraged desiccation of the tissues. Yet, each rainfall encouraged adipocere formation and allowed fungus/mold to thrive on the body. While the rain seemed to enhance skin slippage, direct sunlight permitted the remains to dry and revert to previous coloration.

Chapter 4:
Discussion

Due to the natural relationship established between carrion-related insects and human remains, it has been demonstrated in both the anthropological and entomological literature that insects not only affect the rate of human decomposition via soft tissue disintegration, but also possess the ability to manipulate the effects of autolysis and putrefaction as perceived by the senses. Yet, in the effort to better understand the process of human decomposition, insect activity was restricted, thus allowing the effects of such internal factors to be observed at a decreased rate. However, as representative of an experimental design embedded within an overall scientific methodology, the results of this study involving observations of the visual and olfactory cues of human decomposition and notations of insect activity and environmental variables, coupled with articulated progressions, are compared to the literature from the situated perspectives of both the experimental (A and C) and control (B and D) groups.

Visual and Olfactory Cues Indicative of Human Decomposition

According to Teather (1994) skin discoloration affiliated with human decomposition follows a sequence ranging from pink to blue, followed by green, purple, brown, and black. However, the results of this study support patterns of specific coloration attributed to the effects of livor mortis and the release of bile pigments into the tissues and vascular system as a consequence of the destruction of biliary structures and hemolysis (Clark et al. 1997, Gill-King 1997). While the initial effects of livor mortis

were difficult to track immediately following the placement of A and C onto the platforms, lividity was clearly visible on B and D upon arrival to the Anthropology Research Facility (ARF). Although the pink coloration suggested that D was exposed to a cold environment prior to arrival (Clark et al. 1997), the coloration eventually progressed to red, then purple following placement. However, red and purple were noted on B's ankles and feet respectively, illustrating how livor mortis manifests when the postmortem interval is spent in a seated position.

The oxidation state of the bile pigments circulating among the tissues and within the vascular system further contributed to skin discoloration (Gill-King 1997). Occurring as a result of either the diffusion of sulfhemoglobin (Clark et al. 1997) or biliverdin (Gill-King 1997), generalized green discoloration was noted on the abdomen/pelvis region of B and D at arrival. Yet, as suggested by Clark et al. (1997) and Dix and Graham (2000), green originated from areas of livor mortis on C and continued to spread along the sides of the thorax and abdomen/pelvis regions towards the body midline as decomposition progressed. However, according to Gill-King (1997), the oxidation state of the bile pigments could reflect red, brown, and blue as well, such as in the case of the discoloration of the abdomen/pelvis and thorax regions of A. The occurrence of marbling as a result of hemolysis and the spread of bile pigments and hydrogen sulfide within the vessels of the outer tissue layers reflected blue (Clark et al. 1997), green, purple, and black (Gill-King 1997). Interestingly, despite variations in initial coloration, the marbling of all subjects followed a continuum ranging from "green to purple to black" as suggested by Gill-King (1997:101).

Gases produced as a by-product of bacterial action within an increasingly acidic environment eventually caused swelling in most regions (Dix and Graham 2000, Clark et al. 1997, Fisher 1980, Gill-King 1997, Vass et al. 2002, Love 2001). According to Gill-King (1997), Vass et al. (2002), and Love (2001), these forensically significant gases have been identified and are known to include hydrogen, methane, ammonia, hydrogen sulfide, and carbon dioxide. Yet, unlike the perceived correlation between color changes and certain biochemical reactions, the gases that caused bloating in this study yielded no visual and few olfactory signatures. However, bloating patterns reflected by A, C, and D are comparable to previous documentation. According to Clark et al. (1997), bloating occurs initially in the head/neck region as the face begins to swell, followed by the abdomen, and in males, the scrotum. Yet, initial indications of bloating were recognized in the abdominal area of A, followed by the scrotum and later the head. In the case of C, the abdomen and head bloated simultaneously, with the scrotum noted at full bloat the next day. Although female, D demonstrated a similar pattern regarding the abdomen/pelvis and head/neck regions. As a result, a generalized pattern was recognized among the members of this study: abdomen/pelvis→thorax→head/neck→arms and legs, which contrasts with Clark et al.'s (1997) pattern: head→abdomen→scrotum.

Unlike observations of regional bloating patterns, the detection of regional odor patterns is considered inherently subjective in nature. Generalized odor detection can also be arguably subjective; however, the results of this study yielded comparable timing patterns, with odor detection in affiliation with B and D restricted to a sustained time frame, lasting 31 and 30 days respectively, and A and C continuing through the end of observations. Yet, despite these observed patterns, the data collection methods did not

allow for the identification of specific odor causing compounds, as in the case of Love (2001). Similarly, certain odoriferous substances such as methane, ammonia, putrescine, and cadaverine (Gill-King 1997, Vass et al. 2002) have been identified and reported in the literature, along with fermentation products such as acetone and alcohol (Gill-King 1997). In addition to the quantification of such odoriferous compounds, inadvertent qualification is reflected in the literature, hence describing odor associated with putrefaction as unpleasant (Gill-King 1997) and foul-smelling (Fisher 1980). Yet, while Payne (1965:598) associated "fermenting fruit juices" with the odor detection of insect-free pigs, similar observations were appreciated in reference to A and C (i.e., analogous to household ammonia and fingernail polish remover [acetone]), but were not quantified due to the restrictive nature of the data collection methods.

According to Clark et al. (1997) and Fisher (1980), a dark malodorous or foul-smelling bloodstained fluid, propelled by gases produced during the putrefactive process, can be observed flowing from the mouth, nose, eyes, ears, and rectum (Clark et al. 1997, Vass et al. 2002). Similarly, red, green, and later brown fluid was observed draining from the head/neck and abdomen/pelvis regions of A and C. While the colors of the fluids were appreciated, they were not noted in the color categories due to their inability to contribute to overall skin discoloration.

Skin slippage is a consequence of autolysis at the skin's dermal-epidermal junction, resulting in the detachment of the epidermis from the dermis (Fisher 1980, Clark et al. 1997, Dix and Graham 2000, Bass 1997, Love 2001). While this phenomenon was observed on all subjects of this study, variations in the timing of sustained occurrence existed between the members of the control and experimental

groups. In reference to A and C, fluid-filled pockets, or bullae as described by Clark et al. (1997), were visible as the epidermis proceeded to detach from the dermis. Yet, even after these fluids had drained, the epidermis maintained the appearance of sloughing. Hence, even though autolysis may have ceased at some point during observations, skin slippage was considered to be "present" as long as the epidermis remained attached. Alternatively, the occurrence of maggot activity underneath B and D's epidermal layer appeared to facilitate skin slippage. Consequently, the sloughing of the epidermis did not take more than eight days to complete. A similar occurrence involving hair slippage was observed following the notations of blow fly maggot activity in the head/neck region of C. While hair slippage typically results from autolysis in the scalp region (Dix and Graham 2000), the feeding of these maggots facilitated this process as well.

Various types of molds (Bass 1997) and fungi (Galloway 1997) frequent human remains in moist, humid conditions. Hence, similar varieties of green and black fungi and/or molds were noted on A, B, and D, while a white/fuzzy fungus or mold was noted on A and C, specifically on areas in contact with the platform. However, dry conditions encourage desiccation of remaining tissues (Galloway 1997). While C never revealed signs of desiccation, A's hands and feet were considered. Similarly, desiccation was noted on B and D's arms, head/neck, and legs and arms and legs respectively prior to other regions. Hence, the results of this study reflect regional desiccation patterns initiated by the extremities.

However, according to Gill-King (1997) and Clark et al. (1997), adipocere can form in both humid and dry conditions provided that either an endogenous or exogenous water source is available. Yet, variations in the consistency of this substance exist

depending on whether sodium (crumbly) or potassium (paste-like) is used in the formative reaction involving the hydrolysis of neutral fats (Gill-King 1997). Hence, even though crumbly and paste-like varieties were appreciated on A and C and crumbly on B and D, due to the data collection methods, both forms were simply noted as adipocere.

Deflation occurs as the gases responsible for bloating rupture (Galloway 1997) and gradually expire from the body cavity and surrounding tissues (Clark et al. 1997). However, while all subjects deflated in terms of air or gas removal, A and C appeared to implode upon deflation as the body tissues in the abdomen/pelvis and head/neck regions were pulled inward, ultimately resulting in the wrinkled appearance of all regions. Hence, the deflation (or implosion) of A and C with minimal insect involvement supports a generalized regional pattern: scrotum and tongue→arms, legs, thorax, neck (A) or thorax, arms and legs, and neck (C)→abdomen. This pattern is comparable to Payne's (1965) observations of insect-free pigs in which he notes that the abdomen was the last region to deflate.

Although Rodriguez and Bass (1985) focused on the decomposition of buried remains, a common sequential skeletonization pattern was realized, initiated by the head/neck region and the extremities. A similar pattern was reflected by B and D, involving the arms, legs, and head/neck and arms and head/neck respectively. Yet, despite the skeletonization of B and D, desiccated tissue remained in areas of joint articulation as observed by Galloway (1997).

Insect Activity

The relationship between insects of forensic significance and human remains is typically perceived and thus analyzed in terms of insect development (Merritt n.d., Anderson 2000, Introna et al. 1991, Wells and LaMotte 1995, Haskell et al. 1997, Goff 1993, Castner 2001, Wells and LaMotte 2001, Goff 2000) and patterns of succession (Goff 2000, Merritt n.d., Krogman and Iscan 1986, Haskell et al. 1997, Anderson 2001, Wells and LaMotte 1995, Rodriguez 1982, Payne 1965). While the documentation methods and limited entomological expertise of the observer did not allow for developmental rate analysis, visual assessment of the insects on or in the vicinity of the remains provided sufficient data for a generalized approach to the recognition of successional patterns. Hence, successional pattern analysis of the insects affiliated with B and D, as well as those attempting to cross the barrier of the insect-restricted environment (in terms of the invasion potential of A and C), are compared to previous insect analyses conducted at the Anthropology Research Facility (Rodriguez 1982) and in South Carolina (Payne 1965).

Yet, the results of the previous studies were expressed as a correlation between visual observations of insects and corresponding stages of decomposition. Hence, to compare the results of the insect successions in this study with Rodriguez (1982) and Payne (1965), a similar approach is considered. However, due to variations in stage nomenclatures, comparisons are conducted in terms of which insects were present prior to bloating, throughout bloating, and upon deflation and beyond. Also, to avoid an exhaustive comparison, a small sample of insects is used to reflect commonalities in the successional patterns representative of each case (Table 4.1).

Table 4.1. Successional Patterns of Insects Noted at the Anthropology Research Facility and in South Carolina*

	Prior to Bloating	Throughout Bloating	Upon Deflation and Beyond
A**	flesh flies, blow flies, American carrion beetles	flesh flies, blow flies, wasps, American carrion beetles, clown beetles, black soldier flies, hairy rove beetles, house flies, red-legged ham beetles, pillbugs, brown moths, black scavenger flies, burying beetles	flesh flies, blow flies, wasps, clown beetles, black soldier flies, house flies, red-legged ham beetles, black scavenger flies, ants, minute scavenger flies
B	blow flies, ants, American carrion beetles	blow flies, ants, American carrion beetles, flesh flies, red-legged ham beetles, black soldier flies, wasps, brown moths	blow flies, black soldier flies, flesh flies, red-legged ham beetles, ants, wasps, brown moths, pillbugs, orange flies, minute scavenger flies, black scavenger flies, house flies
C**	flesh flies, blow flies, wasps	flesh flies, blow flies, wasps, clown beetles	flesh flies, blow flies, wasps, clown beetles, black soldier flies, hairy rove beetles, house flies, red-legged ham beetles, pillbugs, brown moths, black scavenger flies, burying beetles, ants, minute scavenger flies
D	blow flies, flesh flies, wasps, ants, black scavenger flies	blow flies, flesh flies, black scavenger flies, ants, wasps, American carrion beetles, black soldier flies, hairy rove beetles, red-legged ham beetles, brown moths	blow flies, flesh flies, house flies, black scavenger flies, black soldier flies, minute scavenger flies, red-legged ham beetles, ants, wasps, clown beetles, orange flies, pillbugs
Rodriguez (1982)	blow flies, flesh flies, house flies	blow flies, flesh flies, house flies, American carrion beetles, clown beetles, rove beetles	house flies, flesh flies, American carrion beetle, clown beetles, hairy rove beetles, sap beetles, red-legged ham beetles, dermestid beetles, scarab beetles
Payne (1965)	flesh flies, blow flies, wasps, ants	blow flies, flesh flies, house flies, wasps, scarab beetles, clown beetles, hairy rove beetles, American carrion beetles, moth, ants, soldier flies	hairy rove beetles, clown beetles, dermestid beetles, scarab beetles

*A, B, C, D: 2002 (ARF); Rodriguez (1982): 1981→1982 (ARF); Payne (1965): 1962, 1963 (SC); For comparisons, not meant to be exhaustive
**Insects attracted to the outside of the structure are reflected in terms of the invasion potential of A and C.

The fewest number of insects were noted prior to bloating, mainly (with the exception of B) blow flies and flesh flies. The American carrion beetle was spotted outside of the structure and in the vicinity of B before A and B bloated, and ants and wasps were affiliated with Payne's (1965) exposed pigs and B and D and C and D respectively. Black scavenger flies were observed in the vicinity of D, while Rodriguez (1982) noted house flies.

Blow flies, flesh flies, and the American carrion beetle were present outside of the structure as A began to bloat. During this time, wasps, clown beetles, black soldier flies, hairy rove beetles, house flies, red-legged ham beetles, pillbugs, brown moths, black scavenger flies, and burying beetles were also noted. Yet, upon deflation, the American carrion beetle, burying beetles, hairy rove beetles, pillbugs, and brown moths were not present outside of the structure. Minute scavenger flies and ants appeared following deflation.

Blow flies, ants, and American carrion beetles, along with flesh flies, red-legged ham beetles, black soldier flies, wasps, and brown moths, were in the vicinity of B at initial signs of bloating. Upon deflation, the American carrion beetle was no longer noted; however, pillbugs, orange flies, minute scavenger flies, black scavenger flies, and house flies were added.

Clown beetles appeared among the flesh flies, blow flies, and wasps outside of the structure as C began to bloat. However, upon deflation, black soldier flies, hairy rove beetles, house flies, red-legged ham beetles, pillbugs, brown moths, black scavenger flies, burying beetles, ants, and minute scavenger flies were present.

Blow flies, flesh flies, wasps, ants, and black scavenger flies, along with American carrion beetles, black soldier flies, hairy rove beetles, red-legged ham beetles, and brown moths were in the vicinity of D during bloating. Yet, by deflation, the American carrion beetle, hairy rove beetles, and brown moths had departed. However, house flies, minute scavenger flies, clown beetles, orange flies, and pillbugs were added to the succession.

According to Rodriguez (1982), blow flies, flesh flies, house flies, American carrion beetles, clown beetles, and rove beetles were included in the overall succession as the subjects of his study began to bloat. However, following deflation, blow flies disappeared and sap beetles, red-legged ham beetles, dermestid beetles, and scarab beetles appeared.

In addition to the flesh flies, blow flies, wasps, and ants affiliated with Payne's (1965) exposed pigs prior to bloating, house flies, scarab beetles, clown beetles, hairy rove beetles, soldier flies, the American carrion beetle, and moths were present while the pigs were bloated. However, following deflation, only hairy rove beetles, clown beetles, dermestid beetles, and scarab beetles were of significance.

Environmental Variables and Rate of Decomposition

As part of an entomological death scene investigation, Haskell et al. (2001) suggest that the procedure for proper temperature data collection should initially include recording minimum and maximum temperatures in the vicinity of the remains and later correlating these readings with corresponding data provided by the closest National Weather Service (NWS) station for the purpose of obtaining an accurate account of larval

growth rates at the scene. Concomitantly, similar methods have been performed at ARF regarding temperature and the rate of human decomposition (Srnka 2003). Yet, while ARF maintains a self-contained weather station with the ability to record minimum and maximum temperature data, the question remained as to whether this data could be considered analogous to death scene readings or should be treated as data originating from a "nearest weather station." Hence, the results of the independent population t-tests involving temperature readings recorded in the vicinity of each donation and corresponding weather station data supported the acceptance of either group of readings as "death scene" recordings.

A similar question surfaced concerning the application of humidity readings also recorded by ARF's weather station. In response, Haskell et al. (2001) support the recording of relative humidity in the vicinity of the remains. With the use of a psychrometer, collected data in the form of dew wettings and dew points can thus be used to contemplate the effects of moisture on both the remains and ambient temperature (Haskell et al. 2001). However, for the purposes of this study, hygrometers were placed near the donations to record humidity data, which was later compared to corresponding weather station readings. In this case, independent population t-tests results indicate that proper humidity data should originate within the immediate area of the remains as indicated by Haskell et al. (2001).

With the clear understanding of the proper origin of temperature and humidity data specific to this study, the effects of this data, in addition to recorded rainfall and noted sky conditions, were considered in the contemplation of how environmental conditions affected the decomposition rate of each donation. Hence, the results of this

study involving the effects of environmental variables on the rate of progression are compared to previous studies conducted at ARF. According to Mann et al. (1990), ambient temperature plays a significant role in the decomposition process. While the collection of winter data involving decomposition in an insect-restricted environment is needed to isolate the effects of temperature on internal factors (i.e., autolysis, putrefaction) of decomposition, the results of this study allow the overall effects of temperature to be perceived in correlation with insect activity (Mann et al. 1990, Rhine and Dawson 1998). Initially high temperatures (i.e., upper 20s to mid-30s Centigrade) encouraged blow fly invasions of B and D, while increasing the invasion potential and scuttle fly activity of A and C. Further insect activity was also supported by similar temperatures, allowing B and D to reflect typical insect successional patterns (Goff 1993, Merritt n.d.). Hence, the resulting insect activity permitted most regions of B and D to show initial signs of skeletonization by days 16 and 17 respectively, which is comparable to Mann et al.'s (1990) estimate of near or complete skeletonization approximating at two to four weeks.

Mann et al. (1990) also correlate increased humidity with insect activity by explaining how desiccated or dry tissue resulting from decomposition in a desert environment (Galloway et al. 1989, Galloway 1997, Rhine and Dawson 1998) generally reflects minimal insect contribution to tissue disintegration. Yet, while similar effects have been observed at ARF during the winter months (Mann et al. 1990), the seasonal observation time frame of this study (i.e., summer) defined the effects of humidity in terms of humid and humid to normal conditions, which ultimately resulted in the delayed (or in the case of C, discouraged) desiccation of soft tissue.

The determination of the effects of rainfall on the rate of human decomposition can be considered in terms of both the relationship to insect, specifically maggot, activity and overall external effects on soft tissues (Mann et al. 1990). Similar to past observations conducted at ARF, maggot activity was rarely disrupted by periodic rainfall episodes (Mann et al. 1990). While typically regarded as an indoor species (Byrd and Castner 2001), scuttle fly larvae affiliated with A and C responded to the rain by migrating inward, thus continuing to feed internally. Also, blow fly maggot activity affiliated with B was not affected by one afternoon rainfall (see Figure 3.16); however, it is not certain whether or not lingering effects influenced the witnessed maggot migration the following morning. Similarly, in reference to D, a maggot migration was observed following an afternoon rainfall, but in this case the maggots were dispersed rather than organized in a group as with B. Yet, contrary to Mann et al. (1990), rain caused the sloughing of remaining tissue on A and C. In addition, rain provided water and moisture for adipocere formation and fungus and/or mold proliferation.

In reference to recorded sky conditions, Goff (1993) suggests that cloud cover discourages fly activity, while Anderson (2001) similarly correlates sunlight exposure to invasion potential. However, the results of this study only allowed for observations pertaining to the drying of tissues following rainfall episodes (A and C).

Progression of Causal Events Affiliated with Decomposition

Human decomposition is a process that begins with cellular breakdown and ultimately results in skeletal remains. Yet, it has been suggested that under ideal conditions, the internal factors of decomposition (i.e., autolysis, putrefaction) alone

possess the ability to "reduce the body to the skeleton" (Love 2001:2, Clark et al. 1997:156). Therefore, limiting insect access to human remains in this study allowed the effects of such internal factors to be observed and documented. As a result, causal events affiliated with the decomposition of human remains in an insect-restricted environment (A and C) proved analogous to those of the baby pig, *Sus scrofa* Linnaeus, in an insect-free environment (Payne 1965), while the decomposition of B and D concomitantly followed a sequential pattern typical of a natural outdoor setting (Bass 1997).

Familiarity with such generalized sequential patterns of decomposition is reflected in the literature as biologists, pathologists, entomologists, and anthropologists designate certain causal events as benchmarks that function to divide the continuum into stages of decomposition (Clark et al. 1997, Williams 1997, Galloway et al. 1989, Galloway 1997, Love 2001, Marks et al. 2000, Bass 1997, Payne 1965). However, due to the recognition of variable decomposition nomenclatures, the initiation of bloating is used as a common benchmark for the discussion of events known to occur prior to bloating, throughout bloating, and upon deflation and beyond (Table 4.2).

The lingering effects of rigor mortis and livor mortis, specifically in terms of waning rigor and fixed lividity (Clark et al. 1997, Williams 1997) are the initially recognized causal events of decomposition (Clark et al. 1997, Williams 1997, Love 2001, Marks et al. 2000). A further causal sequence noted prior to bloating involves the green or gray discoloration (Galloway et al. 1989, Galloway 1997, Clark et al. 1997, Williams 1997) of the abdominal area followed by discoloration of the thorax and neck (Love 2001, Marks et al. 2000). Similarly, Bass (1997) recognizes the reflection of hemolysis (Clark et al. 1997, Williams 1997) in the vascular system as blue and green marbling.

Table 4.2. Causal Events Affiliated with Decomposition*

Prior to Bloating	Throughout Bloating	Upon Deflation and Beyond
--fixed lividity, waning rigor --abdominal color change→thorax and neck: gray→green --skin slippage --hair slippage --hemolysis→resulting in marbling: blue and green --purging fluids: mouth and nose --odor	--abdominal/body swelling --discoloration of head/trunk --marbling --skin slippage --hair slippage --odor --purging fluids: mouth, nose, rectum --leaching of volatile fatty acids --skin appears black with an oily/greasy consistency --molds --skeletal exposure in areas around the nose and eyes, bony eminences	--release of gases --odor --discoloration appearing dark --volatile fatty acids not detectable→tissue consistency is soft and flabby --slow dehydration --adipocere formation and/or desiccation --fungus and/or mold --bones with remaining tissue --bones without tissue --bleaching, exfoliation, demineralization of bone

*Clark et al. (1997), Williams (1997), Galloway et al. (1989), Galloway (1997), Love (2001), Marks et al. (2000), Bass (1997), Payne (1965)

Other events occurring at this time include skin slippage (Clark et al. 1997, Williams 1997, Galloway et al. 1989, Galloway 1997, Love 2001, Marks et al. 2000), hair slippage (Galloway et al. 1989, Galloway 1997), and the purging of fluids from the nose and mouth (Bass 1997) accompanied by putrid odor (Clark et al. 1997, Williams 1997).

Yet, certain patterns introduced prior to bloating continue as the abdomen and other regions begin to swell (Love 2001, Marks et al. 2000, Clark et al. 1997, Williams 1997, Payne 1965, Bass 1997). Such events include discoloration of the head and trunk (Clark et al. 1997, Williams 1997), marbling (Clark et al. 1997, Williams 1997, Love 2001, Marks et al. 2000), skin slippage (Bass 1997) and accompanying bullae (Clark et al. 1997, Payne 1965), hair slippage (Bass 1997), sustained odor, and purging from the nose, mouth, and rectum (Bass 1997, Payne 1965). Additional events involving the leaching of volatile fatty acids from the remains (Love 2001, Marks et al. 2000, Bass 1997) contribute to the oily consistency and black appearance of the soft tissue (Payne 1965), while further patterns result in bone exposure in areas consisting of comparatively thin tissue layering (i.e., eyes, bony eminences) (Love 2001, Marks et al. 2000, Bass 1997). Also, the recognition of mold is noted at this time (Bass 1997).

Upon deflation, odor remains detectable (Payne 1965) as gases are released from the body cavities (Clark et al. 1997, Williams 1997, Galloway et al. 1989, Galloway 1997). Yet, as deflation continues, slow dehydration (Payne 1965) in accompaniment with the expulsion of volatile fatty acids (Love 2001, Marks et al. 2000, Bass 1997) results in the darker discoloration (Galloway et al. 1989, Galloway 1997) and soft and flabby consistency (Payne 1965) of the tissues. However, environmental circumstances dictate adipocere formation and/or the desiccation of remaining tissue (Clark et al. 1997,

Williams 1997, Galloway et al. 1989, Galloway 1997, Bass 1997, Payne 1965), while possibly providing ideal conditions for the proliferation of fungi and/or mold (Bass 1997, Payne 1965). Continuing processes contribute to further appearance of bone with and without soft tissue (Clark et al. 1997, Williams 1997, Galloway et al. 1989, Galloway 1997, Payne 1965, Bass 1997), thus ultimately affecting the decomposition (i.e., bleaching, demineralization, exfoliation) of skeletonized remains (Love 2001, Marks et al. 2000, Bass 1997, Galloway et al. 1989, Galloway 1997).

Chapter 5:
Conclusion

As more than an indication of the point in time in which life ceases to exist, the encompassment of death dictates the recognition of a process consisting of sequential patterns of causal events that when fueled by the internal factors of decomposition (i.e., autolysis, putrefaction) ultimately yields human skeletal remains. Perceived by the visual and olfactory senses, such events involving initial indications of generalized skin discoloration, marbling, skin slippage, hair slippage, the purging of fluids, and odor occur prior to and continue throughout bloating, while dehydration and skeletonization are events noted upon deflation and beyond. In addition, adipocere formation, desiccation, and the proliferation of fungi and/or mold, as influenced by the environment can occur at any point along the continuum.

However, certain external factors exist that affect the rate of this process. Such factors involve the effects of environmental conditions (i.e., temperature, humidity, rainfall, sky conditions) and insect activity, along with the influences of specific circumstances surrounding the death or disposition of the remains.

Research Implications

Assuming the role as an environmental variable, insect activity accelerates the rate of human decomposition by contributing to soft tissue disintegration. Yet, by limiting insect access to human remains, this study offers a method in which the causal events of internal decomposition can be observed at a decreased rate. Hence, with a

progression analogous to the causal events affiliated with Payne's (1965) insect-free pigs, the decomposition of human remains in an insect-restricted environment support the existence of generalized sequential patterns previously recognized in the literature.

Yet, a larger sample size is required to firmly situate these events along the continuum. In response, this study offers a standardized and replicable data collection method involving observations of categorically defined visual and olfactory cues indicative of decomposition as they occur in each region of the body. Similar to previous studies (Galloway et al. 1989, Galloway 1997, Rhine and Dawson 1998, Bass 1997), accumulation of such data can be applied in the further establishment of predictable models in this and in other regions.

Applied Implications

With the passing of the earlier effects of rigor mortis, livor mortis, and algor mortis coupled with the inevitable loss of soft tissue, the responsibility of estimating the postmortem interval (i.e., the elapsed time since death) shifts from the pathologist to the forensic anthropologist. Hence, upon prematurely accepting the role of death investigator, the forensic anthropologist must not only be aware of the proper procedures of a death scene investigation, but also possess the ability to recognize the visual and olfactory cues affiliated with remains in various stages of decomposition. This study offers implications for both in terms of the documentation of environmental variables and the recognition of causal events affiliated with the decomposition process. Furthermore, the entomological perspective applied in this study offers insight into natural and

disrupted insect successional patterns, which are key in both indoor and outdoor death scene investigations.

Ultimately, computer simulations based on numerical codes assigned to represent certain characteristics of regional models as well as external factor variability may eventually be used to assist the forensic anthropologist in the estimation of the postmortem interval. Hence, the required input may potentially involve similar coding in reference to specific visual and/or olfactory signatures familiar to this study along with external factors documented at the death scene.

Bibliography

No author
no date Forensic Pathology
http://www.utmed.com/studynotes/path/block2/forensics.doc

Agur AMR and Lee MJ
1999 *Grant's Atlas of Anatomy*, 10th edition. Lippincott Williams & Wilkins New York, NY.

Anderson GS
2000 Minimum and Maximum Developmental Rates of Some Forensically Important Calliphoridae (Diptera) *Journal of Forensic Sciences* 45(4): 824-832.

2001 Insect Succession on Carrion and Its Relationship to Determining Time of Death. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations.* edited by JH Byrd and JL Castner pp. 143-175 CRC Press Boca Raton, FL.

Avila FW and Goff ML
1998 Arthropod Succession Patterns onto Burnt Carrion in Two Contrasting Habitats in the Hawaiian Islands *Journal of Forensic Sciences* 43(3): 581-586.

Bass WM
1997 Outdoor Decomposition Rates in Tennessee. In *Forensic Taphonomy: The Postmortem Fate of Human Remains* edited by WD Haglund and MH Sorg pp. 181-186 CRC Press Boca Raton, FL.

Byrd JH and Allen JC
2001 Computer Modeling of Insect Growth and Its Application to Forensic Entomology. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 303-329 CRC Press Boca Raton, FL.

Byrd JH and Castner JL, eds.
2001 Insects of Forensic Importance. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* pp. 43-79 CRC Press Boca Raton, FL.

Castner JL
2001 General Entomology and Arthropod Biology. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 17-41 CRC Press Boca Raton, FL.

Clark MA, Worrell MB, Pless JE

1997 Postmortem Changes in Soft Tissues. In *Forensic Taphonomy: The Postmortem Fate of Human Remains* edited by WD Haglund and MH Sorg pp. 151-164 CRC Press Boca Raton, FL.

Dang MT

1996 Standards Employed to Determine Time of Death. Mid-Atlantic Association of Forensic Scientists. http://www.gwu.edu/~fors/maafs/time_od.htm.

Davis JB and Goff ML

2000 Decomposition Patterns in Terrestrial and Intertidal Habitats on Oahu Island and Coconut Island, Hawaii *Journal of Forensic Sciences* 45(4): 836-842.

Dix J and Graham M

2000 *Time of Death, Decomposition, and Identification: An Atlas* CRC Press Boca Raton, FL.

Fisher RS

1980 Time of Death and Changes After Death: Part I Anatomical Considerations. In *Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*, 2nd edition. edited by WU Spitz and RS Fisher pp. 12-32. Charles C. Thomas Springfield, IL.

Galloway A

1997 The Process of Decomposition: A Model from the Arizona-Sonoran Desert. In *Forensic Taphonomy: The Postmortem Fate of Human Remains* edited by WD Haglund and MH Sorg pp. 139-150 CRC Press Boca Raton, FL.

Galloway A, Birkby WH, Jones AM, Henry TE, Parks BO

1989 Decay Rates of Human Remains in an Arid Environment *Journal of Forensic Sciences* 34(3): 607-616.

Gill-King H

1997 Chemical and Ultrastructural Aspects of Decomposition. In *Forensic Taphonomy: The Postmortem Fate of Human Remains* edited by WD Haglund and MH Sorg pp. 93-108 CRC Press Boca Raton, FL.

Goff ML

1991 Comparison of Insect Species Associated with Decomposing Remains Recovered Inside Dwellings and Outdoors on the Island of Oahu, Hawaii *Journal of Forensic Sciences* 36(3): 748-753.

1993 Estimation of Postmortem Interval Using Arthropod Development and Successional Patterns *Forensic Science Review* 5(2): 81-94.

2000 *A Fly for the Prosecution: How Insect Evidence Helps Solve Crimes* Harvard University Press Cambridge, MA.

Goff ML and Flynn MM

1991 Determination of Postmortem Interval by Arthropod Succession: A Case Study from the Hawaiian Islands *Journal of Forensic Sciences* 36(2): 607-614.

Goff ML and Lord WD

2001 Entomotoxicology: Insects as Toxicological Indicators and the Impact of Drugs and Toxins on Insect Development. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 331-340 CRC Press Boca Raton, FL.

Hall RD

2001 The Forensic Entomologist as Expert Witness. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 379-400 CRC Press Boca Raton, FL.

Haskell NH, Hall RD, Cervenka VJ, Clark MA

1997 On the Body: Insects' Life Stage Presence and Their Postmortem Artifacts. In *Forensic Taphonomy: The Postmortem Fate of Human Remains* edited by WD Haglund and MH Sorg pp. 415-448 CRC Press Boca Raton, FL.

Haskell NH, Lord WD, Byrd JH

2001 Collection of Entomological Evidence during Death Investigations. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 81-120 CRC Press Boca Raton, FL.

Higley LG and Haskell NH

2001 Insect Development and Forensic Entomology. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 287-302 CRC Press Boca Raton, FL.

Introna F, Suman TW, Smialek JE

1991 Sarcosaprophagous Fly Activity in Maryland *Journal of Forensic Sciences* 36(1): 238-243.

Krogman WM and Iscan MY

1986 *The Human Skeleton in Forensic Medicine* Charles C. Thomas Springfield, IL.

Love JC
2001 Evaluation of Decay Odor as a Time Since Death Indicator. A Dissertation Presented for the Doctor of Philosophy Degree. The University of Tennessee, Knoxville.

Mann RW, Bass WM, Meadows L
1990 Time Since Death and Decomposition of the Human Body: Variables and Observations in Case and Experimental Field Studies *Journal of Forensic Sciences* 35(1): 103-111.

Marieb EN
1998 *Human Anatomy and Physiology:* 4th edition Benjamin/Cummings, San Francisco, CA.

Marks MK, Love JC, Elkins SK
2000 Time Since Death: a Practical Guide to Physical; Postmortem Events. *Proceedings on American Academy of Forensic Sciences*_ 181-182.

Merritt RW
no date Forensic Entomology: Study Guide #13. http://www.cj.msu.edu/~people/forent.html

Netter FH
2001 *Atlas of Human Anatomy*, 2nd edition edited by AF Dalley ICON Learning Systems, LLC Teterboro, N.J.

Payne JA
1965 A Summer Carrion Study of the Baby Pig *Sus Scrofa* Linnaeus *Ecology* 46(5): 592-602.

Rhine S and Dawson JE
1998 Estimation of Time Since Death in the Southwestern United States. In *Forensic Osteology: Advances in the Identification of Human Remains*, 2nd edition . edited by KJ Reichs pp. 145-159 Charles C. Thomas Springfield, IL.

Richer S
no date Impact of Circumstances Surrounding Death and Decomposition. http://www.umass.edu/ent/forensic/Sarah.htm

Rodriguez WC
1982 Insect Activity and Its Relationship to Decay Rates of Human Cadavers in East Tennessee. A Thesis Presented for the Master of Arts Degree. The University of Tennessee, Knoxville.

Rodriguez WC and Bass WM
1985 Decomposition of Buried Bodies and Methods That May Aid in Their Location *Journal of Forensic Sciences* 30(3): 836-852.

Schoenly K
1992 A Statistical Analysis of Successional Patterns in Carrion-Arthropod Assemblages: Implications for Forensic Entomology and Determination of the Postmortem Interval *Journal of Forensic Sciences* 37(6): 1489-1513.

Schoenly K, Goff ML, Early M
1992 A BASIC Algorithm for Calculating the Postmortem Interval from Arthropod Successional Data *Journal of Forensic Sciences* 37(3): 808-823.

Shahid SA, Hall RD, Haskell NH, Merritt RW
2000 *Chrysomya rufifacies* (Macquart)(Diptera: Calliphoridae) Established in the Vicinity of Knoxville, Tennessee, USA *Journal of Forensic Sciences* 45(4):896-897.

Shalaby OA, deCarvalho LML, Goff ML
2000 Comparison of Patterns of Decomposition in a Hanging Carcass and a Carcass in Contact with Soil in a Xerophytic Habitat on the Island of Oahu, Hawaii *Journal of Forensic Sciences* 45(6):1267-1273.

Sorg MH and Haglund WD
2002 Advancing Forensic Taphonomy: Purpose, Theory, and Process. In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives* edited by WD Haglund and MH Sorg pp. 3-29 CRC Press Boca Raton, FL.

Srnka C
2003 The Effects of Sun and Shade on the Early Stages of Human Decomposition. A Thesis Presented for the Master of Arts Degree. The University of Tennessee, Knoxville.

Tantawi TI and Greenberg B
1993 The Effect of Killing and Preservative Solutions on Estimates of Maggot Age in Forensic Cases *Journal of Forensic Sciences* 38(3): 702-707.

Teather RG
1994 *Encyclopedia of Underwater Investigations* Best Publishing Flagstaff, AZ.

Vass AA, Barshick SA, Sega G, Caton J, Skeen JT, Love JC, Synstelien JA
2002 Decomposition Chemistry of Human Remains: A New Methodology for Determining the Postmortem Interval *Journal of Forensic Sciences* 47(3): 542-553.

Wells JD and LaMotte LR
1995 Estimating Maggot Age from Weight Using Inverse Prediction *Journal of Forensic Sciences* 40(4): 585-590.

2001 Estimating the Postmortem Interval. In *Forensic Entomology: The Utility of Arthropods in Legal Investigations* edited by JH Byrd and JL Castner pp. 263-285 CRC Press Boca Raton, FL.

Williams JA
1997 Death and Decomposition: Course Notes for Selected Topics. Forensic Science. http://www.und.nodak.edu/instruct/moore/FORENSIC.HTM

Appendices

Appendix A: Decomposition

Table A.1. Presence Data for A*

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Color changes: Pink/Red	13→20, 28, 31→34, 35.5→88.5, 91.5→95.5, 99.5→100.5, 104.5→ 114.5, 118.5→ 119.5.	0→16, 21→22, 25→28, 31→34, 35.5→95.5, 98.5→100.5, 104.5→ 114.5, 118.5→ 119.5.	4→22, 25→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→114.5, 119.5.	0→28, 30→34, 35.5→95.5, 98.5→100.5, 104.5→ 114.5, 118.5→ 119.5.	0→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 118.5→ 119.5.
Blue	N/A	7→14, 20.	14→15.	N/A	N/A
Green	12→26, 28, 30→34, 35.5→88.5, 91.5→95.5, 99.5→100.5, 104.5→ 110.5, 112.5→ 114.5, 118.5→ 119.5.	14→28, 30→34, 35.5→88.5.	15→28, 30→34, 35.5→88.5, 91.5→95.5, 98.5→100.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 105.5, 109.5→ 114.5, 118.5→ 119.5.	15→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 105.5, 109.5→ 114.5, 118.5→ 119.5.
Purple	7→17, 21, 30→34, 35.5→95.5, 99.5→100.5, 103.5→ 114.5, 118.5→ 119.5.	0→25, 28, 31→34, 35.5→90.5, 92.5→95.5, 99.5→100.5, 104.5→ 105.5, 110.5→ 112.5, 114.5→ 119.5.	0→28, 30→34, 35.5→91.5, 93.5→95.5, 103.5, 111.5→ 112.5, 118.5→ 119.5.	0→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 118.5→ 119.5.	0→16, 20→28, 30→34, 35.5→95.5, 98.5, 100.5, 106.5→ 112.5, 114.5, 119.5.
Brown	3→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	2→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	2→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	2→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	3→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.

*Seasonal observation time frame: 6-16-02→10-14-02; Decomposition observation time frame: days 0→119.5; No observations on days 29, 35, 96.5, 97.5, 101.5; Total number of observations: 116.

Table A.1. Continued

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Black	7→28, 31→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 119.5.	14→19, 25→27, 31→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 118.5→ 119.5.	7→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→119.5.	0→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 118.5→ 119.5.	9→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 114.5, 118.5→ 119.5.
Marbling	9→28, 30→34, 35.5.	10→28, 30→34, 35.5→95.5.	4→28, 30→34, 35.5→95.5, 98.5.	6→28, 30→34, 35.5→95.5, 98.5→100.5.	7→28, 30→34, 35.5→95.5, 98.5→100.5.
Bloating	17→28, 30→34, 35.5→61.5.	17→28, 30→34, 35.5→59.5.	16→28, 30→34, 35.5→74.5.	17→28, 30→34, 35.5→52.5.	20→28, 30→34, 35.5→54.5.
Odor	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.
Skin slippage	13→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	14→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	17→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	12→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	19→20, 23→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.
Liquids running from orifices	10, 13→28, 30→34, 35.5→59.5, 66.5, 71.5, 80.5→90.5.	N/A	16→24, 31→34, 35.5→55.5, 61.5→72.5, 80.5→93.5.	N/A	N/A

Table A.1. Continued

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Hair slippage	72.5→95.5, 98.5→100.5, 102.5→ 119.5.	N/A	N/A	N/A	N/A
Adipocere	28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.
Fungus/mold	4→26, 28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	13→21, 28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	19, 28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	10→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.
Desiccation	N/A	N/A	N/A	26→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.	23→28, 30→34, 35.5→95.5, 98.5→100.5, 102.5→ 119.5.
Deflation (Post-bloating)	45.5→95.5, 98.5→100.5, 102.5→ 119.5.	60.5→95.5, 98.5→100.5, 102.5→ 119.5.	45.5→95.5, 98.5→100.5, 102.5→ 119.5.	53.5→95.5, 98.5→100.5, 102.5→ 119.5.	55.5→95.5, 98.5→100.5, 102.5→ 119.5.
Insect activity	19, 21→25, 27→28, 30→34, 45.5→95.5, 98.5→100.5, 102.5→ 119.5.	54.5→62.5, 64.5→95.5, 98.5→100.5, 102.5→ 119.5.	64.5→95.5, 98.5→100.5, 102.5→119.5.	65.5→95.5, 98.5→100.5, 102.5→ 119.5.	51.5→95.5, 98.5→100.5, 102.5→ 119.5.
Carnivore/ rodent activity	N/A	N/A	N/A	N/A	N/A
Skeletonization	N/A	N/A	N/A	N/A	N/A

Table A.2. Presence Data for B*

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Color changes: Pink/Red	16→18, 22.	7, 10→18, 22, 60→61.	7, 12→14, 17.	7→14, 16→27, 60.	7→14, 16→17.
Blue	N/A	N/A	N/A	N/A	N/A
Green	22, 59→64, 82→83.	9, 11→12, 15, 22.	7→11, 13, 39.	12, 22.	13→16, 53, 79→83.
Purple	9→10, 12→14.	8→13, 22.	8→13.	9→10, 12, 22.	7→10, 12→24.
Brown	8→14, 19→70, 72→84, 87→91.	10→14, 16, 18→70, 72→84, 87→91.	12→13, 16, 18→38, 40→70, 72→84, 87→91.	10→14, 16, 18→70, 72→84, 87→91.	8, 11→14, 16→18, 22.
Black	11→14, 16→18, 22→49, 53→70, 72→84, 87→91, 93→96.	12→13, 16→25, 88→91, 93→96.	12→14, 16→17, 21, 23→49, 53→70, 72→84, 87→91, 93→96.	7→14, 16→49, 53→70, 72→84, 87→91, 93→96.	7→14, 16→49, 53→70, 72→84, 87→91, 93→96.
Marbling	12→14, 16→18.	9, 12→13, 16→25.	N/A	17→18.	7→14.
Bloating	N/A	11→15.	11→12.	N/A	N/A
Odor	9→40.	9→40.	9→40.	9→40.	9→40.
Skin slippage	9→13.	7→13.	9→12.	10→12.	7→14.
Liquids running from orifices	N/A	N/A	N/A	N/A	N/A
Hair slippage	16→?	N/A	N/A	N/A	N/A
Adipocere	23→70, 72→84, 87→91, 93→96.	23→70, 72→84, 87→91, 93→96.	23→70, 72→84, 87→91, 93→96.	23→70, 72→84, 87→91, 93→96.	23→70, 72→84, 87→91, 93→96.
Fungus/mold	53→64, 79→84, 87→88.	53→55, 87→88.	53→55, 80, 87→88.	53→55, 87→88, 93.	79→83, 87→88.
Desiccation	18→70, 72→84, 87→91, 93→96.	26→70, 72→84, 87→91, 93→96.	21→70, 72→84, 87→91, 93→96.	7→70, 72→84, 87→91, 93→96.	19→70, 72→84, 87→91, 93→96.

*Seasonal observation time frame: 7-05-02→10-02-02; Decomposition observation time frame: days 7→96; No observations on days 71, 85, 86, 92; Total number of observations: 86.

Table A.2. Continued

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Deflation (Post-bloating)	N/A	16→70, 72→84, 87→91, 93→96.	13→70, 72→84, 87→91, 93→96.	N/A	N/A
Insect activity	7→19, 21→70, 72→84, 87→91, 93→96.	7→17, 19, 21, 23→70, 72→84, 87→91, 93→96.	7→19, 21→70, 72→84, 87→91, 93→96.	7→18, 21, 24→70, 72→84, 87→91, 93→96.	7→21, 24→70, 72→84, 87→91, 93→96.
Carnivore/ rodent activity	N/A	N/A	N/A	N/A	N/A
Skeletonization	12→70, 72→84, 87→91, 93→96.	44→70, 72→84, 87→91, 93→96.	16→70, 72→84, 87→91, 93→96.	11→70, 72→84, 87→91, 93→96.	11→70, 72→84, 87→91, 93→96.

Table A.3. Presence Data for C*

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Color changes: Pink/Red	2→3, 7.5→8.5, 10.5→15.5, 17.5, 21.5→22.5, 26.5→67.5, 71.5→72.5, 76.5→86.5, 90.5→91.5.	12.5, 14.5→15.5, 27.5→60.5, 72.5, 77.5→86.5, 91.5.	11.5→13.5, 17.5→18.5, 27.5→64.5, 71.5→72.5, 76.5→86.5, 91.5.	9.5→67.5, 71.5→72.5, 74.5, 76.5→86.5, 91.5.	11.5, 13.5, 15.5, 17.5, 19.5→67.5, 70.5→72.5, 74.5→86.5, 90.5→91.5.
Blue	N/A	N/A	N/A	2→6, 7.5→11.5, 14.5.	11.5→17.5.
Green	6, 7.5→18.5, 24.5→67.5, 71.5→72.5, 75.5, 84.5→86.5, 91.5.	5→6, 7.5→60.5, 82.5, 86.5, 91.5.	3→6, 7.5→60.5.	6, 7.5→17.5, 19.5→67.5.	9.5→60.5, 67.5, 72.5, 74.5→86.5, 90.5→91.5.
Purple	4→6, 7.5→15.5, 17.5, 19.5, 43.5→62.5, 64.5→67.5, 70.5→72.5, 75.5→86.5, 91.5.	7.5→29.5, 33.5→65.5, 70.5→72.5, 75.5, 77.5→86.5, 91.5.	3→6, 7.5→30.5, 32.5, 37.5, 61.5→67.5, 70.5→72.5, 74.5→86.5, 90.5→91.5.	7.5→17.5, 19.5, 21.5, 23.5→26.5, 29.5→31.5, 37.5→67.5, 70.5→72.5, 74.5→86.5, 91.5.	8.5→33.5, 35.5→67.5, 70.5→71.5, 74.5→86.5, 90.5→91.5.
Brown	3→6, 7.5→67.5, 70.5→72.5, 74.5→91.5.	4→6, 7.5→67.5, 70.5→72.5, 74.5→91.5.	3→6, 7.5→67.5, 70.5→72.5, 74.5→91.5.	3→6, 7.5→67.5, 70.5→72.5, 74.5→91.5.	4→6, 7.5→67.5, 70.5→72.5, 74.5→91.5.
Black	9.5→11.5, 15.5, 17.5→67.5, 71.5→72.5, 75.5→86.5, 89.5→91.5.	7.5→12.5, 18.5, 20.5→67.5, 76.5→81.5, 83.5.	13.5, 16.5→67.5, 72.5, 76.5→91.5.	7.5→12.5, 14.5→67.5, 70.5→72.5, 74.5→86.5.	10.5, 12.5, 18.5→67.5, 76.5→84.5, 86.5, 91.5.
Marbling	7.5→11.5.	7.5→17.5, 19.5→26.5.	8.5→36.5.	7.5→17.5, 20.5→28.5.	9.5→18.5, 20.5→32.5.
Bloating	9.5→25.5.	9.5→23.5.	9.5→27.5.	10.5→24.5.	11.5→24.5.

*Seasonal observation time frame: 7-16-02→10-14-02; Decomposition observation time frame: days 2→91.5; No observations on days 7, 68.5, 69.5, 73.5; Total number of observations: 87.

Table A.3. Continued

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Odor	7.5→67.5, 70.5→72.5, 74.5→91.5.	7.5→67.5, 70.5→72.5, 74.5→91.5.	7.5→67.5, 70.5→72.5, 74.5→91.5.	7.5→67.5, 70.5→72.5, 74.5→91.5.	7.5→67.5, 70.5→72.5, 74.5→91.5.
Skin slippage	7.5→67.5, 70.5→72.5, 74.5→91.5.	10.5→67.5, 70.5→72.5, 74.5→91.5.	10.5→67.5, 70.5→72.5, 74.5→91.5.	8.5→67.5, 70.5→72.5, 74.5→91.5.	9.5→67.5, 70.5→72.5, 74.5→91.5.
Liquids running from orifices	7.5, 9.5→19.5, 21.5→23.5, 29.5, 42.5→44.5, 55.5→63.5.	N/A	10.5→11.5, 17.5→20.5, 29.5→41.5, 63.5→64.5, 90.5→91.5.	N/A	N/A
Hair slippage	19.5→67.5, 70.5→72.5, 74.5→91.5.	N/A	N/A	N/A	N/A
Adipocere	11.5→13.5, 17.5→18.5, 21.5→22.5, 42.5→51.5, 61.5→67.5, 70.5→72.5, 74.5→91.5.	11.5→13.5, 16.5, 33.5→34.5, 36.5, 42.5→51.5, 61.5→66.5, 70.5→72.5, 74.5→91.5.	10.5→13.5, 15.5, 17.5, 42.5→67.5, 70.5→72.5, 74.5→91.5.	10.5→18.5, 20.5→23.5, 32.5→34.5, 36.5→40.5, 42.5→53.5, 61.5→67.5, 70.5→72.5, 74.5→91.5.	11.5→13.5, 17.5, 33.5→67.5, 70.5→72.5, 74.5→91.5.
Fungus/mold	7.5→9.5, 37.5→43.5, 63.5→64.5, 66.5→67.5, 76.5→83.5.	8.5→9.5, 63.5.	8.5→9.5, 63.5→64.5.	7.5→9.5, 12.5→13.5, 63.5, 79.5→83.5.	8.5→9.5, 12.5, 15.5, 17.5→18.5, 20.5, 37.5, 63.5→66.5, 76.5→83.5.
Desiccation	N/A	N/A	N/A	N/A	N/A
Deflation (Post-bloating)	21.5→67.5, 70.5→72.5, 74.5→91.5.	24.5→67.5, 70.5→72.5, 74.5→91.5.	20.5→67.5, 70.5→72.5, 74.5→91.5.	25.5→67.5, 70.5→72.5, 74.5→91.5.	25.5→67.5, 70.5→72.5, 74.5→91.5.
Insect activity	10.5→25.5, 27.5, 29.5→67.5, 70.5→72.5, 74.5→91.5.	12.5→25.5, 27.5, 29.5, 32.5→33.5, 35.5→67.5, 70.5→72.5, 74.5→91.5.	15.5→27.5, 29.5→67.5, 70.5→72.5, 74.5→91.5.	11.5, 13.5→22.5, 32.5→33.5, 35.5→67.5, 70.5→72.5, 74.5→91.5.	9.5, 17.5→22.5, 32.5→33.5, 37.5→67.5, 70.5→72.5, 74.5→91.5.
Carnivore/ rodent activity	N/A	N/A	N/A	N/A	N/A
Skeletonization	N/A	N/A	N/A	N/A	N/A

Table A.4. Presence Data for D*

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Color changes: Pink/Red	11→17, 79, 81→86, 90.	9→10, 12→20, 77, 79, 81→86.	9→21, 77, 79, 81→86.	9→10, 12→17, 77, 79, 81→86.	11→23, 79, 81→86.
Blue	N/A	N/A	10→12.	N/A	12.
Green	14→15.	9→17.	9→11, 13→16.	9→17.	13→19.
Purple	12, 14→15, 17.	11→13, 17→18.	10→11, 13, 15→16, 18.	9→17, 19.	9→19.
Brown	10→58, 60→72, 75→79, 81→96.	9→58, 60→72, 75→79, 81→96.	10→58, 60→72, 75→79, 81→96.	12→58, 60→72, 75→79, 81→96.	12→58, 60→72, 75→79, 81→96.
Black	13, 15→37, 40→58, 60→72, 75→79, 81→96.	13→17, 19, 58, 60→72, 75→79, 81→96.	13→17, 21→37, 40→58, 60→72, 75→79, 81→96.	13→17, 20→37, 40→58, 60→72, 75→79, 81→96.	13→14, 16→37, 40→58, 60→72, 75→79, 81→96.
Marbling	11→12, 14→17.	12, 14, 16→18.	13→16, 18.	12→13, 15→17.	12→19.
Bloating	13→14.	12→14.	11→14.	13→14.	13→14.
Odor	12→42.	12→42.	12→42.	12→42.	12→42.
Skin slippage	10→11.	10→13.	11→13.	10→12.	11→13.
Liquids running from orifices	N/A	N/A	N/A	N/A	N/A
Hair slippage	12→?	N/A	N/A	N/A	N/A
Adipocere	23, 66→72, 75→79, 81→96.	21→22, 66→72, 75→79, 81→96.	24→26, 41, 66→72, 75→79, 81→96.	19→21, 23→26, 66→72, 75→79, 81→96.	19→38, 40→58, 60→72, 75→79, 81→96.
Fungus/mold	68→72, 75→78.	75→77.	68→72, 75→77, 82→86.	68→72, 75→77, 81→86.	68→72, 75→77, 81→86.
Desiccation	23→58, 60→72, 75→79, 81→96.	23→58, 60→72, 75→79, 81→96.	23→58, 60→72, 75→79, 81→96.	15→17, 19→58, 60→72, 75→79, 81→96.	19→58, 60→72, 75→79, 81→96.

*Seasonal observation time frame: 7-19-02→10-14-02; Decomposition observation time frame: days 9→96; No observations on days 59, 73, 74, 80; Total number of observations: 84.

Table A.4. Continued

	Head/Neck	Thorax	Abdomen/Pelvis	Arms	Legs
Deflation (Post-bloating)	15→58, 60→72, 75→79, 81→96.	15→58, 60→72, 75→79, 81→96.	15→58, 60→72, 75→79, 81→96.	15→58, 60→72, 75→79, 81→96.	15→58, 60→72, 75→79, 81→96.
Insect activity	9→58, 60→72, 75→79, 81→96.	11→20, 22→23, 26→58, 60→72, 75→79, 81→96.	10→21, 23, 26→58, 60→72, 75→79, 81→96.	11→19, 23→26, 30→58, 60→72, 75→79, 81→96.	11→19, 30→58, 60→72, 75→79, 81→96.
Carnivore/ rodent activity	N/A	N/A	N/A	N/A	N/A
Skeletonization	15→58, 60→72, 75→79, 81→96.	17→58, 60→72, 75→79, 81→96.	16→58, 60→72, 75→79, 81→96.	15→58, 60→72, 75→79, 81→96.	17→58, 60→72, 75→79, 81→96.

Appendix B: Insect Activity

Table B.1. Insects Affiliated With B*

Insects	Initial Notation (Days)	Final Notation (Days)
Flies		
blow flies	7	16
eggs	8	10
maggots	9	18
mass	9	15
migration	15.5**	18
black soldier flies	14	73
flesh flies	14	83
minute scavenger flies	60	73
black scavenger flies	67	75
house flies	76	76
Beetles		
American carrion beetles	9	11
red-legged ham beetles	14	96
Other		
ants	8	96
bites	8	9
wasps	14	84
brown moths	14	31
pillbugs	33	91
orange flies (?)	33	93

*day 0 = day of death; Insect activity observation time frame: days 7→96

**A maggot migration was witnessed during a morning temperature reading.

Table B.2. Insects Affiliated With D*

Insects	Initial Notation (Days)	Final Notation (Days)
Flies		
blow flies	9	94
eggs	9	11
maggots	10	21
migration	18	18
flesh flies	9	79
black scavenger flies	10	55
black soldier flies	13	72
minute scavenger flies	42	63
house flies	52	87
Beetles		
American carrion beetles	11	14
hairy rove beetles	13	14
red-legged ham beetles	13	96
clown beetles	16	16
Other		
ants	10	96
wasps	9	76
brown moths	13	13
orange flies (?)	19	91
pillbugs	25	90

*day 0 = day of death; Insect activity observation time frame: days 9→96

Table B.3. Insects Attracted to the Outside of the Structure*

Insects	Initial Notation (Days)**		Final Notation (Days)**	
	A	C	A	C
Flies				
flesh flies	3	N/A	114	86
blow flies	11	N/A	120	92
black soldier flies	49	21	100	72
house flies	58	30	96	68
black scavenger flies	72	44	79	51
minute scavenger flies	81	53	87	59
Beetles				
American carrion beetles	13	N/A	18	N/A
clown beetles	45	17	114	86
hairy rove beetles	49	21	49	21
red-legged ham beetles	66	38	112	84
burying beetles	73	45	73	45
Other				
wasps	26	N/A	120	92
pillbugs	67	39	67	39
brown moths	71	43	71	43
ants	75	47	107	79

*Due to the invasion potential of these insects, initial and final notations were situated within the observation time frames of A (days 0→120) and C (days 2→92).

**day 0 = day of death

Table B.4. Insects Affiliated With A*

Week	Days	Insects
1	0→6	N/A
2	7→13	N/A
3	14→20	
	19	scuttle fly larva in blood draining from head
4	21→27	
	21	scuttle fly larvae (5 coming out of nose)
	22	scuttle fly puparia (10)
	23	scuttle fly puparium near ear
	24	scuttle fly larva and puparia
	25	scuttle fly larvae
	27	scuttle fly puparium
5	28→34	
	28	scuttle fly puparia
	30	scuttle fly puparia
	31	scuttle fly puparia beetle resembling a burying beetle in decomposition run-off under platform
	32	scuttle fly puparia
	33	scuttle fly puparia
	34	scuttle fly puparia
6	35→40.5	N/A
7	41.5→47.5	
	46.5	scuttle fly larva and puparium
	47.5	scuttle fly larva and puparium
8	48.5→54.5	
	51.5	scuttle fly puparia
	54.5	scuttle fly larvae

*day 0 = day of death; Insect activity observation time frame: days 0→119.5

Table B.4. Continued

Week	Days	Insects
9	55.5→61.5	
	55.5	scuttle fly puparia
	56.5	scuttle fly puparia blow fly
	57.5	red-legged ham beetle in nose scuttle fly puparia blow fly
	58.5	scuttle fly larva
	59.5	scuttle fly larva
10	62.5→68.5	
	62.5	scuttle fly larvae
	65.5	adult scuttle flies
	67.5	blow fly
11	69.5→75.5	
	69.5	scuttle fly larvae
	74.5	scuttle fly puparia
12	76.5→82.5	
	76.5	scuttle fly
	77.5	scuttle fly
	78.5	scuttle fly larvae
	79.5	scuttle flies and puparia
13	83.5→89.5	
	87.5	scuttle fly larvae
	89.5	scuttle fly larvae
14	90.5→96.5	same
15	97.5→103.5	same
16	104.5→110.5	same
17	111.5→117.5	
	116.5	scuttle fly larvae
	117.5	scuttle fly larvae and adults
18	118.5→119.5	same

Table B.5. Insects Affiliated With C*

Week	Days	Insects
1	2→7.5	N/A
2	8.5→14.5	
	9.5	burying beetle near left heel
	10.5	scuttle fly larva near right cheek
	11.5	scuttle fly larva on shoulder
	12.5	scuttle fly larva on thorax
	13.5	scuttle fly larvae
	14.5	scuttle fly larvae and puparia
3	15.5→21.5	
	15.5	scuttle fly larvae and puparia
	16.5	hairy rove beetle (not on body)
	17.5	scuttle fly larvae
	18.5	scuttle fly puparia
	19.5	blow fly maggots near mouth
	20.5	maggot mass in nostrils
	21.5	maggot migration→North
4	22.5→28.5	
	22.5	1 maggot on tarp
	23.5	scuttle fly larva in nose
	24.5	scuttle fly larva
	27.5	blow flies in structure (10 or 15→2 attracted to body: pelvic region)
	28.5	50 + green blow flies→not attracted to body scuttle fly larva

*day 0 = day of death; Insect activity observation time frame: days 2→91.5

Table B.5. Continued

Week	Days	Insects
5	29.5→35.5	
	29.5	scuttle fly larvae in mouth green blow flies on ceiling above head
	30.5	scuttle fly larvae blow flies dying inside structure
	31.5	scuttle fly larva
	32.5	scuttle fly larvae a few blow flies left on ceiling
	34.5	pillbug in structure scuttle fly larvae
	35.5	scuttle fly larvae
6	36.5→42.5	
	37.5	adult scuttle flies
	39.5	blow fly
7	43.5→49.5	
	47.5	adult scuttle flies
	48.5	scuttle flies
	49.5	scuttle flies
8	50.5→56.5	
	50.5	scuttle flies scuttle fly larvae
	51.5	scuttle flies scuttle fly puparia
9	57.5→63.5	same
10	64.5→70.5	same
11	71.5→77.5	
	71.5	scuttle fly larvae clump (not mass) in nostrils
	72.5	scuttle fly larvae: face and chin
12	78.5→84.5	same
13	85.5→91.5	
	87.5	scuttle flies: adults and larvae
	88.5	scuttle flies: adults and larvae
	89.5	scuttle flies: adults and larvae

Appendix C: Environmental Variables

Table C.1. Independent Populations T-test Results: Temperature*

Populations** Tested	Temperature (degrees Centigrade)	t	Sig (2-tailed)
A/ Weather Station	High	-.136	.892
	Low	-.208	.835
B/ Weather Station	High	-2.546	.012
	Low	-.839	.403
C/ Weather Station	High	.170	.865
	Low	-.216	.829
D/ Weather Station	High	-1.491	.139
	Low	-.614	.540

*SPSS 11.0

**Subject-specific readings and corresponding weather station data collected by Smka (2003)

Table C.2. Average Weekly High and Low Temperature for A*

Week	Days**	High	Low
1	0→6	29	19
2	7→13	30	22
3	14→20	32	22
4	21→27	30	22
5	28→34	28	22
6	35→41	30	23
7	42→48	32	22
8	49→55	32	21
9	56→62	33	22
10	63→69	34	22
11	70→76	30	21
12	77→83	35	21
13	84→90	32	20
14	91→97	28	21
15	98→104	21	18
16	105→111	27	20
17	112→118	22	16
18	119→120	19	16

*degrees Centigrade; **day 0 = day of death

Table C.3. Average Weekly High and Low Temperature for B*

Week	Days**	High	Low
1	7→13	30	23
2	14→20	26	21
3	21→27	29	21
4	28→34	30	23
5	35→41	30	21
6	42→48	32	21
7	49→55	31	21
8	56→62	31	21
9	63→69	32	21
10	70→76	32	20
11	77→83	27	21
12	84→90	23	18
13	91→96	27	19

*degrees Centigrade; **day 0 = day of death

Table C.4. Average Weekly High and Low Temperature for C*

Week	Days**	High	Low
1	2→8	30	22
2	9→15	30	23
3	16→22	32	22
4	23→29	32	21
5	30→36	33	21
6	37→43	33	22
7	44→50	31	20
8	51→57	35	21
9	58→64	30	20
10	65→71	28	20
11	72→78	23	18
12	79→85	25	19
13	86→92	21	16

*degrees Centigrade; **day 0 = day of death

Table C.5. Average Weekly High and Low Temperature for D*

Week	Days**	High	Low
1	9→15	29	21
2	16→22	30	23
3	23→29	30	21
4	30→36	32	21
5	37→43	31	21
6	44→50	31	21
7	51→57	32	21
8	58→64	32	20
9	65→71	27	21
10	72→78	23	18
11	79→85	27	19
12	86→92	23	18
13	93→96	22	16

*degrees Centigrade; **day 0 = day of death

Table C.6. Independent Populations T-test Results: Humidity*

Populations** Tested	Humidity (%)	t	Sig (2-tailed)
A/ Weather Station	High	-.981	.329
	Low	.967	.336
B/ Weather Station	High	2.039	.044
	Low	8.364	.000
C/ Weather Station	High	-.913	.363
	Low	-.128	.898
D/ Weather Station	High	1.898	.060
	Low	8.263	.000

*SPSS 11.0

**Subject-specific readings and corresponding weather station data collected by Srnka (2003)

Table C.7. Humidity: A vs. Weather Station*

Location	Very Dry (Days**)	Normal (Days **)	Humid (Days **)
A	28	79	87
Weather Station	24	67	86

*Humidity Scale:
Very Dry = 10-40 %
Normal = 41-70 %
Humid = 71-100 %
**days = total number of days that conditions were very dry, normal, and humid

Table C.8. Humidity: B vs. Weather Station*

Location	Very Dry (Days**)	Normal (Days**)	Humid (Days**)
B	0	60	86
Weather Station	24	64	82

*Humidity Scale:
Very Dry = 10-40 %
Normal = 41-70 %
Humid = 71-100 %
**days = total number of days that conditions were very dry, normal, and humid

Table C.9. Humidity: C vs. Weather Station*

Location	Very Dry (Days**)	Normal (Days**)	Humid (Days**)
C	28	73	78
Weather Station	20	60	76

*Humidity Scale:
Very Dry = 10-40 %
Normal = 41-70 %
Humid = 71-100 %
**days = total number of days that conditions were very dry, normal, and humid

Table C.10. Humidity: D vs. Weather Station*

Location	Very Dry (Days**)	Normal (Days**)	Humid (Days**)
D	0	57	81
Weather Station	20	58	73

*Humidity Scale:
Very Dry = 10-40 %
Normal = 41-70 %
Humid = 71-100 %
**days = total number of days that conditions were very dry, normal, and humid

Table C.11. Total Rainfall and Sky Conditions

ID	Rainfall (in.)	Sky Conditions (Days*)		
		Clear	Partly Cloudy	Mostly Cloudy
A	6 9/10	5	81	35
B	13 9/10	4	66	20
C	6 2/10	3	61	27
D	12 6/10	3	61	24

*Total number of days that sky conditions were clear, partly cloudy and mostly cloudy

Vita

Although born in Macon, Georgia on February 4, 1977, Kimberly Dawn Tomlinson completed her first years of education within the nearby small town of Gray, Georgia. Upon graduating third out of 185 in her high school class in 1995, Dawn ventured farther south to attend Georgia Southern University in Statesboro, Georgia. As a Magna Cum Laude graduate, Dawn received a B.A. in Anthropology in 1999. Having completed the requirements for an M.A. in Anthropology at the University of Tennessee in 2003, Dawn is currently pursuing further knowledge of forensic anthropology within an applied setting in Atlanta, Georgia.