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**THE ROLE OF BODY FARMS AND FORENSIC
ENTOMOLOGY IN UNDERSTANDING THE
DECOMPOSITION OF HUMAN CADAVERS**

Honors Thesis

**Presented in Partial Fulfillment of the Requirements
For the Degree of Bachelor of Science in Biology**

In the College of Arts and Sciences
at Salem State University

By

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Abstract

Forensic biology is an area which analyzes forms of evidence such as hair or blood and more. These tasks are so critical when it comes to looking at a crime scene and trying to figure out what happened during a case.

Another important aspect of forensic biology is the other work being done at body farms. Not many people know body farms exist especially if you live along the seacoast because a greater portion of the body farms are in the middle of the United States. The main point of body farms is to construct different scenes that can occur at a crime scene and see how the body can react differently to decomposition process in comparison to other crime scenes. Seeing these differences is so crucial because it allows crime scene investigators to be able to analyze a crime scene and see if a body has been moved or tell if there is something different that normally wouldn't be. This is going to be due to all the work and research that the people on the body farms do. This may seem like a never-ending process and so much work for those working on these body farms but the impact they make is unbelievable.

Forensic entomology studies the type of insects that take part in the decomposition of cadavers. This part is the most important part that takes place because it is fool proof. The bugs tell you all the truth you need to know because each insect stays for its own important part of decomposition. Therefore, paying attention and looking closely at a decomposing body is so important due to the fact that we can tell how long the body has been decomposing for due to which insect is present.

Forensics is such a huge part of the world we all live in today and whether you choose to be a part of it or watch it from the sidelines is up to you.

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Literature Review

Introduction

“Body Farms” are research facilities in which researchers study decomposition of human remains. Body farms have become used a lot more as the years go by. The first body farm was established at the University of Tennessee’s Anthropological Research Facility in 1980. This being the first one of its kind, started out very small and it was used to do research on how the human body decomposes. As time passed, bodies started being studied more for insect activity, humidity’s affects, and clothing. These body farms all around the United States are what help us to grasp time of death as accurately as possible and how outside factors affect the body. We can use these body donations to determine what can happen to a decomposing human body over a short or long period of time. Once these bodies are decomposed, the bones are measured and the data from them is put into a database to help forensic investigators all over the world to help solve crimes. These bones are also typically given to classrooms to be used as models. All the work done towards body farms is strongly attributed to Dr. William M. Bass (Bass and Jefferson, 2003).

The University of Tennessee

This body farm started off very small, crummy, and close to the school. After it officially opened in 1980, they got their first donation in 1981. This first location didn’t have much privacy which brought up concerns with citizens of the community. “A local group called Solutions to Issues of Concerned Knoxvilleians” (“SICK”) voiced concern about contamination. They asked that Bass move his research area to Oak Ridge,

approximately 25 miles away from the location near the hospital. However, Bass and his research were already well known and appreciated by the University. To appease the public, the University provided funding to install a modesty fence around the area. SICK's complaints ceased "(Klein, 2014). There was also another complaint about this location from the Tennessee State Department of Veteran Affairs about how their veterans weren't getting proper burial. Bass contacted the district attorney's office to discuss what was actually happening with the bodies and how they were treated. The attorneys went to the state legislature and the bill from Veteran Affairs which asked for the bodies to be released for proper burial, was immediately defeated. This complaint from the Tennessee State Department of Veteran Affairs was the last complaint that was received about the body farm. In order to volunteer or work here, the people must get a Hepatitis B immunization and a tetanus shot. The reason why the volunteers and workers have to get immunization is to keep them safe within the research facility and if there are any accidents with one of the bodies or them, then they are properly immunized and don't get any infectious disease from the decomposing bodies.

Western Carolina University

This facility was run by Dr. John A. Williams who bought the university with the intent to open such a program. The only issue that the community had was that they were not made aware of it opening. This program's volunteers were chosen by GPA, reliability, and professionalism and they were required to have a tetanus shot and Hepatitis A and B immunizations. These were there to help prevent diseases from being easily caught. The primary focus of this university is climate and its effects on decomposition rates. In the one article, it stated, "In order for a human donation to reach

complete skeletonization, approximately one to two years are necessary” (Klein, 2014). There is a future hope to expand the ground they have to work with, but they would like to do more burial research so less security is needed which can save more money.

Texas State University

Texas was the third body farm to open up and as of 2014 and is the largest of them all. It was difficult to find a place that was close enough to the university. There were some community concerns such as issues with vultures and their possible interference with air traffic and they were, “worried about body parts falling from the sky onto their children as they play(ed) in the back yard, and (that) the stench and pollution from rotting bodies would render their homes unlivable and unsalable” (Klein, 2014) This body farm is very advanced with many resources such as digitizers, full histology lab, photography studio, and so much more. The number one priority at the university is their security of their research material. Some of the ways in which they keep it secure is through making sure that anyone that enters must be signed in at every location. This is kept by a single gate access to the ranch where the body farm is.

Sam Houston State University

This university was unlike the others because there were no community issues and they had a lot more space for the skeletons than most other body farms. Anyone who enters the body farm must sign in with a confidentiality agreement and get a tetanus shot, and a Hepatitis C shot. They are one of few places that accept hepatitis and HIV donors as well as transportation for the bodies within a specific pickup range. “With Texas’ specific climate and scavenger activity, a body exposed to the elements can reach skeletonization within two weeks. However, if caged or blocked from animal activity, the

decomposition process proceeds more slowly” (Klein, 2014). The climate has a huge impact on how much work and research can be done because as humans we cannot speed up the process of decomposition and we must let it happen on its own. That is the only way to have accurate results that truly mean something. A project was done that studied the effects of ground penetrating radar and how beneficial it can be in the long run. It started as a way to show law enforcement methods that can be very beneficial years after a body was buried. Any animal remains used must be done outside the facility because they only allow humans behind the gate.

Southern Illinois University

This university’s body farm came about with the idea from Dr. David Martin who was initially interested in human decomposition research. Nobody really knew about this part of the facility opening up, so no community issues occurred. Most of the funding for this body farm was through the university and through a grant that Dr. David Martin received for his research. The vegetation is maintained by the staff and its security is secured by two six to ten-foot fences with razor wire at the top of the highest one. The volunteers must have a Hepatitis A and B vaccination and a tetanus shot. They are allowed to do research, collect data, or work in the lab. They do have to go through quite a few trainings to become part of the program. At first this body farm, only post-mortem donations were accepted. After 2012 started, they started accepting donations from people prior to death. Those human donations can be denied if they have any infectious disease that can’t be treated with an antibiotic. Once the bodies have reached skeletonization or mummification, they are then sent to a processing lab. Once maceration has completed, they are stored in archive boxes. (Klein, 2014)

Colorado Mesa University

This body farm was set up by Dr. Michael Bozeman and did have community concerns, but the location was picked once the concerns were addressed. This place first opened in 2012 and started with pigs and then moved toward the first human donation in November of that year. Their funding is primarily based on the university's general funding. There is a morgue area, storage space, an office, and more. This area is secured by a double fence around the outdoor entrance and a single fence just around the rest. The fence is ten feet tall with razor wire on the top. No immunizations are required for this location. There are donations accepted of both pre-death and post-death donors and donors with infectious diseases aren't accepted. This body farm is set to focus on how the climate affects decompositional patterns. They are being used for law enforcement training and soon hope to do cadaver dog training. (Klein, 2014)

There is a difference in how a body farm and the whole process that comes with it works versus how it is displayed in the media. "The colloquial and persistent use of the term 'body farm', the rhetoric that surrounds media reporting, and the sometimes-distasteful display of the subjects, detract significantly from any scientific merit that the public may recognize from such a facility" (Black, 2017). The way our media shows these types of places is what causes body farms to lose their merit. It takes away the importance and significance of the need for these types of facilities. These facilities are not just like any other scientific research facility, these facilities help law enforcement

around the world help find ways to solve a murder or determine the identity of a cadaver and who they were before, for example, a fire happened, and they are unrecognizable.

Body farms are crucial to our thorough understanding of what happens with a body after death and how to be able to determine the time of death. A large part of determining the time of death of a body is the decomposition of the cadaver. There are several stages of decomposition that help forensic anthropologist determine when the cadaver died. There are six stages of decomposition consistency: fresh, bloated, active decay, advanced decay, dry, and remains. (Carter et al. 2007)

Cadavers are in the fresh stage almost immediately after death. A fresh cadaver is a cadaver that died recently. The fresh stage lasts from that day all the way up to one week based on the climate where the body is. The cadaver starts to go through something called, autolysis which is when there is a lack of oxygen in the body and the body goes through aerobic metabolism, which causes the destruction of the cell by enzymatic digestion. Then while autolysis is happening two types of flies, blow flies and flesh flies, are attracted to the body within minutes. (Carter et al. 2007)

The next stage of decomposition is the bloated stage. For the bloating stage, it starts within forty-eight hours after death. The characteristics of this stage are distention of tissue on the cadaver, overall color changes in all body parts, and leaking of volatile fatty acids out. A cadaver becomes bloated in this stage because of the gases within the body being released causing color change, an odor, and the body becomes bloated. The underlying process of this is putrefaction. This causes the internal pressure of the cadaver to increase due to these gases and purge fluids which are created by microorganisms in the body transforming lipids, proteins, and carbohydrates into organic

acids which these acids then start to be forced out of the body through the orifices.

(Carter et al. 2007)

With the bloated stage expanding the skin of the cadaver and maggots brought to the body from the flies, the skin begins to tear which exposes the cadaver's insides to more oxygen which then starts the active decay stage of decomposition. This stage is associated with a rapid amount of weight loss which causes the body to release more fluids outside the body. Active decay is also called "black putrefaction." As this stage starts to end, we see that the maggots start to pupate. Depending on how advanced the maggots are along in their growth cycle helps identify how long the body has been dead.

(Carter et al. 2007)

The transition from advance decay, dry, and remains stages are hard to identify. "A CDI" a Cadaver Decomposition Island, "during 'Advanced Decay' represents an area of increased soil carbon, nutrients and pH." (Carter et al, 2007). Advanced Decay starts at least one week after the initial time of death. The characteristics of Advanced Decay are purging of bodily fluids and exposure of the skeletal elements. It is usually associated with the death of vegetation around the body's CDI. When the vegetation increases around the body, it starts the next stage known as the Dry stage. The increase of vegetation within the body's CDI is when we know the body has reached the Remains stage. The characteristics of this stage is full skeletal elements with little to no flesh on the bones. These final stages of decomposition correspond to a second period of mass loss which is due to the depletion of more fluids coming out of the body. (Carter et al, 2007). In the paper I read (Carter et al, 2007), he experimented with pigs and showed

pictures of what each stage looked like so that readers could get a better idea of how each stage of decomposition looks like.

Another factor with human decomposition is clothing. “Research conducted by the Florida State Crime Lab found that man-made fabrics are more colorfast than natural fibers when exposed to decomposition fluids” (Shirley et al, 2011). This means that most fabrics color wash the body when exposed to fluids from the cadaver. Because humans are made of water, there are many different fluids that come out of cadavers when decomposing. During multiple of the decomposition stages, there are many fluid leaks from fluids through the skin and fluids coming out of the orifices.

At the Colorado Mesa University, there is a Forensic Investigation Research Station (FIRS). There is a study going on there since 2010 that tries to determine time of death with the cycles of microbes in and around the body and how that can help solves homicides and how microbes can help forensic investigators as well. “Outside of TV detective dramas, microbes haven’t yet played a major role in criminal investigations” (Beans, 2018). Jessica Metcalf is the lead researcher on this project. She created a term called the “microbial clock” which corresponds with the microbes surrounding the cadaver. This term references the timing and phase of decomposition and what kind of microbes are on the body. This study is an in-progress study and the microbial clock is not fully determined for all types of decomposition. Metcalf thinks that over the next two to five years that her microbial clock will be able to help forensic investigators determine time of death and hopefully a place of death. Due to the fact that some of the microbes are affected by the temperature of a given area and sometimes for the decomposition of a

body and at the rate it decays might help determine the place or climate that a cadaver was left in.

“Before the advent of body farms in the early 1970s, forensic scientists consulting on criminal cases had to rely on research that was conducted largely on the carcasses of pigs (physiologically similar to humans, relative to other animals). And even now, many countries outside the U.S. still utilize pig carcasses for such research.” (Ruiz, 2018). I thought this was very interesting that using a pig is a close representation of how to deal with a human body. Once Bass -who came up with the idea of body farms- realized how far off he was when asked by the cops to determine the death of someone he knew it was time to come up with a way to examine decomposition more precisely. According to (Ruiz, 2018), at Texas State University, the process of a body arriving at a body farm goes like this: Researchers will photograph and measure while taking hair and blood samples. This will then lead to them using identifying numbers and spread it out around the farm leaving about fifty feet from the rest. This set up can of course be changed by the type of research that they are looking to do which can alter the types of conditions they will put the bodies under.

There have been a lot of setbacks in the forensic science field. I think that we have come a very long way since our first experiences with forensics. We have advanced in so many ways between our basic knowledge and technology. Having these great opportunities such as the body farms makes a huge impact in how we are able to figure out things such as time of death or specific ways in which someone might have died. If it weren't for these amazing resources half of our knowledge that goes towards crime

scenes and deaths would be a lot more difficult to figure out and would take a lot longer time.

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The Role Forensic Entomology in Forensic Biology

There are a lot of different conditions in which bodies can be found and what happened to them before their last breath. The "...use of insects and other arthropods in medio criminal investigations is called forensic entomology..." (Martin-Vega, 2011) For this paper, I will focus on flies as my main insects and all that they bring to the table when dealing with forensic entomology. There are different and specific categories when it comes to flies and cadavers. There are challenges on how to determine what species work on the body at specific times of decomposition because there are so many different types of species that are involved.

These types of species are known as "...necrophagous (those that feed directly on the corpse), predators and parasitoids (those that feed on necrophagous insects), omnivores (that feed on the cadaver and other resources, including associated fauna) and accidental (insects that use the cadaver as source of refuge or shelter and whose presence is due to chance.)" (Oliviera, 2010) Every state and/or country has different levels of temperature that occur in each area which can speed up a decaying process or alternatively, slow it down. Therefore, this means time is of the essence. There are many families of flies, for example, the Piophilidae, which are largely seen in cooler temperatures in the Northern Hemisphere. This specific species can be used to determine the postmortem interval. A lot of species in the Neottiophilinae "develop in exposed carcasses" (Martin-Vega, 2011) while piophilids are "...associated with carcasses in advanced stages of decay..." (Martin-Vega, 2011). Different parts of the world have different temperatures all throughout their year, therefore, it is difficult to say that one

specific species is consistent with a certain stage in all areas. For example, the *P. casei*, otherwise known as the cheese fly, was spotted on an advanced decayed body in Malaysia. There is another species known as *P. megastigmata*, which is known to only be present in South Africa however was also "...recently collected on dead pigs in urban and peri-urban habitats in the Iberian Peninsula, as well as on human corpses in Portugal." The subtribe known as Thyreophorina are known as bone skippers because they are attracted to skeletal remains of big mammalian carcasses. The group known as *Bocainamyia Albuquerque* is typically seen on the final stages of decay (Martin-Vega, 2011).

Brazil

Brazil is a country with large amounts of violence and immensely high death rates. Investigators need to determine the cause of these high rates, leading to numerous studies. In Brazil, they were looking at the types of insects present on cadavers that came across the Institute of Legal Medicine in Recife, Pernambuco. They had looked specifically at the necrophagous species that were present on these cadavers. Pernambuco has a wide variety of land such as beaches, forests, mangroves, and more within a tropical temperature setting. The study aforementioned used numbers to keep the bodies anonymous however, also used those numbers to keep track of each individual body, and all observations were taken three times a week for six months. The cadavers were observed and studied as soon as they entered the Institute of Legal Medicine so that nothing could have contaminated them. These cadavers were "...observed: sex, overall conditions, stage of decomposition, and presence of insects throughout the body. Data from medical records were incorporated into the analyses, including locality of death,

approximate age, estimated postmortem interval, cause of death and decomposition stage.” (Oliviera, 2010) The presence and location of the maggots were determined by three different body regions: head, upper torso with arms, and abdomen with legs. The number of maggots were then split into classification levels such as low consisting of 0-500 larvae, intermediate consisting of 501-1000 larvae, and high consisting of over 1000 larvae. Traps were then made to catch dipteran fauna with a piece of chicken liver. These traps were collected every forty-eight hours in conjunction with the cadaver examinations. All the cadavers were male between the ages of eighteen and fifty-seven years old and a hundred and forty-five out of the two hundred and eighty-five were able to be properly examined without any manipulation present. This study found, “the pattern of colonization by maggots was characterized as follow: head (91.6% of the cases), upper torso + arms (50.0%), and abdomen + legs (33.3% of the cases).” (Oliviera, 2010)

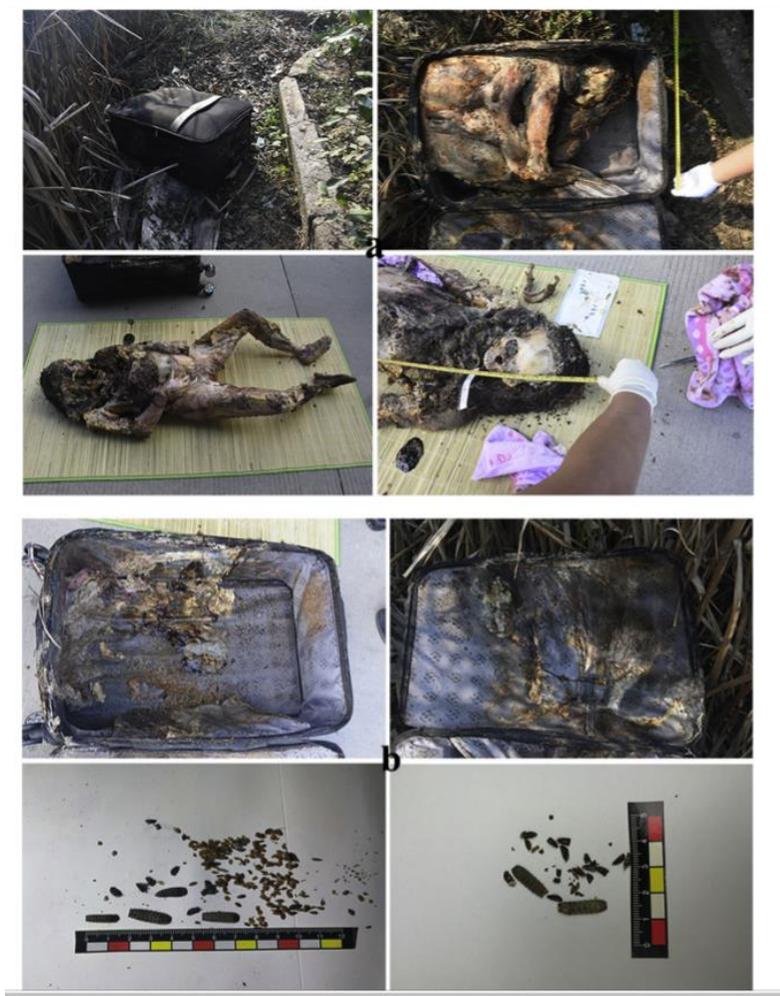
Family	Number of species	Abundance	Frequency	Dominance
Calliphoridae	4	1691	Very frequent	Dominant
Sarcophagidae	7	1290	Very frequent	Dominant
Phoridae	1	1082	Very frequent	Dominant
Muscidae	7	486	Very frequent	Dominant
Fanniidae	2	116	Frequent	Accessory
Stratiomyidae	1	2	Infrequent	Occasional
Anthomyiidae	1	22	Infrequent	Occasional
Total	23	4689		

Table 1: This table was taken from (Oliviera, 2010) showing the distribution of the species found in the study aforementioned.

The percentages for the table above are as follows: Calliphoridae (36.1%), Sarcophagidae (28.0%), Phoridae (23.1%), Muscidae (10.4%), Fanniidae (2.5%), Anthomyiidae (0.5%), and Stratiomyidae (<0.05%).

Guangdong Province, China

This case was dealing with a trolley suitcase that was found in Huizhou City in Guangdong Province near a cemetery. This region has subtropical monsoon climate and the suitcase appeared to be in good condition, the only thing that caught people's attention was the bad smell coming from it. Once police arrived, they used scissors to open the suitcase allowing them to finally see the curled-up body that was in the suitcase. This was a particularly peculiar case because the body was naked and curled on its left side while the left foot was on the external side of the right ribs and the right hand was placed on the left while the left wrist was located between the left calf and right thigh. Another strange thing that occurred was with different levels of decomposition.



The picture shown above is from (Hu, 2019) which demonstrates the way in which the body was laying and decaying.

The evidence examined from the body shows that the body had been there for about fifty-six days. The only insects that were found were necrophagous insects however there weren't any other types of bugs on the body. Due to the slow decomposition process, it was clear that not only did the individual die during a cold season but also, experienced a great deal of cold weather prior to death as well.

According to (Joseph, 2011), forensic entomology was first used in the 13th century in China. The scenario was that a farmer was murdered on the field with a sharp weapon. Everyone had to show their sharp weapons and if the blow flies were attracted to that item then that meant it was the weapon used to murder the farmer. This tactic explains that the item was cleaned off to the point that it would not be visible by the naked eye, however, for any type of insect similar to the blow fly, it would still be present and visible to them or can be smelled by them. Through much research, it has been found that Calliphoridae and Sarcophagidae both arrive within minutes from death while Muscidae don't arrive until the body starts to bloat during decomposition. "Calliphoridae adults are commonly shiny with metallic coloring, often with blue, green, or black thoraxes and abdomen. Sarcophagidae are medium-sized flies with black and gray longitudinal stripes on the thorax and checkering on the abdomen." (Joseph, 2011) The Muscidae are a little different with a gray thorax, four longitudinal dark lines on its back, and containing hair-like projections. According to a study done by K. Tullies and M. L Goff (1987) in a tropical rainforest, there are different stages of decay and they were able to find out the specific types of insects involved in each. For fresh stage decay, they saw

that insects were attracted within the first ten minutes of death but, there wasn't any egg-laying during this time period. For the next stage, bloated stage, is when adult Diptera are attracted to the body. Next, in decay stage, is when the larvae begin to leave to pupate. During post-decay stage, the Diptera larvae leave and there is a lot of arthropod activity on the remaining parts of the body such as cartilage, hair, and small tissues. Finally, in the remains stage, there is a decrease in the amount of adult and larval Diptera.

“Flesh flies were widely reported to colonize on indoor corpses, which may be due to the special biological features.” (Ren, 2018) For those who were battling with drugs in their life, the pattern of flies might look a little different. Drugs can cause a different developmental pattern of flesh flies which can cause a wrongful determination of the body's time of death.

Female blowflies can lay up to three hundred eggs in one lay and it can do that about ten times throughout its life. The eggs will then hatch within twenty-four hours when they are laid at room temperature. Those eggs produce a first instar maggot which molt and produce second instars which molt into third instars known as maggots which will feed off the body for up to six days then leave. Once the maggots leave their skin darkens and hardens and the maggots will pupate. Temperature is such an important factor when using insects as indicators. “A constant temperature of, say, 15° C will affect the development of a maggot differently from a fluctuating temperature of 10-20°C...”(Erzinclioglu, 2003) When they lay their eggs it isn't on an exposed part of the body but typically within a body cavity such as eyes or ears.

Central Europe

According to (Szpila, 1970), in central Europe, there are several different dominant species of necrophagous flesh flies that differ between urban or semi-natural and rural habitats when it comes to carrion (decaying animal bodies). In each area, there is a different species in which is the most dominant on the decaying corpse. However, for a larger range of central Europe, the most dominant species of necrophagous flies are the *S. caerulescens* and the *S. similis*. These two species are the most common species on carrions which means these types of flies are the species you are most likely to see within this specific region along with similar temperatures. Looking at the two species along with the arrival of the blow flies, it seems that these species were the first flesh flies to colonize after the blow flies which is on average about the fifth to tenth day after the carrion was exposed to nature.

“Particularly, *S. caerulescens* is a good candidate for a broad forensic use in Central European cases.” (Szpila, 1970). The advantages of using this species for forensic use is due to the fact that there is early colonization of these flies on carrions, along with rapid and easily identifiable development stages of this species, and large sizes of the adults, which is favorable during the collection process. However, one of the most relevant reason why this species is a good candidate for use in cases is because the location of which these flies live is usually within close distance to the most attractive areas in which it is the easiest to hide dead human bodies.

India

The objective of this individual study (Sharma, 2013), was to determine the postmortem interval after death and gather baseline data for forensic study of flies (specifically blow flies) in India, specifically how they help determine certain times of death and recognition of how long the body has been decaying for. These flies help

indicate the postmortem interval within the first few weeks after death. They gave multiple limitations that would get in the way of determining how long bodies had been decaying. Some of these limitations were myiasis, which is the feeding of maggots on living tissue or dead tissue which are associated with a wound and then confuses the forensic entomologist because it could cause the body to determine that the time of death was a lot further back than it truly is. Another limitation would be if a body is indoors. Having a body indoors can cause there to be a lack of insects coming into the home in which case- this body may be isolated for long periods of time, making it more difficult for flies to get to the body. This could also cause there to be an estimate time of death rather than an exact day or time which indicates the individual could have died around one day before or one day after the estimated time. Another limitation mentioned in the study was dispersal time. Dispersal time is when the larvae leave the corpse to so they can pupate, it sometimes takes time for the larvae to get to the pupation location due to the fact they like to find a protected environment for this. This can take time, and which can also lead to an incorrect calculation of the postmortem interval and time of death.

Forensic entomology is very important to the research in forensics. We are able to learn and see so much we would typically miss with the naked eye. Insects are a major part in our everyday lives and so much more.

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Conclusion

The world we live in changes every single day for better and for worse. Methods of investigating crimes change every single day. We use old techniques from the earlier days and then when we can find something that works better, we update that method and use it. The studies of bodies, decomposition, and forensic entomology are still new topics in a still very new field of science because there is still so much to learn. Every time we think we find a new way to categorize or summarize a process we did not know anything about before, we then find newer processes that makes us think hard about how much we already know and even more about what we do not. This is what makes this field so exciting because you never know what you will learn next or what else could be discovered. So many different aspects merge together to allow us to be able to do all the forensic and investigative work that we must do day to day in that field. Many of us cannot wait to see what new technology and new techniques we will have in these fields.