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Patterns in the Scattering of Remains due to Scavenger Activity

By

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Arts.

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Abstract

Patterns in the Scattering of Remains due to Scavenger Activity

In archaeological and forensic contexts, human remains are frequently found scattered. The recovery of these remains is often variable and inconsistent. There has been little research specifically to improve the methods applied to these contexts. This study attempted to discover patterns in the scattering of remains due to scavenger activity. Twelve human analogues (pigs) were deposited in wooded and open grassland environments; half of these were dressed in human clothing. For 103 days, each pig was monitored regularly. Data on the time and direction of movement of the carcass or any part thereof were collected and analysed for potential patterns. The results provide evidence for patterns in where, when and what is scattered due to scavenging activity. Near daily observations may be the key for discovering these patterns. Determining what influences this pattern development and exploring methods that specifically illustrate these patterns should be primary goals in future research.

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Chapter One

Introduction and Research Objectives

Previous Research

Taphonomy, as defined by Efremov (in Gifford, 1981:366), is the study of the processes involved in converting a once living organic form into inorganic remains. In traditional or archaeological research on taphonomy, studies concentrate on the processes occurring on skeletal remains. These include bone destruction through weathering (Behrensmeyer, 1978; Hill, 1976), diagenesis (studied through diet research: Katzenberg, 1992; Lee-Thorp, et al, 1994; Sillen, 1992; Sillen et al, 1995), trampling (Andrews & Cook, 1985; Andrews, 1995), and selective bone transport through fluvial (Behrensmeyer, 1982; Boaz & Behrensmeyer, 1975), scavenger (Berger & Clarke, 1995; Brain, 1981) or predator (Andrews, 1995; Haynes, 1980, 1982) action. The influence of taphonomic factors on the representational accuracy of an assemblage is a major concern for reconstructing extinct populations (Voohries, 1970) because whole individuals or representative parts of individuals may be destroyed effecting our interpretation of population size and composition.

Usually, these taphonomic processes occur over long time periods, ie. hundreds to millions of years, and are either not applicable or not aptly applied to a forensic context. It is specifically this aspect of taphonomy – the application to short term, forensic situations - that this thesis addresses.

It has been suggested the definition of taphonomy be refined to explicitly include processes of decomposition, decay, selective scatter and transport, and the like, to improve the lack of study in this area (Haglund & Sorg, 1997). Should this revision occur, a total process of site formation may be represented by the term taphonomy and, therefore, may also be applied to forensic contexts (Haglund & Sorg, 1997: 3).

Taphonomy is usually studied to aid in site reconstruction. If the processes producing a given site are understood, then the product may be reduced to the components and, subsequently, the original site. In both archaeological and forensic contexts, reconstruction of the original site is often attempted; however, this reconstruction is almost solely dependent upon the physical condition of the evidence, and the kinds of objects that remain. Many variables can act upon a site in concurrent and interdependent ways, potentially leading to total destruction or disappearance of evidence. Multiple methods of observation focussing on different variables are often employed to address this issue. For example, in a forensic context, time since death estimation has included the use of body temperature (DiMaio & DiMaio, 2001), decomposition and putrefaction sequences and rates (Bass, 1997; Galloway, 1997; Galloway et al, 1989; Mann et al, 1990; Micozzi, 1997; Payne, 1965; Rodriguez & Bass,1983; Shean et al, 1993), insect habitation and succession on carcasses (Anderson, 1995; Anderson & VanLaerhovern, 1996; Hewadikaram & Goff, 1991; Schoenly et al, 1991), scavenger involvement (Haglund, 1991; Wiley & Snyder, 1989), and disarticulation in non-scavenger and scavenger environments (Haglund, 1997, 1991). Unfortunately, once the time since death interval begins to extend past weeks and into months, the precision and accuracy of the estimation using the above methods decreases dramatically (Schoenly et al, 1991).

The recovery of as much information as possible from any site under investigation is of vital importance in both archaeological and forensic situations. In forensic situations, however, where there is next of kin to consider, and/or criminal proceedings in progress or planned, the full reconstruction of past events and the identity of the individuals involved are especially important, and arguably might be seen as requiring a higher standard of attention.

Improving the Recovery of Remains

Within the context of research archaeology, and especially so in salvage archaeology, total recovery is a luxury rarely achieved due to resource limitations, time constraints, or the simple magnitude or complexity of the site or sites under investigation. In a forensic case, the concept of incomplete recovery is intolerable: total recovery is the expectation (Haglund et al, 1988, 1989; Haglund & Reay, 1993). Only a complete recovery of evidence can satisfy the expectations of the relevant legal dimensions of a case as well as the next of kin's emotional issues and the "need to know". Indisputable proof in support of a positive identification is of primary importance in forensic investigations, and a complete recovery provides the foundation for this process.

In the real world, though, even in forensic cases, complete recovery cannot always be achieved or verified. In dealing with this reality, the incomplete recovery of skeletal remains is addressed in the literature and in research in two ways: 1) the development of methods to facilitate identification of incomplete remains, and; 2) the development of methods and approaches to improve recovery, thereby minimizing evidence loss.

One of the most influential taphonomic factors in outdoor situations is the dispersal and destruction of remains by scavengers. Most of the relevant literature cites the various search methods for the detection of buried remains (France et al, 1992; Rodriguez & Bass, 1985) or basic anecdotal evidence for describing how widely distributed certain skeletal elements are found due to scavenger dispersal (Haglund, 1991, 1997). There is little specific and systematic research into understanding and explaining why, how and to where evidence disappears. Due to these situations, it is not surprising that achieved recovery rates from surface contexts are still far from ideal (Haglund, 1991; Haglund & Reay, 1993; Komar, 1999; see also Hill, 1979a: 740).

Dispersal of Remains due to Scavenger Activity

The reconstruction of an archaeological site may be concerned with the function of a site, for example, distinguishing between assemblages created by scavengers and those created by predators (Andrews & Nesbit-Evans, 1983; Blumenschine, 1986; Brain, 1981; Haynes, 1980, 1982; Hill, 1979b; Shipman & Phillips, 1976). The reconstruction of a forensic site is usually concerned with the determination of the time of site formation or time since death. In both situations, where and what evidence remains can give information to both reconstructions. Documentation of the effects of scavengers on the recovery rate of skeletal remains has primarily been a by-product of this research.

Geologic forces (ie. wind, water or land movement) can also disperse evidence; however, the act of dispersal usually occurs over a long period of time (ie. over hundreds of years) and the area of dispersal is smaller than that involving animals. If evidence is dispersed over a large area in a short time period, the dispersal is most probably due primarily to animal involvement (Crader, 1974; France et al,1992 ; Morton & Lord, 2000 & 2001). Animal involvement (including human involvement) can include the killing, dismemberment, scavenging or trampling of the decedent. Many factors and processes can be involved and interrelated in what was dispersed, to where, when, and by what agent. For example, the attraction of scavengers to a carcass can involve a number of variables including: the smell of the remains (which is affected by temperature and season), food requirements of that animal group (which is affected by their population density and season), and human or competitor activity in the area. While these variables can be studied independently, they seldom actually occur alone (Wiley & Snyder, 1989: 899). Therefore, full replication experiments in which the dynamic and static components of nature are observed would be seen as valuable in taphonomic research (Gifford, 1981; Haglund & Sorg, 1997).

To date, there have only been two studies to document the dispersal of remains by scavengers in natural or near natural contexts**:** Crader (1984) and Morton &

Lord (2000, 2001). Morton & Lord's study documented the effects of animal scavenging on child-sized human remains. With data from video recordings, they showed that different animals scavenge at different times (2000, 2001). The area of remains dispersal was approximately thirty feet (10m) and they concluded that an assessment of time since death was difficult due to the condition of the remains (2001). The Crader study intended to demonstrate differences in human and natural agencies of accumulation through the daily monitoring of a discarded butchered buffalo for animal activity. Results found that the dispersal area due to scavengers was large and increased and changed daily (1984). Only a few days had elapsed between the deposition of the carcass and the cessation of animal activity, and only a few fragmentary remains were left at the site upon apparent cessation of animal activity. This study could be characterized by a high disappearance rate of skeletal remains over a very short period of time.

The results of these two studies suggest that, over different periods in a study or experiment, there will be multiple scavengers, and that the dispersal will occur within a short period of time, be over a large area and have a high disappearance rate of skeletal elements.

This Study

The research reported in this thesis constitutes an endeavour to fill in the some of the gaps discussed above. This research focuses on the study of scavenging activity occurring prior to the full skeletonization of remains and is being conducted to test the hypothesis that the taphonomic processes of scavenging animals can influence the survival and location of skeletal remains. If a near-natural context using human analogues (in this project, pig carcasses) is used, it may be possible to detect and then describe many of the variables, interrelated or otherwise, affecting the original site. If patterns can be discovered for what remains are moved, when they are moved, and to where they are moved, comparisons may be discerned between the results and the original site conditions. Such patterns and their comparisons to the original site conditions would aid in developing site reconstruction methods that can be applied to help increase the recovery of remains for forensic situations in particular, but also have application to archaeological situations.

Objectives

The primary objective of this study is to understand better certain taphonomic processes and patterns such that the skeletal remains recovery rate in forensic scenes affected by scavenger activity is improved. From these patterns, refined methods of recovering evidence may be created. This study explores several contexts in which patterns may be present:

1) the timing of initial scavenger activity;
2) the movement of the carcass or any part thereof;
3) the disappearance of specific anatomical elements from the main body of the carcass, and the order in which they disappear; and
4) the comparison between scavenger activity and controlled variables (clothing, environment) or other variables (decomposition rate).

It is also hoped that these results will correspond to the original conditions involved in the deposition (that is, the time since death and the initial location of the carcass). To this end, both qualitative and quantitative methods of documentation, analysis and interpretation are used.

In contrast to previous research in this area, this study incorporates several important methodological differences. This study:

1) is a near-natural field study in which little is controlled. Both the static and dynamic aspects of a field context are observed, minimizing the possibility of unforeseen variables adversely affecting the experiment;

2) is a longitudinal study. Events are documented from deposition through to the time of collection by the researcher;
3) uses a relatively large sample. This ensures that the results are not viewed as anecdotal and may, in fact, be indicative of a large scale pattern, and;
4) uses observations on carcasses of known depositions. Date, time and condition of deposition including state of the carcass are documented so that later activity may or may not be linked to these variables as influences.

Outline

This thesis is formatted to follow the above objectives. Chapter Two presents evidence for a temporal pattern in scavenging activity and includes a newly developed study-specific classification for decomposition stages that serves as an aid to the rest of the study. Chapter Three describes the movement of remains and the perceived patterns in their movement. Chapter Four describes patterns in dispersal of bone elements as influenced by decomposition. Finally, Chapter Five details and integrates the conclusions of the previous chapters and suggests courses for future research.

Chapter Two

Temporal Patterns in Scavenging Activity

Introduction

Time since death (TSD) is traditionally used as a comparative baseline for taphonomic event markers such as decomposition stages (Bass, 1984; Rodriguez & Bass, 1983), disarticulation (Hill, 1979 a&b), and scavenger activity (Haglund, 1991). However, these markers may also be influenced by external factors such as climate, clothing and burial. There is evidence that TSD may not be an accurate guideline and establishing direct and consistent comparisons between TSD and taphonomic event markers may not be possible.

The Tennessee Project[1] (Bass, 1984 & 1997; Rodriguez & Bass, 1983) has remained a cornerstone of decomposition research. However, subsequent studies have found that while changes due to decomposition vary linearly with time, the time of onset and duration of decomposition stages can also vary with climate (Galloway, 1997; Galloway et al, 1989; Komar, 1999), the presence and effects of scavengers (Haglund, 1991 & 1992), temperature (Micozzi, 1986 & 1997), and clothing (Toots, 1965). Through studies like these, it has been shown that decomposition is not independent of external factors and, therefore, its correlation to TSD is not definitive (Mann et al., 1990).

Disarticulation of the skeleton, defined as the separation of a bone at a joint (including through amputation) (Sorg and Haglund, 2002:15), occurs with the decay of the soft tissue, but, like decomposition, it also is not independent of external factors. The actions of carnivores can pull apart prey and reduce it to

[1] Studies at the University of Tennessee Anthropology Research Facility used donated human cadavers to explore time since death and markers that could be used by law enforcement to estimate time since death.

bones in a matter of hours (Haynes, 1982). It is also suggested that clothing can have an effect on the disarticulation sequence due to the influence it can have on the decomposition rate (Toots, 1965). Like the stages of decomposition, the typical disarticulation process of the skeleton has a linear progression independent of external factors (Toots, 1965; Haglund, 1991). While disarticulation stages have been compared to a TSD baseline, due to its interrelatedness with decomposition, the accuracy of such a comparison can be affected by unknown and unseen external factors.

Scavenging activity is usually compared to, and linked with, TSD but, again, has been shown to be highly variable in its effects (Haglund, 1991). While scavenging activity has been documented during all of the stages of decomposition (Galloway, 1997), it has not been the primary focus of prior research. Other studies have been cross-sectional and the results correlating scavenging activity to decomposition stage are not possible (Haglund, 1989 &1991).

Due to the research cited above, TSD may not be a good comparative baseline against which to document taphonomic events. It is the hypothesis of this section of the thesis that there is little to no connection between TSD and scavenging activity and hence, does not make a reliable and accurate comparative baseline. To test this, the initial timing of scavenger activity will be compared to TSD to determine if there is a pattern defining how and when scavengers are attracted to carcasses.

Support of hypothesis generates another hypothesis: that decomposition stage corresponds strongly with scavenging activity. To test this, the initial timing of scavenger activity is compared to the decomposition stage to establish whether or not there is a temporal pattern corresponding to decomposition stage.

Methods and Materials

The likelihood of witnessing scavengers in their natural environment practicing natural behaviours during the experiment was considered as only a remote possibility. Therefore, three methods of inferring or confirming scavenger activity were used: 1) the use of a night time camera with an infrared trigger to photograph animals on site; 2) 35mm slide photographs of gnawing, bitemarks or other injury to the carcass and/or remains from animals, and; 3) movement of the carcass and/or remains that cannot be attributed to geologic, environmental, or human factors.

It was also unknown if a human observer would have an effect in a longitudinal study. A forensic study focussing on this important factor has not been done before. Trappers and hunters use methods to disguise their own scent to increase their predatory success, but can also use methods to attract prey (Bateman, 1973: 197 & 237-239; Dailey, 1970: 10-12, 57; Gibson, 1902: 149,156,160; Harding, 1937: 135, 139-140). It has been shown that human scent in this context can have a significant detrimental affect on the success of catching or killing prey.

As outlined in Chapter One, natural studies have the potential to produce data on many unknown and known variables. Therefore, for this study, controlled variables were kept to a minimum while the sample size was maximized.

Controlled variables included: 1) the presence of the human observer on site at intermittent times; 2) the presence of clothing on the 'decedent', and; 3) the environmental context of the 'decedent'. The presence of a human observer was controlled and tested for through the use of a 'Controlled' group (described in detail below). Activity at this group was compared to an 'Uncontrolled' group (described in detail below). Clothing and environment were controlled and tested for through both the 'Controlled' and 'Uncontrolled' groups. Results of both groups were compared. A great difference in the time of scavenging activity or in the direction which remains were scattered was taken to indicate that the human observer may have had an influence on the study.

In total, twelve human analogues (*Sus scrofa*: see France, et al, 1991 and Schoenly et al, 1991, for justification for the use of pigs) were observed on a near daily basis for the period May – August, 2002 at the Ellerslie Research Station south of Edmonton, Alberta, Canada. Time since death of each pig was within 24 hours of deposition and was considered the same as date of deposition.

This study was conducted at the Ellerslie Research Station located on the South edge of Edmonton, Alberta. While human occupation was close (within 5km) and was continually encroaching, the research station itself was an agricultural farm with one residence and several supplies and machinery buildings. The research station is operated by the University of Alberta and was therefore considered private land. This was posted on signs surrounding the facility. The land had been cleared of forested areas to accommodate the needs of the agricultural studies done there. However, there were some small areas that had been left wooded and were not used by the members of the research facility. The study area of this thesis included two of these wooded areas and their adjacent open grassland areas. A general survey of flora and fauna for the study area is included in the appendix (Table A:2).

Controlled Group: testing for human observer effect

Two surface sites (designated A and B in Figure 2-1) were defined in an open grassland environment and spaced 50m apart to prevent cross-contamination (Anderson & VanLaerhoven, 1996).

Both sites had one adult pig each (weighing approximately 35-50kgs): the pig at site A was unclothed and the pig at site B was clothed. The size of each site

Figure 2-1: Aerial Photograph of Ellerslie Research Station, Edmonton, Alberta taken in 1995 by the National Air Photo Library, Natural Resources Canada. Letters are representative of pig carcass locations in May 2002. Although original photograph was 1: 56000 scale, it was scanned into a computer for reproduction here. All carcasses are at least 50m apart.

corresponded to the smallest surface area covered by each pig carcass. Each site was then monitored for activity. For observations after deposition, leather gloves and shoes that had been rubbed with manure were worn by the observer to mask human scent. This procedure was recommended by a number of sources (Bateman, 1973: 197 & 237-239; Dailey, 1970: 10-12, 57; Gibson, 1902: 149,156,160; Harding, 1937: 135, 139-140).

Deposition of human remains in a forensic context (i.e., the body dump site) involves human activity by the perpetrator and/or accomplice(s); therefore, human activity with regards to deposition of the pig carcasses was not disguised with either the 'Controlled' or 'Uncontrolled' group. However, the intensity of human activity may have been an issue. This 'Controlled' group compared the 'lack' of human activity to an activity 'maximum' of a daily visit by one to two people.

It was postulated that a constant human scent at the 'Uncontrolled' group would deter scavengers, and that the 'Controlled' group would display scavenger activity sooner than the 'Uncontrolled' group.

Uncontrolled Group: testing for patterns due to scavenger activity

Of ten adult pig carcasses (weighing approximately 35-50kgs), six were placed in designated wooded sites (E – K in Figure 2-1) and four in designated open sites (C, D, M, L in Figure 2-1). Of the six in wooded sites, three were dressed in human clothing. Two of the four carcasses in open sites were dressed. Deposition date, time, and location of each were recorded along with the condition of the pig (ie. perimortem wounds). Deposition of the first pig was designated Day 1 of the study (the Calendar of Study is located in the Appendix, Table A:1).

Observational records included scene documentation with a digital camera (Canon S30) and bone modification recording with a 35mm camera (Minolta STR

– 101) using Kodak Ekta Chrome Elite slide film 100 ASA to 400 ASA, depending on weather conditions. Handwritten notes were regularly made describing site conditions, and identifying uncontrolled variables and changes within each site through time. Observations were taken on, or as close to, a daily basis as possible. Each site remained intact after each recording session and the integrity of the scene was maintained throughout the duration of the study. Movement of each carcass, if observed, was recorded through digital photography. The movement was also documented by mapping the position of the carcass and/or remains with respect to previously set control points. These control points were plastic signs painted with letters corresponding to the site name and attached to wooden lathe inserted into the ground. Twelve of these control points were staked into the ground and equally distributed around the initial position of the carcass.

A TrailMaster ® Infrared Trail Monitor consisting of a weatherproof 35 mm camera triggered by a motion detecting infrared beam was also used. The infrared beam was set to trigger the camera if animals came onto the site between the hours of 11pm and 5am. Each day the TrailMaster ® camera was checked for triggers and photos. Film (Kodak Ektachrome Elite 400ASA) was reloaded as required. This equipment was set up to record possible animal activity at two sites (D and M).

'First scavenger activity' (see Table A:3 in Appendix) was defined as any activity observed affecting the carcass, such as pecking at a wound by a bird. As this activity may not have involved the movement of the carcass, 'First scavenger activity' did not necessarily coincide with 'First movement'. 'First scavenger activity' may also have involved, and coincided with the disappearance of the carcass or any remains. Geologic forces in this study area were considered nil (ie., there are no fault lines or water courses, and the slope was negligible). Therefore, disappearance of remains was assumed to be attributable to scavenger activity.

‘Movement’ was defined as any movement of the carcass, in whole or in part, from the site of initial placement that could be measured and plotted on a map regardless of the method of movement. ‘First movement’ and ‘Last movement’ did not include the disappearance of the carcass as this act could not be mapped. ‘Movement’ was recorded as having occurred on the date of the observation. No inferences were made on how much time had passed since the actual movement and the observation event. It should be noted that there may not have been continual activity or movement between ‘First movement’ and ‘Last movement’. These dates only serve as reference points as to when scavengers were attracted and when they may have lost interest.

‘Skin and Bones’ was a temporary descriptive term that suggested that the carcass was past bloating with little solid muscle and fat left on the carcass, and consisted mostly of bones and skin. To minimize the potential for site contamination, the examination and handling period did not include the determination or estimation of the amount of soft tissue left on each carcass (volume and weight). This term was devised for quick visual confirmation of the condition of a carcass and was not intended to represent a decomposition stage. The compilation of the results of this entire study was done concurrently with the development of a study-specific decomposition classification scheme (see pages 21-25).

For the graphic representation of the sequential decomposition changes observed in the materials, digital pictures of each carcass were arranged in chronological order. Identification and creation of decomposition stages as well as the times of onset and duration were based upon this pictorial chronology.

Results

To compare the dates of 'First Scavenging Activity' across the sample, ideally all carcasses would have been initially placed on the site at the same time. However, this could not be accomplished. Only a maximum of six carcasses could be transported at any one time. Three groups of carcasses were placed at the site at different times. The initial day of study was May 3, 2002 when Pigs A, B, C, and D were deposited. Pigs E through K were deposited on May 17th and M and L were deposited on May 24th (Table A:3). The final day of the study was August 15, 2004.

The first day of the study did not correspond to time since death on all the carcasses (ie. Pig E: TSD = 0 on Study Day 15). This inconsistency was resolved in two ways. Placement dates were corrected to Study Day One (May 3, 2002) so that all carcasses were viewed as part of the entire sample or that each carcass was corrected to their TSD and interpreted as an individual study. In the latter case, the TSD for each carcass corresponded to their date of study while in the former, it did not. Each of these ways contributed analytical value to this thesis.

When the TSD of all carcasses was corrected to Study Day One, this allowed the entire sample to be compared for scavenger activity (ie, Pig E: TSD = 15 on Study Day 15). Due to the objectives of this part of the thesis, to find patterns in the timing of scavenger activity, this was especially important. Carcasses placed at the site first may have influenced scavenger activity on those carcasses placed at the site later. TSD of carcasses placed on site after others may not have theoretically been zero as they may have been scavenged sooner than those without the influence of carcasses placed at the site earlier. This cross-contamination would appear as a clustering of events when all carcasses with corrected TSD were compared.

When the TSD of all carcasses was not corrected to Study Day One but, instead, the study day was corrected to the TSD, (ie. Pig E: TSD = 1 on Study Day 1) each carcass could be compared on an individual level. The study day corresponded to TSD and did not take into account possible influences from other carcasses in the area. This was important for documenting and comparing the decomposition of each carcass. This also gave evidence for other factors influencing scavenging activity, ie. environmental context and clothing. For graphical comparison, this correction was defined as 'TSD uncorrected'.

Figures 2:2 – 2:5 show the graphical comparison of time of first scavenging activity to time since death (TSD). 'First Scavenger Activity' was chosen to represent the first possible incidence of scavenger attraction to that particular carcass. It could also involve movement.

With the 'TSD corrected' data, the initial incidence of scavenging activity was later for carcasses in wooded situations compared to those in open contexts (Figure 2-2). Scavenging activity occurred earlier in open grassland situations (min. = 24 days and ave. = 50.5 days) than in wooded situations (min. = 36 days and ave. = 52.3 days). However, as postulated above, there was no clustering of dates to indicate that the carcasses deposited first (A – D) influenced the scavenging of other carcasses. In fact, Pigs B and C were among the last to be scavenged.

However, the 'TSD uncorrected' results (Figure 2-3) were contrary to the above. The timing of initial scavenging activity showed that pigs located in the woods had activity a minimum of 21 days since death whereas open grassland areas had activity no earlier than 24 days since death. The averages, however, indicated that carcasses in the woods were scavenged later than those in open contexts. While this seems to be a contradiction, the chart graphically illustrated a clustering of event dates. As postulated above, a clustering may have indicated

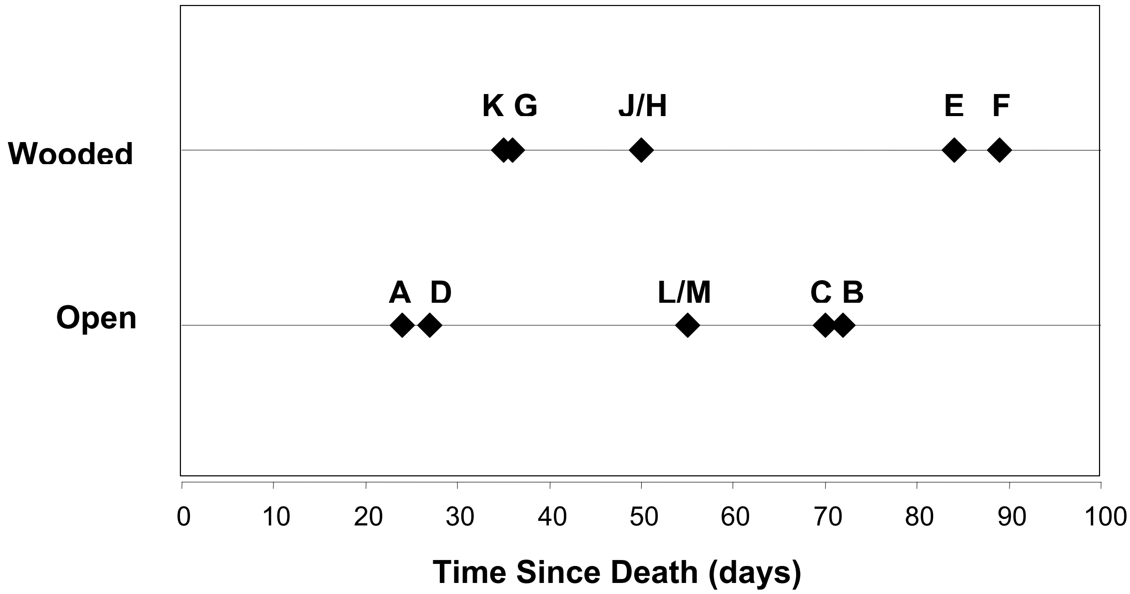

Figure 2-2: First scavenging activity compared to time since death (TSD corrected). Wooded statistics: max. = 89, min. = 36, mean = 62.5, n = 6. Open statistics: max. = 70, min. = 24, mean = 50.5, n = 6.

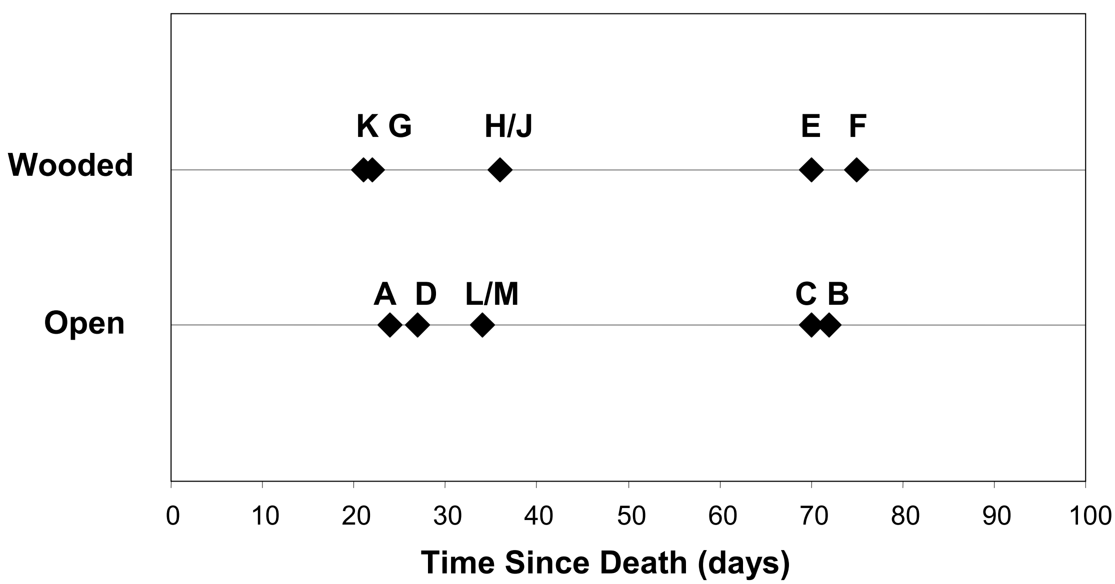

Figure 2-3: First scavenging activity compared to time since death (TSD uncorrected). Wooded statistics: max. = 75, min. = 21, mean = 48, n = 6. Open statistics: max. = 70, min. = 24, mean = 43.5, n = 6.

that the factors involved in the timing of scavenger activity may, in fact, have been related to the individual pig and not the entire site.

As seen in Figures 2-4 and 2-5, clothed carcasses were generally scavenged later than unclothed carcasses. There also appeared to be no site influence on individual carcasses as the trend was the same for both corrected and uncorrected TSD. Scavenging on clothed carcasses began 34 days (uncorrected or 50 corrected days) since death whereas scavenging on unclothed carcasses began 22 days (corrected or 24 uncorrected days) since death. The averages also reflect earlier scavenging on unclothed carcasses.

As with the previous figures, there was no clustering of events when TSD was corrected and this suggested that there was no cross-contamination throughout the sample. However, there did appear to be a clustering again occurring in the 'TSD uncorrected' data. TSD for both clothing and environment clustered around two dates. The first cluster occurred around the one month to one and a half month time period (approx. 25 – 45 days), while the second occurred past the two month period (approx. 70 days) for both clothing and environment preferences. This, again, may have been indicative of factors (ie. decomposition) occurring at each carcass at these times to attract scavengers.

There did not seem to be a connection between TSD and initial scavenging activity. Variability was very large between minimums and maximums for both environmental and clothing controlled contexts. Therefore, there is support for the hypothesis; TSD appeared to be a poor comparative baseline for identifying initial scavenger activity.

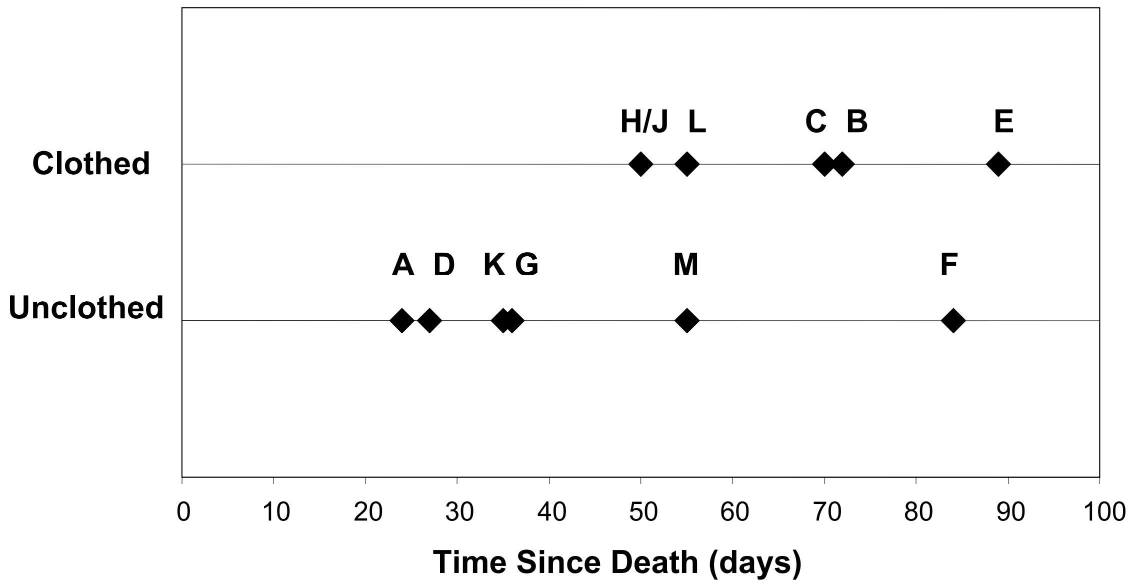

Figure 2-4: First scavenging activity compared to time since death (TSD corrected). Clothed statistics: max. = 89, min. = 50, mean = 69.5, n = 6. Unclothed statistics: max. = 84, min. = 24, mean = 43.5, n = 6.

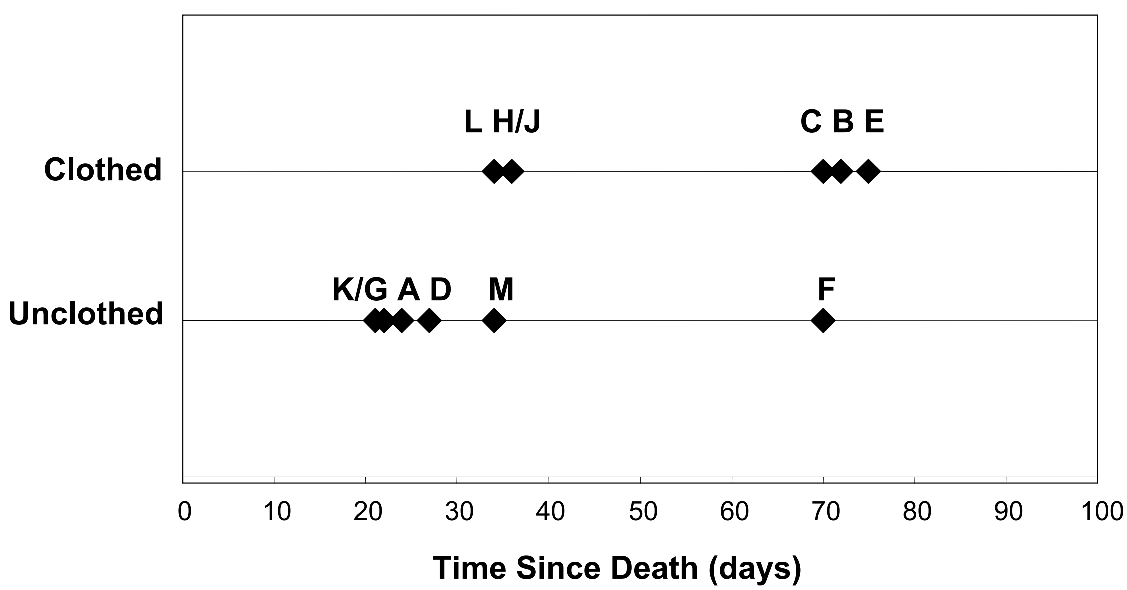

Figure 2-5: First scavenging activity compared to time since death (TSD uncorrected). Clothed statistics: max. = 75, min. = 34, mean = 54.5, n = 6. Unclothed statistics: max. = 70, min. = 22, mean = 33, n = 6.

The second hypothesis involved the determination of a connection between scavenging activity and decomposition stage. It was found that classifications in the literature (Galloway, 1997; Bass, 1997; Rodriguez & Bass, 1983) were difficult to apply to the present study. Clear indicators for the beginning and end of each stage were not available. Therefore, the following study-specific and qualitative classification was created (duration and time of onset data in Table Set A:4) :

1) Fresh (Figure 2-6):
   Beginning of this stage = at the time of death. In this study, placement of the carcass was within 24hrs of death but TSD was not precisely known. For this study, the 'Fresh stage' began at the time of deposit.
   End of this stage = the beginning of 'bloating'. 'Bloating' was defined here as the observation of the expansion or 'ballooning' of the abdomen.
   Flies were almost immediately present and this stage could have had eggs present. No maggots were observed.

2) Early (Figure 2-7):
   Beginning of this stage = from the beginning of 'bloating' (as defined above as the end of the Fresh stage).
   End of this stage = the day after 'bloating' peaks. When the abdomen was observed to 'deflate' or decrease in size in comparison to earlier days, this stage has ended.
   There was some darkening of the skin. Maggots were present.

3) Advanced (Figure 2-8):
   Beginning of this stage = from the decline of 'bloating' (as defined above as the end of the Early stage).
   End of this stage = the beginning of 'collapse' of body cavities. 'Collapse' was the observation that a body part, for example, the head or chest,

Figure 2-6: An example of the ‘Fresh’ Decomposition Stage.

Figure 2-7: An example of the ‘Early’ Decomposition Stage.

appeared to ‘fall’ or collapse inward. The carcass or a part of it appeared to look like skin and bones, with no muscle or fatty tissue underneath (without the ‘padded’ appearance). The bone structure could clearly be seen under the skin.

The decline of bloating was different from the beginning of collapse. The abdomen ceased to increase in size and returned to approximately its original size before ‘collapse’ began. As well, ‘collapse’ in this study was observed to begin at the head and not the abdomen. In succession, the abdomen would cease to bloat, return to approximately its original size, and then ‘collapse’ of the head would begin.
Further or continued darkening of the skin.
Skin slippage or sloughing.
Large maggots were present, very active, in large mounds.

4) Collapse (Figure 2-9):
Beginning of this stage = the beginning of the ‘collapse’ of the body cavities (as defined above in the end of the Advanced stage).
End of this stage = the ‘collapse’ of the entire carcass was complete.
Usually this stage began at the head with the chest and abdomen next, followed by the rump. This stage occurred on one part of the carcass while another part was usually in another stage (ie. the rump still had a ‘padded’ appearance while the abdomen had ‘collapsed’ and the head was beginning to appear ‘mummified’ – see next section). However, the duration of the ‘collapse’ stage was taken as the time it took for the entire carcass to ‘collapse’. At the end of this stage, it appeared as if there was nothing left but ‘skin and bones’.

Figure 2-8: An example of the 'Advanced' Decomposition Stage.

Figure 2-9: An example of the 'Collapse' Decomposition Stage.

5) a) Mummification (Figure 2-10):
   Beginning of this stage = after the carcass had passed through the 'collapse' stage, a large amount of soft tissue may have been present with maggots and beetles still active. However, in comparison to earlier observations, the carcass appeared to be skin and bones.
   End of this stage = only bones and a hard leathery skin 'shell' were left.

   b) Liquification (Figure 2-12a & b):
   Beginning of this stage = a sudden liquefying of the remaining soft tissue, including the skin, into a frothy white liquid.
   End of this stage = the disappearance of the liquid leaving only bones.
   This stage was sudden and the cause was unclear.
   Some carcasses skipped this stage.

6) Skeletonization (Figure 2-11):
   Began after soft tissue had disappeared or decayed.
   Bones were visible and were beginning to lighten ('bleached' in appearance).

As stated in the 'Methods and Materials' section, this classification was derived from a pictorial chronology. All stages, except the liquification sub-stage, could clearly be identified on all pigs.

As shown in Figure 2-13 & 2-14, scavenging activity appeared to correspond with the Mummified stage. Eight out of twelve pigs were scavenged during this stage of decomposition. As well, all twelve pigs were passed the Early stage of decomposition prior to activity. No carcasses were scavenged in the Fresh or Skeletonized stages; however, many remains did not reach the Skeletonized stage by the end date. All remains were gathered at an end date regardless of their decomposition stage.

Figure 2-10: An example of the ‘Mummified’ Decomposition Stage.

Figure 2-11: An example of the ‘Skeletonized’ Decomposition Stage.

Figure 2-12a: Pig G, July 29, 2002 Prior to the 'Liquified' Decomposition Stage.

Figure 2-12b: Pig G, August 6, 2002 During the 'Liquified' Decomposition Stage.

Discussion

Several natural processes and their possible contributing factors were observed:

1) the time of initial scavenger activity did not seem to be influenced by a human observer;
2) scavengers seemed to prefer carcasses in advanced stages of decomposition;
3) the time of scavenging activity did not correspond with time since death or time since deposit. The time of scavenging activity corresponded with decomposition stage, and;
4) unclothed carcasses were scavenged earlier than clothed, and open grassland carcasses were scavenged earlier than wooded ones.

Taphonomic Events

The results shown above allowed for two possible interpretations of the data. ‘TSD corrected’ data considered the study area as a whole. This data showed that scavenging or decomposition of one carcass may have affected another. ‘TSD uncorrected’ data, on the other hand, considered each individual carcass independent of the whole. For this data, the study start date was unique for each individual carcass as each carcass was placed at their location at different times. Results of this data may not have accurately depicted influences from other areas of the site, such as from carcasses deposited earlier.

According to Figure 2-13, Pig A was the first to experience scavenging activity (May 20). Pig A was near to Pig D (Figure 3-1, next chapter), which was the next to be scavenged (May 29). A possible scenario may be that the bird scavenging on Pig A may have alerted the carnivores to the area which subsequently acted upon Pig D. Both A and D were unclothed and, as shown in Figures 2-4 and 2-5, may have been preferred over the clothed Pigs B and C that were also in close proximity. This type of scenario could also be used for Pigs K and G, J and H, L and M, and C and B as, graphically, initial scavenging activity seemed to have

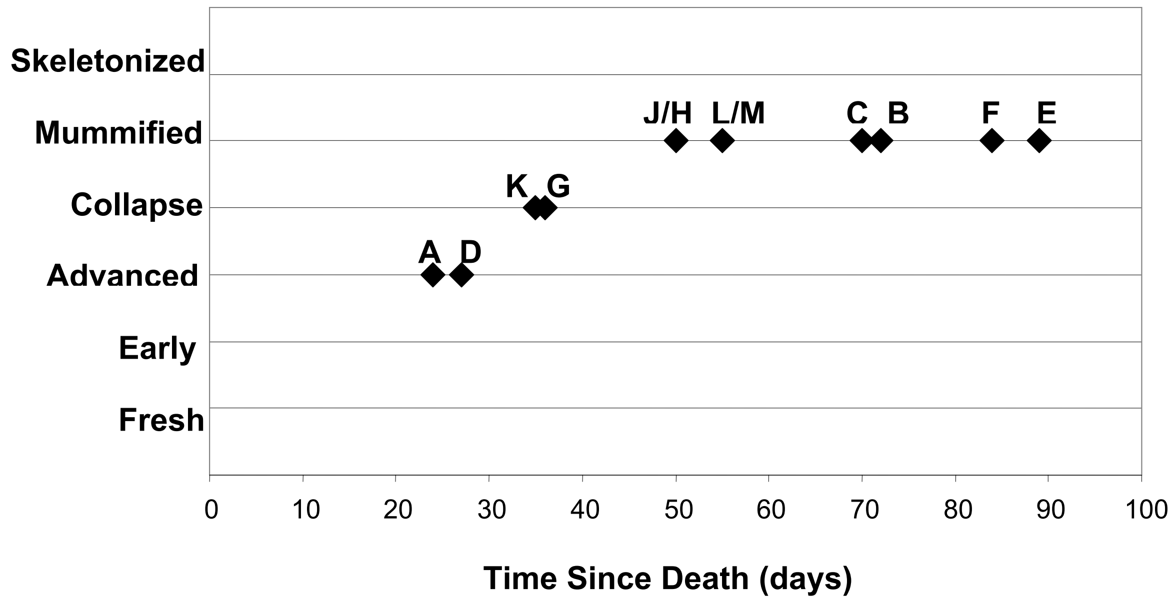

Figure 2-13: First scavenging activity compared to time since death (TSD corrected). Mummified statistics: max. = 89, min. = 50, mean = 69.5, n = 8. Collapse statistics: max. = 36, min. = 35, mean = 35.5, n = 2. Advanced statistics: max. = 27, min. = 24, mean = 25.5, n = 2.

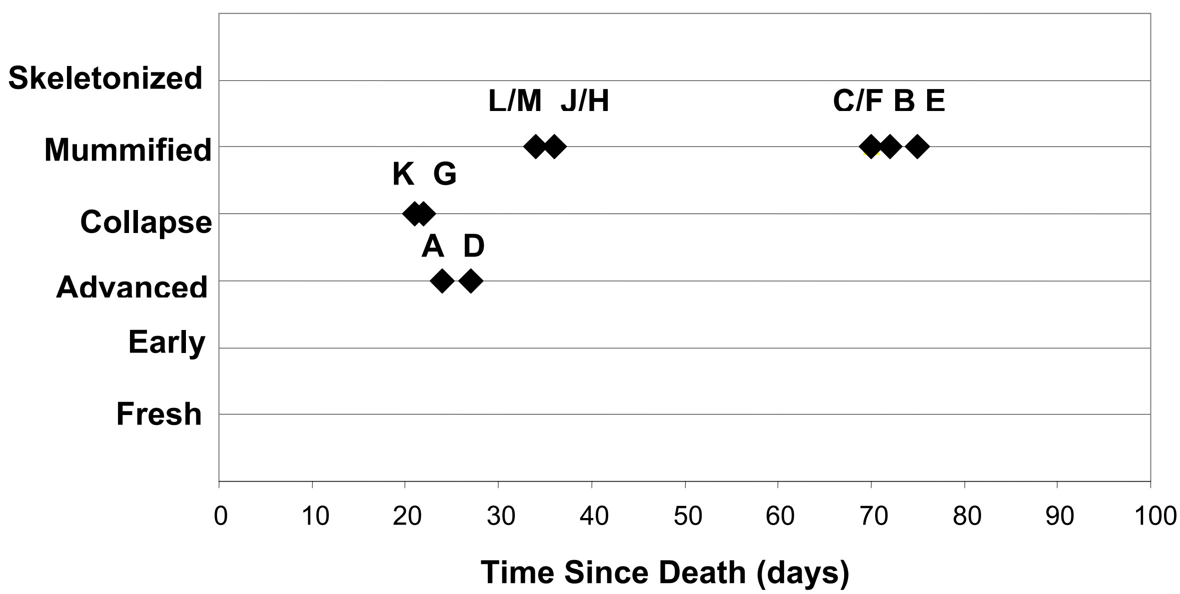

Figure 2-14: First scavenging activity compared to time since death (TSD uncorrected). Mummified statistics: max. = 75, min. = 34, mean = 54.5, n = 8. Collapse statistics: max. = 22, min. = 21, mean = 21.5, n = 2. Advanced statistics: max. = 27, min. = 24, mean = 25.5, n = 2.

occurred on pairs of pigs in close proximity.

‘TSD corrected’ should theoretically have been inapplicable to decomposition onset and duration as it represented possible cross-contamination. Unless carcasses were placed in a group, decomposition stage was independent of the subsequent deposition of other carcasses. However, the results of ‘TSD corrected’ in comparison to decomposition stage (Figure 2-13) showed that two carcasses deposited on Study Day One (Pigs B and C) did not reach the Mummified Stage until after those that were deposited later (Pigs E, J, H, L, and M). This showed that while these carcasses were exposed to the environment longer, they decomposed slower. Both Pigs B and C were in an open grassland context and clothed. Pigs J, H, L and E were also clothed but were in wooded contexts. Therefore, this suggested other unseen variables involved in the decomposition process.

Wounds and cause of death did not seem to influence either decomposition or initial scavenger activity. Pig E had trauma on the belly (probably post-mortem) but was among the last to have scavenging activity. Pig D, the first to be scavenged, had little to no trauma.

Scavenger activity was expected during both day and night with a wide range in the diversity of possible scavengers (canids, domestic and wild, as well as rodents and birds). There was moderate human activity at the site due to its function as an active agricultural educational and research facility. Results showed that scavenger activity (primarily involving movement of the carcass) occurred during the early hours of the morning (usually between 11pm and 5am). Although scavenging could happen during the day (ie. birds), all scavenger pictures were taken during the night.

Decomposition Stages

As mentioned above, the classification system described here was created for use in this study context. Other classification systems or descriptions were found to be inapplicable.

There were two primary differences between traditional classification systems and the one created for this study. The ‘Collapse’ category and ‘Liquification’ sub-category were created for ease of observation. The carcasses in this study were handled as little as possible to minimize any adverse human observer effect. The carcasses were not prodded to assess possible disarticulations or the amount of soft tissue remaining. Descriptions of the decomposition stages were based on field notes and pictures of the carcasses. The ‘Collapse’ category could be easily observed on each carcass and was consistent in timing and duration across the sample. The ‘Liquification’ sub-category was described because it was observed in three pigs and a description of this phenomenon could not be found in the literature. It has been suggested that scavenger saliva may be a catalyst to trigger this ‘liquification’ (Beattie, 2004). While this sub-category may be exclusive to pigs, the causes or processes were not known.

It may be useful in follow-up research to divide the ‘Mummified’ category, as defined here, into ‘Fresh Mummified’ and ‘Late Mummified’. Many of the carcasses scavenged in the ‘Mummified’ stage had large amounts of soft tissue still present (Pigs C, E, G, H, M) and few were nearing the ‘skin and bones’ appearance of later mummification (Pig B). Since this stage had a longer duration (14 – 60 days, see Table Set A: 2), a breakdown of this category into early and late phases may provide further evidence of scavenger preferences. This further division was not applied here because no clear and precise way of determining the beginning and end of these proposed stages could be found.

Determination of Post-Mortem Interval

This study showed that if the timing of scavenging activity had been used to estimate post-mortem interval, the results would have been inconclusive. From Figures 2-2 and 2-3, it can be seen that there was a general tendency for carcasses in wooded areas to be affected by scavenging activity later than those in open areas. A similar general tendency could be seen with the clothed group (Figures 2-4 and 2-5); unclothed carcasses tended to be scavenged earlier than clothed carcasses. However, more in depth comparisons could not be made. The time interval between first and last carcass scavenged in each group was too great to estimate a precise post-mortem interval.

The results showed that the carcass was most likely to be affected by scavengers in the 'Mummified' stage. If an estimate for the timing of the 'Mummified' stage could be obtained and scavenger activity occurred during this stage, this information may help estimate a post-mortem interval.

Conclusions

The hypothesis of this part of the study stated that time since death would not correspond with scavenging activity and, therefore would provide a poor comparative baseline. According to the results, there is support for the hypothesis. It was found that there was a general tendency for unclothed carcasses and carcasses in open areas to be affected by scavenging first. A more precise connection between time since death and scavenging activity on carcasses involving these controlled variables was not possible. A precise post-mortem interval could not be achieved with these results.

However, it was found that initial scavenging activity was more likely to occur on carcasses in a 'Mummified' stage of decomposition. Therefore, it was concluded that decomposition stage would be a better predictor of scavenger activity than clothing, environmental context, or time since death.

Chapter Three

Movement Patterns in Scavenger Activity

Introduction

Scavengers can be very influential in the movement of human remains and are usually primary factors when remains are scattered, absent or damaged. When the post-mortem interval is short (days to weeks vs. months), scavenger activity is usually responsible for producing site characteristics that result in the poor recovery of remains.

In the literature, an understanding of the movement of remains due to scavenger activity is attempted predominantly through anecdotal evidence. While case studies offer the results of what little was recovered (Haglund, 1997 & 1991; Haglund et al, 1990), other studies offer the results of the movements of single sample experiments (Adair & Kolz, 1998; France et al, 1992; Manheim, 2003). Unfortunately, single sample experiments are not able to show possible patterns in how, when or why the remains are scattered. These studies do illustrate that scavengers do effect the movement of remains, but to deal with the issue of increasing recovery rates and recovery success, we must understand the contributing factors and possible patterns involved in the scattering of remains. With this understanding, searches can be better planned and recovery rates improved.

In addition to being anecdotal and of small sample size, many studies are conducted under controlled conditions and are not naturalistic. Studies in the forensic sciences make little mention of ecology and environmental factors influencing scavenger behaviour. Understanding the movement of remains involves having knowledge of what the external factors are and how they influence to where the remains are moved. Including these factors in research is difficult. Ecological and biological research on the behaviour of canid scavengers frequently involves years of data collection based on chance observations (Haynes, 1980; Beckoff & Wells, 1980). Near-natural studies, lacking in forensic science, would be ideal for observing these factors.

It is the hypothesis of this part of the study that there is a pattern in the direction of movement of remains due to the actions of scavengers. Further, it is suggested that any discerned pattern may vary according to environment (in this thesis, wooded or open contexts). An experiment using a relatively large sample of deceased pigs in an near-natural context will be used to test this hypothesis. The movement of each pig carcass and its parts will be compared across the sample to determine if a pattern is present and therefore, if there is support for this hypothesis.

Methods and Materials

Methods primarily the same as those outlined in Chapter Two were used in this experiment. To test for human observer effect, a 'Controlled' group of two pig carcasses was observed and analyzed for differences from the 'Uncontrolled' group in terms of direction of movement. Both groups of pig carcasses, twelve carcasses in total, were equally divided between clothed or unclothed and wooded or open grassland situations. Observations consisted of the recording of the date, time, and location of initial placement and any subsequent displacement of any carcasses. Photographs were taken of any scavenger activity. The TrailMaster ® Infrared Trail Monitor was used to detect animal activity around the carcass.

To record movement, as defined in Chapter Two, a carcass, or any part of it, must have been measured both in the original and terminal positions. The direction of movement of each carcass was compared to all other carcasses to determine if there was a definable pattern. To facilitate comparison across the sample, a detailed map marking the movement of each carcass and its parts was made. Each map was scaled and oriented to True North. The map also included reference points marked by wooden stakes on site prior to the placement of each carcass. Measurements between each of these reference points were also recorded prior to carcass placement. When the carcass or its remains moved, it was measured in reference to at least two of these points. These points were chosen to control for directional error. Once the end date was reached and the map included all observed movement, this allowed for detailed comparisons and the interpretation of possible patterns.

It is important to note here the use of the term ‘Movement’. As defined in Chapter Two, ‘scavenging activity’ included the disappearance of remains. This term could not be used in this part of the study as the disappearance of remains could not be measured. Remains could only be mapped when they were present in known beginning and end points. While a carcass may have been affected by ‘scavenging activity’ (Chapter Two), it may not have moved. The term ‘Movement’ excluded activity that did not inflict movement. The date of ‘Last movement’ (Table A:3) was the last date in which an element had moved from one position to another and could be mapped.

As well, specific descriptive terms to classify directional movement and non-directional movement were assigned. Since a pattern in the direction of movement was sought, a distinction had to be made between carcasses that moved with and without direction. ‘Directionally dispersed’ was used to categorize those carcasses or remains that were moved in a certain direction. ‘Non-directionally dispersed’ was used to categorize those carcasses or remains that were either scattered equally and randomly about a point or that were moved without discernable direction. This categorization helped in determining possible influences on the movement. For example, a random scattering of remains may have been due to bird activity or trampling by non-scavenging animals whereas, if the carcass was pulled into the bush, it may have been due to the scavenger's aversion to human activity or the preference of the animal to have shelter. Decomposition stages were assigned according the descriptions as set out in Chapter Two. The observation date was recorded with each movement (uncorrected TSD for 'Last movement' can be seen in Table A:3 and specific dates for activity can be seen in Table A:5).

Results

Eight of twelve pigs moved and could be termed 'directionally dispersed' and comprised the movement sample. Each of these eight pigs was moved at least five metres from the original depositional point and was characterized by a bone path or a path through the grass indicating animal movement. This 'directionally dispersed' sample was compared for the direction of movement and possible influences in that movement.

The remaining four pigs (A, F, L, and J) moved very little, were scattered equally or randomly about the original deposition point or had a high rate of disappearance of elements. Since they displayed movement but could not be classified as 'directionally dispersed' they were grouped as 'non- directionally dispersed'. Pig L bone elements were moved very little, did not disperse beyond the original body cavity area, and were not measured. Pig J remains were equally and randomly scattered about the original deposition point and were not measured. Pig A had a high rate of disappearance of elements; only those elements remaining could be measured. Pig F moved very little and the carcass location was not measured. Measurement was deemed unnecessary in these 'non-directionally dispersed' cases as a clear contrast could be observed between this groups' movement and that of the 'directionally dispersed' cases.

Maps for the eight 'directionally dispersed' pigs were created (Figures 3-1through 3-9 not including Figure 3-4), scaled and oriented toward North. An arbitrary grid of 5m by 5m was chosen to help in the cross-sample comparison. A map of a 'non-directionally dispersed' carcass (Pig A, Map 3-10) has been added here for comparison. The reference points were documented on each map so that where these points were placed could be recorded graphically. The camera stations on each map served to illustrate the direction from which the observer usually approached each site.

In half of the 'directionally dispersed' carcasses, movement of each carcass (Pigs B, E, G, and H) occurred in a single event. For those carcasses, the maps were based on data from a single day. Even though Pig E displayed movement on two dates, it was included in this group because measurements for only one date were available (see *Pig E* section for details). However, for the other half of the movement sample (Pigs C, D, K, and M) movement occurred over a number of days. The maps for these carcasses contain the dates of the movements of identifiable elements.

Pig B

Pig B was clothed and in an open grassland context. At last observation (June 23rd), this carcass was in the 'Mummified' stage. At the next time of observation (July 13th), the carcass had been moved. There was a path in the long grass from the original deposition point and it was dotted with bone elements. This path led away from a zone of human activity toward a barbed wire fence (West) and into an adjacent farm field. The only remains recovered were from along this path. No remains were found in the adjacent privately owned field. The furthest measurable element was 8.28m from the original depositional point (Figure 3-1: 'Original Nose'). No further movement was recorded. At the time of collection (August 15th), elements closest to the original deposition point included ribs, disarticulated forelimbs, mandible, assorted vertebral elements, bone fragments, os coxae and the clothing.

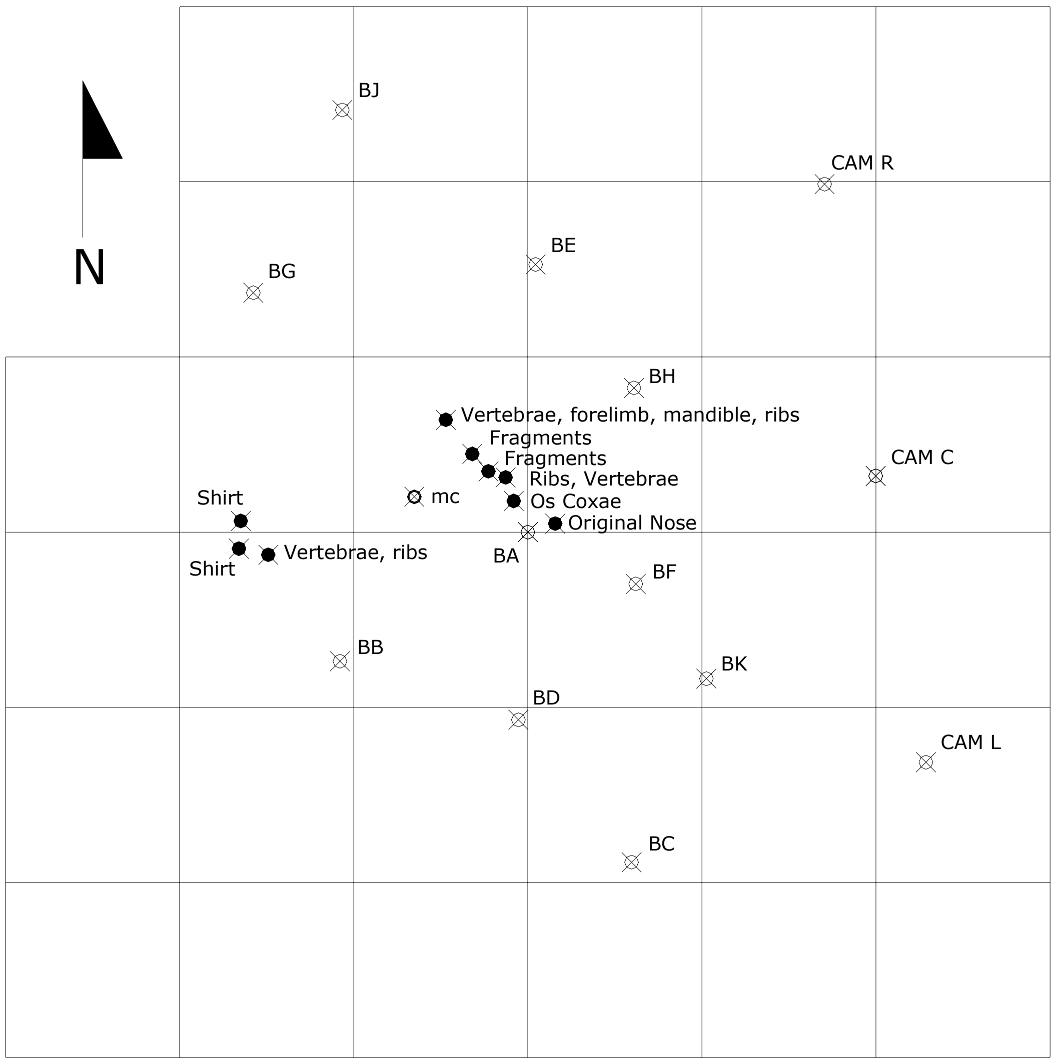

Figure 3-1: Pig B. Map created from data collected on July 13, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc =∑x/n, ∑y/n) = (-3.6m, 1.0m) when 'BA' is (0,0).

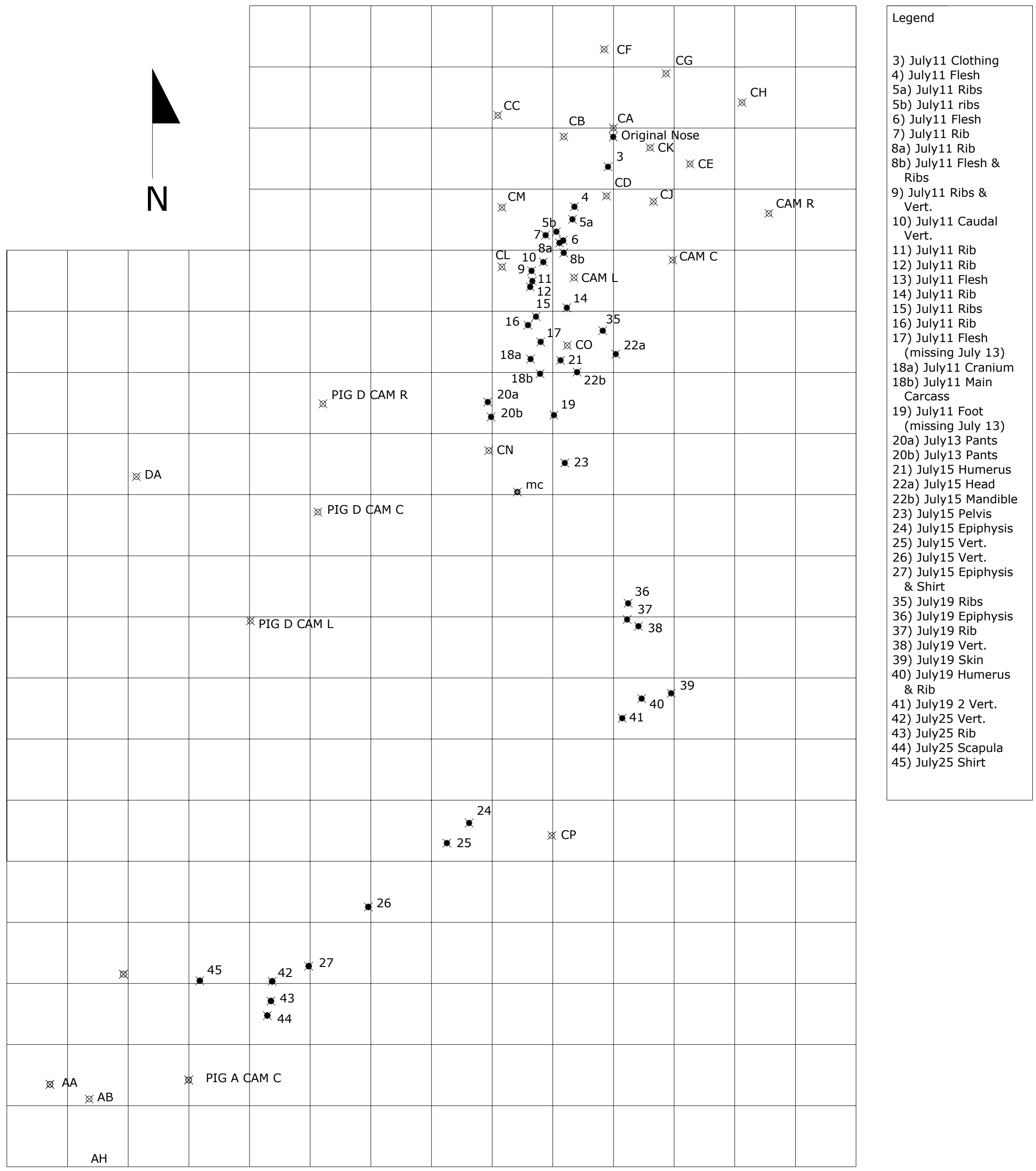

Figure 3-2: Pig C. Map created from data collected on July 11 - 25, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. The observer usually travelled a path between A and D sites (left side) and C site, or straight up the middle of this map. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc =∑x/n, ∑y/n) = (-7.9m, -29.8m) when 'CA' is (0,0).

Pig C

Pig C had the largest degree of movement within the site. Pig C was a clothed pig in an open area context. Observations prior to activity (July 9th) recorded this carcass as in the 'Mummified' stage of decomposition. By the next observation date (July 11th), Pig C had been moved. A path of disarticulated remains was found and was directed to the Southwest (Figure 3-2). Movement continued until July 25th and appeared to be the extension of this path to the Southwest. The shirt (Figure 3-2: '45') and one scapula (Figure 3-2: '44') were the furthest elements at 78m away from the original deposition point (Figure 3-2: 'Original Nose'). Between July 13th and July 25th, small bone elements (ie. vertebrae and fragments) disappeared. Elements closest to the original deposition point included bits of flesh that disappeared within a day (Figure 3-2: '4', '6', & '8'), ribs (Figure 3-2: '5a' & '5b'), and a piece of clothing (Figure 3-2: '3').

Figure 3-2 did not include a '1' or '2' because these elements were missing measurements and could not be mapped. Point #1 included a cervical vertebrae and epiphysis. Point #2 included more cervical vertebrae.

Pig D

This was the first carcass to display 'movement'. Pig D was unclothed and located in an open area context. At the observation prior to movement (May 28th), the carcass was recorded as in the 'Advanced' stage of decomposition. Scavenging was observed on the rump and movement began May 29th (Figure 3-3). The position data for the carcass on May 29th – May 31st were not included on the map because the measurements were incorrectly taken and did not correspond to a single point for a carcass position. Movement continued almost every day until June 17th (see Table A:5). From June 17th through August 15th, the carcass moved intermittently. The carcass was dragged, first West Southwest (to approximately 20m from the original deposition point, Figure 3-3: 'Original Nose'), North along the Western treeline (a distance of approximately 20m), then Southeast, approaching the original deposition point (less than 10m

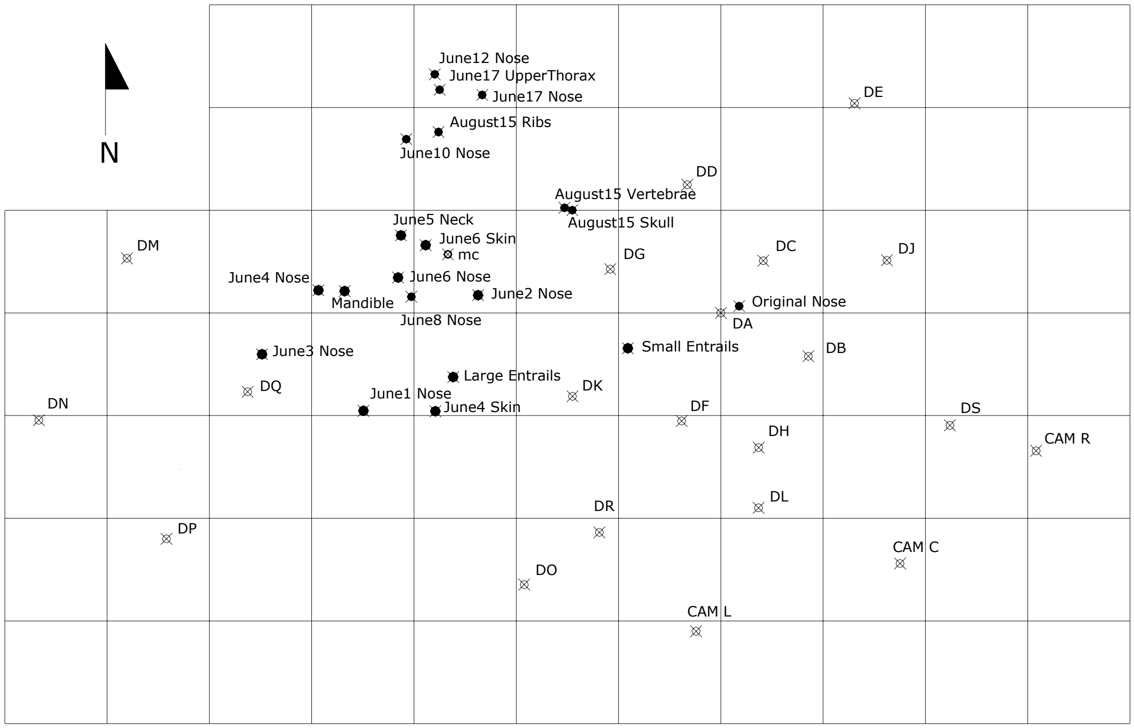

Figure 3-3: Pig D. Map created from data collected on June 1 – August 15, 2002.

Each square = 5m x 5m.

'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.

All other letters represent reference points from which measurements were taken.

Mean centre ($mc = \sum x/n, \sum y/n$) = (-13.3m, 2.8m) when 'DA' is (0,0).

Figure 3-4: A photo showing a coyote on Pig D site. This was taken at 5:12am June 12, 2002 with the TrailMaster® Photographic equipment. The carcass remains are on the left hand side of the picture marked by survey flags.

from ‘Original Nose’). During this time, the carcass was reduced; the flesh was eaten, the limbs disappeared, and finally the bones were gnawed. The cranium remained attached to the body of the carcass until August 15th and therefore, a ‘nose’ could be mapped and compared to the ‘Original Nose’ (Figure 3-3). At the study end date (August 15th), the remaining skeletal elements included the cranium, the disarticulated mandible, and the rib cage with associated thoracic vertebrae.

The TrailMaster® photographic equipment was placed at this site from June 12th until June 26th. Positioned approximately 13.5 m from ‘DA’, the camera took an early morning photograph (5:12am) of a coyote on June 12th (see Figure 3-4). Although the coyote was on site and in the vicinity of the carcass, it was not photographed interacting with the carcass. Prior to the setting up of the camera, on June 2 at 14:30, a black domestic dog was observed at this site; however, it was not seen interacting with the carcass.

Pig E

Pig E was clothed and placed in a wooded context. According to the observations, prior to ‘movement’ (July 29th), this carcass was in the ‘Mummified’ stage of decomposition (see Table A:4). Observations made on July 30th noted movement of the carcass. The dispersed remains of the carcass and the clothing defined a path to the North-Northwest (Figure 3-5). Movement was also noted on August 6th (Table A:5) but measurements could not be taken due to the large amount of foliage in the area. At the study end date (August 15th) remains included a patella found less than 10m from the original deposition point (Figure 3-5: ‘Original Nose’), the right lower leg, some clothing, the cranium, the disarticulated mandible, and the ribs and associated vertebrae. Only the patella and the right lower leg could be measured due to the amount of foliage covering the area.

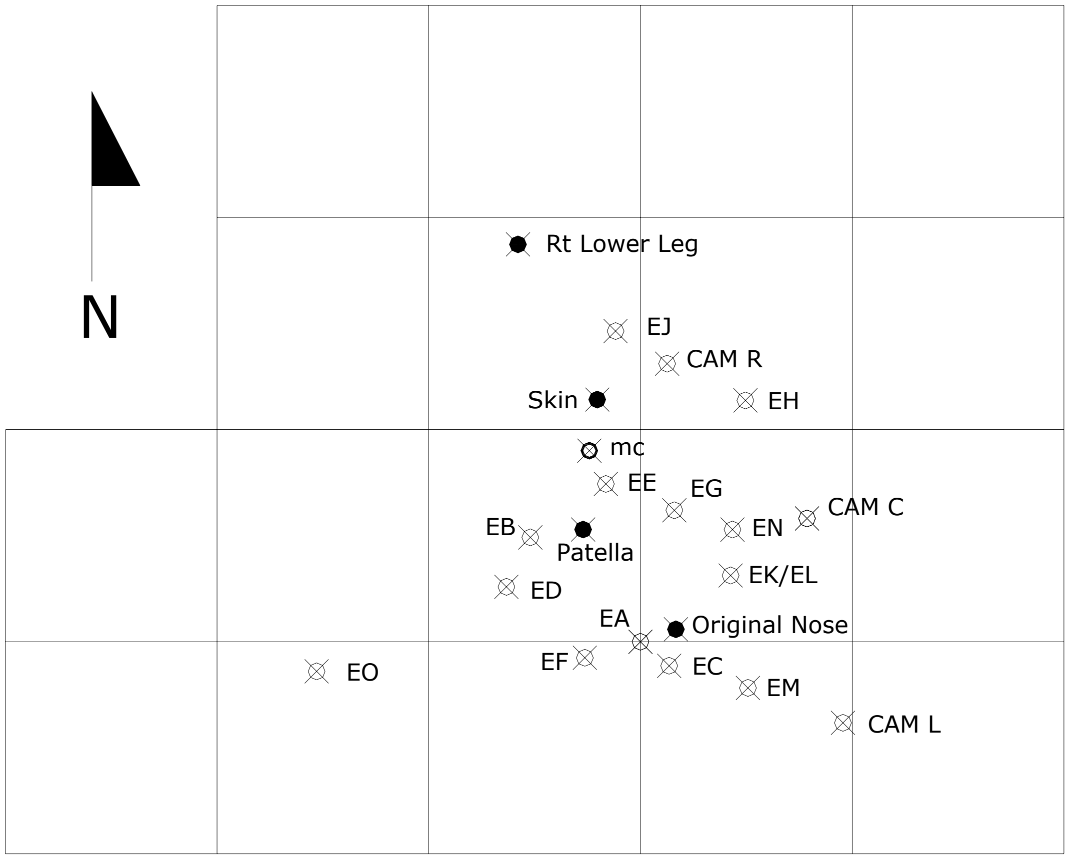

Figure 3-5: Pig E. Map created from data collected on July 30, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = ∑x/n, ∑y/n) = (-1.2m, 4.5m) when 'EA' is (0,0).

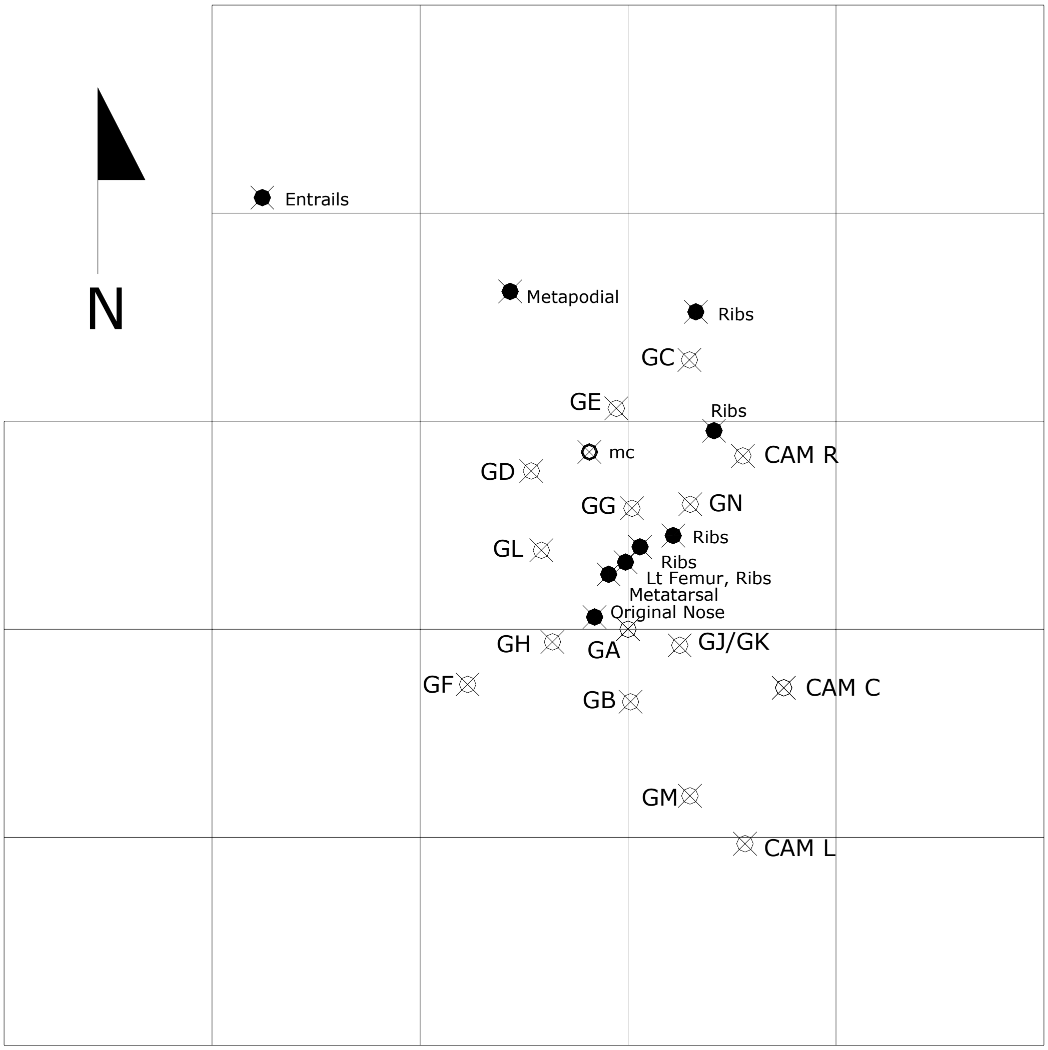

Figure 3-6: Pig G. Map created from data collected on July 29, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = ∑x/n, ∑y/n) = (-0.9m, 4.3m) when 'GA' is (0,0).

Pig G

This carcass was not clothed and was placed in a wooded context. Scavenger activity was observed on June 7th with increased soft tissue damage occurring at a peri-mortem injury site on the throat. Movement was observed only on July 29th. At this time, the carcass was noted to be in a 'Collapse' stage of decomposition (Table A: 4). Skeletal remains formed a path into the bush toward the North-Northwest. Those elements identified at the time of movement were recorded and mapped (Figure 3-6). At the study end date (August 15th), the skeletal remains closest to the original deposition point (Figure 3-6; 'Original Nose') included an articulated vertebral column, both os coxae, both scapula, and disarticulated limb parts.

Differences between skeletal elements identified on the date of movement and the study end date were due in total or in part to the variability experienced in the visibility of the remains on the two dates.

Pig H

Pig H was clothed and recorded as in the 'Mummified' stage prior to movement (July 25). This pig was originally placed on a clearly defined game trail but by the time of movement (July 29th), the trail was substantially overgrown. However, movement of the remains followed this game trail to the West (Figure 3-7). Movement was only noted on July 29th. Remains recovered on the study end date (August 15th) did not differ from that noted on the date of movement (see Table A:5). Remains observed included ribs and associated vertebrae, the cranium and mandible, an os coxae, a scapula inside the shirt, and the left femur. The femur was closest to the original deposition point (Figure 3-7: 'Original Nose') at approximately 5m away. The furthest skeletal remains from 'Original Nose' was the scapula still inside the shirt at 13.7m.

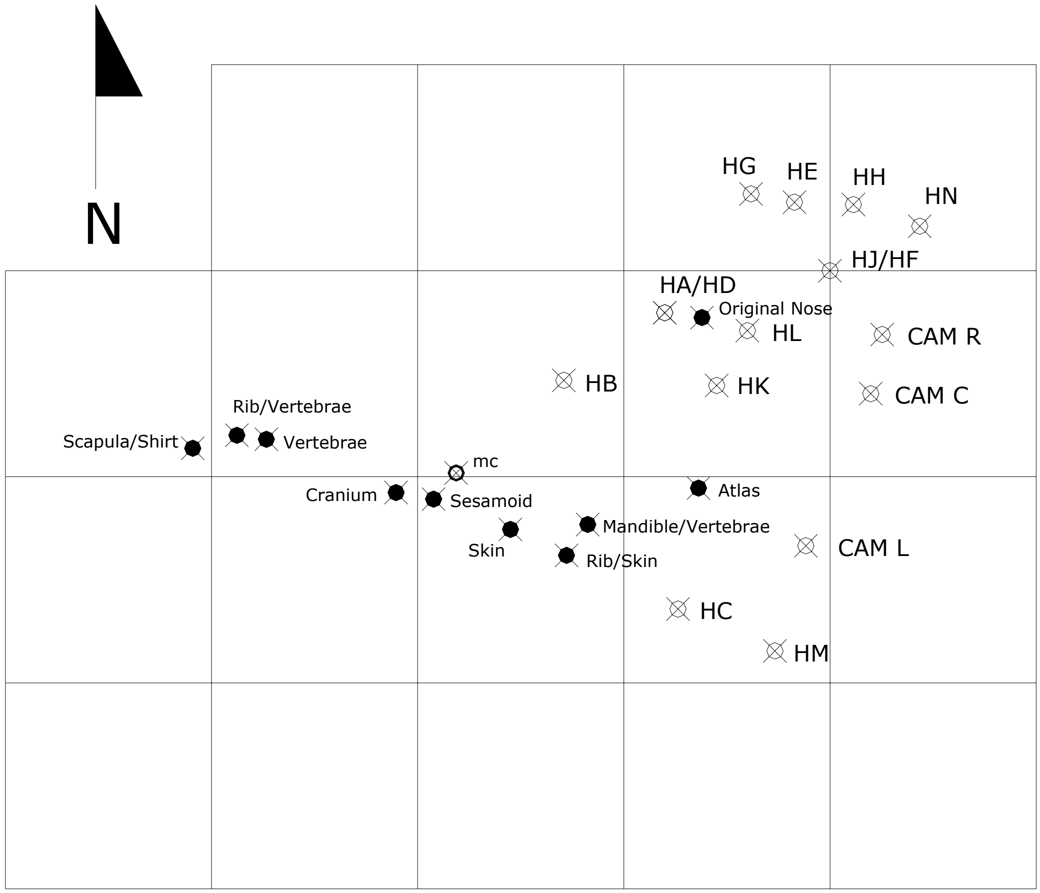

Figure 3-7: Pig H. Map created from data collected on July 29, 2002.

Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = $\sum x/n$, $\sum y/n$) = (-9.1m, -4.9m) when 'HA' is (0,0).

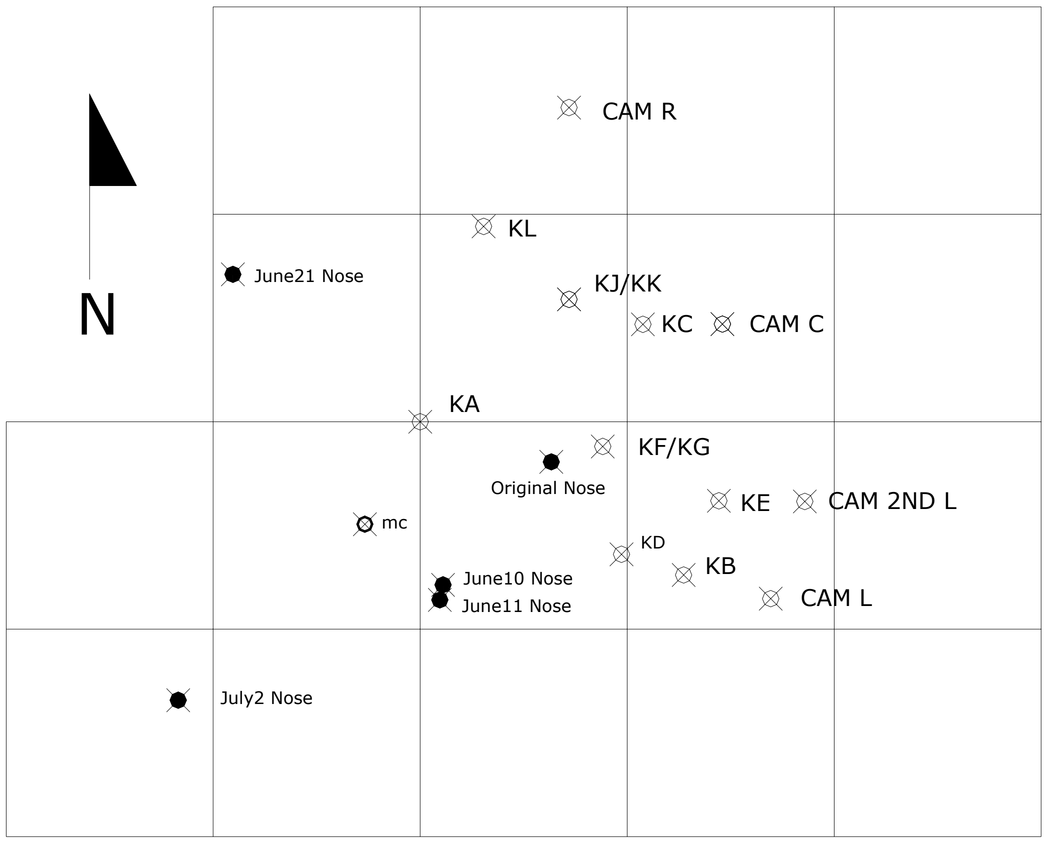

Figure 3-8: Pig K. Map created from data collected on June 10 – July 2, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', 'Cam L,' and 'Cam 2nd L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = $\sum x/n$, $\sum y/n$) = (-12.6m, -2.5m) when 'KA' is (0,0).

Pig K

Pig K was unclothed and placed less than one metre inside the treeline in a wooded context. Prior to movement (June 6th), this carcass was recorded as in the 'Collapse' stage of decomposition. On June 10th movement was noted. A path of skeletal elements led further into the bush to the West (Figure 3-8). At the end of this 'bone path', a skin 'envelope' was found with skeletal remains inside. Since this skin 'envelope' afforded a 'nose' to measure and compare to the 'Original Nose' (Figure 3-8), this was mapped in place of the individual skeletal remains. Very little soft tissue was left either within or outside of the skin 'envelope'. Movement of this skin 'envelope' and its associated skeletal remains continued until July 13th. Those elements closest to the original deposition point (Figure 3-8: 'Original Nose') on the study end date (August 15th) included ribs and fragments. The skin 'envelope', a metapodial and vertebrae were the furthest remains recovered at approximately 10m from the 'Original Nose'.

Pig M

Pig M was an unclothed pig located in an open area context. Prior to movement (June 21st), the carcass was recorded as in the 'Collapse' stage of decomposition. Initial movement on June 26th was a 180° rotation about the nose. Two weeks later (July 9th) the lower limbs were missing and the carcass had moved further (Figure 3-9). By July 25th the right forelimb was missing. A path through long grass toward the South, into the woods and under a barbed wire fence, appeared on this date. Between the date of 'Last movement' (August 6th) and the study end date (August 15th), many skeletal remains disappeared and their end locations could not be mapped (see Table A:5). At the study end date the remains recovered included an os coxae, the rib cage, and the skull. The furthest remains recovered from the 'Original Nose' (Figure 3-9) was the rib cage at over 10m away.

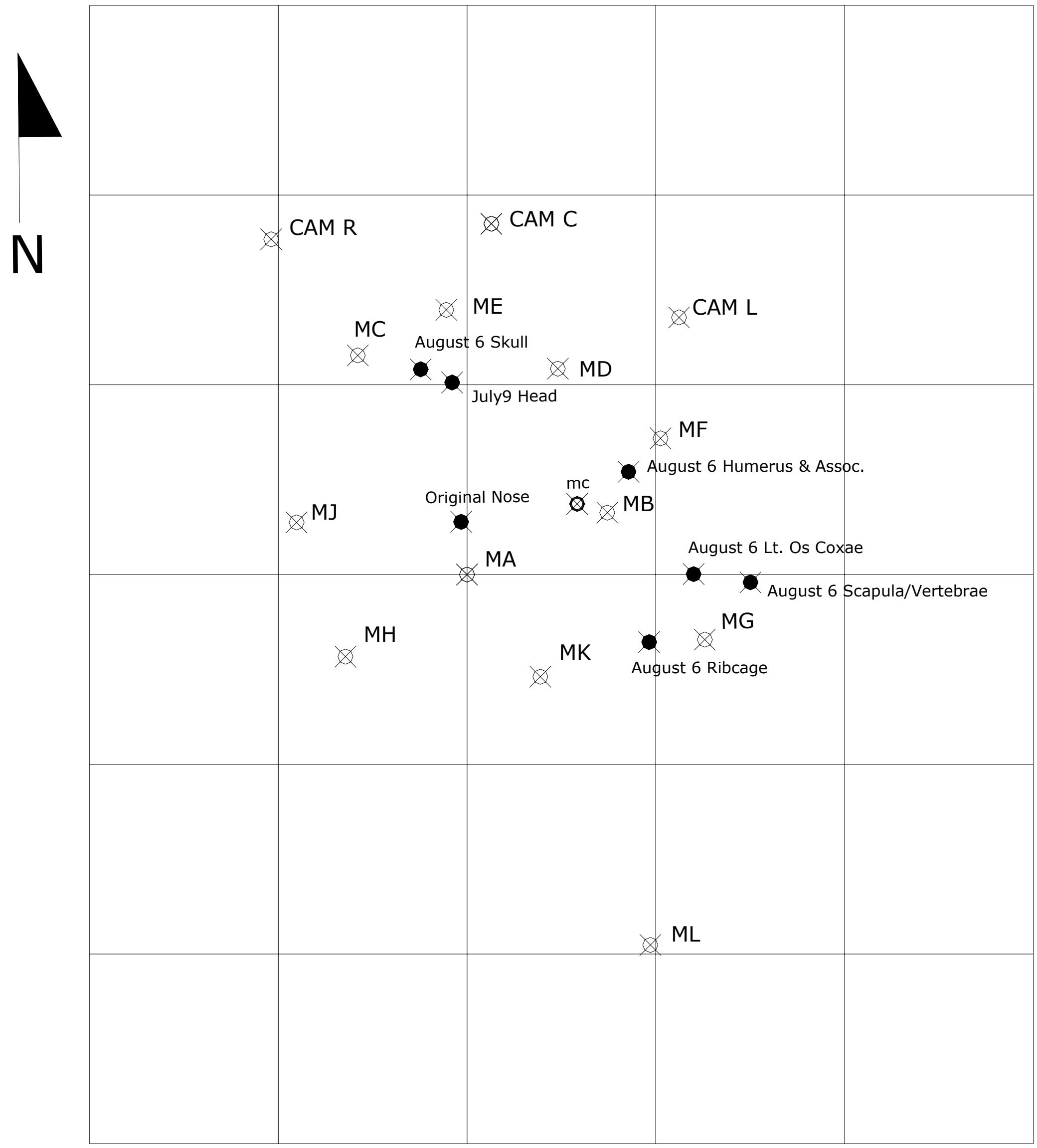

Figure 3-9: Pig M. Map created from data collected on June 26 – August 6, 2002.

Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = $\sum x/n$, $\sum y/n$) = (2.9m, 1.9m) when 'MA' is (0,0).

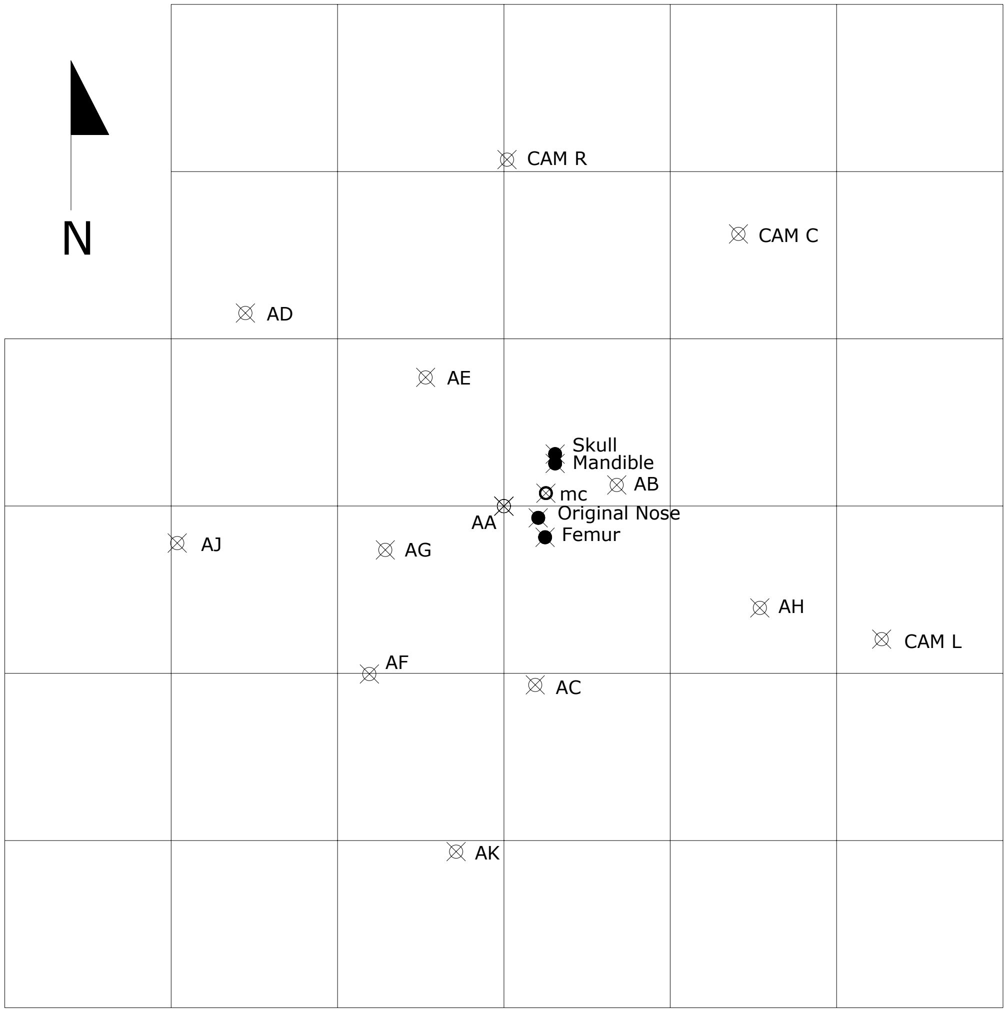

Figure 3-10: Pig A. Map created from data collected on August 15, 2002.
Each square = 5m x 5m.
'Cam R', 'Cam C', and 'Cam L' = camera stations. 'Original Nose' = initial position of the carcass nose.
All other letters represent reference points from which measurements were taken.
Mean centre (mc = $\sum x/n, \sum y/n$) = (1.3m, 0.4m) when 'AA' is (0,0).

15th. The equipment was positioned approximately 9.5m from 'MA'. Several pictures of coyotes were taken and one picture of a deer. The coyote pictures could be of a single coyote returning several times or different coyotes individually visiting the site. As with Pig D, no animal was photographed interacting with the carcass. At the time of initial movement (June 26th), the TrailMaster® photographic equipment was moved from Pig D to this site and remained there until August.

Discussion

There were several processes seen in this part of the study that were anticipated and recorded through the methods used:

1) scavenging activity may not include movement; therefore, it may precede movement of the carcass and/or remains;
2) movement of a carcass and/or remains may be either directional or randomly scattered about a point, and;
3) a pattern in the directional movement of a carcass and/or remains may be identified.

Out of the entire sample (12 pig carcasses), 3 displayed scavenger activity prior to movement.

In developing the methods used here, it was hoped that a pattern in the movement of a single carcass could be observed. The ability to distinguish between 'directionally dispersed' and 'non-directionally dispersed' proved this was possible. Ultimately, all pig carcasses, except one (Pig L), in this study displayed movement; however, eight of the sample moved in a discernable direction. These 'directionally dispersed' carcasses were observed to move in a directional fashion through: 1) the appearance of a 'bone path', or; 2) observing the movement over several days in a particular direction. The 'non-directionally dispersed' carcasses were characterized by a random scattering about a point and/or a high rate of disappearance of remains.

The high rate of disappearance of skeletal remains affected the results of all the carcasses. This was not expected. It was hoped that all skeletal remains could be mapped and recovered. A search was conducted of the adjacent areas, but the recovery of most remains was from the immediate deposition area. Movement and the disappearance of remains usually happened at night and, unless the observer witnessed the abduction of the skeletal remains and tracked them to the end point, mapping and recovery of these missing remains was not possible by the methods employed in this study. Therefore, the total pattern of dispersal and total area covered by the transportation of remains by scavengers could not be documented.

However, a pattern in the 'directionally dispersed' carcasses could be observed. In terms of a general direction, five of these eight pigs moved to the South and/or West. When environment was considered, these carcasses appeared to move away from the path of the observer. Pig M moved to the South; the observer's path was to the North. Pigs D and B moved to the South and West; the observer's path was to the East. Pigs E, H, and K moved West or North; the observer's path was East of these carcasses. In wooded areas, the carcasses were pulled further into the bush (4 of 4). In open areas, the carcasses were pulled toward shelter (ie. the treeline; 2 of 4). The only exception to this was Pig C. This carcass was moved across the path of the observer, away from the research facility, and toward the West. The overall direction of movement of this carcass, however, corresponded to that of the others.

There appeared to be no environmental bias between 'directionally dispersed' and 'non-directionally dispersed' as well there seemed to be no bias for clothing. Both were equally represented by both wooded and open contexts and clothed and unclothed contexts. The mean centre ('mc' on each movement map) was calculated to indicate a mean direction and magnitude for the location of the element remains of each carcass. The mean centre values supported the general direction and magnitude seen on each movement map.

The area of remains scatter was greater in open area contexts. In wooded areas, the remains were recovered within approximately 15m of the original deposition point. In open area contexts, remains were recovered up to 85m away from the original deposition point. However, the disappearance of remains from each carcass suggested that these results might not be accurate. The area of remains scatter might be quite large for all sites and, as pointed out in the literature (Adair & Kolz, 1998; France et al, 1992; Haglund et al, 1990), this was probably the case. It was also suggested here that due to the thick foliage of the wooded sites, the remains could have be present but not recovered. Due to limited manpower and the very large size of the search area, a full search of the area could not be done. However, while it was possible that the data here may not be completely representational of how this dispersal occurred, they may be used as a guideline for what may be expected to be recovered in the area immediate to the original deposition point, and provide guidance as to where to search, thereby potentially improving recovery success.

From the results of this research, a directional pattern in the movement of remains due to scavenger activity was found. Although it is cautioned that the study and season-specific factors may play some as yet undetermined role in influencing the results of this experiment, there is support for the hypothesis.

Conclusions

There is support for the hypothesis for this part of the study. A pattern in the direction of movement of remains due to scavenger activity was observed. Eight of twelve pig carcasses moved in a non-random direction. Out of these eight, 7 appeared to move away from human activity.

Differences were observed between wooded and open area contexts. Carcasses in wooded areas were moved further into the bush and away from the observer's path. Carcasses in open areas were moved away from the observer's path. While the area of remains scatter in wooded areas was smaller than in open areas, these data were suggested as a guideline only. The total area of remains scatter could not be mapped due to the nighttime disappearance of remains.

Chapter Four

Bone Element Dispersal Patterns and Decomposition Stages in Scavenger Activity

Introduction

Previous literature proposes a correlation between amount of scatter, or what bone elements have dispersed, and the time since death (TSD) (Haglund, 1991; Haynes, 1982; Hill, 1979a&b; Toots, 1965). This is usually reported by correlating the disarticulation sequence with TSD as inferred from the remains recovered.

A disarticulation sequence is the ranked order in which bone elements loosen and become separate from the rest of the carcass (Hill & Behrensmeyer, 1984). Usually this occurs in a predictable sequence and has been shown to be consistent across the various mammal species studied. As consistently documented in the previous literature, generally the skull disarticulates first, followed in sequence by the forelimbs at the humerus, the hindlimbs at the femur, and the individual bone elements of each limb. The vertebral column is always listed as the last to disarticulate (Haglund, 1997; Hill, 1979b; Hill & Behrensmeyer, 1984). An inference of disarticulation can be made from recovered remains because of this general sequence. If certain bone elements are recovered (for example, the hindlimbs but not the forelimbs) it can be suggested that the disarticulation sequence may have only progressed to a certain stage and, therefore, may not have been exposed to scavengers or been decomposing for long.

When scavenging occurs during the disarticulation sequence, an entire limb or a section can be easily separated from the carcass and taken by an animal. These sections of carcass are called ‘transport groups’ and can be defined as a group of articulated bone elements that can be transported en masse by a scavenger.

Each of these transport groups can potentially comprise an entire limb and the scavenging of a transport group can increase the rate of disappearance of remains. As the disarticulation sequence progresses, however, transport groups comprise fewer and fewer bone elements. The carcass eventually disarticulates into individual bone elements making transport groups smaller and smaller until they consist of individual bone elements.

The disarticulation sequence involving scavenger activity for humans has been compared to TSD with varying success (Haglund, 1991) and recent research has shown that there is no correlation between the amount of scatter, the direction of scatter, and TSD (Manheim, 2003).

The results of Chapter Two supported the hypothesis that TSD is not a good baseline for which to compare taponomic event markers but that decomposition stage markers are. The hypothesis for this section of the study is as follows: there is a connection between the amount and location of recoverable remains and the decomposition stage of carcasses that have been moved in a non-random manner. The decomposition stage of a carcass can be easily observed without handling the carcass, but disarticulation cannot. Since disarticulation follows a linear sequence much like decomposition, it is suggested here that decomposition influences the formation of transport groups. It is proposed that carcasses exhibiting non-random movement will have more individual bone elements remaining at the original deposition point when they are moved in later decomposition stages than when they are moved during an earlier decomposition stage. This suggests that transport groups are formed and that the size of the transport group corresponds to decomposition stage.

Results supporting the hypothesis will show that the later the decomposition stage at the time of movement, the more remains will be recovered close to the original deposition point.

Methods and Materials

This part of the study used similar methods to those outlined in Chapter Two. To test for human observer effect, a ‘Controlled’ group of two pig carcasses were observed and analysed for differences from the ‘Uncontrolled’ group in terms of the location of certain bone elements. Both groups of carcasses, twelve pig carcasses in total, were equally divided between clothed or unclothed and wooded or open grassland situations. Observations included the recording of date, time, and location of initial placement and any subsequent displacement of any carcasses. Photographs were taken of any scavenger activity. The TrailMaster ® Infrared Trail Monitor and camera equipment were used to detect animal activity around the carcass.

In addition, carcasses defined in Chapter Three as ‘non-directionally dispersed’ were considered a control group against which the ‘directionally dispersed’ carcasses could be compared. To be considered a control group, the ‘non-directionally dispersed’ carcasses: 1) did not display the formation of transport groups, and therefore, all categories of bone elements were represented; 2) had the majority of remains recovered located close to the original deposition point, and; 3) had no differences between decomposition stages in the amount of remains recovered.

For both ‘directionally’ and ‘non-directionally dispersed’ carcasses, photographs and observational notes were used to determine the bone elements recovered. For ‘non-directionally dispersed’, bone elements recovered on the study end date (August 15, 2002) were used. For ‘directionally dispersed’ carcasses, the study end date was not used because bone elements may have disappeared between this date and the date of ‘Last movement’. A connection between movement of the carcass and remaining elements was sought; the use of the ‘Last movement’ date more likely represented the location of each bone element as it related to this movement. Therefore, bone elements recovered on the date of ‘Last movement’ were used for the ‘directionally dispersed’ carcasses.

The grid placed on the maps from Chapter Three served as an arbitrary location guide for bone elements recovered from ‘directionally dispersed’ sites. A $100m^2$ area around the ‘Original nose’ (the four squares surrounding it) was used as an arbitrary limit to describe qualitatively what was close to the original deposition point. Photographs and observational notes were used to describe the locations of bone elements from ‘non-directionally dispersed’ carcasses.

The decomposition stages and their descriptions from Chapter Two were used here. The terms ‘directionally dispersed’ and ‘non-directionally dispersed’ as defined in Chapter Three were also used. Therefore, the categorization of carcasses into decomposition stage and type of movement were continued in this portion of the study.

This part of the study was not initially anticipated, and it was felt that the data may have been incomplete. General categories representing transport groups were used here to minimize the affects of any missing data. The category ‘Cranium’ represented any recovered parts from the cranium or mandible. The category ‘Ribs/Vert.’ represented any recovered parts from the ribs or vertebrae, including the os coxae. The category ‘Scapula’ represented the recovery of any parts from either scapula. The categories ‘Limbs’, ‘Forelimbs’, and ‘Hindlimbs’ represented any recovered parts from these respective groups from either side. Therefore, a single bone element may have represented the presence of a particular category.

Results

The raw data for bone element recovery from each site can be found in Appendix Table A:5.

Table 4-1 provides a comparison of bone elements recovered close to the original deposition point. The ‘non-directionally dispersed’ carcasses exhibited those attributes sought for a control group: all categories were represented and recovered close to the original deposition point with no bias for decomposition stage.

Table Set 4-2 provides a comparison between all bone elements recovered and those recovered close to the original deposition point for ‘directionally dispersed’ carcasses. More bone elements were recovered outside of the $100m^2$ arbitrary limit than inside it, and more bone elements were recovered from carcasses in later stages of decomposition than earlier stages at the time of movement. Generally, ‘directionally dispersed’ carcasses in later decomposition stages had more remains close to the original deposition point than those in early stages.

Pig G appeared to be an outlier in this context. The pattern of bone element recovery was similar to ‘non-directionally dispersed’ sites in number and location. This may have indicated that the formation of transport groups did not occur in the scavenging of this carcass. When this carcass was omitted from the table, a pattern was clear.

Despite movement and decomposition stage, the data clearly showed that bone elements from the ‘Ribs/Vert.’ category were commonly recovered. Only Pig D in the early decomposition stage of ‘Advanced’ did not show the recovery of elements within the $100m^2$ limit. The data also showed that while the cranium or parts of the ‘Cranium’ were recovered, it was not commonly found close to the original deposition point.

Table Set 4-1 **Elements Remaining Within $100m^2$ of Original Deposition Point With Respect to Decomposition Stage**

'Directionally Dispersed' Sites

	Cranium	Ribs/Vert.	Up. Limbs	Lw. Limbs
Advanced				
Pig D				
Collapse				
Pig G		x	x	x
Pig K		x	x	
Mummification				
Pig B		x	x	
Pig C		x		
Pig E		x ?		x
Pig H		x		x
Pig M	x	x	x	

'Non-Directionally Dispersed' Sites

	Cranium	Ribs/Vert.	Up. Limbs	Lw. Limbs
Mummification				
Pig F	x	x	x	x
Pig J	x	x	x	x
Skeletonization				
Pig A	x	x	x	x
Pig L	x	x	x	x

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Table Set 4-2 'Directionally Dispersed' Sites: Remaining Elements

Remaining Elements at Last Movement

	Cranium	Ribs/Vert.	Up.Limbs	Lw. Limbs
Advanced				
Pig D	x	x		
Collapse				
Pig G		x	x	x
Pig K		x	x	
Mummification				
Pig B		x	x	
Pig C	x	x	x	x
Pig E	x	x	x ?	x
Pig H	x	x	x	x
Pig M	x	x	x	

Remaining Elements Within 100m^2 of Original Deposition Point

	Cranium	Ribs/Vert.	Up. Limbs	Lw. Limbs
Advanced				
Pig D				
Collapse				
Pig G		x	x	x
Pig K		x		x
Mummification				
Pig B		x	x	
Pig C		x		
Pig E		x ?		x
Pig H		x		x
Pig M	x	x	x	

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Scavenging or Disappearing Sequence

The data from 'directionally dispersed' carcasses seemed to indicate the formation of transport groups. Carcasses in early stages of decomposition (Pig D and K) lacked limb bone elements close to the original deposition point and fewer limb bone elements in total were recovered. This suggested that these bone elements were taken from the carcass en masse in transport groups. The interpreted outlier (Pig G) would suggest that transport groups were not formed for this carcass.

From the data, a sequence of disarticulation stages relating to scavenger activity was compiled. Data from two 'directionally dispersed' carcasses (Pig D and Pig M) over successive days were used. Data from other 'directionally dispersed' carcasses provided an indistinguishable sequence, or the movement was a single event. This sequence was based on Haglund (1989, 1997). A summary of these stages is shown in Table Set 4-3 with tabulated information from Haglund (1989, 1997) for comparison.

Stage 0: This stage was characterized by the scavenging of flesh on the rump.

> On the first day of scavenging activity (TSD uncorrected = 27), Pig D had many bite marks and missing flesh on the upward side of the rump (the carcass had initially been placed on its left side). This continued for two days (TSD uncorrected = 29).
>
> On the first day of activity for Pig M (TSD uncorrected = 33), no biting or tearing off of flesh was observed. The carcass had been rotated 180° with no displacement. On the seventh day of activity (TSD uncorrected = 40), the rump showed signs of scavenging, like Pig D, and this continued for at least two days (TSD uncorrected = 42). This carcass was initially placed on its right side.

Stage 1: This stage was characterized by scavenging of the flesh on the thorax and throat.

On the third day of scavenging activity for Pig D (TSD uncorrected = 30), the abdomen and throat showed evidence of scavenging. Torn and missing flesh around the underside of the carcass was observed.

Although Pig M was observed on a daily basis, it was not observed going through this phase.

Stage 2: This stage was characterized by the disappearance of limbs.

On the eighth day of activity (TSD uncorrected = 35) the left forelimb of Pig D disappeared. At this point, both hindlimbs and the other forelimb were being scavenged and were nearly disarticulated. The carcass had also been moved considerably and the mandible was disarticulated. Four days later (TSD uncorrected = 39), the right forelimb disappeared. By the twentieth day of scavenging activity (TSD uncorrected = 47), only one hindlimb, the thorax with the articulated cranium and os coxae were remaining. By the next day (TSD uncorrected = 48), the os coxae and the remaining hindlimb had disappeared.

On the fourteenth day of activity (TSD uncorrected = 47), both hindlimbs on Pig M disappeared. A trail through the long grass towards the South was observed. On the thirtieth day of activity (TSD uncorrected = 63), the right forelimb disappeared.

Stage 3: This stage was characterized by the presence of an articulated vertebral column and rib cage.

> Both Pigs D and M were picked clean of flesh and all limbs were missing at the date of 'Last movement'. Disarticulated crania and articulated vertebral columns with rib cages remained. At the study end date (TSD uncorrected = 105), the ribs of Pig D had been gnawed, disarticulated and some had disappeared but the vertebral column was still articulated in some places. The cranium was also still present.

Stage 4: This stage was characterized by the presence of bone fragments. Everything else disappeared.

> The ribs and vertebral column of Pig M had disappeared and only the cranium and fragments were remaining at the time of collection (TSD uncorrected = 69).

The formation of this disarticulation sequence provided a framework for the interpretation of the formation of transport groups. The remains of these carcasses corresponded with the remains of the other 'directionally dispersed' carcasses (except G), suggesting that transport groups were also formed for these carcasses.

Discussion

There were several processes seen in this part of the study that were anticipated and recorded through the applied methods:

1) more bone elements were recovered from randomly moved carcasses than those that were moved in a non-random fashion;

Table Set 4-3 Disarticulation Sequences: *Homo sapiens* Compared to *Sus scrofa*

Homo sapiens

Stage	Unit	Temporal Range
0	removal of soft tissue with no disarticulation	4 hours to 14 days
1	destruction of the ventral thorax characterized by absence of the sternum and damage to distal ribs, accompanied by evisceration and removal of one or both upper extremeites, including scapulae and partial or complete removal of clavicles.	22 days to 2.5 mths
2	fully or partially separated and removed lower extremities	2 to 4.5 mths
3	nearly complete disarticulation with only segments of vertebral column articulated	2 to 11 mths
4	total disarticulation and scattering, with only cranium and assorted skeletal elements or fragments recovered	5 to 52 mths

Stage and Unit portion of this table: Haglund 1989 (derived from Toots, Hill, & Haynes)

Time Ranges: Haglund 1997

Sus scrofa (derived from Ellerslie Project 2002)

Stage	Unit	Temporal Range for Time Since Deposit
0	removal of soft tissue on rump	27 to 42 days
1	destruction of the ventral thorax from pelvic to throat area	29 days (Pig D)
2	separation and disappearance of forelimbs	34 to 64 days
	separation and disappearance of hindlimbs	47 days
3	nearly complete disarticulation with only segments of vertebral column and associated ribs articulated	48 to 75 days
4	total disarticulation and scattering, with only cranium and assorted skeletal elements or fragments recovered	69 days (Pig M)

Based on Haglund 1989 & 1997 stages

2) the most commonly recovered bone elements for both randomly and non-randomly moved carcasses were the ribs and vertebrae. These were also most commonly recovered close to the original deposition point regardless of decomposition stage and type of movement;
3) the amount and type of bone elements recovered close to the deposition point was influenced by the type of movement and decomposition stage, and;
4) transport groups were formed and subsequently used by scavengers. There was a contrast between random and non-random movement and what bone elements were found and where.

There was support for the hypothesis: there was a connection between the amount and location of recoverable remains and the decomposition stage of non-randomly moved carcasses. More bone elements were recovered within $100m^2$ of the original deposition point than outside of it in 5 of 7 'directionally dispersed' carcasses. For the 'non-directionally dispersed' carcasses, the majority of remains were recovered within $100m^2$ of the original deposition point in 4 of 4 cases. For those 'directionally dispersed' carcasses that were in later decomposition stages (the 'Mummified' stage), an average of 2 of 4 bone element categories were recovered within $100m^2$ of the original deposition point. For those 'directionally dispersed' carcasses in earlier decomposition stages (the 'Advanced' and 'Collapse' stages), an average of 1.67 of 4 bone element categories were recovered within $100m^2$ of the original deposition point. In addition to this, for those 'directionally dispersed' carcasses that were in later decomposition stages, an average of 3 of 4 bone element categories were recovered outside of $100m^2$ of the original deposition point. 'Directionally dispersed' carcasses in earlier decomposition stages, had an average of 2.33 of 4 bone element categories recovered outside of $100m^2$ of the original deposition point.

The disarticulation sequence developed here corresponds well to Hill (1979a) and Haynes' (1982) quadruped mammalian disarticulation sequences, as well as to Haglund's (1991) disarticulation sequence for humans. Although pig carcasses were used, it is proposed that the sequence created here corresponds well to both human and other mammal data and lends support to the use of pigs as human analogues.

If the carcass had been moved in a non-random manner, then transport groups may have formed and used by scavengers to disarticulate the carcass. The observations from Pig D and M led to the ability to develop a disarticulation sequence of which they may be considered two ends of a spectrum. Pig D may have represented an early decomposition stage in which few remains were recovered and recovered further away from the original deposition point. Pig M may have represented a later decomposition stage in which more remains were recovered and recovered closer to the original deposition point. The majority of the other 'directionally dispersed' carcasses fit within this spectrum. This spectrum demonstrated the pattern as proposed by the hypothesis; more elements were recovered closer to the original deposition point the later the decomposition stage was at the time of movement. This pattern suggested a comparison with the disarticulation sequence developed here and, therefore, the formation of transport groups that scavengers could use to transport limb bone elements away from the original deposition point.

While the results supported the hypothesis, there were some issues that needed to be addressed. The results of the outlier, Pig G, suggested that transport groups were not formed for this carcass. For this carcass, more remains were recovered close to the original deposition point than any other 'directionally dispersed' carcass. A possible explanation may be that the disarticulation sequence did not correspond to this decomposition stage. The criteria used to qualitatively describe the decomposition stages may not have accurately corresponded to the internal processes of decay that affected disarticulation.

However, due to the conditions of this study, a more hands-on approach to discovering the disarticulation stage was not possible.

If the outlier, Pig G, was omitted from the sample of 'directionally dispersed' carcasses, the sample size was then seven; two carcasses in earlier decomposition stages being compared to five in later decomposition stages. These are very small sample sizes and may not have been indicative of an overall pattern. However, the statistics were revised as follows:

- in earlier decomposition stages, an average of 1 of 4 bone element categories were recovered within $100m^2$ of the original deposition point and an average of 2 of 4 of bone element categories were recovered outside of $100m^2$ of the original deposition point.

A phenomenon witnessed here but not described in the literature might also have influenced the location of bone elements. For several of the 'directionally dispersed' carcasses in later decomposition stages, a skin 'envelope' was observed. This skin 'envelope' was mummified skin still intact and present with disarticulated skeletal remains inside. In all cases with this skin 'envelope' (Pigs B, C, E, and K), the 'envelope' was dragged and the disarticulated bones fell out to mark the path of travel. Although the bone elements were disarticulated, the presence of this skin 'envelope' would form a transport group enabling the movement of already disarticulated bone elements. This would not allow the comparison of a disarticulation sequence to the decomposition stages and would also not allow the observer to infer the formation of transport groups as described earlier. It was not known to what degree this skin 'envelope' had influenced the results here. The conditions and mechanisms surrounding the formation of the skin 'envelope' were not unknown.

Conclusions

The hypothesis for this section of the study was supported by the results. A connection between decomposition stage and the amount and location of bone elements recovered in non-randomly moved carcasses was apparent. It was found that in earlier decomposition stages, carcasses that moved non-randomly had fewer bone elements recovered, both overall and close to the original deposition point, than represented by those in later decomposition stages.

In addition to the data supporting the hypothesis, several other processes were witnessed. Rib and vertebral elements were common leftovers for all carcasses regardless of type of movement and decomposition stage. While the formation of transport groups may be inferred by the results, the formation of a skin ‘envelope’ may influence results in ways not anticipated or observed.

Future research may be able to use specific bone element frequencies instead of bone element categories. This, as well as studies on the effects of the skin ‘envelope’, may lead to a better comparison of disarticulation sequence with decomposition stages. A larger sample may provide better comparisons between and within decomposition stages so that outliers wouldn’t affect the results and interpretations greatly.

Chapter Five

Summary of Research and Conclusions

The primary question posed in this study was whether there were patterns in the scattering of remains due to scavenger activity. The overall results support the hypothesis that there are patterns.

Chapter One presented an outline of previous research. Due to methodology and the type of studies being done, the research cited did not gather data that would suggest a pattern in the scattering of remains due to scavenger activity. It was therefore proposed that a near-natural study maximizing sample size might provide data to support an hypothesis that there was a pattern. This study had a sample size of twelve pig carcasses placed in wooded and open grassland situations. While half the sample was clothed, few other variables were controlled.

Chapter Two proposed an hypothesis that while there may be a temporal pattern in scavenging activity, it does not correspond to time since death. Further to this, Chapter Two proposed that scavenging activity corresponded to decomposition stage. A study-specific and qualitative decomposition stage classification was created because of the inapplicability of those in the literature. The results supported both these hypotheses. It was found that scavenging on the sample occurred over a two month period and did not correspond accurately to time since death. However, activity occurred on mainly 'Mummified' carcasses. This supported the hypothesis that scavenging activity corresponded to decomposition stage.

Chapter Three proposed the hypothesis that there is a pattern in the movement of remains due to scavenging activity. Non-random movement described movement biased in a certain direction, whereas random movement was equally distributed about a point. Results showed that a distinction could be made between non-random and random movement. This distinction provided support for the hypothesis. In addition, it was found that the majority of carcasses had been moved non-randomly and in a South and/or Westerly direction. This direction corresponded to the movement of the carcasses away from the observer's path, concentrated human activity, and toward natural shelter. However, factors involved in this movement were undetermined.

Chapter Four proposed the hypothesis that the decomposition stage at the time of non-random movement could influence the location and type of remains recovered. While this part of the study was not initially anticipated, it was found that enough data had been collected and could be analysed for a pattern. The results for this section also supported the hypothesis. First, the results showed that randomly moved carcasses had the greatest number of bone element categories recovered both overall and close to the original deposition point. Secondly, carcasses moved in a non-random manner in earlier decomposition stages had fewer bone element categories remaining both overall and close to the original deposition point. The results also showed that the most commonly recovered bone element category was the 'rib/vertebrae' category regardless of type of movement or decomposition stage.

Overall, there has been support of each hypothesis proposed by this study. As well, several additional processes were observed while conducting this study. For instance, once scavenging of a carcass had begun, it likely continued until there was nothing left but bones. There was a high rate of disappearance of carcass parts. While this was supported by the literature, the methodology used here could not be used to recover those elements. Phenomena not reported in the literature were observed here as well; a skin 'envelope' that may influence scattering of remains and the yet unexplained 'Liquified' decomposition phase that was witnessed in three carcasses.

Several patterns in the scattering of remains due to scavenger activity were found. This study may help increase the recovery rate of remains by providing possible factors shown to influence the scatter of remains. The results showed that carcasses were most likely to be scavenged in later decomposition stages and, therefore, fewer remains were likely to be recovered close to the original deposition point. However, when the location and environment were taken into account, remains were likely to be recovered in a direction away from concentrated human activity and/or towards natural shelter. The results also showed that if the ribs and/or vertebrae of a carcass could be found, these remains may be indicative of the original deposition area.

Current ongoing research is attempting to replicate the patterns found here. The same location, sample size and methodology are being used and preliminary results suggest that the interpretations and patterns are consistent. Future studies should include research into the phenomenon of the skin ‘envelope’ and the ‘Liquified’ decomposition stage. Different locations, seasons and variables (ie. injuries, carcasses sizes, etc.) should also be considered for future research.

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Appendix

Table A:1 **Calendar of Study May - August 2002**

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		May	1	2	3 Study Day 1 Ave T = -2.3 Ave RH = 46.03	4 Study Day 2 Ave T = -1.2 Ave RH = 76.1
5 Study Day 3 Ave T = 0.95 Ave RH = 70.9	6 Study Day 4 Ave T = 3.2 Ave RH = 35.8	7 Study Day 5 Ave T = 3.3 Ave RH = 42.1	8 Study Day 6 Ave T =4.2 Ave RH = 46.7	9 Study Day 7 Ave T = 5.1 Ave RH = 49	10 Study Day 8 Ave T = 7.5 Ave RH = 45.2	11 Study Day 9 Ave T = 10.5 Ave RH = 47.5
12 Study Day 10 Ave T = 11.4 Ave RH = 42.8	13 Study Day 11 Ave T = 15.1 Ave RH = 33.6	14 Study Day 12 Ave T = 11.4 Ave RH = 54.7	15 Study Day 13 Ave T = 8.7 Ave RH = 47.2	16 Study Day 14 Ave T = 9.6 Ave RH = 47.5	17 Study Day 15 Ave T = 10.3 Ave RH = 57.8	18 Study Day 16 Ave T = 12.9 Ave RH = 63.6
19 Study Day 17	20 Study Day 18 Ave T = 15.9 Ave RH = 40.1	21 Study Day 19 Ave T = 7.6 Ave RH = 66.6	22 Study Day 20 Ave T = 5.4 Ave RH = 48	23 Study Day 21 Ave T = 6.8 Ave RH = 34.3	24 Study Day 22 Ave T = 6.8 Ave RH = 62.3	25 Study Day 23 Ave T = 9.7 Ave RH = 48.9
26 Study Day 24 Ave T = 14.3 Ave RH = 35.8	27 Study Day 25 Ave T = 16.2 Ave RH = n/a	28 Study Day 26 Ave T = 18.5 Ave RH = 45.9	29 Study Day 27 Ave T = 18.1 Ave RH = 41.0	30 Study Day 28 Ave T = 16.3 Ave RH = 42.2	31 Study Day 29 Ave T = 14.2 Ave RH = 39.3	
					June	1 Study Day 30 Ave T = 13.2 Ave RH = 41.1
2 Study Day 31 Ave T = 15.5 Ave RH = 47.6	3 Study Day 32 Ave T = 14.7 Ave RH = 58.9	4 Study Day 33 Ave T = 17.4 Ave RH = 50.6	5 Study Day 34 Ave T = 16.7 Ave RH = 52.3	6 Study Day 35 Ave T = 12.2 Ave RH = 54.0	7 Study Day 36 Ave T = 11.1 Ave RH = 43.4	8 Study Day 37 Ave T = 12.4 Ave RH = 56.2
9 Study Day 38 Ave T = 14.3 Ave RH = 64.3	10 Study Day 39 Ave T = 15.2 Ave RH = 50.1	11 Study Day 40 Ave T = 15.5 Ave RH = 40.39	12 Study Day 41 Ave T = 17.8 Ave RH = 35.0	13 Study Day 42 Ave T = 19.2 Ave RH = 38.0	14 Study Day 43 Ave T = 19.3 Ave RH = 42.1	15 Study Day 44 Ave T = 20.5 Ave RH = 46.7
16 Study Day 45 Ave T = 18.9 Ave RH = 59.5	17 Study Day 46 Ave T = 12.6 Ave RH = 85.8	18 Study Day 47 Ave T = 9.8 Ave RH = 85.6	19 Study Day 48 Ave T = 13.4 Ave RH = 67.5	20 Study Day 49 Ave T = 16.4 Ave RH = 53.0	21 Study Day 50 Ave T = 19.3 Ave RH = 43.9	22 Study Day 51 Ave T = 22.0 Ave RH = 34.7
23 Study Day 52 Ave T = 22.9 Ave RH = 46.5	24 Study Day 53 Ave T = 20.2 Ave RH = 64.0	25 Study Day 54 Ave T = 22.1 Ave RH = 53.2	26 Study Day 55 Ave T = 25.4 Ave RH = 42.0	27 Study Day 56 Ave T = 23.6 Ave RH = 54.9	28 Study Day 57 Ave T = 18.1 Ave RH = 73.1	29 Study Day 58 Ave T = 16.1 Ave RH = 84.9
30 Study Day 59 Ave T = 14.5 Ave RH = 63.0						

Table A:1 (con't) **Calendar of Study May - August 2002**

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
July	1 Study Day 60 Ave T = 14.3 Ave RH = 48.0	2 Study Day 61 Ave T = 14.5 Ave RH = 46.01	3 Study Day 62 Ave T =15.8 Ave RH = 51.9	4 Study Day 63 Ave T =15.7 Ave RH = 61.2	5 Study Day 64 Ave T = 13.6 Ave RH = 59.1	6 Study Day 65 Ave T = 15.8 Ave RH = 49.3
7 Study Day 66 Ave T = 20.4 Ave RH = 42.0	8 Study Day 67	9 Study Day 68 Ave T = 20.0 Ave RH = 63.2	10 Study Day 69 Ave T = 22.8 Ave RH = 58.5	11 Study Day 70 Ave T = 25.5 Ave RH = 54.9	12 Study Day 71 Ave T = 26.8 Ave RH = 47.7	13 Study Day 72 Ave T = 26.2 Ave RH = 48.9
14 Study Day 73 Ave T = 20.3 Ave RH = 69.2	15 Study Day 74 Ave T = 19.5 Ave RH = 54.0	16 Study Day 75 Ave T = 21.6 Ave RH = 43.0	17 Study Day 76 Ave T = 24.5 Ave RH = 47.2	18 Study Day 77 Ave T = 21.0 Ave RH = 71.1	19 Study Day 78 Ave T = 18.4 Ave RH = n/a	20 Study Day 79 Ave T = 16.1 Ave RH = 71.6
21 Study Day 80 Ave T = 17.0 Ave RH = 64.0	22 Study Day 81 Ave T = 19.0 Ave RH = 56.3	23 Study Day 82 Ave T = 22.3 Ave RH = 49.5	24 Study Day 83 Ave T = 22.2 Ave RH = 63.9	25 Study Day 84 Ave T = 24.4 Ave RH = 56.0	26 Study Day 85 Ave T = 17.6 Ave RH = 79.5	27 Study Day 86 Ave T = 15.3 Ave RH = 82.5
28 Study Day 87 Ave T = 15.1 Ave RH = 72.4	29 Study Day 88 Ave T = 13.6 Ave RH = n/a	30 Study Day 89 Ave T = 12.5 Ave RH = 63.2	31 Study Day 90 Ave T = 6.9 Ave RH = 90.9			
			August	1 Study Day 91 Ave T = 8.9 Ave RH = 73.3	2 Study Day 92 Ave T = 7.1 Ave RH = 92.6	3 Study Day 93 Ave T = 8.7 Ave RH = 76.2
4 Study Day 94 Ave T = 8.8 Ave RH = 80.3	5 Study Day 95 Ave T = 11.5 Ave RH = 91.3	6 Study Day 96 Ave T = 12.3 Ave RH = 94.8	7 Study Day 97 Ave T = 14.4 Ave RH = 76	8 Study Day 98 Ave T = 16.7 Ave RH = 68.9	9 Study Day 99 Ave T = 17.1 Ave RH = 77.2	10 Study Day 100 Ave T =13.5 Ave RH = 84.5
11 Study Day 101 Ave T = 13.8 Ave RH = 77.4	12 Study Day 102 Ave T = 15.8 Ave RH = 71.8	13 Study Day 103 Ave T = 18.0 Ave RH = 64.9	14 Study Day 104 Ave T = 12.9 Ave RH = 81.5	15 Study Day 105 Ave T = 9.7 Ave RH = 91.8	16	17

"Ave T" = Average air temperature over a 24hr period.

"Ave RH" = Average relative humidity, in percent, over a 24hr period.

Table A:2 Flora/Faunal Survey of Ellerslie, 2002

	Common Name	Genus	Species	Occurrence
Mammals				
	Red Squirrel	*Tamiasciurus*	*hudsonicus*	sparse
	House Mouse	*Mus*	*musculus*	only seen once
	Deer Mouse	*Peromyscus*	*maniculatus*	only seen once
	White Tailed Deer	*Odocoileus*	*virginianus*	nighttime
photographs				
	Coyote	*Canis*	*latrans*	nighttime
photographs				
	Domestic Dog	*Canis*	*familiaris*	only seen once
Birds				
	Boreal Chickadee	*Parus*	*hudsonicus*	common
	Black-caped Chickadee	*Parus*	*atricapillus*	common
	Yellow Warbler	*Dendroica*	*petechia*	relatively common
	American Crow	*Corvus*	*brachyrhynchos*	common
	Black-billed Magpie	*Pica*	*pica*	scarce
	American Robin	*Turdus*	*migratorius*	very common
	House Wren	*Troglodytes*	*aedon*	common
	Swainson'sTrush	*Catharus*	*ustulatus*	only seen once
	Red-winged Blackbird	*Agelaius*	*phoeniceus*	only seen once
	Northern Oriole	*Icterus*	*galbula*	only seen once
	Savannah Sparrow	*Passerculus*	*sandwishensis*	common
	Song Sparrow	*Melospiza*	*melodia*	very common
	Red-tailed Hawk	*Buteo*	*jamaicensis*	only seen in 1 area
	Grey-colored Sparrow	*Spizella*	*pallida*	common
	Hairy Woodpecker	*Picoides*	*villosus*	only seen once
	Barn Sparrow	*Hirundo*	*rustica*	relatively common
	House Sparrow	*Passer*	*domesticus*	relatively common
	Vesper Sparrow	*Pooecetes*	*gramineus*	relatively common
	Downy Woodpecker	*Picodiodes*	*pubescens*	only seen once
Wildflowers				
	Tall Larkspur	*Delphinium*	*glaucum*	relatively common
	Western Canada Violet	*Viola*	*regulosa*	very common
	Fairy Bells	*Disporum*	*trachycarpum*	common
	Common Dandelion	*Taraxacum*	*officinale*	very common
	Penny Cress	*Thlaspi*	*arvense*	very common
	Star-flowered Solomon's Seal	*Smilacina*	*stellata*	common
	Canada Anemone	*Anemone*	*canadensis*	common
	Tall Lungwort	*Mertensia*	*paniculata*	common
	Wild Mustard	*Brassica*	*kaber*	common
	Bunchberry	*Cornus*	*canadensis*	relatively common
	White Pea Vine	*Lathyrus*	*ochroleucus*	relatively common
	Prickly Wild Rose	*Rosa*	*acicularus*	very common
	Veiny Meadow Rue	*Thalictrum*	*venulosum*	common
	Common Wild Rose	*Rosa*	*woodsii*	common
	Northern Bedstraw	*Galium*	*boreale*	common
	Wild Vetch	*Vicia*	*americana*	very common
	Wild-white Geranium	*Gernaium*	*richardsonii*	common
	Nodding Onion	*Allium*	*cernuum*	very common
	Cow Parsnip	*Heracleum*	*lanatum*	very common
	Common Pink Wintergreen	*Pyrolla*	*asarifolia*	common
	Fireweed	*Epilobium*	*angustifolium*	common
	Canada Thistle	*Cirsium*	*arvense*	very common

Table A:2 (con't) **Flora/Faunal Survey of Ellerslie, 2002**

	Common Name	*Genus*	*Species*	*Occurrence*
Shrubs				
	Saskatoon Serviceberry	*Amelanchier*	*alnifolia*	common
	Twining Huneysuckly	*Lonicera*	*glaucenscens*	very common
	Red Raspberry	*Rubus*	*idaeus*	common
Trees				
	Balsam Poplar	*Populus*	*baslamifera*	very common
	Trembling Aspen	*Populus*	*tremuloides*	very common
	Paper Birch	*Betula*	*papyrifera*	very scarce
	White Spruce	*Picea*	*glauca*	common

Table A:3 **Taphonomic Events**

	Deposit date	Conditions of deposit	Last in original position	First movement	First scavenger activity	"Skin & bones"	Last movement
Pig A	Fri, May 3, 2002 @ 1800	unclothed	Sun, June 23, 2002	Sat, July 13, 2002	Sun, May 26, 2002	Tues, June 4, 2002	Sat, July 13, 2002
	TSD uncorrected = 1	controlled activity until July 13, 2002	TSD uncorrected = 52	TSD uncorrected = 72	TSD uncorrected = 24	TSD uncorrected = 33	TSD uncorrected = 72
Pig B	Fri, May 3, 2002 @ 1800	clothed	Sun, June 23, 2002	Sat, July 13, 2002	Sat, July 13, 2002	Mon, June 17, 2002	Sat, July 13, 2002
	TSD uncorrected = 1	controlled activity until July 13, 2002	TSD uncorrected = 52	TSD uncorrected = 72	TSD uncorrected = 72	TSD uncorrected = 46	TSD uncorrected = 72
Pig C	Fri, May 3, 2002 @ 1800	clothed	Tues, July 9, 2002	Thurs, July 11, 2002	Thurs, July 11, 2002	n/a	Thurs, July 25, 2004
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 68	TSD uncorrected = 70	TSD uncorrected = 71	n/a	TSD uncorrected = 84
Pig D	Fri, May 3, 2002 @ 1800	unclothed	Tues, May 28, 2002	Wed, May 29, 2002	Wed, May 29, 2002	n/a	Thurs, Aug. 15, 2004
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 26	TSD uncorrected = 27	TSD uncorrected = 27	n/a	TSD uncorrected = 103
		camera on site June 12 - June 26					
Pig E	Fri, May 17, 2002 @ 1800	clothed	Mon, July 29, 2002	Tues, July 30, 2002	Tues, July 30, 2002	Thurs, July 18, 2002	Thurs, Aug. 6, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 73	TSD uncorrected = 74	TSD uncorrected = 74	TSD uncorrected = 62	TSD uncorrected = 80
Pig F	Fri, May 17, 2002 @ 1800	unclothed	Tues, July 23, 2002	Thurs, July 25, 2002	Thurs, July 25, 2002	Thurs, July 18, 2002	Mon, July, 29, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 67	TSD uncorrected = 69	TSD uncorrected = 69	TSD uncorrected = 62	TSD uncorrected = 73
Pig G	Fri, May 17, 2002 @ 1800	unclothed	Thurs, July 25, 2002	Mon, July 29, 2002	Fri, June 7, 2002	Thurs, July 18, 2002	Mon, July, 29, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 69	TSD uncorrected = 73	TSD uncorrected = 21	TSD uncorrected = 62	TSD uncorrected = 73
Pig H	Fri, May 17, 2002 @ 1800	clothed	Thurs, July 25, 2002	Mon, July, 29, 2002	Fri, June 21, 2002	Fri, June 14, 2002	Mon, July, 29, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 69	TSD uncorrected = 73	TSD uncorrected = 35	TSD uncorrected = 28	TSD uncorrected = 73
Pig J	Fri, May 17, 2002 @ 1800	clothed	Mon, June 17, 2002	Fri, June 21, 2002	Fri, June 21, 2002	Mon, June 17, 2002	Fri, June 21, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 31	TSD uncorrected = 35	TSD uncorrected = 35	TSD uncorrected = 31	TSD uncorrected = 35
Pig K	Fri, May 17, 2002 @ 1800	unclothed	Sat, June 8, 2002	Thurs, June 6, 2002	Thurs, June 6, 2002	Sat, June 8, 2002	Tues, July 2, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 22	TSD uncorrected = 20	TSD uncorrected = 20	TSD uncorrected = 22	TSD uncorrected = 42
Pig L	Fri, May 24, 2002 @ 1800	clothed	Fri, June 21, 2002	Wed, June 26, 2002	Wed, June 26, 2002	Sat, June 15, 2002	Wed, June 26, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 58	TSD uncorrected = 33	TSD uncorrected = 33	TSD uncorrected = 22	TSD uncorrected = 33
Pig M	Fri, May 24, 2002 @ 1800	unclothed	Fri, June 21, 2002	Wed, June 26, 2002	Wed, June 26, 2002	n/a	Thurs, Aug. 6, 2002
	TSD uncorrected = 1	uncontrolled activity	TSD uncorrected = 58	TSD uncorrected = 33	TSD uncorrected = 33	n/a	TSD uncorrected = 73
		camera on site June 26 - Aug. 15					

Events are recorded to have happened on observation dates even though event may have happened between observation dates.
"Movement" as defined in Chapter Two can be random or non-random movement of remains from their original position.

Table Set A:4 **Decomposition Stages for Ellerslie 2002**

Beginning and End Dates *

Pig	Fresh	Early	Advanced	Collapse	Mummified	Liquified	Skeletonized
A	M 3-7	M 7-16	M 16-29	M 29 - Jn 6	Jn 6 - Jy 13	not seen	Jy 13 - end
B	M3-10	M 10-19	M 19-27	M 27 - Jn 17	Jn 17 - Jy 13 (move)	n/a	Jy 13 - end
C	M 3-14	M 14-29	M 29- Jn4	Jn 4 - 24	Jn 24 - Jy 11 (move)	n/a	Jy 13 - end
D	M 3-12	M 12-20	M 20 - 29 (move)	n/a	n/a	n/a	M 26 - end
E	M 17-18	M 18-27	M 27-Jn10	Jn 10 - 23	Jun 23 - Jy 30(move)	Aug 6 - end	n/a
F	M 17-19	M 19-26	M 26-Jn6	Jn 6 - Jy 2	Jy 2 - end	Aug 6 - end	n/a
G	M 17-18	M 18-24	M 24-Jn4	Jn 4 - Jy 29 (move)	n/a	Jy 29 - end	n/a
H	M 17-25	M 25-28	M 28-Jn4	Jun 4 - 14	Jn 14 - 29 (move)	n/a	Jn 29 - end
J	M 17-24	M 24-28	M 29-Jn4	Jun 4 - 17	Jn 17 - end	n/a	n/a
K	M 17-19	M 19-27	M27-Jn1	Jn 1 - Jn 6 (move)	n/a	n/a	Jn 6 - end
L	M 24-29	M 24-Jn 1	Jn 1 - 4	Jun 4 - 10	Jn 12 - 26	not seen	Jn 26 - end
M	M 24-26	M 26- Jn 1	Jn 1 - 4	Jun 4 -10	Jn 10 - 26 (move)	n/a	Jn 26 - end

'M' = May, 'Jn' = June, 'Jy' = July, 'Aug' = August, '(scav)' = indicates date initial scavenging activity observed, 'end' = collection date (August 15, 2002)

Duration and Onset Ranges*

Pig	Fresh	Early	Advanced	Collapse	Mummified	Liquified	Skeletonized
A	4	9	13	8	38	not seen	33
B	7	9	8	21	27	n/a	n/a
C	11	15	6	20	18	n/a	n/a
D	9	8	6	n/a	n/a	n/a	n/a
E	1	9	14	13	38	9	not seen
F	2	7	11	26	44	9	not seen
G	1	6	11	56	n/a	17	not seen
H	8	3	7	10	15	n/a	n/a
J	7	2	6	13	60	not seen	not seen
K	2	8	5	5	n/a	n/a	n/a
L	5	8	3	7	14	not seen	51
M	2	6	3	7	16	n/a	n/a
Duration	1 - 11	2 - 15	3 - 13	7 - 56	14 - 60	9 - 17	33 - 51
Stage Onset	1	2 - 12	7 - 26	11 - 32	18 - 52	75 - 90	37 - 72

* values in days (TSD uncorrected)

'Skeletonized' stage not seen in Pigs E, F, G, & J by end of study

Table A:5 **Bone Elements Remaining**

	Remains on Scavenging Activity Dates		Remains on End Date		
Pig A					
13 – Jul	disart and scatter		15 – Aug	cranium	
	both femur			mandible ulna	
	cranium+mandible			forelimb w/ scapula	
	art. And disart vert.			epiphyses	
	Scapula			femur	
	Humerus				
	Epiphyses				
	Ulna				
	Coxygeal vert				
	½ os coxae				
Pig B					
13 – Jul	**Last Movement**		15 – Aug	same as July 13	
	disart ½ ox coxae				
	ribs				
	fragments				
	disart forelimbs				
	mandible				
	assort. Vert.				
Pig C (only elements that moved noted)					
11 – Jul	clothing	foot	15 – Aug	os coxae	forelimb
	flesh	cranium+mandible		vert – some of each	
	ribs/vert	main carcass		femur	hindlimb
	forelimbs			cranium+mandible	
13 – Jul	Pants (foot disappeared)				
15 – Jul	Ribs/vert (main carcass disappeared)				
	cranium+mandible	shirt			
	humerus	os coxae			
	vert	epiphysis			
19 – Jul	Ribs/vert	epiphysis			
	flesh	humerus			
25 – Jul	**Last Movement**				
	ribs/vert	shirt			
	scapula				

Table A:5 (con't) **Bone Elements Remaining**

Pig D

Date	Remains on Scavenging Activity Dates	Date	Remains on End Date
29 – May	rump eaten	15 – Aug	**Last Movement**
31 – May	belly eaten		cranium
	throat eaten		rib cage w/ assoc. thoracic vert
1 – Jun	entrails removed and left out		ribs disart w/ epiphyses
3 – Jun	thorax clean		
	hindlimbs nearly disart		
	forelimbs still firmly art		
4 – Jun	mandible disart		
	small piece of maxilla		
	skin and hair left on distal feet		
5 – Jun	left forelimb disart and missing		
	maxilla frag missing		
	right scapula disart but held by tissue		
7 – Jun	ribs moved w/in articulation		
8 – Jun	poss. Vert disarticulation		
	right femur disart from os coxae		
9 – Jun	right forelimb missing		
	sternum missing – due to gnawing?		
12 – Jun	both femura now disart but held by tissue		
17 – Jun	thorax (ribs) disart from head/spine (cerv.)		
	and from lumbar spine/os coxae/l. hindlimb		
18 – Jun	os coxae missing		

Pig E

Date	Remains on Scavenging Activity Dates		Date	Remains on End Date	
30 – Jul	thorax decayed or scavenged		15 – Aug		
	possibly all bones still present			ribs/vert	cranium
6 – Aug	**Last Movement**			dis & art limbs	scapula
	all present from July 30 but noted:			mandible pants	
	mandible scapula				
	ribs/vert	clothing			
	femur	assorted elements (ie. epiphyses)			
	cranium moved to observer's path (road)				

Table A:5 (con't) Bone Elements Remaining

Pig	Date	Remains on Scavenging Activity Dates		Date	Remains on End Date	
Pig F						
	29 – Jul	skin present		15 – Aug		
		most bones present including:			ribs	scapula
		ribs	femur		os coxae	ulna
		scapula	cranium		art & disart vert	cranium
		epiphyses	os coxae		epiphyses	femur
		ulna	art & disart vert			
Pig G						
	7 – Jun	soft tissue damage at throat		15 – Aug		
	29 – Jun	**Last Movement**			Difficult to distinguish due	
		Recognizable elements include:			to body fluids but include:	
		Both scapula	humerus		disart. Limbs & assoc. bones	
		Both os coxae	ribs/vert		art. Vert	
		Metapodial			Both scapula and os coxae	
Pig H						
	29 – Jul	**Last Movement**		15 – Aug		
		ribs	shirt		little change from July 29	
		skin	mandible			
		rt. Femur	cranium			
		os coxae	disart. Vert			
		scapula				
Pig J						
	21 – Jun	most present including:		15 – Aug		
		scapula	skin		little change from June 21	
		both forelimbs	ribs/vert			
		cranium+mandible				
		hindlimbs (one visible in pants)				

Table A:5 (con't) Bone Elements Remaining

	Remains on Scavenging Activity Dates			Remains on End Date
Pig K				
10 – Jun	hindlimb	both forelimbs	15 – Aug	
	lumb. Vert	cerv. Vert		little change from June 21
	left metatarsal	ribs		
	mandible	thor. Ver		
	scapula	skin		
11 – Jun	forelimb	skin		
	mandible ribs/vert			
21 – Jun	**Last Movement**			
	little change from June 11 with:			
	possible missing ribs			
Pig L				
26 – Jun	cranium+mandible	shirt	15 – Aug	
	ribs/vert	shorts		same as for June 26
	epiphyses	8 art. Vert		
	lower limb elements			
Pig M				
26 – Jun	entire carcass		15 – Aug	
9 – Jul	lower limbs missing			few elements recovered
	upper limb and rib cage present			
25 – Jul	rt forelimb gone (presence of scapula unknown)			
	lt forelimb present			
	axial skeleton			
6 – Aug	**Last Movement**			
	scapula	ribs/vert		
	lt os coxae	cranium		
	mandible	humerus		