ASSESSING POST MORTEM INTERVAL OF *SUS DOMESTICUS* IN A NORTHERN CALIFORNIA ENVIRONMENT.

M.A. Thesis Proposal

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I. Abstract

Taphonomic studies provide useful data to the disciplines of forensic anthropology and archaeology. The complex relationship between the environment and decomposition rate results in a need for taphonomic studies in multiple environments to be performed. While taphonomic studies on human remains are prolific in the Midwest, a lack of knowledge upon the rates of decomposition in the west, specifically California, remains**.** This thesis investigates the rate of decomposition to produce a skeleton in Northern California utilizing clothed and unclothed domestic pig subjects. Domestic Pigs (*Sus scrofa domesticus*) have been chosen for a number of forensic experiments as analogues for human cadavers due to their availability as well as certain physical characteristics they share with humans. Taphonomic research has been conducted in regards to scavenger activity (Bright 2011), however this study attempts to address how temperature and clothing impact decomposition rates. This study expects to find that those subjects in full sunlight and clothed will decompose at an accelerated rate and that when compared with subjects from the southern California study, the northern California subjects will decompose faster.

Four domestic pig cadavers will be utilized for this study; two will be clothed in 100% organic cotton clothing, while the two others will remain in a nude state. Each pair, clothed and nude, will be placed within a microenvironment of full sunlight or full shade and observed every three hours until carcasses stop showing changes; then every third day until changes cease; then weekly for twelve weeks. All observations will be used to calculate a Body Region Score (BRS) for three regions: head and neck, torso, and limbs; the three Body Region Scores are

summed for a Total Body Score (TBS). TBS will be used to calculate Accumulated Degree Days (ADD) and estimate the post mortem interval (PMI) for each stage of decomposition, until subjects are skeletonized. ADD of the four Northern California subjects will be directly compared to the subjects of a similar Southern California Study (Sharplin 2012) to look for statistical differences dependent on environment and condition.

II. Introduction

The purpose of this study is to analyze the effects of the decomposition process, focusing on the time to produce a skeleton in an arid environment with clothed and unclothed domestic pig subjects. This research will be addressing the role in which clothing and sunlight play in the rate of decomposition in Northern California environments and comparing the Accumulated Degree Days (ADD) of the four subjects to the ADD of those used in a similar study in Southern California to see if there is a statistical difference between the two California climates in regards to decomposition rates. Previous studies have shown that there is a correlation between ADD and Post Mortem Interval (Megyesi 2005, Myburgh 2013) while others have indicated that decomposition is accelerated when clothing is involved (Sharplin 2012).

This particular project is relevant as no research around the rate of decomposition in Northern Californian environments has been conducted. Numerous studies have noted the complex relationship between environment and decomposition, specifically how the rate of decomposition responds to several environmental variables such as temperature, humidity percentage and entomological activity (Bornemissza 1957; Reed 1958; Payne 1965; Galloway 1989; Prieto et. al 2004; Megyesi 2005; Simmons 2007; Parks 2011). Due to the fact that the

rate of decomposition varies greatly by region, season and environment, there is a need for controlled experiments that help forensic anthropologists better understand how specific variables affect that rate. Experimental taphonomic studies have become prolific since 1980 in specific regions. In 1980 Dr. William Bass established the Anthropological Research Facility at Tennessee Knoxville which has become one of the main contributors to human taphonomic studies (Rottenstein 2006). However because environment plays a major role upon the rate of decomposition it is crucial that taphonomic studies are performed in other regions to create accurate time frames of PMI in these areas.

Understanding local environments is key to any Taphonomic study, thus the lack of research done in Northern California presents a problem. Due to the lack of data, little is known of the variables that may influence the rate of decomposition for this area. This research will provide a tool for law enforcement, medical examiners, as well as archaeologists that can be used for clandestine burials in Northern California. The primary goal of this research is to better understand the rate of decomposition for Northern California, the role clothing and sunlight play upon that rate, and to test the reliability of Megyesi's ADD regression equation to accurately estimate the PMI. This study will also be compared with a similar study done in 2012 to better understand the differences in rates between a Southern CA environment and a Northern California Environment. This study will measure the rate of decomposition through visual observation, monitoring 4 pig pairs (one clothed/ one nude) in sunlight, and shade.

III. Background

The primary goal of forensic anthropology was aiding in the identification of human remains in forensic contexts. Taphonomic studies have helped to provide scientific

methodology based in the natural sciences to the discipline of forensic anthropology to aid in data collection. As past anthropologists only saw the field as a way of gathering evidence or creating biological profiles, forensic taphonomy has shown the field as an opportunity to apply scientific method to a forensic scene in order to collect information relevant to reconstructing the events surrounding death, body disposal, and placement at the scene (Dirkmaat 2008). Previous methodology largely relied on skeletal collections composed of unclaimed bodies or collections that have been shown to be inadequate as the basis for analyzing modern forensic cases due to secular changes as well as other factors (Dirkmaat 2008). This was particularly problematic after the cases of Daubert v. Merrel Dow Pharmaceuticals, Inc. (1993) and Kumho Tire Company v. Carmichael (1999), leading to the creation of the Daubert Standards.

The Daubert Standards moved the focus from the experts experience to the experts methods, demanding that methodology was more quantitative in nature rather than qualitative and therefore, replicable. Replicable methods are essential as they specify direct results, rather than analogies. The testability and reliability of replicable methods ensures that conclusions are objectively arrived at rather than subjectively formulated (Dirkmaat 2008). The Daubert standards have increased the urgency of improving analytical methods in forensic anthropology and taphonomic studies have led to three new outcomes that helped to expand the role of forensic anthropologists.

Forensic taphonomic research pushed for scientifically grounded estimates of postmortem interval (time-since-death), based on decompositional factors (primarily soft tissue, but in later stages may include bone modification factors), entomological evidence, chemical methods, and associated physical evidence modification (Dirkmaat 2008).

Quantitative methodologies helped forensic anthropologists better reconstruct the original position and orientation of the body as well as understand the characterizations of the role played by human intervention (as a taphonomic agent) on the remains, through the process of ‘‘stripping away’’ all other ‘‘natural’’ agents affecting the remains (Dirkmaat 2008). Taphonomic studies of decomposition have allowed forensic anthropologists to better understand how much time has passed between the time of death and the recovery of remains. However many factors may influence the rate of decay creating challenges in estimating an exact post mortem interval (PMI) or concrete stages of decomposition. Factors influencing decomposition include intrinsic factors (contributed by the body) such as weight, size of the cadaver, inflicted trauma, presence of clothing, disarticulation, and embalming; extrinsic factors (contributed by the environment) such as burial type, temperature, humidity, aridity, sunlight exposure, rainfall, soil PH, insect and faunal activity (Sharplin 2012).

Decomposition can be broken down into two categories: autolysis and putrefaction. The onset of decomposition is due to a process called autolysis, where cells are deprived of oxygen creating a domino effect in which carbon dioxide in the blood increases, pH decreases and wastes accumulate which poison the cells (Vass 2001). This process can also be referred to as “self-digestion” and begins within minutes after death. Cellular enzymes begin to dissolve the cells from inside out causing them to rupture and release nutrient-rich fluids. Autolysis does not generally become visually apparent for a few days and is first observed by the appearance of fluid filled blisters and skin slippage (Vass 2001). The body acclimates to ambient temperature (algor mortis), blood settles in the body causing discoloration of the skin (livor mortis and the cellular cytoplasm has gelled due to increased acidity (rigor mortis) (Vass 2001:1990).

Putrefaction can begin once enough cells have ruptured and enough nutrient-rich fluids become available (Vass 2001). Putrefaction is the destruction of the soft tissues of a body by the actions of micro-organisms, resulting in the catabolism of tissue into gases, liquids and simple molecules (Vass 2001). Active decay can begin once gases have been purged from the body due to putrefaction. Separate from soft tissue decomposition, bone undergoes another complex process called diagenesis. Diagenesis serves to alter the proportions of organic (collagen) and inorganic components (hydroxyapatite, calcium, magnesium) of bone exposed to environmental conditions, particularly moisture (Vass 2001). The process of autolysis, putrefaction and diagenesis work together to return the complex structures composed of proteins, carbohydrates, sugars, collagen and lipids returning to their simplest building blocks (Vass 2001).

Decomposition is a continuous process, beginning at the time of death and continuing until a skeleton has been produced, therefore it is impossible to create concrete stages of decay. However several researchers have attempted a quantitative approach to systematically place a time estimate around the successive stages of decay (Bornemissza 1957; Reed 1958; Payne 1965; Galloway 1989; Prieto et. al 2004; Megyesi 2005; Rottenstein 2006; Simmons 2007; Sharplin 2012; Myburgh 2013). For this thesis a quantitative method is utilized based on Megyesi and Colleagues ADD regression equation developed to estimate PMI through scoring the stages of decomposition as they progress.

IV. Methods

The primary focus of this research will be to assess the impact clothing and temperature have upon decomposition rates. Furthermore this study will compare data with a like study to

see the differences in ADD and PMI between a Southern California climate and a Northern California climate. This thesis will utilize a total of four subjects, pairs of pigs (one clothed and one unclothed), in separate micro-environments (full sunlight/ partial sunlight/ shade) in Northern California to measure the post mortem interval (rate of decomposition) until it produces a skeleton. All four pigs (Sus scrofa domesticus) will be purchased from Millar Swine Farms in Glenn, CA. Each pig will weigh approximately 100 lbs (45.36 kilograms) analogous with the size of a young adult human; all pigs will be of the same biological sex. To avoid adding additional bias into the experiment, the pigs will be transported live by Millar Swine Farms from Glenn, California to Sheridan, California (a distance of approximately 64 miles) where the experiment will take place. Once euthanized the pigs will be placed in their microenvironments, two of which will then be dressed in 100% organic t-shirts and blue jeans. The remaining two pigs will be left in their natural (or nude) state. Each Pair of pigs (one clothed; one nude) will be placed at one of the two micro-climate locations: full sunlight or full shade.

Domestic Pigs (Sus scrofa domesticus) have been chosen for a number of forensic experiments as analogues for human cadavers due to their availability as well as certain physical characteristics they share with humans (Payne 1965; Shean et. al 1993; Turner and Wiltshire 1999; Seets 2003; Archer 2004; Rottenstein 2006; O'Brien et. al 2007; Schoenly et. al 2007; Cross and Simmons 2010; Sharplin 2012; Caballero et. al 2014; Zanetti et. al 2014; Card et.al 2015). Similar to humans, pigs are relatively hairless and share a similar digestive tract due to an omnivore diet, thus the contents within their gastrointestinal tract will be closer to that of a human's during decomposition. Because this experiment analyses the effects of clothing on the rate of decomposition, a mammal with less fur was preferred (Sharplin 2012)

The decomposition experimental site location is in Sheridan, California is on the back acre of Mr. Jim Bradley's 10 acre privately owned property at approximately 38°59'47.41"N 121°22'15.69"W. This site is approximate 34 meters above sea level. This region of California is typically classified as a Mediterranean climate characterized by hot summers and mild low temperatures in the winter with rainfall. Annual average temperatures for this region range between 39°F (4°C) and 97°F (36°C) with humidity percentage levels ranging from very dry to dry (average 12-17%) in summer months and humid to very humid 62%-99 in winter months; annual rainfall at 42.28 inches with an average 0.39 inches in the summer (June- September).

After placing the pig carcasses in the experimental microenvironment locations, observations will be taken every three hours from 9 a.m. to 6 p.m. daily (9:00 a.m., 12:00 p.m., 3:00 p.m., and 6:00 p.m.). Once the carcasses stopped showing changes, observations will be taken every third day, then weekly for twelve weeks. A final period of observations and sample collection will be made six months after the start date. All four pig carcasses will be protected from scavengers using large dog crates reinforced with 1 inch chicken wire on all sides, including the base as scavengers can dig beneath the soil to access carrion. Crates will be anchored to the soil using a ShelterLogic solid steal EasyHook Anchor Kit. Chicken wire will be re-enforced using zip ties.

Observations will be recorded as the pig carcasses progress through decomposition. Changes in skin color and location of discoloration upon the body; bloat circumference measured below the second nipple; presence or absence of lividity (blood pooling under the skin); and skin slippage (gloving as well as formation of postmortem bullae, or fluid filled pockets between skin layers); odor; kill wound, oral, nasal and anal discharge; skeletal

disarticulation, tooth loss; and insects and arachnids present will all be recorded for this study. Further, the identification and growth stage of the insects and arachnids involved with the carrion as well as their location and proximity to the pig carcasses will all be recorded.

Table: 1.1 Decomposition Events by Visual Inspection

Observation	**Measurement**
Skin Color and Location	Visual Observation
Bloat Circumference	Measured in Inches
Lividity (Blood pooling under the body)	Present/Absent
Skin Slippage	Present/Absent
Odor	Present/Absent
Kill Wound Discharge	Present/Absent
Nasal Discharge	Present/Absent
Anal Discharge	Present/Absent
Skeletal Disarticulation	Present/Absent
Toothloss	Present/Absent
Insect/Arachnid	Few/Some/Many

Microenvironment observations around each cadaver will include ambient temperature readings taken 10 inches above the soil, measured in degrees Celcius with a ActiveAir™ Indoor-Outdoor Digital Thermometer with Hygrometer (Hydrofarm, Santa Fe Springs, CA); relative humidity measured at 10inches above the soil as a percentage using a ActiveAir™ Indoor-Outdoor Digital Thermometer with Hygrometer (Hydrofarm, Santa Fe Springs, CA); soil temperature will be taken in the same location at one end of each pig's enclosure using a Taylor Stainless Steel Instant-Read Dial Thermometer (Taylor Precision Products, Oak Brook, IL); sky appearance will be recorded by visual inspection and recorded as either Clear, Few Clouds, Some Clouds, Partly Cloudy, or Cloud Cover; and rainfall will be measured in inches using a Taylor Precision 2700N ClearVu 5 inch 90 Capacity Rain Gauge (Taylor Precision Products, Oak Brook, IL).

All temperature and humidity measurements from the microenvironment experimental sites will be compared with the measurements from the nearest National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA) weather station at Lincoln Regional Karl Harder Field (KLHM) Lat: 38.9092°N Lon: 121.3513°W Elev: 121ft. These weather station measurements will be compared with our site temperature and humidity measurements for statistical significance.

Table 1.2: Measurements of microenvironment ambient conditions, units and instruments.

Measurement	Units	Instrument
Ambient temperature taken	Measured in degrees Celcius	ActiveAir™ Digital Thermometer
10 inches above the soil		Hygrometer
Relative humidity	Measured as a percentage	ActiveAir™ Digital Thermometer
		Hygrometer
Soil Temperature taken at	Measured in degrees Fahrenheit	Taylor Stainless Steel Analog Instant Read
one end of the pig enclosure		Dial Thermometer
Sky appearance	Recorded as either no clouds (clear sky),	Visual Inspection
	few clouds (more sky visible), some clouds	
	(half sky/half clouds), Partially cloudy (some	
	sky visible), or cloud cover (no sky visible)	
Rainfall	Measured in Inches	Taylor Precision 2700N ClearVu 5
		Inch Capacity Rain Gauge

For this particular study, a modified version of Galloway's decomposition stages were used. Galloway proposed four stages of decomposition: fresh, early decomposition, advanced decomposition, skeletonization. Galloway cautions that decomposition cannot be placed into sequential ranking, however in order for the final decomposition scores to reflect the total amount of accumulated decomposition, four stages were modified into sequential ranking (Megyesi et. al 2005). Stages within each category describe the appearance and general characteristics of the remains and are then scored with an assigned point value, starting with 1 (fresh) and increasing in point value for each progressive stage (Megyesi et. al 2005). Separate

point systems are assigned to three regions of the body as stages of decomposition do not equally apply to all parts (Megyesi et. al 2005).

The independent variables for this study will be the microenvironments of full sunlight and full shade, the weather station data as well as entomology. The dependent variables in this experiment will be the decomposition events as well as entomology. In this case entomology is both an independent as well as a dependent as they are both a cause and effect in the rate of decomposition study. Entomological activity is caused by the local environment and it can affect the rate of decomposition of the remains. Because of the small sample size, running statistical tests will not yield correct information regarding rates of decomposition. Rather daily observations will be charted via scatterplot charts and line charts to better understand the progression of decomposition. These charts will help us better understand the rate in which the cadavers pass from one stage to the next. Further we will be able to analyze if there are differences in the rate of decomposition between those that are clothed versus those that are nude as well as analyze differences by microenvironment. This will allow us to test our first hypothesis and see if there is a difference in decomposition rates by condition and environment. Lastly, these statistical tests can be compared to the Southern California study performed in 2012 to understand the difference in decomposition rates by region.

V. Expected Findings

This study expects that sun exposed, clothed pigs will decompose at a faster rate than the rest of the subjects. Direct sunlight propels bacterial growth accelerating decomposition, whereas in cold climates bacterial growth is inhibited retarding decomposition from progressing. Because clothing not only increases body temperature, it also provides areas

where bugs can safely reproduce within the layers of fabric. The increased temperature partnered with heightened entomological activity will likely lead to an accelerated decomposition rate. Furthermore, the location in Sheridan, CA is approximately 13 degrees warmer on average than the site for the Southern California study performed in 2012. The increase in overall temperature suggests that the subjects of this experiment may decompose faster.

VI. Schedule

January- May 2017:	Complete IRB, Work on Lit Review.
	Edit Methods Chapter.
	Design forms for recording data.
June- August 2017:	Data Collection in Sheridan, CA
September- December 2017:	Statistical analysis of data. Continue Writing Thesis
	Turn in First Draft by end of Semester
January-May 2018:	Final draft of thesis, meet with committee for feedback.

Complete edits and submit thesis to committee for approval by deadline.

VII. Committee

- Dr. Mark Griffin (Primary Advisor)
- Dr. Cynthia Wilczak (Second Reader)

VIII. Bibliography:

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