FIRE ANTS (HYPMENOPTERA: FORMICIDAE) EFFECT ON CARRION DECOMPOSITION AND ESTIMATION OF TIME SINCE DEATH

THESIS

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CHAPTER I

INTRODUCTION

Each year unidentified human remains, in various stages of decomposition, are discovered. The location, positioning, manner of deposition, and stage of decomposition of these remains, as well as the degree and nature of arthropod involvement can provide important clues regarding the cause, manner and time of death. In order to analyze and interpret such evidence law enforcement officers often call upon the skills of forensic specialists such as, pathologists, anthropologists and entomologists.

One of the most critical aspects of forensic investigations of death is ascertaining an accurate estimation of the time-since-death (called postmortem interval or PMI) since an accurate estimation can narrow down the potential pool of missing persons to aid in the identification of the remains and exclude possible assailants. There are a number of scientific techniques used to determine time since death. If a body is discovered soon after death the skills of a pathologist or medical examiner are employed to obtain time since death. However, in death

investigations, the discovery of a body is often delayed. As time progresses and soft tissue decomposes, a PMI determination by a pathologist or medical examiner becomes more difficult and less accurate (Anderson and VanLaerhoven 1996). It is at this time that the expertise of forensic anthropologists is needed to examine the stages of morphological decomposition as it relates to PMI. Accordingly, entomologists also may be asked to examine arthropod colonization patterns to estimate a minimum PMI.

In their examinations and analyses, forensic scientists must consider the natural and man-made processes a corpse may be subjected to after death that can have a profound influence on decomposition and insect development and succession. These processes, such as the affects of temperature, geographical location, and carcass size, have been closely scrutinized and subject to a great deal of research (Anderson 2000; Kneidel 1984; Kuusela and Hanski 1982; Payne 1965; Smith 1986; Tantawi *et al.* 1996; Tullis and Goff 1987). However, there are still many variables that require further research.

Casual observations of the decomposition processes in the fields and pastures of Texas consistently note the presence of red imported fire ants, *Solenopsis invicta* (Buren), on and in the vicinity of decomposing carrion. Examination of forensic literature revealed that little research has been performed on the effects fire ants have on carrion decomposition and their interaction with associated arthropod

communities. This interaction is the focus of this research on decomposition processes and PMI estimation.

CHAPTER II

LITERATURE REVIEW

Forensic Anthropology and Time Since Death: Stages of Decomposition

Forensic anthropologists are often asked to assist law enforcement investigators and medical examiners in the recovery and identification of human skeletal and decomposing remains. This involves a detailed analysis of the remains to assess age, sex, race, height, pathology, cause and/or manner of death, and time since death.

There are a number of methods used by forensic scientists to estimate the PMI, but in their assessments forensic anthropologists tend to emphasize the decay and decomposition of soft tissues. Decomposition is a continuous process without distinct stages (Schoenly and Reid 1987). Nonetheless, entomologists have tried to divide this process into a number of descriptive stages (Payne 1965; Tantawi *et al.* 1996; Tullis and Goff 1987). Most often employed in describing decomposition is the five stage division described by Tullis and Goff (1987) which includes; fresh, bloat, decay, advanced decay and dry remains.

Fresh

The fresh stage begins at the death of the individual. In this stage, externally, the body may still appear fresh. Flies begin to colonize the body, laying their eggs or larvae within the natural body orifices or wounds that are present (Goff 2000; Tullis and Goff 1987). During this stage the internal bacteria, which before death were feeding on the contents of the intestine, begin to digest the intestine itself, eventually breaking out of the intestine, digesting the surrounding internal organs, and releasing fluids into the body cavities. It is at this point that the fresh stage terminates.

Bloat

The bloat, or putrefaction stage, is the most distinctive phase of decomposition. Bacterial and other microbes present inside of the body produce gases such as hydrogen sulphide, methane, cadaverine, and putrescine (Early and Goff 1986). In the absence of oxygen these gases cause the abdomen of the carcass to expand and produce a distinctive and putrid smell that is characteristic of this stage (Early and Goff 1986). The greatest number of eggs and larvae are deposited during the early to mid portion of this phase. The presence and metabolic changes caused by larval masses and anaerobic bacteria result in an increase in the internal temperature of the carcass and a breaking down of the corpse (Early and Goff 1986). As the larvae begin to feed on the carcass, fluids

begin to seep from orifices and wounds causing the body to deflate (Goff 2000). This marks the end of the bloat phase.

Decay

The decay stage begins when the body deflates as a result of perforations in the abdominal wall caused by feeding larvae (Tullis and Goff 2000). During the early to mid portion of this phase the larvae mass will continue feeding on the body. The continuation of larvae activity will result in higher internal body temperature relative to ambient temperature. As the decay stage nears its end the larvae migrate from the body in order to pupate, and the carcass will be reduced to approximately 20% of original body weight (Goff 2000).

Advanced Decay

As the decay stage finishes and larvae continue to migrate from the body, the internal temperature of the carcass begins to coincide with the ambient air temperature (Tullis and Goff 1987). This assimilation of temperatures marks the beginning of the advanced decay stage. During advanced decay the internal organs are reduced to a paste-like material, once this matter is consumed and desiccated, the dry remains stage begins.

Dry Remains

The dried remains stage is characterized by the presence of only the bones and hair and the body being reduced to approximately 10% of

its original body weight (Goff 2000). At this point there are generally few insects on the body associated with decomposition.

The entire decomposition process can be completed in weeks to years. These processes will occur at variable rates depending on a number of factors, including temperature, humidity, rainfall, season, geographical location, carcass type, accessibility, position, and weight. Other factors, such as the presence of trauma, insect abundance and type, as well as vertebrate and invertebrate scavengers can also influence decomposition rate of a corpse (Anderson 2000; Payne 1965; Tullis and Goff 1987).

Forensic Entomology and PMI

The primary use of entomology in the forensic context concerns the examination of succession patterns and developmental rates of succession fauna for estimation of the PMI (Catts and Goff 1992). Estimation of the PMI relies on a forensic entomologist's ability to correlate the species or stage of development of arthropods present on the corpse to an elapsed period between colonization of the body by Diptera and the discovery of the body (Catts and Haskell 1990). There are two general approaches that use arthropods to estimate PMI, 1) development-based and 2) succession-based PMI estimation.

Developmental data are used to determine the minimal PMI and are most applicable in the early phases of decomposition when the immature stages of the first arthropod colonizers are present (Catts

1992). When a corpse is found in the early stages of decomposition, the presence of immature flies (Diptera) may be used to determine the minimum PMI by reverse estimation of the development of the collected arthropods from stage when collected to period of deposition. Studies have been conducted to estimate the range of development for many of these forensically important flies (Anderson 2000; Byrd and Butler 1996; Byrd and Butler 1997; Byrd and Butler 1998; Catts and Goff 1992; Smith 1986). Therefore, based on the known variation for these species, it is possible to provide a range of the minimum PMI.

In the later stages of decomposition, when the early colonizers are no longer present, PMI of a corpse also can be estimated from the succession patterns of carrion-arthropods (Byrd and Castner 2000; Catts 1992). In such cases, the composition of taxa found on a corpse at the time of discovery (corpse fauna) is usually compared with the composition of the arthropod assemblage at a given period of time derived from an animal model (baseline fauna) to estimate the PMI (Byrd and Castner 2000; Schoenly *et al.* 1996).

Relevant Species: Development and Succession

Insects are generally the first to discover a corpse, often within minutes of death, and are the primary fauna associated with carrion. Each stage of decomposition is attractive to different species and each stage of decay provides an ideal habitat for certain species to deposit offspring and feed (Anderson 2000; Payne 1965). This occurrence results

in a predictable succession of arthropod species mirroring the stages of decomposition of the carcass.

Insects can be associated with a corpse in a variety of ways and may be classified according to their ecological role. In regards to carrion fauna, three distinct categories are recognized including necrophagous species, parasites and predators of the necrophagous species, and incidental species.

Necrophagous species feed and breed on the carrion itself (Catts and Goff 1992; Payne 1965; Smith 1986). These species are often the most important species in providing useful forensic information and typically occur in succession. Most commonly, this group includes species in Coleoptera and Diptera, which are the primary groups of insects associated with carrion, and comprise about 60% of the necrophagous fauna found on carrion (Payne 1965).

Of the Coleoptera, histerid, silphid and staphylinid beetles are the first to arrive (Watson and Carlton 2003). Late arrivers, such as beetle species in Dermestidae, Rhizophagidae, Ptinidae, and Tenebrionidae invade a corpse in the dry stages of decomposition after early colonizing taxa have already left the remains.

Necrophagous dipteran species, most commonly in Calliphoridae, Sarcophagidae, Muscidae, and Piophilidae are typically the first insects to arrive and are commonly associated with the early stages of decomposition (De Jong 1994; Tantawi *et al.* 1996; Watson and Carlton

2003). It is the rapid invasion and colonization of bodies by the adult flies in these families that have the most profound affect on decomposition. Deposition of offspring by adult flies results in the presence of large numbers of dipteran eggs and larvae. The life cycle of Diptera consists of egg, three larval instars, prepupa, pupa, and adult stages.

Eggs hatch within 24 hours. Resulting larvae will feed on the corpse, disseminating bacteria and secreting enzymes that enable them to consume its soft tissue. The maggots will then pass through three larval stages (instars) punctuated by molts. Their development through these instars takes anywhere from several days to several weeks and will vary depending on the species, environmental conditions, and number of larvae present. The first two larval instars and the early third instar feed actively corpses. The insects feed on the liquid between the muscle fibers, then the fibers themselves, thus, accelerating the decomposition process (Byrd and Castner 2000; Catts and Haskell 1990; Smith 1986).

After a given period of time and growth, late third-instar larvae or pre-pupae, will migrate away from the body in order to burrow into the soil and pupate. As they do so their exoskeleton will shorten, fatten and harden, ultimately becoming the pupal case, or puparium. In about two weeks, depending on the temperature, the adult fly will emerge from the puparium (Byrd and Castner 2000; Catts and Haskell 1990; Smith 1986).

As the necrophagous species feed directly on corpses they attract the secondary group of insects which are the parasites and predators of the necrophagous species (Catts and Goff 1992; Payne 1965; Smith 1986, Tantawi *et al.* 1996). This group includes coleopterans. These species do not necessarily occur in succession, but follow the occurrence of their prey. Although these species are less understood in terms of their usefulness in forensics, they are considered the second most important group that occurs on corpses due to their ecological dynamics and interaction with the corpses and decomposer community.

Incidental species compromise the final category of carrion arthropods and commonly include species in Orthoptera, Hempitera, Araneae, Blatteria, and Lepidoptera (Byrd and Castner 2000; Catts and Haskell 1990; Smith 1986). These arthropods can be found in and around the body at any stage of the decomposition process and, as their name suggest, have little forensic significance at this time.

In correlating stages of development of arthropods with time elapsed before discovery of the body forensic entomologists must consider the effect environmental factors have on arthropod succession and developmental rates.

Factors Affecting Decomposition and Arthropod Development and Succession

Many interrelated factors and processes can affect the decomposition rate of carrion and arthropod development (Anderson 2000; Tantawi *et al.* 1996). Geographic location, as relates to

temperature, humidity, arthropod species, carcass size, arthropod community composition and competition, and vertebrate and invertebrate scavenging are some of the primary factors examined in relation to carrion decomposition and arthropod development and succession.

Every geographical region is characterized by season, temperature, and humidity; all of which can be major external factors acting on carrion decomposition rate and development and succession of carrion arthropods (Anderson 2000; Smith 1986; Tantawi *et al.* 1996). Therefore, each distinct geographical region will have differential arthropod species, composition and developmental times. This regional difference influences the overall rate of decomposition since arthropod activity is either accelerated or inhibited depending on temperature (Tantawi *et al.* 1996).

Temperature is strongly correlated to the metabolic activity of maggots; typically, each stage of blow fly development will progress at a slower rate as the temperature decreases (Davies and Ratcliffe 1994). Research on the time spans for species development at different temperatures is critical for estimating time since death of a corpse (Anderson 2000; Byrd and Butler 1996; Byrd and Butler 1997; Byrd and Butler 1998; Catts and Goff 1992; Smith 1986). In addition to influencing arthropod development and the rate of decay, temperature also affects the types of arthropods that arrive at a carcass in a given

season. Smith (1986) found that a corpse exposed in the spring and summer has different fauna from one exposed in the late fall or winter, when arthropod activity has decreased or ceased.

Humidity can also affect arthropod development as blow flies are typically sensitive to moisture levels (Payne 1965; Tantawi *et al.* 1996). Payne (1965:600) states that "excessive moisture and extremely high temperatures had a pronounced effect on the succession", blow fly larvae will leave a carcass and at a certain level will even cease development. Additionally, Tantawi *et al.* (1996) demonstrated that there are distinct differences in decomposition rates of carcasses in the summer or spring than those in the fall. They speculated that this difference was probably due to greater rainfall and higher humidity. Conversely, it has also been noted when conditions are too dry many of these arthropods will not complete development (Payne1965).

The size of a corpse can also have a profound affect on the rate of decomposition as well as the carrying capacity for fly larvae. Smaller size bodies offer a more limited food resource that can in turn affect the survival and development of the arthropods feeding and breeding on it (Kneidel 1984; Kuusela and Hanski 1982). Ultimately, this factor can alter the speed at which it passes through the stages of decomposition. As a result of a limited food resource inter- and intra-specific species competition is intensified, and there is lower maggot survival, stunted

larval development, and greater susceptibility to predation by vertebrate and invertebrate scavengers (Kneidel 1984).

Effects of invertebrate and vertebrate scavenging and predation on both large and small corpses can also impact the succession of insects on corpses (Anderson 2000). Feeding on flesh by vertebrate scavengers can intensify oviposition by creating alternate openings on the carcass for fly oviposition. Scavengers can also have a reverse effect by devouring so much of the carcass that arthropod colonization is reduced or eliminated.

Invertebrate predators can also have a major impact on necrophagous insects and decomposition (Early and Goff 1986; Stoker 1995; Wells and Greenberg 1994). One such predator is the fire ant, *Solenopsis invicta.*

Fire Ants Role in Decomposition

The effects of the red imported fire ant, *Solenopsis invicta,* (Hymenoptera: Formicidae) on North American wildlife have been examined since their introduction (Allen 1994). Findings have shown that through competition and predation fire ants have the ability to substantially harm both individual species as well as faunal communities. A wide range of organisms are impacted by the predation of fire ants including other insect communities, plants, small mammals, birds, and reptiles. In relation to decomposition, fire ants are present at

all stages of decomposition and are opportunistic feeders, preying on whatever is most readily available.

Early studies on decomposition and decomposer communities, such as the carrion fauna study performed by Fuller (1934), noted the presence ants in association with carcasses, but did not recognize them as relevant elements of carrion fauna. One of the earliest instances in which their role as active and aggressive predators was recognized was by Pimmentel (1955) who, in his decomposition studies in Puerto Rico, reported that fire ants were seen attacking and killing Diptera larvae.

Their role as important members of carrion arthropod communities was documented in a number of studies in the 1960s and 1970s, which recognized them as feeding on carrion as well as predators of other necrophagous insects (Cornaby 1974; Payne 1965; Payne 1968; Payne and Mason 1971). Payne (1965) mentions observing ants feeding on the lips, noses, and eyes of the baby pigs, *Sus scrofa* (Linneaus), used in his decomposition study. He also noted their carrying of fly eggs and maggots from the carcasses. Additionally, in a later studies Payne *et al.* (1968) and Payne and Mason (1971), note that in conjunction with sphaerocerid and phorid flies, ants were the dominant fauna present on decomposing carrion. Ants arrived at corpse within three to six hours after death and remained through all stages of decomposition. In another study (Cornaby 1974) ants were found to be the most prevalent predator on frog and lizard carcasses. They were observed feeding on the

flesh of the carrion and predating on all life stages of Diptera and Coleoptera.

Once it had been established that ants play an active role in carrion decomposition and decomposer communities, researchers began to more closely examine their specific effects. Summerlin *et al.* (1984) conducted an experiment on the survival of horn fly, *Haematobia irritans* (Linnaeus), larvae in bovine manure isolated and exposed to fire ants. Results indicated a significant reduction in the survival of the horn flies exposed to fire ant predation. Wong (1984) found that the Argentine ant, *Iridomyrmex humilis* (Mayr), played a considerable role in reducing Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), populations by as much as 38.8%. In a later study Wong (1988) examined the chance of survival for *Ceratitis capitata* and oriental fruit fly, *Dacus dorsalis* (Hendel), larvae attacked by fire ants in both laboratory and field sites. Results indicate that larvae attacked by fire ants had a significantly lower chance of survival, as did migrated maggots and emerging flies. Vinson (1991) examined the effect fire ants had on decomposing arthropod community of small plants and found that, while the decomposing plants not exposed to fire ants had rich species diversity and abundance, the plants exposed to fire ants had lower diversity and abundance. These results indicate that fire ants can decimate a small, but essential community of organism and decomposers.

In a more recent study Wells and Greenberg (1994) examined the effect of fire ants and carcass type (albino rat, domestic rabbit, and Angora goat carcasses) on the daily occurrence of post feeding carrion-fly larvae. Findings indicate that in the case of rat carrion the presence of fire ants eliminated the presence of Diptera on the carrion and in the case of the rabbits and goats significantly reduced the number of days Diptera were present on the carrion.

Stoker *et al.* (1995) performed a similar study in order to determine the effects fire ant invasion has on invertebrate carrion decomposers under the condition of scarce (mouse carcasses) and abundant (poultry carcasses) resources. Results of this study reveal that the presence of fire ants has dramatic effect on the carrion community associated with mouse carcasses, yielding little to no species diversity and low species abundance. On the larger poultry carrion the number of blow flies trapped in the flying-insect samples was much lower.

The objective of my research is to examine the influence fire ants have on carrion decomposition in central Texas, U.S.A. Three carrion sources were isolated from fire ant contact, and three were exposed to fire ant activity. The effect of fire ants on the decomposition process, biomass loss, maggot removal and predation, number of flies visiting a carcass, variety of arthropods recovered from the pitfall traps, and duration of Diptera oviposition were examined. This study is designed to enhance the field of forensic anthropology and entomology by

providing a better understanding of how fire ants can affect carrion decomposition, arthropod communities and the estimation of time since death.

CHAPTER III

MATERIALS AND METHODS

Study Sites

This research was conducted at a single site in a rural area of San Marcos, Texas, U.S.A. from June 15, 2006 to June 30, 2006. The study was set up in a pasture on the property of Dr. Grady Early. The site was selected on the basis of a number of criteria including accessibility by vehicle, space to distribute the carcasses, limited public access to minimize potential human interference, and the presence of *Solenopsis invicta*.

Presence of *Solenopsis invicta*

The site was tested for the presence of fire ants by distributing five 96 milliliters plastic vessels containing a portion (approximately 10 grams) of hot dog over an area measuring approximately 7.62x7.62 meters. The containers were placed out at 6:00 a.m., recovered an hour later, sealed and placed in a freezer set as -15°C. Once the ants were dead, they were transferred to fresh containers containing 70% ethanol and were later counted.

Carcass Type

The experimental design used six pig, *Sus scrofa*, carcasses to simulate human decomposition. Pigs were chosen since they decompose in a similar manner as human cadavers (Anderson and VanLaerhoven 1996; Catts and Goff 1992). This resemblance in decomposition is a result of a similarity in internal anatomy, due to their omnivorous diet similar gut content, fat distribution, size of chest cavity, lack of thick fur, and skin type (Anderson and VanLaerhoven 1996; Catts and Goff 1992). Each of the six pigs was killed by a gun shot to the cranium with a 22 caliber pistol.

Since it is important to observe insect activity and decomposition processes as soon after the time of death as possible, the pigs were covered tightly with a tarp during transport to the research site and promptly transferred to a freezer set at approximately -20°C where they were stored until research began. Approximately 24 hours before the trial began the freezer was unplugged, but remained sealed, to allow the pigs to thaw. They were removed at 5:00 p.m. on Thursday June 15th and then arranged at the study site.

Site Setup

Each of the six pig carcasses was placed on a wood frame with chicken wire grates measuring 1.19x.058 meters. Chicken (2.54centimeter hexagonal) wire was used to ensure the carrion maintained contact with the ground to simulate natural decomposition as realistically as possible (Figure 1).

Figure 1. Wood framed and chicken wire grate.

Since carrion attracts many scavengers, a wood framed and chicken wire cage was placed over the grates to inhibit scavenging (Figure 2). The cages measured 1.22x0.61x0.61 meters and were removable for easy access to the carrion for weighing and sampling (Figure 3).

Figure 2. Wood framed and chicken wire cages used to protect carrion.

Figure 3. Removable lid to allow easy access to the carcass.

The cage for each of the three control Pigs #1-3 (those isolated from fire ant activity) and the three experimental Pigs #4-6 (those exposed to fire ant activity) were positioned a minimum of approximately three meters apart. This was done in order to simulate an isolated resource for insects inhabiting each carcass since proximity can confound succession patterns (Goff 2000; Tomberlin and Adler 1998). The distance between the three control and three experimental pigs was approximately five meters (Figure 4).

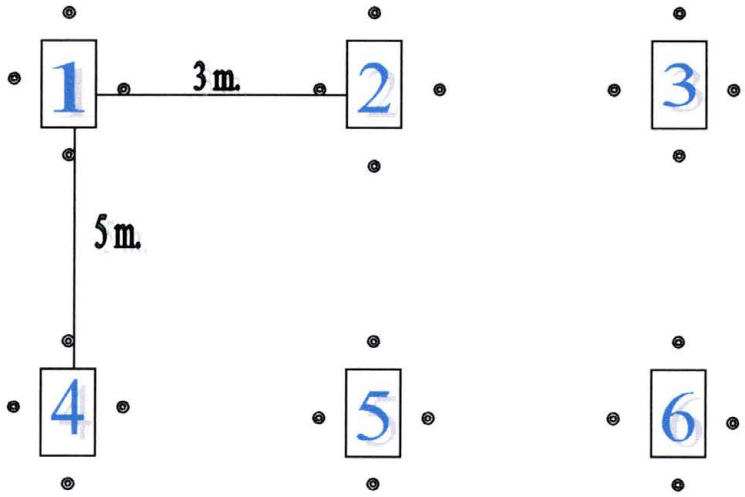

Figure 4. Site layout.

To restrict fire ant activity on the control carcasses the area was treated for fire ants prior to research and a chemical barrier (AMDRO Ant Block) was applied in a 1.5 meter radius of the control pigs every three days.

Temperature Data

Since insect activity and carrion decomposition are influenced by temperature, high and low temperature as well as humidity and rainfall data were obtained from http://www.nesdis.noaa.gov/. The weather station was located at the San Marcos Municipal Airport, approximately eight kilometers from the study site and can be found in Appendix A.

Research Questions and Variables Examined

Each carcass was visited three times a day for a period of two weeks. Observations were made and recorded daily at 6:00 a.m., 1:00 p.m., and 6:00 p.m. Descriptions of each carcass included general observations on vertebrate and invertebrate activity, and anomalies that had occurred since the previous description.

Six different factors were examined for each pig during the course of research including; number of flies visiting, duration of the time flies were ovipositing, the rate at which larvae were removed by fire ants, the difference in the percentage of body weight lost, contents of pit fall traps, and a visual assessment of changes in the decomposition process.

Photographs

Photographs of each pig were taken every other day using a Nikon CoolPix L1 camera. Photographs were used for later reference and to accompany visual observations made about decomposition phases.

Weight Data

The average weight of the pigs was 22.24 kilograms. Each carcass was weighted at the time of placement and each following day to determine the rate of tissue removal, or biomass, during the decomposition process (Goff 2000). Weights were recorded each afternoon of the trial. In order to weigh each pig there were four chains (approximately 0.91 meters in length) extended from the corners of each wooden grate. The chains extending from each corner were attached together at their tips using a large clamp (Figure 5).

Figure 5. Chain and clamp used in weighing.

The grates could then be hung from the hook of a deer scale that was mounted to a wooden tripod that was placed above the pigs for each weighing.

Each carcass could be hoisted above the ground to record free weight. Prior to placing the carrion on the grates, the grates and attached chains were weighed, recorded, and later subtracted from the daily carrion weights. In order to maintain orientation of each carcass, the positioning of the corner of each frame was marked with a small metal stake.

Larva Removal

The number of larvae being removed by fire ants was observed for one minute three times daily, at approximately 6:00 a.m., 1:00 p.m., and 6:00 p.m. Distinct trails could not be identified so each side of each of the three experimental enclosures was observed for one minute and removal was recorded when an ant carrying larva passed the perimeter of the enclosure.

Insect Sampling

Arthropods on each carcass were sampled in order to compare the insect activity between the control and experimental carrion. During each trial, insects were collected using sweep net, pitfalls and hand-picking. Using the sweep net method insects were sampled from each of the carcasses daily. Pitfalls and hand-picking of insects was performed every other day. All insects, eggs, and larvae were preserved in 70% ethanol

and stored for later identification (Byrd and Castner 2000; Catts and Haskell 1990; Drees and Jackman 1999; Furman and Catts 1992; Hall 1948; Taber 2000; Tschinkel 2006).

Number of Flies Netted

During the trial the number of flies visiting the carcasses were sampled and collected by use of sweep net. Using this method flies were sampled from around each carcass once daily (at approximately 1:00 p.m.) using a 38.1 centimeter sweep net with a 0.91 meter handle. The technique was to make four rapid, back and forth sweeping motions (Catts and Haskell 1990). The number of flies captured at each carcass was recorded.

Pitfall Traps

Pitfall traps were used to sample the quantity and type of arthropods present at each station. The time at which the larvae first began to migrate from the carrion was also noted.

In order to ensure that arthropods at a site have an equal chance of entering each trap four proximal pitfall traps were placed on each side of each carcass, approximately one meter from the cage (Figure 6).

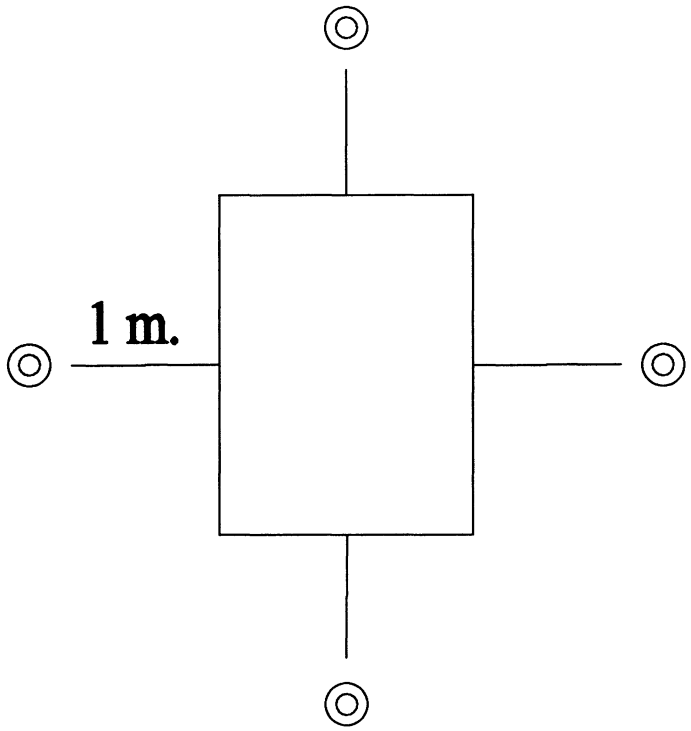

Figure 6. Layout of pitfall traps.

Plastic cups (207.01 milliliters) were used for the pitfalls. Cups were placed into the dirt so that the lip of each container was flush with the ground; they were then filled half way with a salt and soap solution, since other preservatives such as alcohol or formalin may prove either attractive or repulsive to selective arthropod groups (Luff 1986) (Figure 7).

In order to keep out debris and prevent the entry of animals and precipitation, plywood covers were designed to stand above each pitfall trap. The covers were constructed with a (7.62x7.62 centimeter) piece of plywood staked into the ground with four (7.62 centimeter) nails in each corner. The covers stood approximately 2.5 centimeters off the ground over the lip of the cup (Figure 8).

Figure 7. Pitfall trap.

Figure 8. Pitfall trap cover.

The cups were emptied and replaced every other day. Contents of traps were collected by straining the preservative through a cheese cloth. The contents were then rinsed with water and placed into a specimen container with 70% ethanol. Each sample was numbered according to date and the carcass it was associated with and stored for later identification.

Duration of Oviposition

The average duration of time flies were on the control and experimental carrion was recorded to determine if there was a significant difference in time flies spent ovipositing on the control and experimental carrion. Once (approximately 1:00 p.m.) each day the duration of stay of three haphazardly selected flies was recorded for each carcass, time recording ceased at five minutes. Observation made on duration of stay ceased on the fifth day of observation as fly activity significantly decreased and no clear pattern of stay was observed.

CHAPTER IV

RESULTS AND DISCUSSION

Decomposition and Visual Observations

Day 0

On June 15th the six carcasses were placed in the field at approximately 6:00 p.m. Day of placement of the carcasses in the field was recorded as Day 0, and marked the fresh stage of decomposition (Figure 9). After placement the carrion were observed for approximately 30 minutes. Within several minutes of placement flies were observed on all the carcasses, primarily in mouth and ears. No ants were observed at this time. Flies seemed to show no preference between the control and experimental carrion.

Figure 9. Pig 5, Day 0, in the fresh stage of decomposition.

Day 1

On the morning of Day 1 adult dipteran were abundant on all carrion, most notably in the area of Pig 1. There were no dipteran eggs visible on any of the carrion. Additionally several yellow jackets, *Vespula squamosa* (Drury), were noted and collected from control Pig 2 and experimental Pigs 4 and 5.

Ant activity was observed on all experimental carrion (Pigs 4, 5, and 6) throughout Day 1. Ants were observed feeding on the genitals, anus, eyes, and snout (Figure10). First evidence of the bloat stage, slight expansion of the abdominal area, began on the afternoon of Day 1 for all six carrion.

Figure 10. Ants feeding on the genital area of Pig 4, Day 1.

On the evening of Day 1 dipteran eggs were visible in and around the ears, the mouth (Figure 11), the nostrils, and eyes of control Pigs 1 and 3 and experimental Pig 6. Ants were observed feeding on fly eggs on all three experimental carrion, but at this time no eggs were observed being removed from the perimeter of the cage (Figure 12).

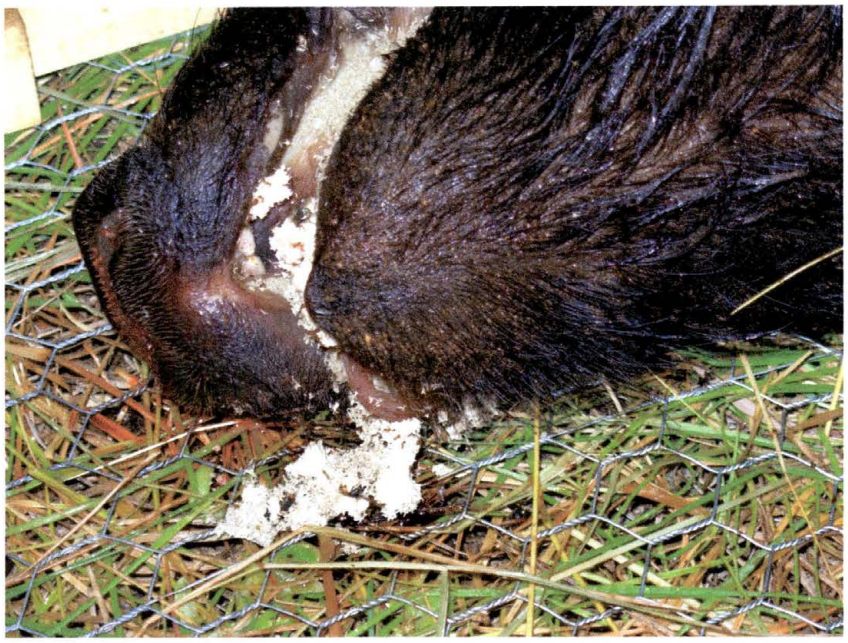

Figure 11. Dipteran eggs in the mouth of Pig 5, evening of Day 1.

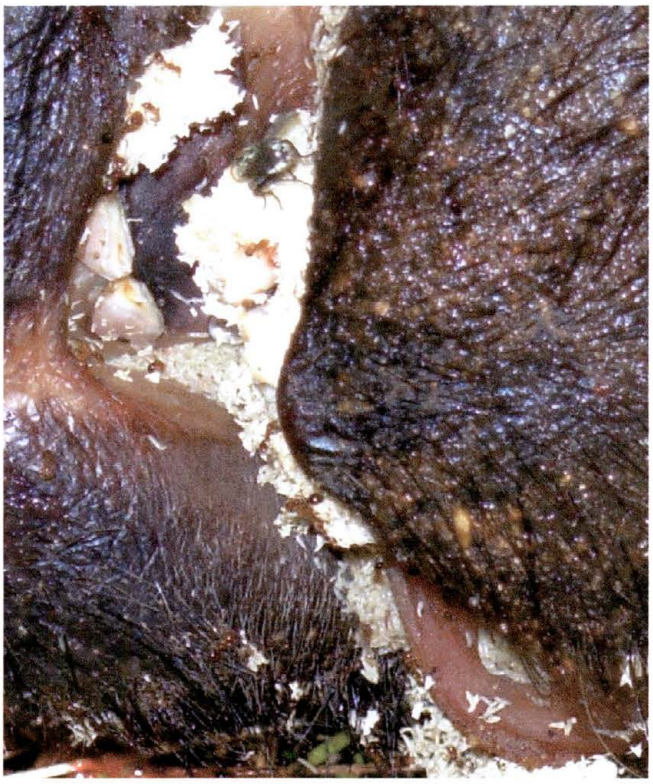

Figure 12. Ants feeding on the dipteran eggs in the mouth of Pig 5, evening of Day 1.

Day 2

Rainfall (approximately 1.46 centimeters) occurred during the night of Friday June 16th and on the morning of Saturday June 17th. Therefore, no data were collected on the morning of Day 2.

On the afternoon of Day 2 adult dipteran were active on all six carrion, once again it was noted that control Pig 1 had discernibly more fly activity. Calliphorid eggs and first instar larvae were found on all carrion, concentrated in mouth, ears, eyes, and nostrils. In the case of all three experimental carrion, ants were observed feeding directly on the carrion in the genital area and anus. Ants were also seen removing the eggs and larvae from the mouths and snouts of all three experimental carrion.

The bloat stage had advanced by an initial increase in the biomass of the control and experimental carcasses, possibly due to gas expansion and increasing insect activity (Figure 13). From photographs and visual observations the onset of the bloat stage began at approximately the same time for the control and experimental carrion.

Figure 13. Pig 6, Day 2, in the bloat stage.

By the evening of Day 2 there were tears in the skin of the stomach of control Pigs 1 and 3 as well as experimental Pigs 5 and 6, as the bloat stage progressed to the decay stage. At this time dipteran eggs and larvae were seen in the genitals and anus of control Pig 1 and experimental Pig 6.

Day 3

Rainfall occurred the night of June 17th and throughout the day of June 18th, accumulating approximately 0.66 centimeters.

On the morning of Day 3 the smell of decomposition was considerably more pungent. There were large perforations in the stomachs of all six pigs; additionally skin began to slip off the legs of control Pig 1 and experimental Pigs 5 and 6 (Figure 14).

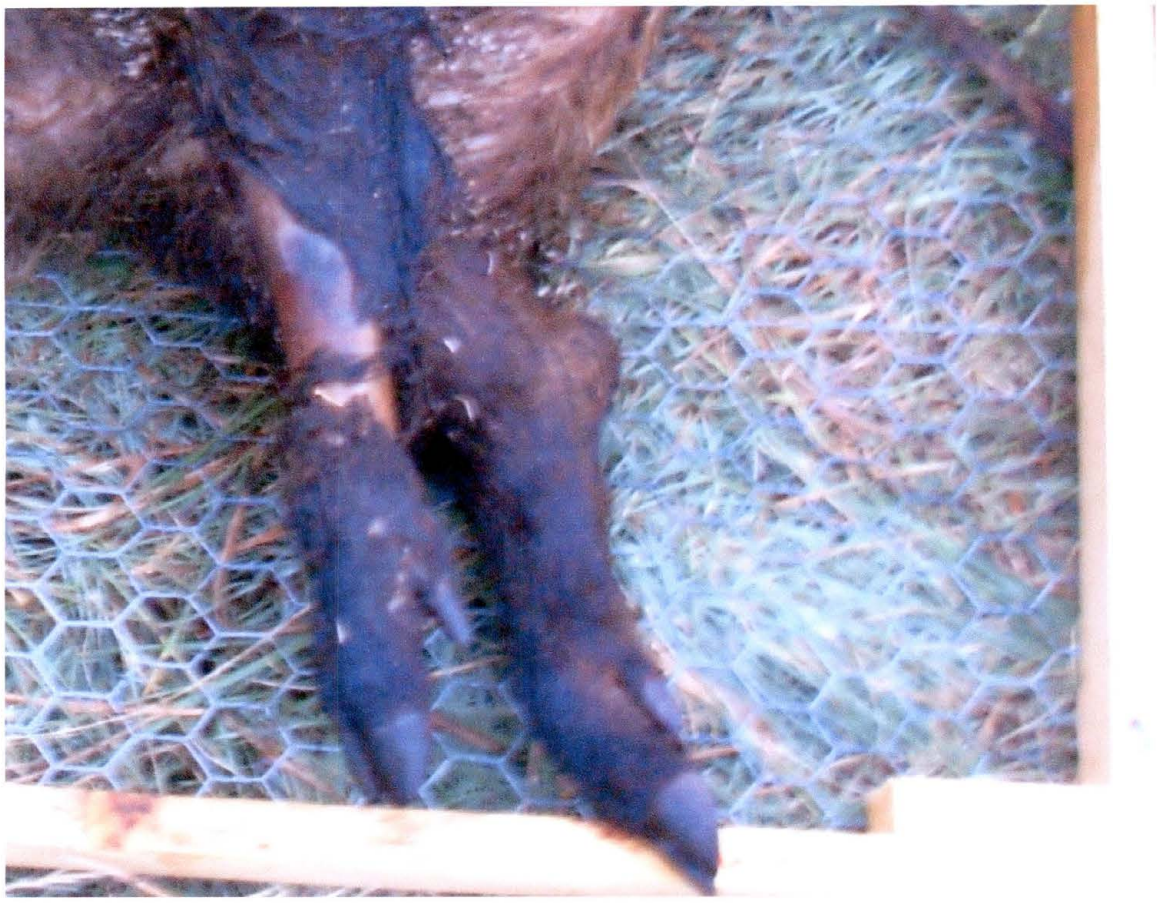

Figure 14. Skin slipping off the leg of Pig 5, Day 3.

Dipteran eggs as well as first and second instar larvae were observed in the orifices and stomach perforations of all six carrion. Ant activity was reduced from the previous day, ants were observed only on experimental Pig 4, but no larvae were removed.

By that afternoon all six carcasses had deflated as the decay stage progressed. The carrion began leaking fluids from all orifices and perforations in the abdominal wall. Larvae were dispersed over all of the carcasses but were predominately in the area of the stomach (Figure 15). Ants were feeding on and removing larvae from all experimental carrion.

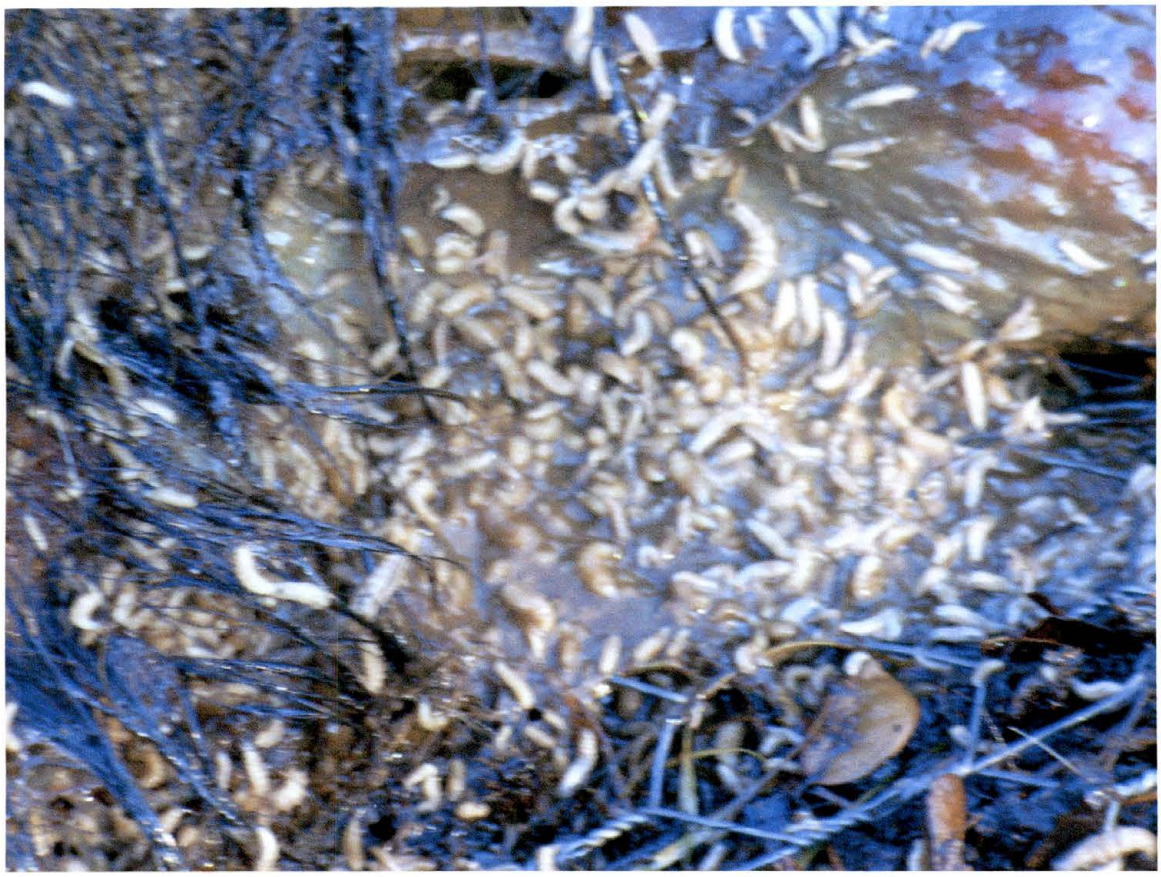

Figure 15. Stomach area of Pig 5, evening of Day 3.

Day 4

On the morning of Day 4 there was a reduction in the amount of fly activity for all six carrion. The carrion appeared deflated and larvae blanketed them, spilling over into the surrounding areas. Most notably control Pig 2 appeared to have the greatest amount of larvae activity with the carcass almost completely blanketed with larvae (Figure 16).

Figure 16. Pig 2 on the afternoon of Day 3, blanketed in larvae.

Ants were not seen on the carcasses but remained around the edges of the carrion feeding on larvae that had fallen off the carrion. Seven maggots were observed on the surface of an ant bed approximately 1.37 meters from the perimeter of the wooden grate containing experimental Pig 4. Approximately 0.61 meters from the perimeter of experimental Pig 5's grate five larvae were found on an ant bed.

Day 5

At this time larvae activity decreased in the area of the head and appendages. Patches of skin were absent on the appendages as well as the skull exposing bone. There were still numerous first, second, and third instar larvae in the area of the torso. It was noted that two teeth from control Pig 1 were found approximately 2 feet from the perimeter of

the side of its enclosure indicating some sort of small scavenger had accessed the carrion.

Dipteran activity had reduced, with the exception of Pig 1, as numerous flies were concentrated around its cage. Ants remained at the periphery of the cages and continued to feed on the larvae. Ants were observed on the head of experimental Pig 4. Once again larvae were found on near by ant beds. The ant bed 1.37 meters from experimental Pigs 4 had 6 had larvae on its surface and an ant bed located between experimental Pig 5 and Pig 6's enclosure had four larvae on its surface.

Day 6 and Day 7

On Day 6 the number of larvae on the carrion began to decrease as they entered the migratory phase. Ants were abundant and feeding on larvae in the areas surrounding experimental Pigs 4, 5, and 6 and further from the carcass on the migrating larvae. Additionally, ants were observed in areas of the experimental carrion stomachs, and they appeared to be feeding on the flesh. The skin on the appendages and head of the carrion started to appear dry, while the stomach area and what was left of the entrails remained moist.

By Day 7 the remaining maggots were concentrated under the carrion and on the peripheries of the cages. Ants continued to feed on the larvae migrating from the experimental carrion and were seen in small numbers feeding directing on experimental Pigs 4 and 5 in the stomach area.

Days 8-15

In the second week of the trial, dipteran activity declined, in the case of the control carrion the number of dipteran netted was approximately a third of that of the first week and in the case of the experimental carrion approximately half. The number remaining larvae continued to decrease, ants continued to feed on migrating larvae until they were completely absent by the evening of Day 10. Ants were sporadically seen feeding directly on the internal tissue of the experimental carrion until approximately Day 12.

The carrion continued to dry out and by Day 12 all the carrion had entered the dry remains phase of decomposition as all that remained the carrion was hair, dried tissues, and bone (Figure 17).

On the afternoon of Day 13 numerous newly emerged flies were observed covering the surrounding areas including the bushes, tripod, and enclosures (Figure 18).

Figure 17. Pig 1, Day 12, dry remains stage.

Figure 18. Emerging flies, Day 13.

Biomass Loss

Decay curves for each carrion were constructed by plotting time against the percent of original animal weight (Figure 19).

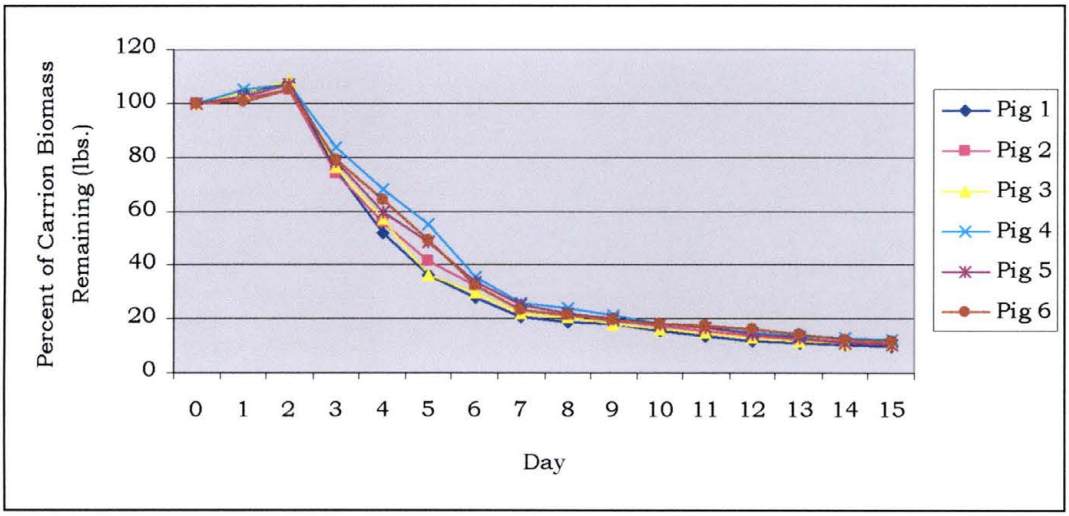

Figure 19. Percentage of biomass remaining for the individual pigs.

Average percentage of biomass loss was calculated for the control and experimental carrion and a decay curve was constructed to examine any variation between the control and experimental carrion (Figure 20).

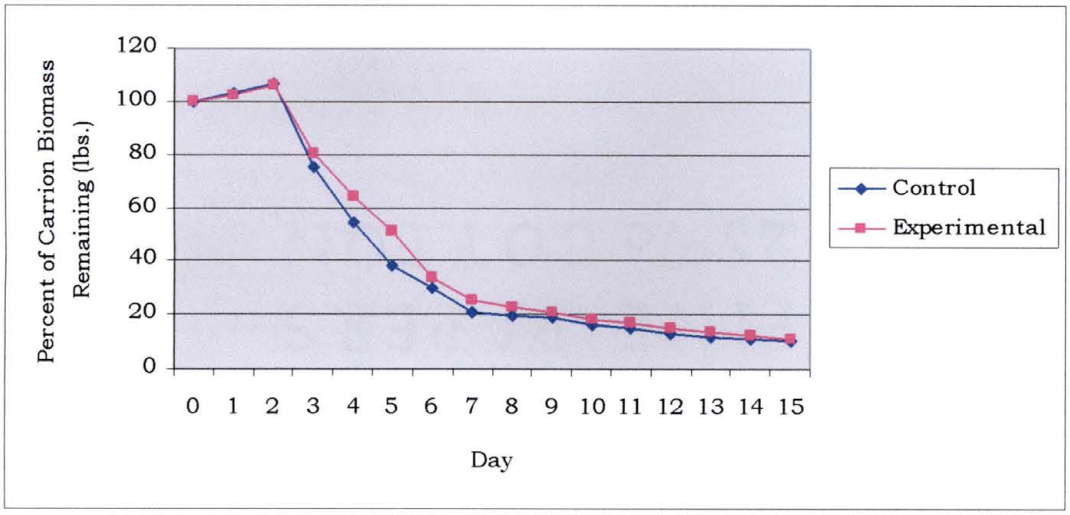

Figure 20. Average percentage of biomass remaining for the control and experimental pigs.

In terms of visual observation and analysis all five stages of decomposition appear to have run concurrently in the control and experimental carrion. The fresh stage lasted from Day 0 until the afternoon of Day 1. The bloat stage began the afternoon of Day 1 and continuing through early in Day 3. The decay stage initiated on the morning/afternoon of Day 3 and lasted until approximately Day 6. The advanced decay began the end of the first week and lasted until approximately Day 10. By the end of the second week all six carrion were in the dry remains phase as bone was exposed and all remaining tissue had dried and mummified.

However, when examining the stages of decomposition in terms of biomass loss there was variation between the control and experimental carrion. During the fresh and the onset of the bloat stage, the two decay curves were very similar as the fresh stage and the bloat stage occurred concurrently in the control and experimental carrion. The bloat stage was marked by an increase in body weight beginning on the afternoon of Day1 and lasting through Day 2. Weight loss continued to run concurrently on Day 3. During the beginnings of the decay phase on Day 4 and Day 5 the control carrion had slightly greater body weight loss. This coincides with the days that maggot removal was greatest, Day 4 and 5. Stoker's (1995) study yielded similar results as he noted that after the initial stages of decomposition the breakdown of the exposed carrion stalled.

By Day 6 the difference was not as apparent, however, throughout the remainder of the study the control carrion had increased, though only slightly, biomass loss.

In describing the five stages of decomposition Goff (2000) noted that by the end of the decay stage only about 20% weight of the carrion remained and by the end of the advanced decay stage only about 10% remained (Goff 2000). Considering this, the control carrion entered the advanced decay stage around Day 7 or 8 and the experimental on Day 9. The control entered the dry remains phase on Day 13 or 14 while the experimental carrion retained just slightly more than 10% of their body weight at the time the trial ceased.

Ant Activity

Pitfall Traps

The number of ants removed from the pitfall traps was recorded to demonstrate if the chemical barrier was effective (Table 1).

Table 1. Fire ants recovered from pitfall traps of control and experimental carrion.

	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14	Total
Pig 1	2	0	0	0	3	2	1	8
Pig 2	3	3	0	0	8	1	4	19
Pig 3	5	1	2	1	1	0	0	10
Pig 4	250	420	435	135	100	35	15	1390
Pig 5	85	230	980	260	290	80	35	1960
Pig 6	130	240	780	125	130	48	20	1473

The chemical barrier used seems to have been effective in eliminating fire ants from the area of the control carrion. The cumulative

number of fire ants recovered from the control pitfalls over a period of two weeks was 37 as compared to the experimental pitfalls which yielded 4,823 fire ants.

Larva Removal

The number of larvae removed from the carcass was recorded three times daily for each of the experimental carrion (Table 2). Larvae removal by fire ants began on Day 2 and lasted through Day 10 at which time few larvae remained. Removal was greatest on Days 4 and 5.

Table 2. Total number of larvae removed by fire ants.

	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Total
Pig 4	7	18	27	33	11	4	3	1	3	107
Pig 5	4	9	13	19	5	3	5	2	0	60
Pig 6	6	22	32	21	15	6	3	5	1	111
Total	17	49	72	73	31	13	11	8	4	

Observations of larvae removal indicate that the fire ants prey upon the experimental carrion and dipteran eggs and larvae throughout the day, but were most active in the early morning.

Fire ants were active during all phases of decomposition. Prior to the appearance of dipteran eggs and larvae the fire ants fed directly on the carrion, focusing on open areas and orifices, mainly the genitals and anus. When eggs were initially present fire ants continued to feed on the carrion as well as the eggs.

Larvae removal was greatest during the decay phase on Days 4 and 5. The number of ants recovered from the pitfall traps was also greatest

following this period of heightened activity, Day 6. As the larvae to ant ratio increased the fire ants shift from feeding on carrion to preying on the larvae. Additionally at this time the fire ants remained in the periphery of the carrion, feeding mainly on the larvae falling off the carcasses.

As the larvae migrated from the carrion, fire ants continued feeding on the larvae directly on the carrion as well as capturing larvae as they migrated away. Though sparse, fire ants were observed on the carrion even after all larvae activity had ceased.

Insect Sampling

Insects collected were keyed down to species when possible, while incidental species where identified to the family level (Byrd 2000; Drees and Jackman 1999; Furman and Catts 1982; Hall 1948) (Table 3).

Table 3. Arthropods collected pitfall for both the control and experimental carrion.

ORDER	FAMILY	GENUS AND SPECIES
Diptera		
	Calliphoridae	
		Chrysomya rufifacies (Macquart)
		Cochliomyia macellaria (Fabricius)
	Muscidae	
		Musca domestica (Linnaeus)
		Haematobia irritans (Linnaeus)
Coleoptera		
	Histeridae	*Saprinus lugens* (Erichson)
		Hister impressus (Fabricius)
	Dermestidae	*Dermestes lardarius* (Linnaeus)
Hymenoptera		
	Formicidae	*Solenopsis invicta*
	Vespidae	*Vespula squamosa*
Orthoptera	Gryllidae	
	Acrididae	
Blattaria	Blattidae	
	Blatellidae	
Araneae	Lycosidae	
	Salticidae	
Hemiptera	Cicadellidae	
	Coreidae	
	Lygaeidae	
Lepidoptera	Nymphalidae	
	Noctuidae	

Number of Flies Netted

From sweep net samples, the dominant calliphorid species identified was *Chrysomya rufifacies* compromising approximately 87% percent of the total flies netted (Figure 21).

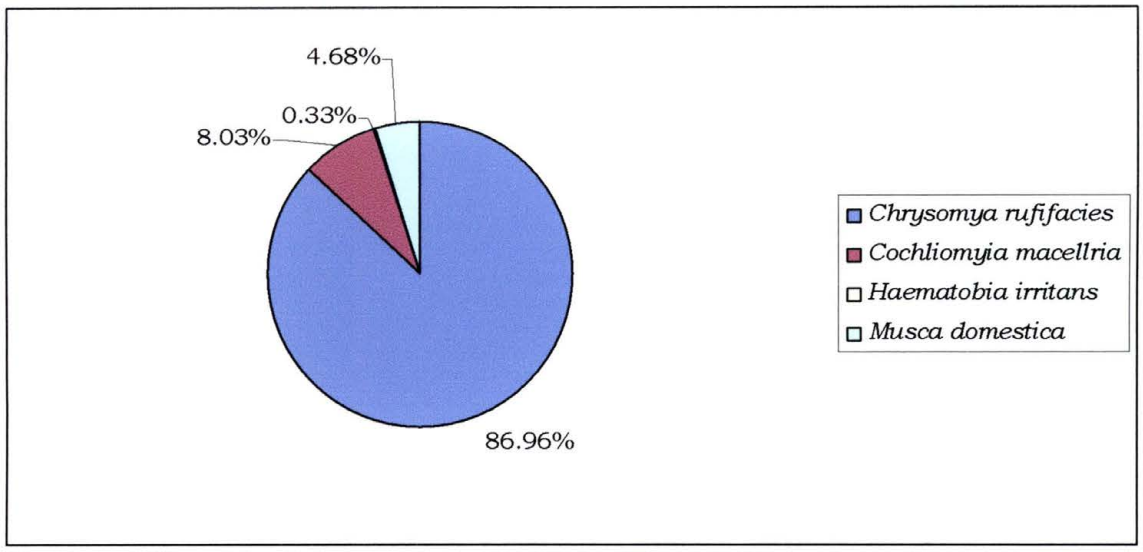

Figure 21. Percentage of dipteran species netted.

The cumulative number of Diptera adults (all species) collected on each day of sampling for both the control and experimental carrion were recorded (Figure 22).

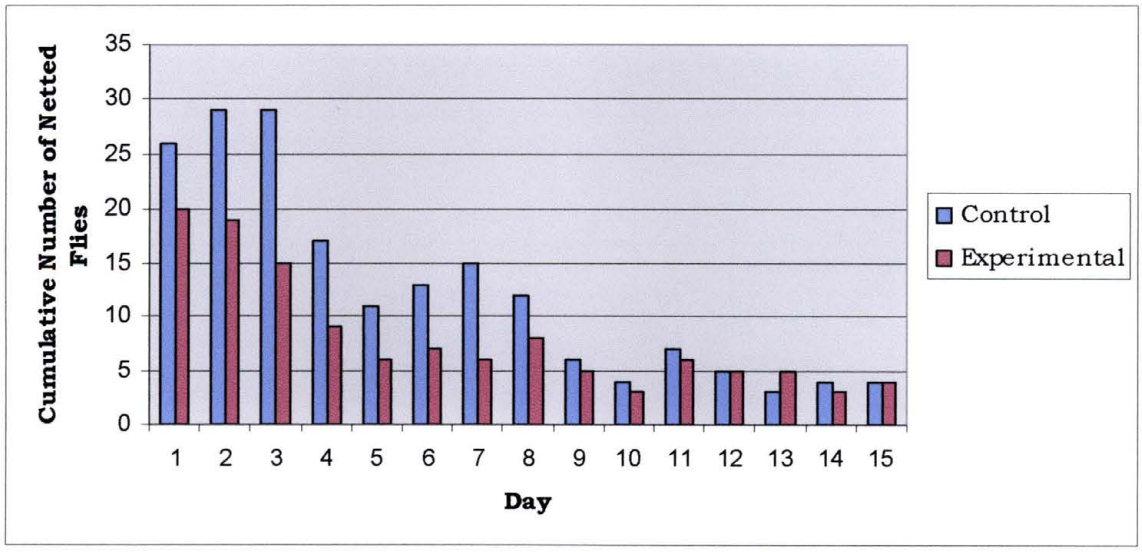

Figure 22. Cumulative number of Diptera adults (all species) collected on each day of sampling for the control and experimental carrion.

Fly activity was greatest for both the control and experimental carrion during the first four days of the trial. Flies were present during

the entire trial; however, their numbers were greatly reduced during the second week. Comparison of the numbers of netted flies from the control and experimental carrion indicate that during the first week of the trial, flies showed preference for the control carrion over the experimental carrion. Beginning in the second week there was little variation in the number of flies netted for the control and experimental carrion.

This is consistent with previous studies such as Wells and Greenberg's (1994) study which indicates that *Cochliomyia mallcelleria* and *Chrysomya rufifacies* associated with carrion and exposed to fire ant activity, displayed a lower proportion ($F = 5.63$; $df = 1$; $P = 0.03$ and $F = 11.42$; $df = 1$; $P = 0.02$ respectively) of days present than those not exposed. Additionally, Stoker *et al.* (1995) used an aerial net and heated funnel to sample the number of flying insects from around carrion both protected from and exposed to fire ant activity. The number of Diptera visiting the carrion exposed to fire ants was significantly less than the protected carrion; and in some cases, the flies completely avoided the carrion with fire ants.

It should be noted that it is possible the greater number of Diptera associated with the control carrion may not have been the result of the absence of fire ant activity. This variation may have been more dependent on the increased fly activity in the case of Pig 1. Pig 1 consistently demonstrated the greatest degree of fly activity. It is not

entirely clear why this difference was observed; however, as decomposition progressed, it was noted that Pig 1 was the only carrion with full bowels. It is possible the presence of fecal matter, which can be attractive to certain dipteran as an oviposition site and protein source, is the reason for the degrees of fly activity at Pig 1 (Goff *et al.* 1991; Hughes *et al.* 1972).

Pitfall Traps

Pitfall traps were emptied every other day beginning with Day 2 through Day 14. The timing of larvae appearance and quantities of arthropods was compared for the control and experimental carrion (Table 4).

Table 4. Cumulative number of larvae recovered from the pitfall traps of the control and experimental carrion.

	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14
Control	0	0	870	544	13	3	0
Experimental	31	24	645	382	7	5	0

The number of larvae recovered from the pitfall traps was compared for the control and experimental carrion. On Days 2 and 4 no larvae were found in the pitfall of the control carrion. On Days 6 and 8 pitfalls for the control carrion were filled with thousands of larvae as they entered the wandering stage. Day 10 demonstrates a decline in the number of larvae recovered from the pitfalls, and by Day 14 no larvae were recovered.

On Days 2 approximately 31 calliphorid eggs were collected from the pitfall traps associated with the experimental carrion, Pigs 4, 5, and 6. Day 4 yielded a total of 24 larvae were found in the pitfall of the experimental carrion. As in the case of the control carrion on Days 6 and 8 pitfalls were filled with hundreds of larvae as they entered the wandering stage, Day 10 demonstrated a decline in the number of larvae recovered from the pitfalls, and by Day 14 no larvae were recovered.

Data pairs were tested using a significant difference ($P < 0.05$) in means t-test for the H_o hypothesis that on Days 6 and 8 the number of larvae recovered from the pitfalls are equal for the control and experimental carrion. The means between the number of larvae recovered from the pitfalls of the control and experimental carrion are significantly different on Day 6 and Day 8 ($\alpha = 0.05$, df = 2, $t = 5.53$), thus the H_o hypothesis was rejected.

For the control carrion, larvae were first found in the pitfall traps on Day 6. Conversely, larvae were recovered from the experimental carrions pitfall traps beginning on Day 2. Since the larvae had not yet entered the wandering phase and the larvae were found in conjunction with numerous fire ants it is likely they ended up in the pitfall as the ants carried them away.

Wong (1988) found that fire ant predation had a significant influence on the survival rate of wandering and emerging Diptera. Similarly during pitfall collection on Days 6 and 8, as the larvae entered

the wandering phase, significantly more larvae were recovered from the pitfalls associated with the control carrion. It is possible this is the result of predation by fire ants, who were actively feeding on the wandering larvae.

The number and type of arthropods removed from the pitfall traps were recorded to see if the presence of fire ants affected other carrion insect species (Figure 23).

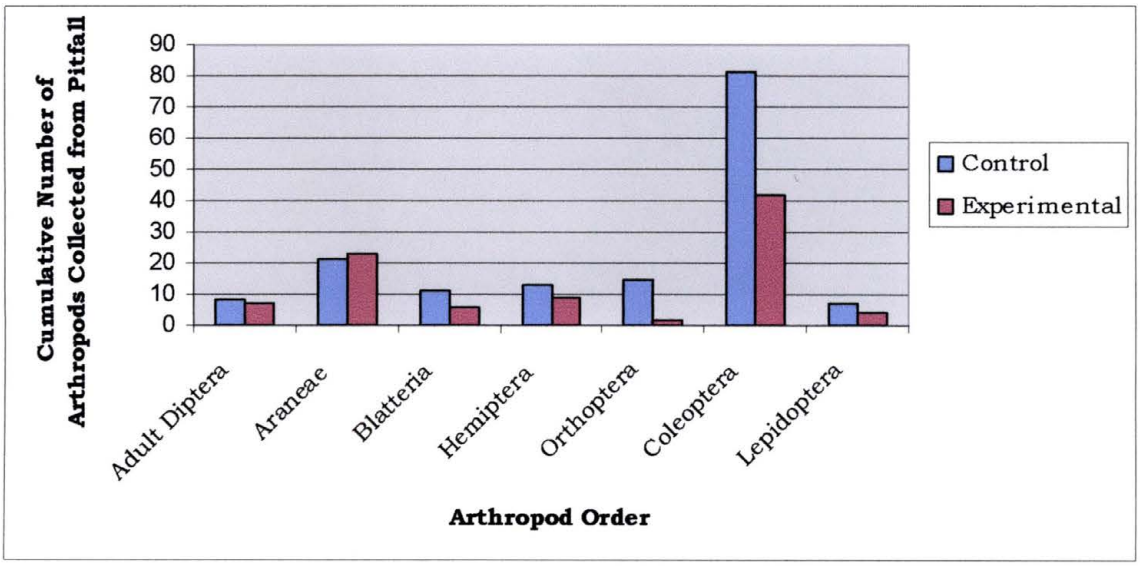

Figure 23. Cumulative number of arthropods collected from pitfall traps of the control and experimental carrion.

For each order, data pairs were tested using a significant difference ($P < 0.05$) in means *t*-test for the H_o hypothesis that the number of arthropods collected from the pitfall traps would be equal for the control and experimental carrion.

The means between the number of adult Diptera, Araneae, Blattaria, Hemiptera, and Lepidoptera recovered from the pitfalls of the

control and experimental carrion would not be statistically significant. However the means between the number of Orthoptera (α =0.05, df =12, t =2.98) and Coleoptera (α =0.05, df =12, t =3.26) were statistically significant, thus for these two orders the H_o hypothesis was rejected.

Differences in species composition between the control and experimental carrion were observed. It seems that the presence of fire ants may have had an affect of the number of Coleoptera visiting the carrion. Stoker (1995) notes that in rat carcasses exposed to fire ants Coleoptera were completely absent. In the same study Stoker also examined poultry carrion and found that although Coleoptera were present in association with the carcasses exposed to fire ants they were in significantly fewer numbers.

Duration of Oviposition

Since there was no distinguishable pattern to length of oviposition, observations of this variable ceased after the 7th day. Duration of stay for both the control and experimental carrion was greatest during the first 2 days of observation. It decreased as larvae activity increased, but increased slightly as the larvae began to migrate from the carrion (Figure 24).

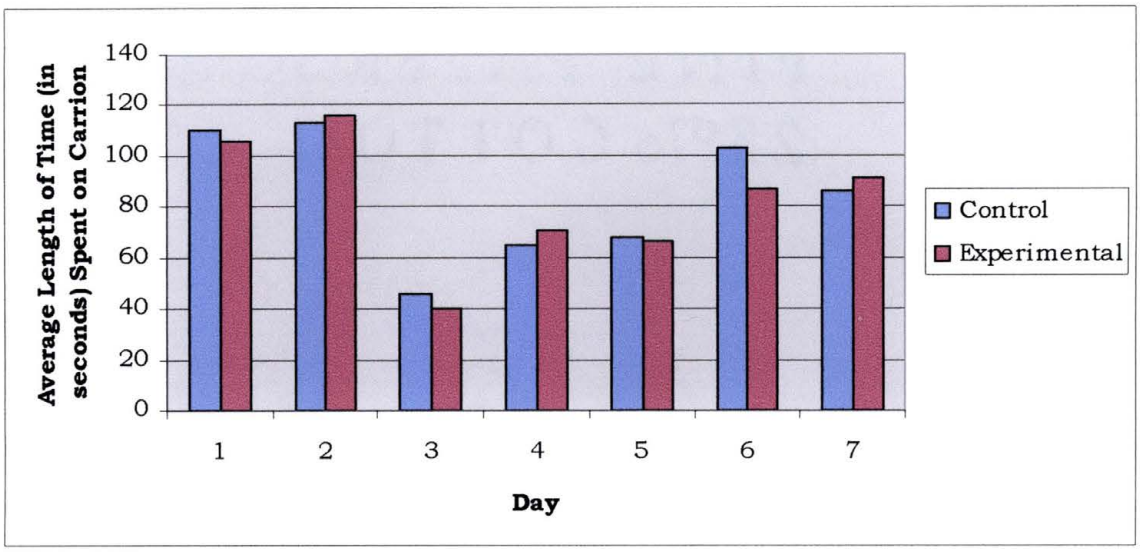

Figure 24. Average length of time (in seconds) flies spent ovipositing on the control and experimental carrion.

Data pairs were tested using a difference ($P<0.05$) in means *t*-test; for the H_o hypothesis that the means between the duration of oviposition for the control and experimental were the same through the trial. The means between the control and experimental carrion were not significantly different ($\alpha = 0.05$, $df = 12$, $t = 0.017$), the H_o hypothesis is retained.

Analysis indicates that the presence of fire ants did not have an effect on the duration of time flies spend ovipositing on the carrion. This finding may have been a result of the size of the carrion. In previous studies using small carrion fire ants were able to completely take over the corpse causing visitation and oviposition of flies to cease (Wells and Greenberg 1994; and Stoker et al. 1995). In the same studies, using larger carrion, the number of fire ants was not great enough to overwhelm the corpse, and flies were present and ovipositing.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this study was to determine the effect that the presence of fire ants had on carrion decomposition. This knowledge will contribute to a better understanding of carrion decomposition in Texas to aid in forensic analysis and estimation of time since death.

Summary

After examination of the research variables, it is clear that there was some variation between decomposition and insect activity in the control and experimental carrion.

Phases of decomposition appeared to run concurrently in the control and experimental carrion, but there were slight differences in percentages of weight loss. These differences were greatest at the time of larvae removal at its peak, Days 4 and 5. Additionally, the slowing of weight loss caused by fire ant predation may have impacted the onset of the subsequent decay stages by a couple days (Catts and Goff 1992; Goff 2000).

Fire ants were active during all phases of decomposition. Prior to the appearance of dipteran eggs and larvae, ants fed on the flesh of the carrion itself. As eggs and larvae became more numerous on the carrion, fire ants began to prey upon them as well as feed on the carrion. During the peak of larvae activity, when larvae overwhelmed the carrion, fire ants moved off the corpse and fed on the larvae around the periphery of the carrion. After larvae began to migrate from the carrion the fire ants resumed feeding on the carrion as well as prey on the migrating larvae.

The average number of flies netted at the control carrion was consistently greater during the first week of the study; however, this may have been the result of increased fly activity associated with Pig 1. Analysis of the contents of the pit fall traps indicated, in the case of the experimental carrion, larvae were found in the traps as early as Day 2; this was likely the result of predation by fire ants. Additionally, as larvae entered the wandering phase, significantly more were recovered from the control pitfalls.

The same incidental species were found on both the control and experimental carrion. However, pitfall traps revealed significantly higher numbers of Orthoptera, and more importantly Coleoptera in the pitfall of the control carrion. The presence of fire ants did not necessarily affect the arthropod community composition but rather the abundance of certain arthropod species. There was no difference in the length of time

flies spend ovipositing on the carrion, though this result may have been different if the ratio of carrion size and number of fire ants were altered.

Problems and Future Research

This study was preformed to provide a basic analysis of the variables of decomposition and arthropod development and succession that may be influenced by the presence of fire ants. However, limitations of this trial should be noted so future research can be performed accordingly. The primary shortcomings of this trial are that it was only conducted once. Repetition of the study would improve the reliability and statistic significance of the results. Additionally, due to time restraints at the point the pigs were obtained the carrion used in this study had be frozen for a period of time before the trial began. It is not uncommon for frozen carrion to be used in decomposition studies (Payne 1965; Wells and Greenberg 1994) and studies have shown no significant difference in dipteran development and size (Day and Wallman 2006). However, freezing of vertebrate tissues causes some disruption of internal cell structure, which in turn can slightly favor aerobic decay over anaerobic putrefaction during the first few days/stages of decomposition, and this may accelerate rates of decomposition (Micozzi 1986). Thus, it would be preferable to use fresh carrion in order to simulate the decomposition process as realistically as possible.

Another factor that should be considered is the use of a chemical barrier in order to eliminate fire ant activity. Use of poisons could potentially affect the presence and quantity of other arthropods in the community (Stoker *et al.* 1995). In order to avoid possible alteration of arthropod communities, other studies have been performed in laboratory settings (Summerlin *et al.* 1984; Wong 1988) or have isolated the carrion from ant activity by elevation (Stoker *et al.* 1995; Vinson 1991; Wells and Greenberg 1994). Given the available resources and size of the carrion in this study, the use of chemicals was the most practical method for isolating the carrion from fire ants. Nonetheless, in future studies, if possible, the use of chemicals and poisons should be avoided because they may alter arthropod community composition and quantity.

The brevity of the decomposition process should also be noted. The high temperatures during the Texas summer greatly accelerated the decomposition process (Anderson 2000; Byrd and Butler 1996; Byrd and Butler 1997; Byrd and Butler 1998; Catts and Goff 1992; Smith 1986). Performing similar studies during cooler seasons would likely slow the decomposition process. Variable weather conditions would also likely affect the number of flies and fire ants present and in turn altering decomposition dynamics.

Furthermore, it appears that the size of the carrion may have influenced the effect fire ants had on decomposition rate and arthropod succession. Studies using small carrion, such as rats or mice, report

that the presence of fire ants greatly reduced and, in some cases, eliminated the presence of other carrion arthropods (Stoker *et al.* 1995; Vinson 1994; Wells and Greenberg 1994). The effects of the presence of fire ants on larger carrion, such as poultry, rabbits, and goats, seemed to be less profound in the alteration of the number of individual species. (Stoker *et al.* 1995; Wells and Greenberg 1994). The relationship between carrion size and the effects and intensity of fire ant predation should be addressed in future studies.

Other factors that warrant further examination include proximity of the carrion to the fire ant mound as well as mound size. In this study the carrion were placed near, but not on or in direct contact with fire ant mounds. This variable should be examined as it may have an impact on the decomposer community.

Conclusions

The most basic application of this study is the recognition of fire ants as a relevant element of carrion fauna and the importance of examining their interaction with other decomposer communities. The results of this study indicate that the presence of fire ants, under specific conditions, did not greatly disrupt carrion decomposition or insect succession. However, some variations in decomposition, biomass loss, and number of associated arthropods were noted. Since the rate of decomposition and species composition of carrion in fauna can be highly variable, further research is still necessary to better understand the

relationship between the effects of fire ant predation and variation in season (temperature, rainfall, and humidity), carrion size, body location, and proximity to fire ant mounds.

APPENDIX A:

Weather data for June 2006 obtained from

http://www.nesdis.noaa.gov/

July 12-2006

June 2006 — Daily Weather Report for San Marcos

Station- San Marcos 41-7983-07	June	2006	WS FORM B-91 (12-93)	U.S. Department of Commerce	
State- TX	County Hays			National Oceanic and Atmospheric Administration	
Time	Temp- 8AM	Precip- 8AM	Standard Time- CD	National Weather Service	
Temperature F.	Precipitation		Avg Rainfall forJune is 4.84"	Record of Climatological Observations	
24 HRS ending at OB	24 hr amounts				

Day	MAX	MIN	at OB	Rain	Snow	Hail	Hrs Precipitation was Observed	fog	ice	hail	thndr	stm	avg wind	hi wind	cmfrt	AM Observations & Remarks	PM Observations & Remarks
1	83	68	69	0.27			1:25am/2:40a/ 3:40a/ 5:55a/ 11:35a/ 4:25p-5:00pm						4.6	24		cloudy, warm, windy, light rain all day	cloudy, warm, windy, humid, brief rain at 4:25pm
2	90	67	70	0.00									2.8	17		PC, warm, humid, breezy	PC, hot, humid, breezy
3	92	70	72	0.00									2.6	16		PC, warm, humid, breezy	PC, hot, humid, breezy
4	94	72	74	0.00									3.7	16		PC, warm, humid, breezy	PC, hot, humid, breezy
5	94	71	74	0.00									5.5	20		ovrcst, warm, humid, breezy	clear, hot, humid, windy
6	95	70	73	0.00									4.9	18		PC, warm, humid, breezy	clear, hot, humid, windy
7	97	73	75	0.00									4.6	17		PC, warm, humid, breezy	clear, hot, humid, windy
8	98	72	76	0.00									3.0	15		PC, warm, humid, breezy	clear, hot, humid, windy
9	95	73	76	0.00									3.8	17		PC, warm, humid, breezy	clear, hot, humid, windy
10	95	72	72	0.00									5.3	21		PC, warm, humid, breezy	PC, hot, humid, breezy
11	96	74	74	0.00									5.4	17		PC, warm, humid, breezy	PC, hot, humid, breezy
12	96	75	73	0.00									3.1	15		clear, warm, humid, breezy	PC, hot, humid, breezy
13	100	72	74	0.00									2.6	14		clear, warm, humid, breezy	PC, hot, humid, breezy
14	96	77	77	0.00									5.0	19		cloudy, warm, humid, windy	PC, hot, humid, breezy
15	95	77	78	0.00									7.1	25		cloudy, warm, humid, windy	cloudy, hot, humid, windy
16	94	77	78	0.00									9.8	27		cloudy, brief rain, warm, humid	cloudy, hot, humid, windy
17	92	67	74	1.46			4:15a/ 4:55a/ 7:50a-9:10a				1	1	7.6	43	3	cloudy, warm, hi winds @ 7:45am, rain	cloudy, warm, windy, humid
18	82	68	73	0.66			2:35a-3:20a/ 4:15a/ 4:50a-6:20a				1		3.8	32		cloudy, rain at times early am, warm, humid	PC, hot, humid, windy
19	95	75	76	0.00									4.9	21		clear, warm, humid, breezy	clear, hot, humid, windy
20	88	75	77	0.00									5.3	22		PC, warm, humid, breezy	PC, hot, humid, windy
21	92	77	78	0.00									6.5	25		PC, warm, humid, breezy	PC, hot, humid, windy
22	94	77	78	0.00							1		5.0	28		PC, warm, humid, breezy	PC, hot, humid, windy
23	96	76	77	0.00			in am visibility 1 mil	1					3.2	14		fog early am, clearing, PC, warm, humid	PC, hot, humid, breezy
24	89	76	76	0.00									3.7	15		PC, warm, humid, breezy	PC, hot, humid, breezy
25	95	72	74	0.00									3.9	20		PC, warm, humid, breezy	PC, hot, humid, breezy
26	93	76	76	0.00									6.8	25		PC, warm, humid, breezy	PC, hot, humid, breezy
27	90	68	72	0.00									3.9	16		PC, warm, humid, breezy	PC, hot, humid, breezy
28	93	65	71	0.00									2.9	19		PC, warm, humid, breezy	PC, hot, humid, breezy
29	92	69	72	0.00									2.7	15		PC, warm, humid, breezy	PC, hot, humid, breezy
30	95	74	75	0.04			7:55pm						3.8	21		cloudy, warm, breezy	cloudy, hot, humid, breezy
31																	
avg	93.1	72.5		2.43				1	0	0	3	1	4.6	43	3	comfort level this month-	
								fog days	ice days	hail days	thndr days	stm	avg wind	hi wind	cmfrt		

Observer- Steve Sands Station Index No. 41-7983-07 Supervising Office- New Braunfels, TX

APPENDIX B:

This appendix includes the daily recorded weight and percentage body weight remaining for each control and experimental carrion.

Pig 1		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	22.14	100
1	22.99	103.84
2	23.86	107.77
3	16.65	75.2
4	11.48	51.85
5	8.04	36.31
6	6.14	27.73
7	5.54	25.02
8	4.21	19.02
9	3.96	17.89
10	3.42	15.45
11	2.94	13.28
12	2.54	11.47
13	2.43	10.98
14	2.24	10.12
15	2.19	9.89

Pig 2		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	15.24	100
1	15.56	102.1
2	16.06	105.38
3	11.31	74.21
4	8.45	55.45
5	6.34	41.6
6	4.91	32.22
7	3.55	23.29
8	3.27	21.46
9	2.96	19.42
10	2.69	17.65
11	2.38	15.62
12	2.05	13.45
13	1.85	12.14
14	1.8	11.81
15	1.71	11.22

Pig 3		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	23.81	100
1	24.64	103.49
2	25.76	108.19
3	18.18	76.35
4	13.53	56.82
5	8.71	36.58
6	7.1	29.82
7	5.28	22.18
8	4.98	20.92
9	4.32	18.14
10	3.88	16.3
11	3.57	14.99
12	3.14	13.19
13	2.85	11.97
14	2.63	11.05
15	2.45	10.29

Pig 4		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	22.18	100
1	23.26	104.87
2	23.77	107.17
3	18.55	83.63
4	15.15	68.3
5	12.19	54.96
6	7.9	35.62
7	5.81	26.19
8	5.32	23.99
9	4.81	21.69
10	4.09	18.44
11	3.71	16.73
12	3.33	15.01
13	3.08	13.89
14	2.88	12.98
15	2.69	12.13

Pig 5		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	18.78	100
1	19.3	102.77
2	20.05	106.76
3	14.79	78.75
4	11.23	59.8
5	9.19	48.94
6	6.27	33.39
7	4.75	25.29
8	4.19	22.31
9	3.76	20.02
10	3.45	18.37
11	3.18	16.93
12	2.68	14.27
13	2.43	12.94
14	2.1	11.18
15	1.89	10.06

Pig 6		
Day	Weight (kilograms)	Percentage of Body Weight Remaining
0	31.3	100
1	31.43	100.42
2	32.93	105.21
3	24.84	79.36
4	20.09	64.19
5	15.49	49.49
6	10.19	32.56
7	7.38	23.58
8	6.72	21.47
9	6.16	19.68
10	5.77	18.43
11	5.42	17.32
12	5	15.97
13	4.4	14.06
14	3.87	12.36
15	3.65	11.66

APPENDIX C:

This appendix includes the daily record of the number of flies netted for each control and experimental carrion.

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**	**Day 11**	**Day 12**	**Day 13**	**Day 14**	**Day 15**	
Control Carrion																Total
Pig 1	15	13	16	7	6	9	7	6	2	2	3	1	2	2	3	94
Pig 2	6	7	6	4	2	2	3	2	3	2	2	3	0	2	0	44
Pig 3	5	9	7	6	3	2	5	4	1	0	2	1	1	0	1	47
Total	26	29	29	17	11	13	15	12	6	4	7	5	3	4	4	185
Experimental Carrion																
Pig 4	7	6	3	4	1	3	0	3	3	0	1	4	1	0	1	37
Pig 5	9	8	5	2	3	1	2	4	1	3	2	0	3	2	1	46
Pig 6	4	5	7	3	2	3	4	1	1	0	3	1	1	1	2	38
Total	20	19	15	9	6	7	6	8	5	3	6	5	5	3	4	121

APPENDIX D:

This appendix includes the daily record of duration of oviposition (in seconds) for each control and experimental carrion.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	
Control Carrion								Average
Pig 1	106	201	67	84	24	222	29	105
Pig 2	79	81	49	58	112	37	108	75
Pig 3	145	57	22	53	68	50	121	74
Average	110	113	46	65	68	103	86	
Experimental Carrion								
Pig 4	163	63	36	94	33	115	89	85
Pig 5	70	82	52	48	107	85	44	70
Pig 6	85	203	32	71	58	61	140	93
Average	106	116	40	71	66	87	91	

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