# Insect Colonization and Accessibility of Concealed Carcasses

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**Abstract**

Investigating decomposition patterns from real-life scenarios in which remains are found is a prominent need for the forensic science community. Blow flies are an important part of forensic entomology as their stages of development help to estimate the time of colonization, allowing forensic entomologists to help law enforcement with narrowing down a timeline for their investigation. We assessed the effects of three different forms of concealment on insect colonization and the decomposition process. The concealment methods used in this study were a comparison of two types of each of the following: carpet, suitcases, and plastics. Within this study pig heads were used in place of human remains to examine insect access of concealed remains and colonization patterns. We found differences in colonization and accessibility as well as insect diversity across concealment types.

## Introduction

Remains are often concealed in order to minimize their detection from law enforcement and civilians in order to conceal criminal activity. Forensic entomology is the application of insects to investigations (Sanford, 2015). Forensic entomologists use the development of blow fly larvae to estimate the time of colonization (TOC) of the remains, which can assist investigators in narrowing down the time since death (Sanford, 2015). While concealment of a body is common in homicide cases, research about the effects that concealment has on insect activity and decomposition is limited. The goal of this research project was to assess the insect activity and decomposition process when carcasses are concealed by using carpet, plastic, and suitcases.

*Carpet*: There has been some research on the effects of various coverings such as tarps, blankets, and other fabrics, however, studies looking specifically at the effect of different types of carpeting on insect activity are nonexistent. One study compared tarp and blanket coverings to a control with no covering and found that there was not any statistically significant difference in the rate of decomposition (Dautartas, 2009). A case report describes remains that were wrapped in carpet and is disposed of down a rock slope in British Columbia, with the top and bottom of the carpet unsealed. Different species were found in different areas of the carcass, and it was also noted that the insects pupated within the carpet roll (Anderson, 2001). The lack of research about the topic of rolling a carcass in carpet poses many questions that this research could potentially provide insight about. The findings of this study will help to answer questions during investigations of corpses rolled in carpet by demonstrating its effects on decomposition and insect access. I hypothesize that the exposed pig heads will be colonized before the carpet-rolled pigs but have a similar rate of decomposition—however, the thinner carpet of the two types will likely be colonized before the thicker carpet. I also predict that there will be a difference in species that colonized the pig heads for each treatment group.

*Suitcase*: Another mode of concealment with an easily accessible common household item, is a suitcase. Although the suitcase is sealed by zippers, blow flies can still find a way inside and a few studies document the ability of blow flies to access bodies concealed in suitcases (Bhadra et al., 2014, Magni et al., 2019). A pilot study conducted in western Australia examined pigs in one type of suitcase and found that the decomposition of concealed pigs shows

a more "wet decomposition" compared to their controls, with differences in the rate of colonization and the fly species collected (Magni et al., 2019). Another study looked at colonization through zippers, as that is the main access point in which the flies and their larvae are able to enter the suitcases (Bhadra et al., 2014). In this study, Bhadra et al. (2014) found that of the first instar larvae tested within their study, 89% were able to colonize the bait by passing through gaps between the teeth of the zipper. Another finding was that the rate of colonization in comparison to their controls was different by multiple days. Although studies on insect accessibility have been performed, no studies have examined varying suitcase exteriors, such as soft fabric vs. hard plastic. The objective of our research is to determine if two different suitcase materials have an impact on insects accessing and colonizing remains. I hypothesize that the different exteriors would affect the insect's ability to colonize and access the body. I would predict the insects would be able to enter both types of suitcases through the zippers, but more insects would lay their eggs on the outside of the fabric suitcases compared to laying eggs on the plastic suitcases.

*Plastic*: Similar to suitcases and carpet, garbage bags are an easily accessible form of concealment. Plastic concealment prolongs or in some cases prevents insect access and colonization. Insect colonization from flies and beetles play an important role in the rate at which decomposition occurs (Campobasso, 2001). Without direct insect access, decomposition rates should occur at a slower rate compared to carrion that have direct insect access. Previous studies concerning the progression of decomposition involving plastic have discovered that insect colonization still occurs despite not having direct access to the remains (Weger, 2020). Despite insect colonization, the remains did decompose at a slower rate than exposed bodies (Scholl, 2017). Two types of plastics were used in this study, mint-scented plastic garbage bags and thick contractor bags. The objective of this study was to examine the effects of plastic on decomposition and determine how different plastics can affect insect colonization. I hypothesize that the thinner, mint- scented bags would have the most and diverse insect colonization between the plastic treatments. It was predicted that both treatment groups would have insect colonization and that the control group would have the most colonization and diversity of insects.

**Materials and Methods**

This study was conducted at Purdue University's Entomology Field Operations Building (EFOB) in the fall of 2020. Pig heads were used as a model of human decomposition. Cages were assembled to prevent vertebrate scavengers from having access to the pig heads. The average weight of the pig heads was 6.79 kg. Six large cages (1.14m x 0.77m x 1.35m) were used for the suitcase treatments and 20 small cages (1.52m x 0.91m x 0.61m) were constructed with chicken wire and zip ties. Small cages were secured to the ground with garden staples. All pig heads were placed 20 ft apart and treatments were assigned using a random number generator. Temperature and relative humidity data were collected hourly using a datalogger (HOBO MX2300, Onset Computer Corporation, Bourne, MA).

*Control*s *and insect collection for all treatments*: For the controls, the pig heads were each placed on the surface of the ground and left outside in the open air to decompose and attract insects without any means of concealment. A cage was placed over each control. Photographs and notes were taken every data collection day to document changes in decomposition and insects present, and samples of insects were collected. Collection of fly eggs, larvae, and pupae were collected if available for sampling. Live samples were placed in quart sized plastic containers filled with about 300mL of sawdust and a piece of beef liver for the larvae to feed on

until they pupate and emerged as adults. All adult blow flies were then pinned and morphologically identified using Jones et al. (2019). Beetles were collected and stored in vials with 70% ethanol, and identified using Castner and Byrd (2000).

*Carpet*: For the carpet concealment portion of this project, 4 pig heads were used for two different polyester carpets with polypropylene backing (Table 1). Each pig head was placed a few inches from the edge of the carpet piece and then rolled 2-3 times until the end of the carpet was secured under the weight of the head. A small cage was placed over each carpet roll and secured to the ground with garden staples.

*Suitcase*: Two different suitcase materials were used in this study, a soft fabric and a hard plastic. Both suitcase styles were closely related in weight and dimensions (Table 1).Three pig heads were assigned to each suitcase treatment. Every day, the exteriors of the suitcases were examined for insect colonization, the suitcases were opened and photographed to document any changes visually and to document any insect activity.

*Plastic*: For concealing the remains in plastic, two types of plastic garbage bags were used, each with four replicates (Table 1). The thin, mint-scented plastic treatment were placed separately into two layers of mint-scented garbage bags. Each bag was secured by using the plastic at the opening of the bag to wrap around itself and create a knot from the plastic itself. The same method was applied to the thick contractor bag treatment group. The pig heads were placed into two knotted bags, and small cages were placed over each, secured to the ground with garden staples. Bags were opened to examine for insect access and colonization.

**Table 1.** Information about each type of carpet, suitcase and plastic used in the study.

| Concealment Type | Size and/or Type | Other Details |
|---|---|---|
| *Carpet* | | |
| Thin | 16 oz/yard | TrafficMaster Hot Shot II |
| Thick | 46 oz/yard | Home Decorators Collection Clareview |
| *Suitcase* | | |
| Soft | 23 x 14.2 x 11", 7.1 lbs | American Tourister 4 Kix, Black/Grey |
| Hard | 21.6 x 14.9 x 10", 7.34 lbs | AmazonBasics Hardside, Black |
| *Plastic* | | |
| Thick | 55 g | Thickness: 6.0mm |
| Mint-scented | 60 g | Thickness: 1.7mm |

## Results

The maximum temperature during our study was 19.92°C, and the lowest temperature recorded was 5.53°C. For relative humidity, the maximum recorded was 79.28% and minimum of 54.53%.

Controls: All controls of our control pigs were found to be colonized within 24 hours from when first placement. Colonization was found in eye socket, mouth, nasal cavity, in the ears, as well as underneath the pig heads. Of the insects collected, only six adults were reared as well as two adult flies collected by sweep netting over the top of one head. The flies identified as *Phormia regina* (n=6)*, Lucilia coeruleiviridis* (n=2) and Sarcophagidae (n=1).

*Carpet*: There were a total of 52 Diptera specimens (Figure 1), and 21 adult Coleoptera specimens (Figure 2) reared or collected from the carpet treatments Most pigs were colonized after 24 h, and all pigs were colonized after 48 h (Figure 3). There were pupal cases lodged in several of the carpets at the end of the experiment (Figure 4).

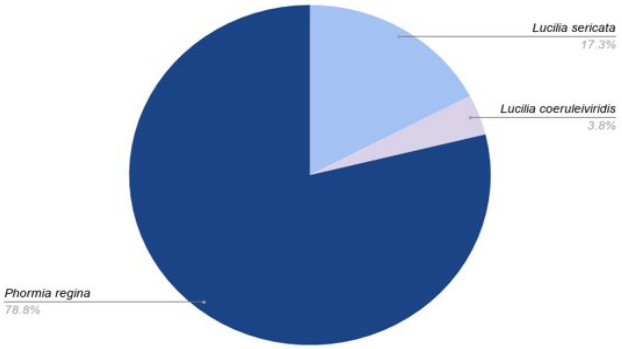


**Figure 1.** The species distribution of Diptera specimens collected from the carpet treatment.

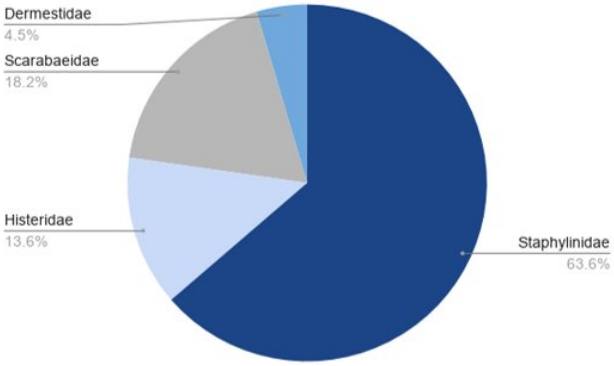


**Figure 2.** The family distribution of Coleoptera specimens collected from the carpet treatment.

**Figure 4.** Blow fly pupae (arrows) lodged in carpet.

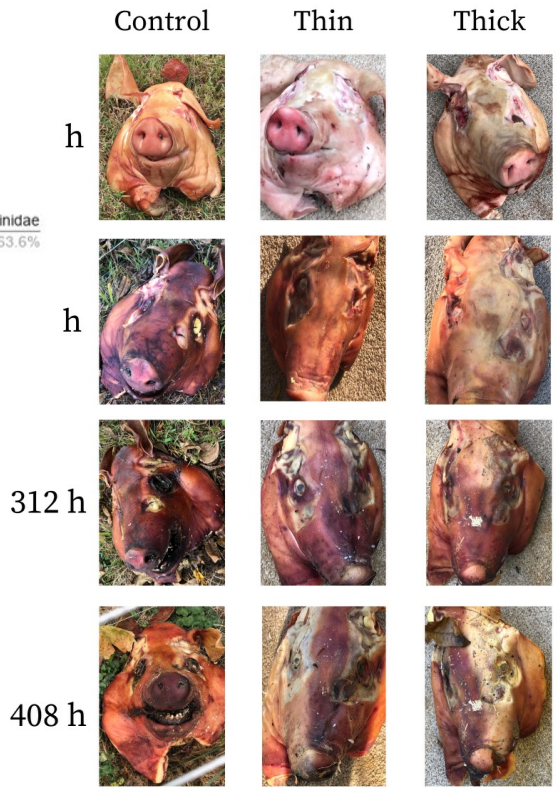


**Figure 3**. Decomposition over time of the carpet treatments compared to controls.

*Suitcase*: From the suitcases, only two adults were successfully reared and were identified as *Lucilia sericata* and Sarcophagidae. Many of the larvae collected were *Lucilia coeruleiviridis*, which is difficult to rear and has low survival rates in the lab.

Initial colonization was observed after 216 hours in one of the soft suitcase replicates (Figure 5). Colonization in the hard suitcases was not observed until after 336 hours, and this was also the first noted presence of eggs laid on the exterior zipper of one of the suitcases. By the end of the study all three hard suitcases had insect colonization, whereas only two of the soft suitcases were colonized.


**Figure 5.** Progression of suitcase treatment decomposition compared to controls.

**Figure 6.** Blow fly egg masses and larvae activity on plastic bags.

*Plastic*: The only colonization documented in both plastic treatments was on the outside of the exterior bag inside the plastic folds and near the knot (Figure 6). No insect activity was ever observed inside the interior plastic bags. The first signs of colonization were observed 264 hours after the start of the experiment and the average colonization time was 336 hours. In total, 80 specimens were collected and/or reared from the plastic treatment groups. The most abundant species collected was *Chrysomya rufifacies* and three other blow fly species were collected, as well as one beetle (Figure 7). The thick plastic treatment was colonized by *C. rufifacies* only, whereas the mint-scented treatment was colonized by four species. All the replicates, control and experimental, reached advanced decomposition. Purging of decomposition fluid was documented in the thick plastic treatment after 408 hours (Figure 8). Not all replicates experienced purging. Skin sloughing was seen in all replicates across both treatments.

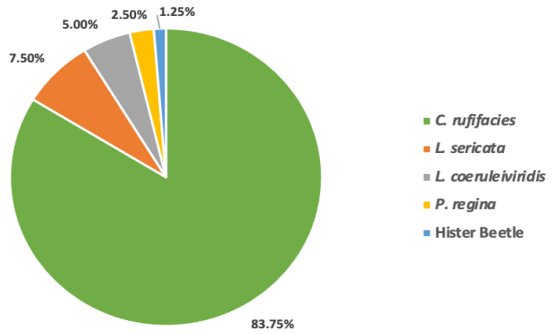


**Figure 7.** The species distribution of Diptera and Coleoptera specimens collected from the plastic treatment.

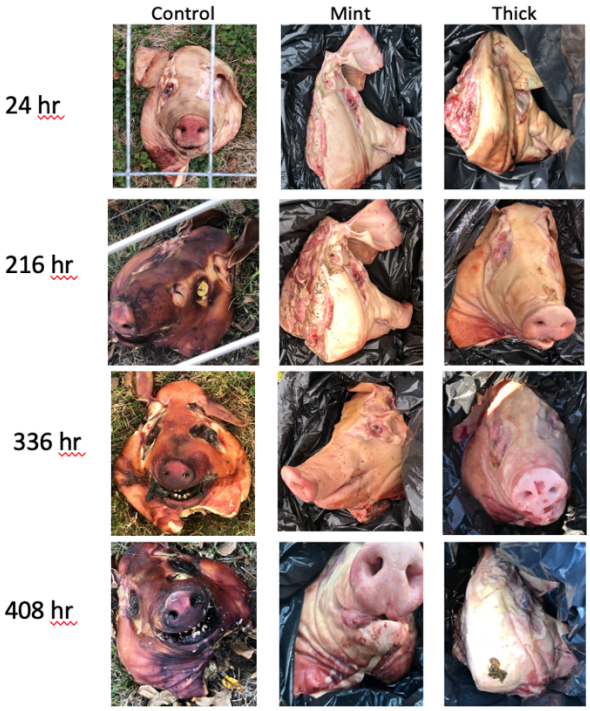


**Figure 8.** Progression of decomposition for thin and thick plastic treatment.

**Discussion**

*Carpet*: In both types of carpet (thick and thin), there were blow fly pupae lodged within the carpet, which reflects the behavior that was observed in Anderson (2001). Prepupal blow flies typically move away from their food source in order to pupate, so this behavior is different than it would be, had the carrion not been rolled in carpet. The species collected from the carpet treatment pigs were similar to the controls. Both the control pigs and carpet pigs were predominantly colonized by *Phormia regina*. However, *L. sericata* colonized the carpet treatments. Only 25% of the egg/larvae samples collected had reared adult flies in them, so it is not clear if the different carpet treatments had an effect on the species that colonized the pig heads. The pig heads were all colonized after 48 hours, so there was not a notable difference in the time of colonization among the two treatment groups. The controls had a slightly higher rate of decomposition compared to both carpet treatments, and the thinner carpet treatment pigs were farther along in the decomposition process, which was characterized by more black discoloration. The controls differed from the carpet treatment pigs in overall appearance due to the carpet allowing moisture to have contact with the heads.

Future research on carpet concealment could provide more information about the possible difference in species that colonize carpet concealed remains versus exposed remains. Due to the low survival rate of the collected larvae, conducting a similar study, perhaps at a different time of year, might provide more specimens for a more accurate and thorough assessment.

*Suitcase*: All but one suitcase was colonized (all three hard and two soft) meaning that there was accessibility for the blow flies to reach the remains in both suitcase types. Even though not all soft suitcases were colonized, the ones that were had a larger quantity of egg masses and larvae masses. Although we expected more egg/larval masses would be found on the exterior of the soft suitcases, only the hard suitcase had eggs laid on the exterior zipper. The rate of colonization of the different suitcase types compared to the control pigs; while the. controls were colonized within 24 hours, colonization was not observed until 216 hours in the soft suitcases and 336 hours in the hard suitcases.

We believe the location where the uncolonized suitcase was laid may have played a factor into this, as this was in the same location in the carpet trail where delayed colonization was found. Even though only two of the soft suitcases were colonized, these two replicates showed the largest amount of insect activity of all of the suitcase replicates. A larger quantity was egg/larvae masses were found in the soft suitcases in comparison to the hard suitcases as well as more feed on the pig heads inside.

Further research could be done on this topic to continue the advancements and steps taken in order to shrink the knowledge gap of this particular means of concealment. A study with the same suitcases but at different times of year and another randomization of spots at the site could have effects on results. More studies conducted could also lead to more adult flies reared which would allow for better understanding of insect diversity.

*Plastic*: The results from this experiment both supported and contradicted aspects of the hypothesis. We predicted that the thinner, mint-scented plastic treatment would have the most insect colonization and the control group would have the most colonization and diversity of insects. The results supported the prediction that the mint-scented bags would have the most and diverse colonization between the two plastic treatment groups. However, the control group did not have the most diverse insect colonization, mostly likely due to the low survival of *L. coeruleiviridis* in the lab. The mint-scented treatment was colonized by four species of blow flies and one beetle was also collected. The thick plastic treatment was colonized as well, but only by *C. rufifacies.* Colonization did not occur for the plastic treatments until 264 hours, whereas the controls were colonized after 24 hours, indicating that plastic concealment inhibits insect access. This gives reason to believe that the plastic concealment did slow down decomposition rates. While the thick plastic treatment group did not see colonization, there was a large number of Hemerobiidae brown lacewings. Dozens were found on each thick treatment replicate, in the folds of the plastic and in the folds of the knot. This was a unique finding because Neuroptera are not known to be carrion related insects.

It was concluded that the mint-scented treatment group was more favored by insects than the thick contractor treatment group. This was determined based on the greater diversity of colonization seen on the mint replicates compared to the thick replicates. The mint treatment group saw the first signs of insect colonization. The mint-scented plastic bags were the first to start smelling of decomposition. All replicates across both treatment groups reached advanced stages of decomposition. Purging of decomposition fluid was documented in one replicate in the thick contractor plastic treatment group.

Further research could be done regarding this topic. In order to get a more accurate understanding of how decomposition was affected by plastic type, the isolation of the variables of plastic thickness and scent need to be controlled for. This study should be repeated again using the same thickness of plastic bags, having one plastic be scented and the other not. This study could also be repeated using different degrees of plastic thickness with neither plastic type being scented.

**Conclusion**

Concealment of corpses is not limited to just carpet, plastic bags, and suitcases. There are countless examples of the lengths that people may go to conceal a body, and the concealment methods that were researched in this project are just a few. Research on the topic of concealment is important because the materials used could affect the rate of decomposition and insect colonization. It is also important to note the geographical locations on where studies like this are conducted, as it is known that insects are temperature dependent and factors such as temperature, humidity, and environmental conditions such as rainfall can have a significant impact on insect growth and development. Even though numerous efforts have been made to understand these processes, minimal research has been done specifically related to the concealment methods we chose to include in our study. Our findings indicate that concealment in carpet does not inhibit insect access, whereas concealment in suitcases and plastic bags can delay or inhibit insect access and colonization  Although this research is limited in its scope, it has the potential to help

future forensic investigations when remains are found to be in a concealed environment by allowing for further understanding of TOC of insects found on concealed remains.

**Acknowledgements**

Thank you to Dr. Krystal Hans for her guidance and support during this project. We also thank Purdue University for providing the facility to conduct this research.

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