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Forensic Entomology

Insect Succession – Northern Colorado

Thomas Nissen

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Abstract

Forensic entomology is considered a relatively new field of entomology yet insects have been around for millions of years. Insects have been associated with dead animals and humans for centuries. The remains of insects have been recorded from Ancient Egypt to the present time. Recent advancements have been with data presented to the courts that show that there is a specific order to insects arriving on a corpse and that order helps to determine time of death. This study investigates the order of insect succession in the northern front range area of Colorado.

Forensic Entomology

Insect Succession – Northern Colorado

Insects are the first recorded animal life on the planet. Estimates put the first fossilized insects around 396 million years ago – during the Devonian Period. The specimen was the *Rhyniognatha hirsti*; the closest relative being the modern Springtail. This particular specimen likely had wings and mouthparts that resembled that of a Mayfly – which is a flying insect (Pfadt, R.E. 1971).

Moving forward about 396 million years to insects of today. Insects are the most diverse group of animals on the planet. More than half of all living organisms are insects with the possibility of over 90% of animal life resides in this class.

Insects are found on six of seven continents – Antarctica being the sole exception. Insects exist in all types of environments which does include a small number found in aquatic environments.

Insects are considered pests to humans yet the diversity of different insect species include parasitic insects; disease vectors to humans and animals; pollinators, which are beneficial to mankind; predators of other insect species and consumers of carrion – the decaying flesh of animals, including humans. The latter is a benefit otherwise mankind would be waist deep in bodies.

This last group is the focus of this research project – research in forensic entomology.

Introduction to Forensic Entomology

What is forensic science and what is forensic entomology?

Forensic science is “the use of scientific knowledge and technology in civil and criminal matters, including case resolution, enforcement of laws and national security” (Rivers, 2014).

When a civil case occurs, a scientific forensic analysis takes place to help resolve the issue at hand. Today's society has been indoctrinated to this term and a belief exists that when a forensic scientist is called to the stand to testify, that scientist is an expert and the jury will be given an exact answer to the issue before them and therefore will find the defendant on trial, guilty. The jury will be home for dinner. This is not what happens contrary to television examples of cases solved and defendants goes to the "pokey" – all within 43 minutes. This could not be farther from the truth.

Reality – the process of "forensics" requires a team of individuals, over time, working together that may or may not present evidence leading to a criminal conviction or a civil judgement.

A forensic scientist will utilize the scientific method – adherence to defined unbiased approaches to defining, conducting and interpreting experiments – to analyze physical evidence which will enable them to provide expert testimony in court.

A large part of this examination and subsequent testimony relies on physical evidence. Physical evidence is any part or all of a material object used to establish a fact in a criminal case; such as bullet casings or fragments, clothing, dental crowns and yes, fly maggots. Physical evidence would be used by the prosecution to "prove" beyond a reasonable doubt, the defendant committed a particular crime. The forensic scientist will work to establish these particular facts (Rivers, 2014).

How does any of this relate to "bugs?"

The field of forensic entomology is the study of insect biology as it relates to societal problems that come to the attention of the legal profession and that often must be resolved by legal proceedings (Kronsky, 2019).

Forensic entomology has advanced “leaps and bounds” within sixty (60) years. This has been accomplished through experts in medical fields otherwise known as medical entomologists. This discipline has come about because carrion insects have been seen and collected feeding on corpses at crime scenes. Again, television has assisted in this by televising shows aimed at the public’s attention. Example of such would be the CBS show, *CSI-Crime Scene Investigation*, that was on for many years, whereby the chief investigator was an entomologist and as the character collected the “bug suspects” from the scenes and was able to identify the specimen and ultimately lead to the capture of the “bad guy.”

The courts – again after decades – are recognizing the rationale for the use of insects in forensic investigation. These little “witnesses” can provide more objective evidentiary information than that provided by witness testimony. The insects provide possible variation to the appearance of the corpse that has been decomposing for longer than 24 to 48 hours as well another form of evidence lacking any other scientific basis (Krinsky, 2019).

While one might think or believe that forensic entomology is a “new” concept, this could not be further from the truth.

Brief History of Forensic Entomology

The earliest recorded historical information on “forensic entomology” comes from China, around 907 and 960 A.D. Flies were observed landing on the head of a man, deceased, which indicated a blow to his head.

The first known case that associated insects to a murder – again in China -was described by Sung Tzu in 1247 A.D. This was told that a farmer was murdered; slashed by a sickle. At the inquest, all farmers were told to gather their sickles and place them on the ground. Within a short period of time, flies were seen gathering one sickle, when there were 70 to 80 sickles on the

ground. The one sickle that flies were attracted to had residual blood on it – incriminating the owner of the sickle, the suspected murderer (McKnight, 1981).

Several hundred years later the first recognition that insect development on a corpse would be useful in determining the interval from the time of death until discovery of the body. This occurred in Europe in the Mid-19th Century. This case dealt with the corpse of a baby found in an apartment in France whereby the time of death was traced back to the apartments former tenant. This was described in a book published in 1894 by P. Megnin.

Advancing into the Twentieth Century and propelling forensic entomology involved an English case whereby Doctor Buck Ruxton was under investigation for homicide in 1935. The dismembered remains of Mrs. Ruxton and her nursemaid were found in a stream bed. The neat disarticulation of the bodies suggested that the murderer had some anatomical knowledge. Blow fly maggots (*Calliphora vicina*) were found on the remains of the body, specifically third-instar larva. This indicated that the remains must have been placed in the ravine 12 to 14 days before the discovery. This was consistent with the disappearance of the victims from Doctor Ruxton's house. The fly evidence helped to convict Doctor Ruxton, found guilty and hanged for his crimes (Krinsky, 2019).

Studies since this time have refined the analysis of the progression of arthropods associated with different stages of decomposition (Nuorteva, 1977; Smith, 1986; Campobasso, et. Al 2001).

Purpose / Research / Background

It is to this end that this study was undertaken. To determine not only the different stages of decomposition in a particular area of the country but the order of insect succession associated with that decomposition.

Insect succession – again through history -is a predefined order, a predictable pattern.

One study found that a specific tick species dating back 2500 years found on a dog (which had died from unknown causes) was mummified with the tick, *Rhipicephalus sanguinis*; this represents the oldest record of ticks on any animal species and points toward parasitism on dogs (and humans) – from this time period to present day (Otranto, et al, 2014).

A better example of insect succession would be the recovered remains of insect species found during excavation of an ancient site from Huaca De La Luna, Peru. This site was the location of ancient civilization, the Moche people. The insect species found were Sarcophagia (flesh flies); Coleoptera (*Trogidae*; *Omorgus subgrosus*); plus Hymenoptera (parasitic wasps) and carcass beetles (*Frocididae*). These species recovered from a site estimated to be from 100 to 750 A.D. (Huchet, 2010).

Going back even farther in history to Biblical references indicate that more than 120 referenced insects were as follows, 34 as locust and grasshoppers; 11 as moths and 9 to flies – including 20 references to “worms” -which were fly larvae. Flies were associated with pestilence, disease and death. One Biblical reference was, “three flies can eat more than a lion.” Obviously, ancients associated insects with both life and death (Huchet, 2010).

The Egyptians embalmed/mummified their deceased in hope of preventing flies from destroying the corpse whereas the Moche people did not do this; resulting in insect species being able to be identified centuries later.

We know from historical findings and writings that insects have been around humans for the entire existence (both in life and death) of the human race. What insects arrive first at a crime scene and which leaves last, is the question.

One study conducted by Zeariya, M. et al (2015) on both dogs and rabbit carcasses showed that the blow fly (*Chrysomya albiceps*) was the first to arrive and the most abundant; followed by *Musca domestica*; *Sarcophagidae*; *Piophilidae*; and *Phoridas*. These were followed by the Coleoptera's (*Dermestes maculatus* and *Hister, sp*). Following these species were the *Vespidae* and the *Formicidae* (ants). (Zeariya, 2015).

Another study conducted on a goat cadaver by Jyoti Thakur (2019) had in order of succession (with overlap), Diptera (flies), Coleoptera (beetles) and Hymenoptera and Formicidae (ants). The first – Diptera – were the Bluebottle flies, the last were the hide beetle (*Trox suberosus*).

Another study by Magni, Paola (2013) showed the order of succession on human remains found in two wells, were in this order, Diptera - *Calliphora vicina*, *Fanniidae*, *Muscidae*; *Trichoceridae*; *Sphaerocordidae*; *Psychodidae*; *Nematocera*; followed by the Coleoptera (*Cleridae*).

Continuing to prove a succession pattern from another study involving a pig carcass in a semidesert area of Mexico, the order was Diptera, Coleoptera and Hymenoptera and Formicidae (Valdes, P.M. 2010).

The next study also involving a pig (close to human similarity) was in Ghana, Africa. The order of this study with overlapping species were the Diptera; Hymenoptera (Family Formicidae – ants); Coleoptera; Hemiptera (*Pyrrhocoridae*) and Lepidoptera (*Saturniidae*). (Kyerematen, 2013).

These studies indicate that there is an order of succession of insects that arrive on a body after death has occurred. The areas of study indicated those of the world from semidesert regions

to wet, tropical areas. The first insect arriving consistently were species of Diptera – the blow fly. The orders after fly arrival with overlap to a certain degree were also in a distinct order.

This study represents an order in a semi-arid region of the United States, the State of Colorado, specifically Northern Front Range. The hypothesis order following the previously mentioned studies would be the Diptera first, followed by Coleoptera to Formicidae – ants.

Hypothesis

The hypothesis of this study will be the order of insect succession on decomposing cadavers will follow the same pattern as the previously cited studies. The elevation and semi-arid nature of the location will not have an impact on the order of succession.

Weather patterns and changes will have little to no effect on the order of succession.

Would specific deceased species have any effect, minimal or otherwise, on this order of succession. The species to be studied are mammal; avian; reptile and amphibian.

Method

To begin a brief explanation of the stages of decomposition of vertebrate animals need to be explored. There are five (5) distinct stages of decomposition which are as follows:

Stage 1: Fresh Stage (0-1 day after death). This stage begins after the heart stops beating. From the moment of death, the body begins to cool or warm to match the ambient temperature of the surrounding area. Between 3 to 6 hours after death, rigor mortis begins – the muscles become rigid and cannot relax; this is caused by chemical changes in the body postmortem microbial proliferation within the body – decomposition of proteins leads to stage 2 – purification.

Stage 2: Bloat (2 -6 days). Microbial proliferation is underway. Anaerobic metabolism begins; gases within the body causes distention of the abdomen causing the cadaver to have a bloated appearance. Gas pressure builds up; liquifying tissues (froth) escapes from natural orifices; the body might rupture. Maggots hatch and feed on tissue. Purging of gases and fluids result in strong distinctive odors associated with decay.

Stage 3: Active Decay (5 – 11 days). Greatest mass loss from liquefaction of tissues and disintegration becomes apparent; strong odor persists. End of active decay is signaled by migration of maggots away from the body to pupate.

Stage 4: Advanced Decay (10 – 24 days). Decomposition is inhibited due to loss of readily available cadaver material. Insect activity is reduced.

Stage 5: Dry Remains – Skeletonization (24 – 70⁺ days). All that remains is dry skin, cartilage and bones. If all soft tissue is removed, cadaver is completely skeletonized.

Source: Gennard, D (2012).

These five (5) stages of decomposition were observed and noted on the specimens collected.

There were four specimens of animals collected as previously noted and observed. These specimens are as follows:

Mammal: Raccoon “*Prosyon lotor*”

Order: Carnivora

Family: Proyonidae

Description: Head / Body 18-28” long

Tail: 8 – 12” long

Weight: 12 – 35 pounds

Body salt and pepper mixture in color; black mask over eyes.



Mouse: Plains Harvest Mouse, *Reithrodontomys montanus*

Order: Rodentia

Family: Cricelidae

Description: Head / Body $2 \frac{1}{5}$ to 3" long

Tail: $2 - 2 \frac{3}{5}$ " long

Colors: Pale grayish; belly, feet and underside of tail white



Source: Burt, 1980. Photo's courtesy of same source.

Avian: Bird, Yellow-Rumped Warbler, *Setophaga coronate*

Class: Aves

Order: Passeriformes

Family: Parvlidae

Genus: *Setophaga*

Description: Slate gray/black streaks on breast, yellow patches rump, flanks, head,

Two white wing bars

5 – 6" in length



Hairy Woodpecker; *Leuconotopicus villosus*

Class: Aves

Order: Piciformes

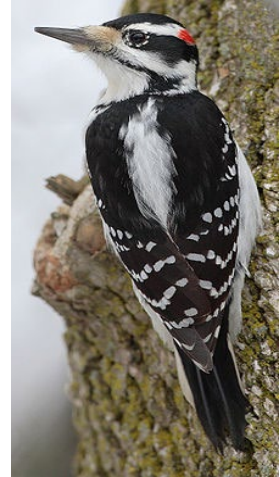
Family: Picidae

Genus: *Leuconotopus*

Description: Black/white with white belly; black wings
with rows of white spots.

White stripe down back; long black bill; red mark on back of head

Male; approximately 9" long



American Robin; *Turdus Migratorius*

Class: Aves

Order: Passeriformes

Family: Turdidae

Genus: *Turdus*

Description: Male

Gray with rusty red breast; black head and tail; white eye ring

Length 9 – 11" long



Source: Tekiela, S (2001). Photo's courtesy of same source.

Amphibian: Western Toad; *Anaxyrus boreas*

Class: Amphibia

Order: Anura

Family: Bufonidae

Genus: *Anaxyrus*

Description: Large species; between 2.2 to 5.1” long

White or cream dorsal stripe; dusky gray/greenish dorsally

Parotoid glands are oval, widely separated

Male has smoother skin



Source and photo courtesy of: Stebbins & McGinnis (2018).

Reptile: Bull Snake; *Pituophis cateniper*

Class: Reptilia

Order Squamata

Family: Colubridae

Genus: *Pituophis*

Description: Adults between 4” to 6” long; Weight 2.2 to 3.3 pounds

Coloring of yellow with brown, white, black, some with

reddish blotching; constrictors.



Common Garter Snake: *Thamnophis sirtalis*

Class: Reptilia

Order: Squamata

Family: Colubridae

Genus: *Thamnophis*



Description: Patterns of yellow stripe on a black, brown/green background

Total length of around 22" to a maximum of 54"

Weight around 5.3 ounces

Source and photo's courtesy of: Stebbins & McGinnis (2018).

Location of Study

The above specimens were collected between Timnath, Colorado and the western edge of Fort Collins, Colorado, i.e., the foothills.

Elevation of Timnath, Colorado is 4865'

Elevation of Fort Collins, Colorado: 5003'

Latitude and longitude of Fort Collins, Colorado

40.5853⁰ N, 105.0844⁰ W

Latitude and longitude of Timnath, Colorado

40.5291⁰ N, 104.9853⁰ W

Location of the specimens during the study was at Weld County Road 76 on Northwest Drive (1/8 mile north of WCR 76; east 1/8 mile from WCR (Weld County Road) 15.

Latitude / Longitude: 40.32'22.6068 N; 104.92.6094 W

Elevation: 4797'

The methods used to collect the observable data was that group one (1), consisting of the mouse, Yellow-Rumped Warbler and the bull snake was started on May 6, 2020 and proceeded through May 25, 2020. The temperature range in this time period was between 38⁰ F as a low, to a high of 86⁰, humidity range between 14% to 75%.

Group two (2) was between June 9, 2020 to June 22, 2020 consisting of the robin, raccoon and the mouse. Temperature range during this period was between 60⁰ F to 94⁰ F; humidity range between 14% to 65%.

Group three (3) began June 24, 2020 through July 6, 2020. This group consisted of the garter snake, the raccoon and the toad. Temperature range between 74⁰ F to 95⁰ F; humidity between 14% to 28%.

Group four (4) consisted of the raccoon and the woodpecker and began July 12, 2020 through August 22, 2020. Temperature range was between 70⁰ F through 95⁰ F; humidity between 8% to 58%. The difference in group four is the raccoon was wrapped in a heavy canvas t-shirt to simulate a “body dump” wearing clothes.

Group five (5) began with two (2) raccoons only; one loosely and completely wrapped in plastic; the other in tightly wrapped plastic wearing a canvas t-shirt – again to simulate bodies being dumped wrapped in plastic material, such a shower curtain. This group began August 22, 2020 and ran through September 4, 2020. Temperature ranges from 80⁰ F to 98⁰ F; humidity between 7% to a high of 68%.

Observation

The observation began with group one (1), consisting of the Yellow-Rumped Warbler (Avian); Bull Snake (Reptile) and a field mouse (mammal). This observation period was between May 6, 2020 through May 25, 2020.

Location was the western portion of Weld County, Colorado with an elevation of 5003'.

Temperature range was a low of 31⁰ F to a high of 81⁰ F. Humidity range from a low of 14% to a high of 100% (days that it rained).

First species studied was the bird; beginning May 6th through May 12th. The bird was placed in a plastic container and elevated (not left on the ground). The date of death (DOD) was May 6th; temperature at time of death (TOD) was 67⁰ F (19⁰ C); humidity at 30%.

During this time period, the area of study received several days of rain which damaged this specimen to the point that no additional insect species arrived on the body except for the following species listed below.

The first observed species to arrive was the Bluebottle fly followed by the Crane fly; both arriving on the 8th of May. There were no arrivals the first two days of the study.

The following day (the 9th), a single Black Fly was observed with another Crane Fly. On the 10th, Bluebottle fly and Black fly had returned. Rain started again on the 11th which effectively ended all observed species on the bird. The rain was heavy at times which affected the body of the bird – the plastic container facilitated the ending of the bird under observation as it held the water, which surrounded the bird.

The Bull Snake was the second specimen collected. This was on May 15th; the snake was a “road kill” – i.e., got run over by a vehicle. Damage to the body was midline; rigor was beginning to set in; stage 2 decomposition was in progress.

The snake was placed in a shallow “grave” and stretched out to full length. Temperature at time of placement was 61⁰ F; humidity at 95%; rain was continuing.

The observation of the snake was from May 15th through May 25th; temperature range was between 46⁰ F to 86⁰ F; humidity from 14% to 100%.

The first insect activity were ants and the Bluebottle fly. Ant activity persisted throughout the observed period of the snake.

Fly activity was for the first three (3), consisting of the Bluebottle Fly, Greenbottle fly and the Bronzebottle fly. Day three of observation noted the presence of beetle activity. Specifically, species of Clown, Sexton and Skin beetles.

The fifth day (May 18th), revealed that the underside of the snake had been “eaten” away at multiple locations inside and outside the body. Sexton beetles were the only observed beetle at this point.

On the 21st, grubs were present in the cavity of the snake; the skeleton was visible along the first 1/3 of the body. Ant activity remained.

From the period of the 22nd through the 25th, ant activity remained; no beetles or flies were present. Stage five (5), skeletal stage was evident.

By the 25th, the body was flattened out; ants present. Observation for the snake was completed at this time.

The last observed specimen for Group One (1) was the field mouse.

The mouse was an inside the residence capture (mouse trap); date of death was May 21st; temperature at the time was 76⁰ F; humidity at 24%. The mouse was placed between the bird and the snake; approximately three (3) feet apart from each; temperature range was mid 50's to a high of 81⁰ F; humidity between 14% to 100%.

The first day – May 25th, there was no insect activity; on day two insect activity began and remained through the 25th.

The only observed insect activity on the mouse were ants – no flies, no beetles. Weather could have been a factor as rain continued for several days during this period. By May 25th, the body of the mouse had been completely flattened out – rain might have been the contributing factor as the rain was heavy at times rather than insect activity as had been observed on the snake.

Group one (1) observation ended on May 25th. Appendix A; page 48

Group Two

Group two (2) consisted of a raccoon (mammal); a toad (amphibian) and a bird (avian).

The observed dates were between June 9, 2020 through June 22nd; temperature range from a low of 60⁰ F to a high of 94⁰ F; Humidity range from a low of 14% to a high of 65%.

The raccoon was the first specimen to be collected. This occurred on June 9th between 1 to 2 AM MDT. The cause of death - struck by a motor vehicle.

The first day (Stage 1 – Fresh), had no insect activity.

Day two; rigor mortis set in; still no insect activity noted.

Day three; Bluebottle flies only were present. Day four (June 12th), all three fly species were now noted (Blue, Green and Bronzebottle flies); swarming activity was noted.

Day five; the body was rolled over exposing massive ant activity; maggot activity present but not a maggot mass and small black beetles present (skin beetles).

Day six revealed two different instar stages.

Day seven had maggot mass activity at the head – which was noted as the site of injury by the vehicle. Ant activity was present (Red Harvester ants) but another species had arrived –

red/black ants, which were observed carrying off the maggots. This was the first predation observed.

Day eight had larger maggots noted within the mass; potentially 3rd instars present. The same insect activity noted on the previous day remained.

Day nine (June 17th) observation was that stage 2 bloat was gone; the skin had collapsed upon the body portion facing upward. Again, the body was rolled over exposing major maggot activity which had moved; the body showed a “pock-marked” appearance. The upper body portion facing weather conditions had a leathery appearance.

Insect activity included more of the red/black ants taking maggots (predation). What was observed at this time was the lack of beetle activity both above and below the body surface.

Day ten revealed a smaller amount of maggot mass activity, this was possibly due to the noted predation; 3rd instar to adults or weather related as there was a 30⁰ F drop in temperature.

Day eleven (June 19th) presented the presence of a new predator – the Robin. Which was observed feeding on the maggot mass. The corpse was noted as being relatively clean of any maggot mass activity.

By June 20th; stage 4 – advanced decomposition was present. Rove beetles observed once the body was turned over again; small maggot mass reappeared.

The following day presented no new insect activity.

June 22nd; skeletal stage evident; no new activity observed. With this apparent, the observed period for the raccoon was completed and the body was buried so as not to be a deterrent to insect succession on the next specimen to be studied.

The next specimen to be studied was the toad, which started on June 13th. The toad was captured and humanely euthanized. The toad was set out; no activity noted on the fresh death.

The second day presented a unique learning opportunity. The toad was gone, no parts, nothing – just gone. Something had taken the toad; no evidence existed as to what had done this. The learning experience was that the specimens had to be protected from much larger predators when under observation.

As ground toads are plentiful in the summer in this area, another specimen was captured and humanely euthanized; this was on June 15th. Temperature was 94⁰ F; humidity at 16%; time of death was 12:30 PM MDT.

Unlike the previous specimen, this one was placed under a wire screen to avoid being taken by a larger predator. The screen was large enough to allow insect activity to pass through without any obstruction.

On day two; June 16th; temperature at 93⁰ F; humidity at 17%; only Bluebottle flies were present.

Day three; temperature at 94⁰ F; humidity 15%; red ants were observed swarming the specimen. Bluebottle flies remain.

Day four; temperature 65⁰ F; humidity 40%; cooler day; ant activity present – Harvester ants only (red). Watching ant activity, it appeared that the ants were actually burying the toad. The toad would be uncovered the next day.

Day five; the toad was completely buried. The body was uncovered; looking at the anterior end within the cavity, beetle grubs were observed – their appearance would be described as “armor-like larva.” The toad was left uncovered. Temperature this day was 62⁰ F; humidity at 65%.

Day six, June 20th; the toad was examined; the body was a “shell only” – again completely buried. Insect activity was ant only. Temperature at 72⁰ F; humidity at 50%.

Day seven; temperature 80⁰ F; humidity 50%. Again, ants were the sole activity on and around the body.

Day eight; temperature 82⁰ F; humidity 20%; no new activity observed. The body of the toad was a shell only (stage 5 - skeletal stage for a toad). Based upon this observation, no further information would be obtained from the toad specimen, this concluded the toad specimen.

The next specimen to be observed in group two would be Avian, a female Robin.

The robin was found deceased on June 9th; time of death appeared to be earlier in the morning. The bird had flown into a window – the cause of death. Conditions at the time were a temperature of 60⁰ F; humidity at 24% - this day was windy which appeared to have caused the bird to fly into the window.

Day one was June 10th; temperature at 77⁰ F; humidity at 22%; this would be stage 1 with no insect activity observed.

Day two; temperature 84⁰ F; humidity 19%; insect activity was Bluebottle flies and one (1) horse fly.

Day three; temperature 94⁰ F; humidity 14%. Greenbottle flies have appeared, with the Bluebottle flies.

Day four; temperature back down to 77⁰ F; humidity 36%. Both Greenbottle and Bluebottle flies present; ant activity observed under the body; small black beetles are now present. With the exception of the flies, the activity was on the underside of the body.

Day five; temperature 93⁰ F; humidity 15%; insect activity same as the previous day.

Day six; temperature 94⁰ F; humidity 16%; new insect activity was the small black beetle (skin beetle) – there were only three beetles noted.

Day seven; temperature 93⁰ F; humidity 15%; beetle activity same as previous day; other insect activity remained the same as well.

Day eight; temperature 93⁰ F; humidity 15%; no beetle activity; only ants remained at this point.

Day nine; temperature 65⁰ F; humidity 40%; ants remain and four (4) beetles -skin – have returned.

Day ten; temperature 62⁰ F; humidity 65%; no new activity; same species as previous day were observed.

Day eleven; temperature 65⁰ F; humidity 52%; same activity as previous two days.

Day twelve; temperature 72⁰ F; humidity 40%; same activity but beetle population has increased by two – total of five (5) beetles currently present. Do not know if the temperature rising and humidity lowering would be a correlation to beetle increase numbers – even by two?

Day thirteen; June 22nd, temperature 82⁰ F; humidity 20%; no new activity observed at this point. The robin was in stage five as only the skeleton remained surrounded by its feathers holding the corpse together. Nothing new to be discovered or observed on the robin at this time. Observation on the robin was concluded.

With the conclusion of the observation of the robin, group two was concluded as well. Group three to begin. Appendix B; page 52.

Group Three (3)

Group three consisted of a reptile (garter snake); an amphibian (toad) and a mammal (raccoon).

Observed dates were June 24, 2020 through July 5th. The temperature range was between 74⁰ F to 95⁰ F; humidity range was a from a low of 14% to a high of 54%.

The first specimen to be observed was the raccoon.

The raccoon was struck by a motor vehicle in the western part of Fort Collins, Colorado between the hours of midnight and 1 AM on June 27th. The raccoon's intestines were eviscerated; the head/cranium were open and the raccoon died in the median between north and southbound lanes of traffic.

The body was found at approximately 07:00 AM; same date. The body was placed in a plastic container and then placed in a refrigerator at a specimen specific unit at the CDC – Centers for Disease Control (address 3156 Rampart Road). The body was kept in the refrigerator (temperature approximately 38⁰ F); until the end of the day. The body was then transported to the study area and placed in the field for observation.

The body was placed in a shallow “grave” for observation (depth approximately 3”). Once in place, the body was almost completely covered with Greenbottle flies. The flies appeared to be interested in the open intestinal area as well as the injury to the head. Temperature was at 87⁰ F, humidity 28%.

Day two; June 28th, temperature 92⁰ F; humidity 14%. The intestines were covered with Greenbottle and Bronzebottle flies; stage 2 – bloat – was apparent.

Day three; temperature 95⁰ F; humidity 15%; flies continued to be present; ants and small black beetles (skin) arrived. The heat appeared to cause the body to begin advancement to stage 3 – decomposition stage.

Day four; temperature 90⁰ F; humidity 18%; same activity present as previous day.

Day five; July 1st, temperature 88⁰ F; humidity 14%; maggot mass activity now on both the internal and exterior surfaces – 1st instar. Ants remained present.

Day six; temperature rose back up to 95⁰ F; humidity at 14%; maggot mass present; ants remain. Rove beetle now observed in and around the body cavity. The exposed intestines have dried out.

Day seven; temperature 92⁰ F; humidity 14%; the body is now devoid of substance – has flattened out. Exposed skeletal areas have been “picked clean” – white in appearance. The intestines have a leather-like appearance. Beetle activity around the head and body. Maggots no longer present; ants remain.

Day eight; July 4th, temperature 89⁰ F; humidity 14%. The body is devoid of any mass; has flattened out. The exposed intestines are completely dried out and blackened; bones are white in color and dried out as well. The smell of decomposition is gone. Stage 5 is apparent. The only remaining insect activity are ants – smaller in number but still present as are a small number of skin beetles.

Day nine; temperature 91⁰ F; humidity 18%. There is no mass left of the body; the hide is the only part of the body that remains. The exposed bones are dry and white. A few maggots remain – greatly reduced in number – and now earwigs are observed under what remains of the body.

The raccoon at stage 5 had no additional observed insect activity; no additional information was to be gained at this time. The raccoon was buried.

The garter snake was the next observed subject. It should be noted at this time that observation of the snake was concurrent with the raccoon and the toad.

The garter snake was run over by a tractor tire on June 24th; time of death was 12:05 PM MDT. The size of the snake was approximately 2' long. This was considered Stage 1 – Fresh Death; temperature was 91⁰ F; humidity at 24%.

As the snake's observation period were the same as the raccoon, temperature range would be the same – 74⁰ F to 94⁰ F; humidity range 24% to 54%.

June 24th through June 28th; the only observed insect activity were the red Harvester ants; no flies; no beetles.

On June 29th; temperature 94⁰ F; humidity 14%; an unknown species appeared to have attempted to move the body – the movement was not far but it was moved. Only observed activity were the ants as the body had the appearance of being almost “cut” in half.

June 30th; temperature 90⁰ F; humidity 18%; same observation as the previous day.

On July 1st; temperature 88⁰ F; humidity 14%; the body had been severed at the midsection. Ants were the only species present; the snake was considered stage 5 at this point.

Day nine (July 2nd); temperature 95⁰ F; humidity 14%, ant activity only, which is now smaller in number. No other insect activity.

Day ten; temperature 92⁰ F; humidity 14%; the body is brittle to the touch; the skeleton has been exposed in multiple locations; minimal ant activity present.

At this time, the body has been severed in multiple locations; skeleton exposed, no further information was to be gained from the snake and the body was buried.

The toad was the last of group three. The toad was captured and humanely euthanized on June 29th; time of death 1:00 PM MDT. Temperature was 94⁰ F; humidity 14%; stage one begins.

Day two; temperature 90⁰ F; humidity 18%; no fly activity observed; ants have appeared.

Day three; temperature 88⁰ F; humidity 14%; Greenbottle flies appeared; ants remain; stage 2 would appear to have begun.

Day four; temperature 95⁰ F; humidity remained at 14%; only ants observed; no other activity present.

Day five; temperature 92⁰ F; humidity still at 14%; observation was that the body appeared to be “life-like” as seen from above looking down on it; then the body was rolled over. Ant activity clearly present as was a small maggot mass – the body had been literally “hollowed out.”

Day six; temperature 89⁰ F; humidity still 14%; massive ant movement was now under and around the body – which had been hollowed out. This was considered to be stage 5.

Day seven; temperature 91⁰ F; humidity 18%; the body was rolled over again; the entire cavity was eviscerated. Nothing of the toad remained except for the body “shell” – which was leather-like to the touch. Only observed insect activity remained the ants.

With the observation of the hollowed-out toad body, no other information was to be gained; the toad was buried.

Group three observation was completed with the burial of the toad. Group four (4) was to begin. Appendix C; page 59.

Group Four

Group four (4) consisted of the observation of only two (2) species. One would be another Avian (woodpecker). The other would be a mammal – a raccoon with a twist.

Observation dates ranged from July 12, 2020 through August 14, 2020.

Temperature range was from a low of 70⁰ F to a high of 98⁰ F. Humidity range between a low of 7% to a high of 58%.

The raccoon date of death was July 12th, 2020; time of death approximately 06:00 AM MDT. The raccoon was struck by a moving vehicle causing injury to the head only. Blood was visible from the right ear to the left jaw; no other visible injuries found.

The twist. The body of the raccoon was placed in a heavy canvas T-shirt; only the head was exposed. This was done to simulate a “body dump.” The question to be posed would the clothing have any effect on insect succession of species already observed or would the presence of clothing slow down the rate of decomposition or succession.

The body wearing the T-shirt was placed in a 4” deep hole to simulate a shallow grave site not covered with dirt.

Day one; July 13th, temperature was 84⁰ F; humidity 58%. Greenbottle flies and ants observed; stage 2 – bloat had begun.

Day two; temperature 70⁰ F; humidity 57%. Greenbottle flies present with maggots now observed, 1st instar. Ants present with skin beetles. All insect activity appeared to be centered around the head area – the exposed, visible injury area to include the mouth and eyes. No maggot activity under the T-shirt.

Day three; temperature 78⁰ F; humidity 47%. Insect activity around the head as previous day indicated; beetle activity had risen as well. First observed millipede was noted. The ground under the body was checked and was found to be moist (body fluid leeching into the T-shirt and ground). Larval/maggot mass present – under the body.

Day four; temperature rising, now at 92⁰ F; humidity dropping to 14%. Insect activity again consisted of skin beetles; the maggot mass under the body had grown. Another mass was found on the body under the T-shirt. The mandible was now exposed; the body had deflated. Stage 3 decomposition had begun.

Day five; July 17th, temperature at 94⁰ F; humidity 16%; Insect activity same as the previous day.

Day six; temperature 93⁰ F; humidity 18%. Insect activity present as was noted by the maggot mass which appeared to have decreased in number on the body proper under the T-shirt and from around the head. Ants and beetles remained with another new species present – earwigs. Stage 4 advanced decomposition appeared to have begun.

On day seven; temperature 92⁰ F; humidity 21%. Insect activity appears to be slowing down; ants are now the most prominent species present which had now added larger black Carpenter ants. Those Carpenter ants were “carting off” maggots. Beetle activity had also subsided.

Day eight; temperature 92⁰ F; humidity 16%. Insect activity was the same as the previous day’s observation.

Day nine; temperature 92⁰ F; Humidity 19%; again, minimal activity. The majority of the insects remaining were the ants; very few beetles observed. Stage 5 – skeletal had begun.

Day ten; temperature 88⁰ F; humidity 29%; no change from the previous day – minimal activity noted.

Day eleven; temperature 93⁰ F; humidity 15%; only species remaining were the ants.

July 24th through August 3rd; the temperature range was between 85⁰ F to 93⁰ F; humidity was low with an average around 14%. The head was covered by the hide but only skeletal remained. Body was flat with little or no activity present.

Observation on August 4th; temperature 88⁰ F; humidity 21%; only the hair covering the skeleton remained. Question to be asked, did the hair preserve the body due to being covered by the T-shirt?

August 5th through August 12th; the average temperature was around 95⁰ F; Humidity average at 9%. Only skeletal remains present; insect activity collected appeared to be maggots, black in color, segmented and “fuzzy” in appearance. These maggots, in reality, grubs, were identified as Skin Beetles – Dermestid. These grubs appeared were cleaning the bones.

On August 14th; the T-shirt was removed. Skeletonization complete, the body was literally “falling apart.”

No additional observation of information to be gathered at this point and the body was buried, completing the raccoon portion of group four.

The second (2nd) observed specimen that was observed was the woodpecker which ran concurrently with the raccoon.

The woodpecker date of death was July 31st; time of death was 07:00 AM MDT. The woodpecker was observed flying into a window at the CDC building (3156 Rampart Road, Fort Collins, CO). The cause of death appeared to be from a broken neck after striking the window. Stage one (1) – fresh death starts.

Day one, August 1st; began, all temperature and humidity were the same as the raccoon during this period. No activity noted.

Day two; Greenbottle fly – singular- was noted as the only species present.

An interesting side note was that the bird went through stage 1, 2, 3 to stage 4 within three (3) days; then began stage 5.

On August 6th; the temperature at 89⁰ F; humidity 21%; the bird is now in stage 5, skeletonization. Only feathers were covering the skeleton – feathers were moved which exposed the bones. No insect activity was observed. Only noted insect activity was day 2 – and that was followed by a minimal number of ants with that singular fly.

On August 7th and 8th; temperature 95⁰ F; humidity 8%; same observation as previously noted.

On August 9th to August 13th; temperature averaged around 94⁰ F; humidity at 9%; observed activity was the presence of skin beetles. Also noted were cigar-shaped grubs – same as those seen on the raccoon. Again, these grubs appeared to be cleaning the bones.

On August 14th; only the skeleton remained – covered by feathers.

No additional observation was to be made at this time; the bird was buried and that completed group four observation. Group 5 A and 5 B would now be started. See Appendix D, page 68.

Group 5 A and 5 B

This group was to further simulate “body dumps “– both of these specimens were raccoons but differed in how the body was covered and buried.

The specimen – 5A -was a raccoon that died of natural causes – if one can ever say that getting struck by a car is natural cause of death. The date of death was August 19th; temperature 98⁰ F; humidity 7%.

This specimen was fully wrapped in plastic only; buried approximately 3-4” deep; again, to simulate a shallow grave site with a body wrapped in plastic – no clothing on the body.

On August 20th and August 21st; the plastic observed was not wrapped tightly; the seams were loose (which would be similar to a hurried dump). The plastic was holding moisture from the body (temperature 92⁰ F; humidity 21%). Insect activity was observed to be inside the plastic; there was maggot mass activity noted. Skin beetles present. Stage 2 bloat had begun, as the plastic was holding to the body as it was swelling inside the plastic.

On August 23rd and 24th; temperature 93⁰ F; humidity 19%; major insect activity was noted and present consisting of flies, beetles and maggots inside and outside the plastic. Ants now were present as well. The plastic appeared to have accelerated the stages of decomposition as was apparent from the odor that stage 3 – decomposition – was in progress.

On the 25th; temperature 87⁰ F; humidity 23%; the body was putrefied and had flattened out. Maggot mass activity present; ant activity intensified inside and outside the plastic.

On the 26th; temperature 84⁰ F, humidity 38%; the body appeared to be flat at this time. Shoulder skeletal portion visible; maggot mass continued. Ant presence appeared to have increased as well. Additional skin beetles had arrived. The body had progressed into stage 4.

On the 27th; temperature 89⁰ F; humidity 38%; no significant changes from the previous day observed. What was new was the arrival of rove beetles – which were attempting to move what was left of the intestine.

August 28th; temperature 80⁰ F; humidity 48%; the body was now in stage 5 -skeletal. Maggot mass was significantly reduced in size as was beetle activity. Ant presence was reduced as well.

On the 29th; temperature 81⁰ F; humidity 30%; the body is flat. The plastic did preserve the hide over the skeleton; all insect activity reduced or was no longer, present.

Based upon these observations, no additional information could be gathered on specimen 5A; the body was completely buried at this time. Appendix E, page 76..

Specimen 5 B

Specimen 5B – raccoon – was struck again by a vehicle; date of death August 21st; time of death approximately 03:00 AM MDT. No visible injury observed on the body.

This raccoon was dressed completely in a canvas T-shirt – leaving the head completely exposed – and then wrapped tightly in plastic. The plastic on specimen 5A was looser than on 5B; 5B was now more tightly sealed. The body was buried in a hole 4” deep. This again to simulate a body dump in a shallow grave but the perpetrator would have taken a little more time in wrapping the body with clothing before burying said body.

Day one (the 22nd); temperature 98⁰ F; humidity 7%; placement of 5B ran concurrent with 5A but were not in close proximity to each other. Greenbottle flies were the first to be observed on this specimen.

Day two; temperature 93⁰ F; humidity 21% - the current weather conditions for Northern Colorado at this time, which may or may not have had any significant effect on insect succession, was the heavy presence of smoke from multiple wild fires taking place west of Fort Collins, Colorado.

Greenbottle flies were observed attempting to “breach” the plastic – which they did through the folds of the plastic found by the flies. This was done even though the plastic had been drawn tighter than on the previous specimen. Flies found a way under the plastic onto the body. No maggot mass activity at this time; the body was entering into stage 2 – bloat. The body was swelling which in turn was beginning to stretch the plastic. This swelling appeared to have helped the flies to gain entry.

Greenbottle flies were observed on the exterior of the plastic; adult flies observed inside the plastic proper. Several deceased flies seen as well as live ones.

Day three; temperature 93⁰ F; humidity 19%; bloat continued. Live flies within the plastic but no maggot activity as of this date. The body bloat had stretched the plastic.

Day four; temperature 87⁰ F; humidity 28%; body was not as bloated as the previous day; fly activity was reduced on the outside; inside the plastic fly activity continued and maggot activity was observed. Noted species at this time were Greenbottle and Bluebottle flies, ants and skin beetles.

Day five; temperature 81⁰ F; humidity 38%; the body is slowly moving through stage 2 – bloat – as it appeared smaller than the previous day. Maggot mass was reduced in size from the previous day; ants remained.

Day seven; temperature 89⁰ F; humidity 38%; same insect activity as the previous day. Multiple dead flies seen on the outside of the plastic; maggot mass activity remained within the plastic. The body bloat continued to decrease in size.

Question considered at this time would be if the plastic was tightly stretched and sealed, would this retard the stages of decomposition? The bloat stage did appear to be longer in duration than was observed on specimen 5A.

On the 28th; temperature 80⁰ F; humidity 68%; the body completed stage 2 – bloat -and had gone into stage 3 – decomposition. The body when it progressed through stage 2, had stretched the plastic, which allowed insects (flies) to gain entry to the body. The reduction in body size had caused additional entry points via the stretched-out plastic. Fly entry was made easier; maggot mass activity was now noted on three different locations on the body proper. The insect species remained as flies, maggot mass, ants and beetles.

August 29th through September 1st; temperature range was cooler at an average of 81⁰ F; humidity range around 36%. As the body had gone through the bloat stage and had separated the plastic in several locations, the body appeared to have gone through complete decomposition (stage 3 and 4) and now progressed into stage 5 -skeletal.

Insect activity remained the same as previously noted with the exception of the ants. Ant activity had actually increased as the observation was that the ants appeared to be consuming everything that remained – including the remaining maggots.

On September 2nd, temperature 85⁰ F; humidity 20%; the observation was the same as the previous day.

On the 3rd; the body was removed from the “grave” and the plastic and T-shirt taken off. The hide was now exposed over the skeleton. The plastic and T-shirt apparently held everything “together.” The body – what was left – was basically, for a lack of a better way to describe it – was a “bag of bones.”

The maggot mass was gone completely; one singular skin beetle remained.

Nothing more was to be obtained through observation of specimen 5B; the body was completely buried.

With the completion of observation of specimen 5B, the observation portion of this experiment was concluded. Appendix F; page 81.

Results/Observation

As previously noted, insects have been around for a very long time. Only recently though, have insects been studied relative to decaying bodies; the birth of forensic entomology, so to speak.

What was observed over the course of time was that there “appeared” to be an order by which insects would arrive at the scene of a deceased body and that the body would go through different “stages” of decomposition which in turn, would draw to that body different insect species.

Studies have been done from forensic archeology – think Ancient Egypt as an example – to modern excavation of tombs, burial sites and graves. What has been found to be consistent with these findings, have been the presence of insects entombed with the bodies.

Now comes the question of “who” arrives first and who is the last to leave.

That has been the purpose of this study. What insect species will arrive first and what species will be the last to arrive and then leave the body. The area of study was Northern Colorado; east of the Rocky Mountains (think Front Range) and not the far eastern plains. There would be correlation to insect succession on the plains to a certain degree.

Colorado is a semi-arid state with a mean elevation of 6800 feet (lowest point at 3317'; highest at 14,440"); the semi-arid nature of the state is considered via the high plains, which has a low humidity point, moderate precipitation, abundant sunshine, cool, clear nights. On average Colorado is dry averaging only 17 inches of precipitation a year. Drought is a persistent issue because of the low rain fall (Fodor's Colorado – full Color Guide; 2021).

The question then would be what does the physical nature of the state have to do with insect succession on a corpse? Are the insects here different than in tropical or subtropical areas or would succession be similar in Colorado compared to other areas of the world?

Insects are not only diverse but can and do adapt to various climates. Some do not adapt (at least for the present) and an example of this would be the mosquito, *Aedes aegypti*. *Aedes* is not a mosquito that is found in Colorado, yet the *Culex sp.* mosquito is found worldwide with the exception of extreme northern regions of the temperature zone (Krinsky, 2019).

With the above factors in mind, this study was undertaken to find out what would be the insect succession of this region of Colorado as previously defined. The purpose of this would be to assist law enforcement in determining possible time of death of a victim assisted by the

discovery of insect species found at a crime scene in excess of 72 hours. This is considered a “classic body dump” scenario.

The study was started on May 6, 2020 and concluded on September 4, 2020.

During this period, the temperature range was between 31⁰ F as a low to a high of 98⁰ F; the average temperature was 64.5⁰ F.

The humidity range was a low of 7% to a high of 95% with an average of 51%. This is a rather high average for a semi-arid state.

The mean elevation for the location of the specimens was determined to be 5083’ above sea level.

Four species of animals were chosen as test subjects, representing four (4) different classes. Those examples are as follows:

Class Reptilia

Class Amphibia

Class Aves

Class Mammalia.

Specific examples in **Class** Reptilia were the Common Garter Snake and two (2) Bull snakes.

Class Amphibia example were the Great Plains Toad (*Anaxyrus cognatus*).

Class Aves were three (3) different species; the Woodpecker, Robin and Yellow-Rumped Warbler.

Class Mammalia was one (1) field mouse and five (5) raccoons.

The reasoning behind these four classes was to determine if insect succession would be the same for all four species or would the “corpse” draw different insect species at different times during the five stages of decomposition.

Five groups of specimens were done at various times – two (2) different seasons – which then involved different weather conditions, temperature and humidity. Not all four species were done at the same time, spreading those available species out over the course of four and a half months. Species collected were the ones that were available at the time of the study.

No animals were inhumanely caught or killed. The exception were the toads, all others died from “natural causes” – the birds flew into windows breaking their necks on impact; the snakes and raccoons were struck by moving vehicles. Those struck by moving vehicles were driven by other drivers, not the author of this paper. The mouse was caught by a cat which snapped the neck. The toads were captured and humanely euthanized by ether.

The order of insect succession for group one is as follows on chart one:

Chart One			
	Avian	Reptilia	Mammalia
	Yellow-Rumped Warbler	Bull Snake	Field Mouse
Greenbottle Fly		X	
Bluebottle Fly	X	X	
Crane Fly	X		
Black Fly	X		
Bronzebottle Fly		X	
Horse Fly			X
Harvester Ants		X	X
Black Ants			X
Clown Beetle		X	
Sexton Beetle		X	
Skin Beetle		X	
Rove Beetle		X	

Chart two for group two

Chart Two			
	Avian	Amphibian	Mammalia
	Robin	Toad	Raccoon
Greenbottle Fly	X		X
Bluebottle Fly	X	X	X
Crane Fly			
Black Fly			
Bronzebottle Fly			X
Horse Fly	X		
Harvester Ants	X	X	X
Black Ants			
Red/Black Ant			X
Clown Beetle			
Sexton Beetle			
Skin Beetle			
Rove Beetle			X

Group three chart as follows:

Chart Three			
	Reptilia	Amphibian	Mammalia
	Garter Snake	Toad	Raccoon
Greenbottle Fly		X	X
Bluebottle Fly			
Crane Fly			
Black Fly			
Bronzebottle Fly			
Horse Fly			
Harvester Ants	X	X	X
Black Ants			
Red/Black Ant			
Clown Beetle			
Sexton Beetle			
Skin Beetle			X
Rove Beetle			X
Earwig			X

Chart four indicates the arrival of the millipede as follows:

Chart Four		
	Mammalia	Avian
	Raccoon - T Shirt	Woodpecker
Greenbottle Fly	X	X
Bluebottle Fly		
Crane Fly		
Black Fly		
Bronzebottle Fly		
Horse Fly		
Harvester Ants	X	X
Black Ants	X-PREDATION	
Red/Black Ant		
Clown Beetle		
Sexton Beetle		
Skin Beetle	X	X
Rove Beetle		
Earwig	X	
Millipede	X	

Group five represents the body dump scenario involving wrapping the raccoons in plastic as well as one (5B) wearing a T-shirt, as follows:

Chart Five --"Body Dump"		
	Mammalia	Mammalia
	5A - Raccoon - Plastic Only	5B - Raccoon -T-Shirt/Plastic Wrap
Greenbottle Fly	X	X
Bluebottle Fly		X
Crane Fly		
Black Fly		
Bronzebottle Fly		
Horse Fly		
Harvester Ants	X	X
Black Ants		
Red/Black Ant		
Clown Beetle		
Sexton Beetle		
Skin Beetle	X	X
Rove Beetle	X	
Earwig		
Millipede		

The above data and collection / observation of insect activity on the body specimens that was consistent with all five groups are as follows:

First to arrive – Greenbottle fly followed by Bluebottle fly.

At almost the same time or relatively close were the small red Harvester ants.

As the bodies were decomposing through the five stages of decomposition, towards the end of stage two into stage three were the appearance of the Dermestid beetles – the skin beetle.

Other insect species did arrive on different groups and different samples such as the Crane Fly, the Black Fly, the Horsefly, Sexton Beetle, Clown Beetle and Rove Beetle. These particular species were not consistent in succession.

Predator species did arrive as well to prey on maggot masses such as the Black Ants and were noted on observation and collection but again, they were not consistent.

Millipedes and Earwigs appeared in group three (3) and group four (4) and while the former is a predator (on some species), the latter is not and both appeared to be opportunistic on the specimens as their numbers were small and inconsistent. Appendix G & H page 89 & 106.

Conclusion

The purpose of this study was to help police investigators in determining time of death of a victim in the Northern Colorado region on the Front Range, i.e., prairie lands. The reason is a homicide victim will be “dumped” in fields due to the wide open, isolated areas in this part of the state.

The bodies are normally found at a later time and it is often difficult to determine time of death due to the later stages of decomposition – normally Stage 5, skeletal. What is consistent with the discovery of these victims is the presence of insects, either on or about the body or within the plastic that seems the “normal” way to dispose of the body either by dumping or burial – shallow “graves” mostly.

The presence of insects or insect remains is often overlooked by investigators, either through lack of training (as in collecting them) or a sheer aversion to insects. The majority of people just don’t like insects and consider them a nuisance to be shoed away or killed. This lack of knowledge certainly would not help to determine the time of death of the victim. Possible

results from this lack of knowledge might result in a suspect eluding capture and prosecution of the crime.

The results of this study do indicate an order of insect succession on a deceased victim and those pesky little insects should not be ignored but rather captured and/or caught for further analysis and investigation into the crime.

The order of succession based upon this study for the Northern Front Range area of Colorado would be Greenbottle and Bluebottle flies, ants and skin beetles. The latter two insects might change if the body was inside a structure and found post 72 hours after death but the former would still be the first to arrive even inside a structure.

The information provided in this study will be made available in the near future in a more user-friendly permanent format for distribution to local law enforcement agencies. As the author of this study is in a command support structure in a law enforcement agency, and has in the past been the investigator of homicide cases involving victims which have been “dumped” in the county wrapped in plastic (normally shower curtains), the one element that I and others overlooked were the presence of insects at the scene. This also included finding victims within homes, again, the insect presence was seen but not documented for evidentiary purposes or collected for identification.

Insects are a part of deceased victims be it human or animal and the identification and collection is becoming more and more paramount as time of death is now associated with the victims via the identification of the which insect species arrived first and the last one to leave.

Educating law enforcement to their “partner” that is at those scenes is becoming more and more known to the public – now it is time to educate investigators and other law

enforcement officers to their importance. This will only help to assist the victim in helping to identify the perpetrator of the crime being investigated.

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Appendix Contents

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Appendix A – Group One

Yellow-Rumped Warbler (DOD 5/6/20)



Bluebottle Fly/ Crane Fly



Crane Fly



Stage 5 -- The specimen has been reduced to feathers /skeleton only



Bull Snake Specimen



Bluebottle Fly



Greenbottle Fly

Harvester Ants



Grub



Appendix B – Group Two – Raccoon, Toad & Robin

Raccoon – DOD 06/09/20



Maggot Mass



Maggot Mass

Maggots



Stage 5 – Skeletal

Toad Specimen – DOD 06/13/20



Toad getting buried – ants



More ant activity burying the toad



After unburying the toad, grubs observed anterior end; ant activity remained



Hollowed out, shell only remained



Stage 5 - Leather-like appearance; shell only; interior had been “hollowed out”

Robin – Female; DOD 06/09/20



Ant activity which was on the underside of the body; small beetle activity



Stage 4 – activity limited to ants; body mass reduced



Stage 5 – Skeletal; all that remained was the skeleton covered by feathers

Appendix C – Group 3 – Raccoon; Garter Snake; Toad

Raccoon: DOD 06/27/20



Injuries: eviscerated intestines; head/cranium open





Stage 2 – Greenbottle flies arrived almost instantaneously





Mobile larvae of the beetle present – possibly carrion beetle larvae



Stage 4 – Stage 5: Bones are dry and white; maggot mass present; ants present



Rove Beetle (s) present



Maggot mass / larvae present in and around body



Stage 5 – Skeletal – hide covering bones only; minimal to no activity left

Specimen: Garter Snake DOD 06/24/20



Only insect activity is the red Harvester Ants – which are beginning to sever the body in two



Ants have severed the body



Stage 5 – Skeletal: ants have exposed skeleton

Specimen #3 – Toad: DOD 06/29/20



Placement of the toad – no visible activity noted



Upon turning toad over – had been hollowed out – all ant activity



Toad been “hollowed out” by ants; only body shell remained; leather-like to the touch

Appendix D – Group Four – Raccoon & Woodpecker



Raccoon wrapped in heavy canvas – only head was left exposed







Maggot mass present – the canvas had not deterred flies from egg laying





Maggot mass on the body and beside the body



Stage 5 – skeletal stage. Canvas pulled back, hair covering skeletal structure only; no body mass



Stage 5 – The canvas shirt had no deterrent effect on insect succession; shirt kept the body intact as far as the hide/hair and skeletal structure integrity only.

Group 4 – Woodpecker



Greenbottle fly noted; beetle grub only; noted for immature activity (immature carrion beetle)





The Woodpecker went through stages 1, 2, 3, 4 to stage 5 within 3 days; only feathers and skeleton remained; insect activity was no longer noted once skeletal stage was present





Skeleton / feathers only – no insect activity noted at this stage



Appendix E – Group 5 A Raccoon only

Raccoon wrapped in plastic – simulate a body dump wrapped in plastic



Plastic did not deter fly present; Greenbottle, Bluebottle and Bronzebottle flies present



Bronze



Presence of maggot mass under plastic; flies remain





Bloat stage (2) has stretched plastic; allowed fly entry; maggot mass within plastic





Beetles arrived; flies/ maggots remain





Body has progressed into stage 5; plastic completely stretched out and open; maggot mass reduced; beetle activity reduced; ants remain Body is skeleton; hide covering only



Appendix F – Raccoon

Raccoon dressed in heavy canvas T-shirt; wrapped in plastic; tighter than previous specimen.

This to simulate a body dumped wearing clothing but wrapped in plastic (common occurrence at a crime scene).



Even when tightly wrapped, flies managed to find a way in through the seams



Ants arrive outside the plastic; beetles arrived outside of the plastic





Bluebottle flies present; one Horse fly present (Tabanidae). Bloat stage (2) has opened plastic up, allowing flies to enter





Plastic opened; entry for flies apparent; maggot mass within the plastic





Body after bloat stage opened plastic, went through decomposition to advanced decomposition; body appears to be late Stage 4, progressing to Stage 5. Insect presence – C Shaped beetle grub with ants present.





Stage 5 apparent – bones becoming obvious





Stage 5 – only remains are the bones and the hair; ant activity only insect remaining





Once the plastic was breached during bloat stage, insect presence appeared inside the plastic and T – Shirt. The body was decimated from within; plastic assisted with this process.



Appendix G

Log of Specimens and Samples Collected

Group One

Avian (bird) Species: Yellow Rumped Warbler (DOD 5-6-2020) Time: 12:30 MDT

Elevation: 5003' Ft Collins – Specimen left in plastic container, on paper – not exposed to ground surface

Location: 3156 Rampart Road, Fort Collins, Colorado

Temperature at TOD 67⁰ F (19⁰ C) / Humidity 30 %

Wind: SE at 9 MPH

Reptile – Snake (Bull Snake) DOD: 05/14/2020

Location: Prospect Road at Summit View, Fort Collins, CO

Temperature at TOD 65⁰ / Humidity 45% / Wind at 5 MPH

Mammal – Field Mouse DOD: 05/21/2020 Sex: Female

Location: Weld County Road 76 and Northwest Drive

Temperature at TOD 76⁰ / Humidity at 24% / Wind not a factor, inside building capture

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				
05/06/20	67 ⁰ Hum 30%	Bird	No samples this date	1 – Fresh

05/07/20	66 ⁰ Hum 25%	“	No “arrivals”	
“	“			
05/08/20	55 ⁰ Hum 25%	“	Bluebottle fly/Crane Fly	
“	“			
05/09/20	Range 37-55 ⁰ Hum 38%	“	Black Fly/Crane Fly	
“	“			
05/10/20	Range 36-56 ⁰ hum 55%	“	Bluebottle/Black Fly	2 –
Bloat?				
05/11/20	Range 31-46 ⁰ Hum 75%	“	No specimens (raining)	
“	“			
05/12/2020	Range 36-55 ⁰ Hum 55%	“	No specimens – cool; rain	
damaged				

Due to rain damaged specimen, no additional data recorded on this species

05/15/2020 Snake – rigor setting in; visible injury (snake was run over), skin removed mid-body; size approximately 3” at removal site; tail also had visible injury (refer to photo #)

Specimen placed in ground – approx. time of this placement at 5:30 PM MDT

Temperature at 61⁰ Humidity at 95% - was raining

No visible insect activity at time of placement

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				

05/16/20	46-66 ⁰ Hum 38-75%	Snake	Ants (Harvester)/Bluebottle
2 – bloat			
05/17/20	55-66 ⁰ Hum 40-74%	“	Bluebottle/Greenbottle/Horse
Fly/Ants “			
05/18/20	50-82 ⁰ Hum 45%		
“	“	“	/Bronzebottle/Beetle arrival
05/19/20	86 ⁰ Hum 34%	“	Beetles -Clown, Sexton, Skin
3-Advanced			
05/20/20	86% Hum 15%	“	Bloat gone; underside eaten
away at multiple locations along body towards anterior end; smaller beetles collected (underside white), inside and outside body; larger beetle collected (Sexton) – bloat is gone, advanced stage of decomp now present			
05/21/20	76 ⁰ Hum 24%	Snake	Grub present in cavity; Rove
Beetle Skeleton now visible along first 1/3 of body / ant activity remained present -			
Stage 4 to 5			
05/22/20	81 ⁰ Hum 14%	“	Multiple locations along body
opened; No beetle activity; ant activity remains			
Stage 5 -Skeletal			
05/23/20	76 ⁰ Hum 24%	“	No fly/beetle activity/ Ants
remain 5			
05/24/20	Temp mid 50's Hum 100%	“	Rained for several hours over 1”
total / no specimens			

05/25/20 Temp mid 60's Hum 80-90% “ Snake remains flattened out
(Rain?); multiple entry-exit points/ specimens Ants (greater than 10, small black ants)

At this point, the snake specimen examination and collection was completed

Mammal – Field Mouse DOD: 05/21/2020 Sex: Female

Location: Weld County Road 76 and Northwest Drive

Temperature at TOD 76⁰ / Humidity at 24% / Wind not a factor, inside building capture

Placement was between snake and bird

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				
05/21/20	76 ⁰ Hum 24%	Mouse	No activity/fresh	1 –
Fresh Death				
05/22/20	81 ⁰ Hum 14%	“	Ants	
1	-- appearance of mouse was almost flattened out			
05/23/20	76 ⁰ Hum 34%	“	Black ants present; body	
flattened out; small holes along fur posterior portion begin to appear				
05/24/20	Temp in mid 50 range Hum 100%	“	Rain for several hours, over 1” /	
No specimens				

05/25/20 Temp in mid 60's " Body is completely flattened
out and soaked; specimens remain as ants

Due to rain damage, this was last day of collection and examination of the mouse and
completion of Group One

Group Two

Mammal – Raccoon DOD 06/09/2020 TOD Early AM between 1 -2 AM MDT;
nocturnal species, struck by vehicle- visible head injury; location of W Prospect and Overland
Trail, Fort Collins, CO / Temperature @ 60⁰ Humidity 24%

Amphibian – Frog/Toad DOD 06/13/20 TOD 6: 15 PM MDT; Location Weld County
road 76 and Northwest Drive; captured and euthanized humanely / Temperature 77⁰ Humidity
34%

Avian – Bird – Robin Female DOD 06/09/20 Early AM / Location Weld County Road 76,
Northwest Drive

Temperature @ 60⁰ Humidity 24%

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
06/09/20	@60 ⁰ Hum 24%	Raccoon	No Samples	1 – Fresh
06/10/20	@65 ⁰ Hum 25%	"	No samples; rigor mortis set	

06/11/20 Temp 84° Hum 19% “ Bluebottle Fly 1 –
Rigor gone, blood present

6/12/20 Temp 94° Hum 14% “ Green/Blue/Bronze Bottle
Flies(swarming) Stage 2 – Bloat

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
06/13/20	77° Hum 36%	“	Same fly activity – body rolled over, massive ant activity present/ Beetle present (small Black Beetle / maggot activity now present)	
06/14/20	93° Hum 16%	“	Maggot mass present (Question – two different species or two different instars?)	
06/15/20	94° Hum 16%	“	Maggot mass activity at head – site of original injury; less noted at belly and tail – activity of ants – red/black ants have arrived and are carrying off maggots – first noted incident of predation	Stage 3 – Bloat gone, decomposition
06/16/20	93° Hum 15%	“	Several pockets of maggot activity (bloat gone) – same insect activity as previous day; larger maggots noted with the mass (3 rd instar)	
06/17/20	93° hum 15%	“	Observation: all bloat is now gone; skin has collapsed upon itself on the part of the body facing upwards into the weather;	

body flipped over; earth under the body moist with major maggot activity; notable holes now present on the body surface; the body portion that was up displays a leathery appearance; body that was down against the ground surface was moist and pock marked – all observation photographed (Photo number)

Insect activity – more red/black ants have arrived taking maggots with them (predation); noted was the lack of beetle activity both above ground and again on underside of the body

06/18/20 62⁰ Hum 65% “ Smaller pockets of maggot activity observed (predation; 3rd instar to adult; or weather related with a 30⁰ temperature drop) / no new species present

06/19/20 65⁰ Hum 40% “ As the body was rolled over previous day, new predator arrived – The Robin – birds appeared to have eaten the maggot mass as instars present exposed to birds not ready to molt to adult flies/ corpse relatively clean of maggot activity

Stage 4 –

Advanced decomp

06/20/20 @70⁰ Hum 50% “ Small scarab beetle observed (Rove Beetle); body was turned again – new maggot mass present

06/21/20 80⁰ Hum 70% “ No new insect activity present

06/22/20 82⁰ Hum 20% “ No new activity - Stage 5 –

Skeletal Stage present

With skeletal stage present and no new insect activity, observation and collection of the mammal specimen completed

Group 3

Reptile – Garter Snake

DOD: 06/24/20 TOD: 12:05 MDT

Size approximately 2' long; Field west of Weld County Road 76 and Weld County Road 15;

Runover by a tractor tire fresh death on this day – Stage 1 begins

Amphibian – Frog

DOD: 06/29/20 TOD: 1:00 PM

MDT; location Weld County Road 76 and Northwest Drive; captured/ humanely euthanized

Mammal – Raccoon

DOD: 06/27/20 TOD: Between

12:00 and 1:00 AM; Description: Raccoon was struck by a vehicle, eviscerated intestines; head /cranium was opened; placed in medium of roadway on West Drake between Shields and Taft Hill, in Fort Collins, CO

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
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06/27/20	87 ⁰ Hum 28%	Raccoon	Raccoon recovered	approximately 6 hours after approximate death, condition as noted; almost immediate coverage by Greenbottle flies when body was placed for observation; area of fly interest was exposed intestines and exposed head/cranium area
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06/28/20	92 ⁰ Hum 14%	“	Intestines covered in	Greenbottle flies; Bronzebottle flies
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Stage 2 – bloat beginning

06/29/20 95⁰ Hum 15% “ Flies continue to appear; ants
 now present; small black beetles Heat causing
 body to Stage 3 – Decomp

06/30/20 90⁰ Hum 18% “ Same activity present as
 above 3

07/01/20 88⁰ Hum 14% “ Large maggot activity present
 both internal and external (3rd instar?) / Flies as noted remain; ants remain
 3

07/02/20 95⁰ Hum 14% “ Maggot Activity present/ants
 present/ Beetles present (Rove) in an around body cavity / intestines have dried out
 4

07/03/20 92⁰ Hum 14% “ Observation – body is now
 devoid of substance, flattened out; exposed body has been “picked clean” – white; intestines are
 leather-like in appearance; beetle activity around head, body / maggots are not present / ants
 remain

07/04/20 89⁰ Hum 14% “ Body now devoid of any
 mass, i.e. flat; exposed intestine dried out and blackened; bones are white and dried out/ decomp
 smell gone, Stage 5 present at this point; remaining insect activity ants, beetles (Skin beetle)

07/05/20 91⁰ Hum 18% “ Observation: no mass left of
 the body; hide only remains, exposed bones dry and white; some maggot mass remains; Earwig
 activity exposed after body was moved

As the Raccoon is now at Stage 5, no additional observation or collection will be done;
 the body was buried

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				
06/24/20	91 ⁰ Hum 24%	Garter Snake	None	Stage
1 – Fresh Death				
06/25/20	86 ⁰ Hum 27%	“	“	No activity yet “
06/26/20	74 ⁰ Hum 54%	“	“	Red ants (Harvester), no
flies	“			
06/27/20	82 ⁰ Hum 28%	“	“	Ant activity only
06/28/20	94 ⁰ Hum 24%	“	“	Ant activity only
06/29/20	94 ⁰ Hum 14%	Garter Snake	Observation: Unknown species	
attempted to move the body; was not moved far from original position; ant activity only, body is				
displaying the ant activity as the body appears to be almost cut in half				
06/30/20	90 ⁰ Hum 18%	“	“	Observation same as above in
reference to ant activity				
07/01/20	88 ⁰ Hum 14%	“	“	Observation: Snake body has
now been cut in two places at the midsection; ants only species present -- would appear Stage 5				
is now apparent				
07/02/20	95 ⁰ Hum 14%	“	“	Ant activity has lessened
Stage 5				

07/03/20 92⁰ Hum 14% “ “ observation; Body is brittle to the touch; exposed skeletal remains, multiple places; minimal ant activity

As the body has been severed in multiple places, skeleton exposed; no further observation to be done on the snake at this time; body buried

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				
06/29/20	94 ⁰ Hum 14%	Frog/Toad	DOD/ TOD 1:00 PM MDT 1-	
Fresh Death				
06/30/20	90 ⁰ Hum 18%	“	“	No fly activity; ants present
1				
07/01/20	88 ⁰ Hum 14%	“	“	Greenbottle Flies/ ants
2				
07/02/20	95 ⁰ Hum 14%	“	“	ants only; no other activity
observed 2				
07/03/20	92 ⁰ Hum 14%	“	“	Observation: the body
appears remain “life-like” as observed from above; the body was rolled over; once rolled, ant				
activity clearly present as was small maggot activity – the body had been hollowed out				

07/04/20 89⁰ Hum 14% “ “ Observation: Massive ant movement under and around the body; as noted, body is “hollowed out” - Would appear to have Stage 5 now present

07/05/20 91⁰ Hum 18% “ “ Observation: Body rolled; entire cavity has now been eviscerated; nothing remains except the body shell – leather-like to the touch; only species present at this point – ants

As the body has been hollowed out, not additional observation at this point; body was buried

Group 4

Mammal – Raccoon DOD 07/12/20 TOD: Approximately 6:00 AM MDT ; location Weld County Road 76 and Weld County Road 15; Raccoon struck by a vehicle, off roadway, injury to head -visible blood from right ear to left jaw; no other injury observed

Avian – Woodpecker DOD: 07/31/20 TOD: Approximately 07:00 AM MDT; location 3156 Rampart Road (CDC facility) Fort Collins, CO

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
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07/12/20 80⁰ Hum 38% -no wind/calm Raccoon Observation – to simulate a “body dump” – the body was placed in a shallow 4” hole and wrapped in a heavy canvas t shirt with only the head exposed – question then – will clothing restrict insect succession or possibly delay it? Stage 1- Fresh

07/13/20 84⁰ Hum 58% ‘ Greenbottle flies/Ants
Stage 2 – Bloat

07/14/20 70⁰ Hum 57% “ Greenbottle flies/Maggots
appear -1st instar/Ants present and Black Beetles – Skin Beetle // note – all activity around the head, mouth, eyes – no maggot activity under T shirted body

Stage 2- Bloat

07/15/20 78⁰ Hum 47% “ Insect activity around the head opening as previously described/ beetle activity remains/ first observation of millipedes; ground under the body was checked, moist, ;larval mass was present at this site as were more of the noted black – Skin Beetles

07/16/20 92⁰ Hum 14% “ Observed insect activity present as the Back – Skin Beetle; maggot mass under the grown larger; mass noted within the body under the T Shirt; mandible now exposed; body starting to “deflate”

Stage 3 – decomp

07/17/20 94⁰ Hum 16% “ Insect activity same as previous day

07/18/20 93⁰ Hum 18% “ Observation : insect present activity, minimal number of maggots on body under T Shirt and around head; ants and

beetles remain; new observed insect – Earwigs

Stage 4 – Advanced Decomp

07/19/20 92⁰ Hum 21% “ Insect activity appears to be slowing down; ants most prominent species; larger black ants (Carpenter?) are now “carting off” the maggots; minimal beetle activity

Stage 4 – Advanced decomp

07/20/20 92⁰ Hum 16% “ Same activity as noted above

07/21/20 92⁰ hum 19% “ Observation: minimal activity, majority of species present remain ants; few beetles present

Stage 5- Skeletal begins

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
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07/22/20	88 ⁰ Hum 29%	Raccoon		Insect activity continues; beetles are minimal
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07/23/20	93 ⁰ Hum 15%	“		No change as far as insect activity; only species present is ants
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Stage 5

07/24 to 08/03/30 Temperature range between 85⁰ to 93⁰ Humidity low – Observation: Head is now skeletal ,body appears to be flat; minimal activity around body

08/04/20	88 ⁰ Hum 21%	“		Observation: Hair covering skeletal remains; was hair preserved due to T Shirt?
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08/05 to 08/12/20 95⁰ Hum 8% - Observation: Complete skeletonization under T Shirt, remains are hide, hair and bones; minimal number of ants remain

08/13/20 94⁰ Hum 9% “ Observation: Only skeleton remains; presence of black in color maggot, segmented and “fuzzy” in appearance noted (skin beetle – dermestid); were they cleaning the bones?

08/14/20 At this stage, the shirt was removed; skeletonization completed; body was falling apart

No additional observation or information to be collected at this point, raccoon was buried

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of
Decomp				
08/01/20	88 ⁰ Hum 50%	Wood Peaker	No activity, DOD 07/31/20	
1				
08/02/20	90 ⁰ Hum 28%	“	“	Greenbottle fly
Interesting note – the bird went through stage 1, 2, 3, to 4 within 3 days; then went to stage 5				
08/6/20	89 ⁰ Hum 21%	“	“	Complete skeletonization;
feathers covering bones; moved feathers, bones exposed – no insect activity noted; only noted insect activity was noted at day 2; with minimal number of ants present				
08/08/20	95 ⁰ Hum 8%	“	“	Observation: Same as above

08/09 thru 08/13/20 94⁰ Hum 9% “ “ Observation: small black beetle makes appearance (Skin Beetle); cigar shaped maggot noted (same as raccoon) – cleaning bones?

08/14/20 98⁰ Hum 7% “ “ Skeleton only under feathers

No additional information to be obtained at this point, bird buried

Group 5A and 5B

This group was to further simulate a “body dump “ – both specimens were raccoons but differed in how the body was buried

Date	Temperature/Conditions	Specimen	Sample Collected	Stage of Decomp
------	------------------------	----------	------------------	--------------------

08/19/20	98 ⁰ 7%	Raccoon – 5A	- This raccoon was fully wrapped in plastic only, buried approximately 3” deep; no external visible trauma	
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DOD: 08/19/20

08/23/20	92 ⁰ Hum 21%	“	“	Observation: Plastic not wrapped tight, loose with seams; plastic holding moisture from the body – majority insect activity noted within the plastic; exterior observation of maggot mass activity; small black beetles present
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Stage 2 - Bloat

08/24/20	93 ⁰ Hum 19%	“	“	Observation: major insect activity present, beetles, flies, maggots both inside and outside the plastic; ants now present
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Stage 3 – Decomp

08/25/20 87⁰ Hum 23% “ “ Observation: Body putrefied
and flat; maggot mass activity present; ant activity inside and outside the plastic

Stage 3

08/26/20 81⁰ Hum 38% “ “ Observation: Body
appearance is flat; shoulder skeletal portion visible; maggot mass continues; ant presence
increase; Skin Beetles present

08/27/20 89⁰ Hum 38% “ “ Observation: No change since
previous day noted; exception would be observed beetle attempting to move part of the intestine
(Rove Beetle)

08/28/20 80⁰ hum 485 “ “ Observation: Body into Stage 5
– skeletal; maggot mass reduced in size; beetle activity reduced; ants present

08/29/20 81⁰ Hum 30% “ “ Observation: Body is flat,
plastic preserved the hide over skeleton; activity reduced Stage 5-

Skeletal

No additional information to be gathered at this time, body buried

Appendix H

Insect Collection

Number	Common Name	Order	Family	Genus / Species
1.	Bluebottle Fly	Diptera	Calliphoridae	Calliphora
	vicina			
2.	Crane Fly	Diptera	Tipulidae	
3.	Black Fly	Diptera	Calliphoridae	Phormia
	regina			
4.	Harvester Ant	Hymenoptera	Formicidae	Pogonomyrmex
	occidentalis			
5.	Greenbottle Fly	Diptera	Calliphoridae	Lucilia
	illustris			
6.	Horse Fly	Diptera	Tabanidae	
7.	Greenbottle Fly	Diptera	Calliphoridae	Lucilia
	illustris			
8.	Fly Pupae	Diptera	Possible Calliphoridae	Brown in
	color			
9.	Clown Beetle	Coleoptera	Histeridae	Saprinus pennsylvanicus
10.	Sexton Beetle	Coleoptera	Silphidae	Nicrophorus orbicollis

11.	Skin Beetle	Coleoptera	Dermestidae	Dermestes maculatus
12.	Skin Beetle maculatus	Coleoptera	Dermestidae	Dermestes
13.	Larva – Beetle	Coleoptera	Immature carrion beetle	
14.	Rove Beetle	Coleoptera	Staphylinidae	Platydracus fossator
15.	Rove Beetle	Coleoptera	Staphylinidae	Platydracus fossator
16.	Larva Stage -Bluebottle Fly	Diptera	Calliphoridae	Calliphora vicina
17.	Larva Stage	Diptera	Calliphoridae	Calliphora vicina
18.	Harvester Ant occidentalis	Hymenoptera	Formicidae	Pogonomyrmex
19.	Larva Stage	Diptera	Calliphoridae	Calliphora vicina
20.	Larva – Beetle larva)	Coleoptera	Immature carrion beetle (armor-like	
21.	Larva- Beetle	Coleoptera	Immature carrion beetle (armor-like larva)	
22.	Fly on Beetle Pupa -	Diptera	Tachinidae	
23.	Midsection of a Plains Garter Snake (Thamnophis radix) – consumed by Harvester Ants			
24.	Rove Beetle	Coleoptera	Staphylinidae	Platydracus fossator

- | | | | | |
|-----|--|------------|---------------|----------------------|
| 25. | Larva Stage -Bluebottle Fly | Diptera | Calliphoridae | Calliphora vicina |
| 26. | Larva -Skin Beetle | Coleoptera | Dermestidae | Dermestes ater |
| 27. | Skin Beetle / Millipede (C. Diplopoda) | | | |
| 28. | Rove Beetle | Coleoptera | Staphylinidae | Platydracus fossator |
| 29. | Pupa – Beetle | | | |
| 30. | Pupa – Beetle | Coleoptera | Dermestidae | Dermestes maculatus |
| 31. | Greenbottle Fly (Lucilia illustris) with Skin Beetle (Dermestes maculatus) | | | |
| 32. | Skin Beetle
maculatus | Coleoptera | Dermestidae | Dermestes |
| 33. | Black dump Fly
leucostoma | Diptera | Muscidae | Hydrotaea |
| 34. | Beetle Abdomen (Skin)
maculatus | Coleoptera | Dermestidae | Dermestes |

Group One – KEY – Black (number 1)

Group Two – KEY – Red (number 15)

Group Three – KEY – Blue (number 25)

Group Four – KEY – Dark Green (number 31)

Insects Collected and Stored



All photographs taken of the species and the collection belong to the author.