Chemical Exposure and Blow Fly Oviposition Behavior

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Abstract

Insects play an important part of forensic science because they assist with estimates of time of colonization (ToC), which may provide information on the minimum post-mortem interval (mPMI). Factors that may influence these estimates include the application of household chemicals, which may affect decomposition and insect attraction and arrival to remains. Fetal pig carcasses were treated with bleach, fabric softener or distilled water, and placed outside to monitor decomposition and insect activity during the fall season. Decomposition was observed and Total Body Scores assigned, and samples of insects were collected to determine primary colonizing species. Decomposition rate was faster for distilled water and fabric softener treated carcasses, reaching skeletonization by day 6, whereas carcasses treated with bleach had a slower rate of decomposition. Four species of blow flies colonized the pig carcasses. Time to first oviposition event was affected by chemical treatment, with oviposition on distilled water and fabric softener treated carcasses occurring at 2 and 27 h, respectively. Carcasses treated with bleach were colonized by 188 h, on average. The slow decomposition rate and oviposition of pig carcasses treated with bleach indicate that further studies must be conducted to provide information for forensic entomology estimations. Household chemicals are often used by perpetrators to destroy or limit physical evidence, and this impacts the colonization behavior and decomposition of remains.

Introduction

Forensic entomology is the study of insects in a criminal investigation (Byrd & Castner 2001). When remains are accessible to insects, the insects will colonize the body with eggs, which hatch into larvae and begin consuming the tissues. Blow flies and carrion beetles are the most common insects found on or near decomposing remains. These insects help forensic entomologists calculate the minimum post-mortem interval (mPMI), time of colonization (ToC), and accumulated degree hours or days (ADH or ADD) (Joseph et al. 2011).

Blow flies (Diptera: Calliphoridae) are usually the first insects to discover decomposing remains. They are attracted to the decomposition odor and seek any natural openings or covered areas to oviposit, or lay their eggs. The female blow flies lay their eggs in natural openings of the body, such as the eyes, ears, nose and mouth, as this protects the fragile eggs from predation and ambient weather conditions and the eggs will hatch into larvae and feed in these openings (Bugajski 2011).

When perpetrators are attempting to alter or hide physical evidence, household chemicals and cleaning products may be used to disguise the scent of decomposition or eliminate physical evidence on remains. Charabidze et al. (2009) examined the attraction of blow flies to rat carcasses treated with six different household products and found a delay in blow fly activity in three products; gas, perfume and mosquito repellent. In the carcasses treated with mosquito repellent, there were fewer female blow flies and less oviposition (Charabidze et al. 2009).

Another study used seven household chemicals that were applied to pig carcasses and the most common oviposition sites (Bugajski 2011). The results from this study showed that there was a significant difference in the development rates of the flies from the chemicals. On the pigs treated with Raid, there was a noticeable lack on blow fly activity. It was stated that not a single blow fly oviposited on any of the Raid treated pigs. It was also stated that the pigs treated with lime, OFF!, acid and bleach had altered the life events of the blowflies when compared to the controls, thus, having an effect on the mPMI estimations (Bugajski 2011).

The quick arrival of blow flies to remains allows forensic entomologists to calculate the TOC, which can provide information about the time since death.. Understanding how household chemicals on the remains may influence this estimate, and can provide valuable information for the field of forensic entomology. Remains soaked in household chemicals will have a different odor profile, and could result in a delay of insect arrival and slower decomposition rates when compared to control pig carcasses.

Materials and Methods

The experiment was performed at the Entomology Field Observations Building (EFOB) field site in fall 2021, the average temperature was 20.45 ℃. In this study, pig carcasses (mean weight 1330.33 g) were initially placed into 18.93 L buckets that contained 3.79 L of a chemical treatment and submerged for 24 h. The chemical treatments consisted of two household products, bleach (Clorox Germicidal Bleach, Oakland, CA) and fabric softener (Downy, Cincinnati, OH), with the control of distilled water (Ice Mountain, Stamford, CT). After 24 h, pig carcasses were removed from the buckets and were placed on the ground approximately 18.29 meters apart. All pig carcasses were laid on their left side, with the head facing north. Carcasses were protected from vertebrate predators by a cage constructed of hexagonal wire (1.52 m x 0.91 m x 0.61 m) and secured to the ground with metal stakes. Data loggers (HOBO MX2300, Onset Computer Corporation, Bourne, MA) were used to record hourly temperature throughout this experiment.

Data collection occurred every twenty-four hours, with photographs to document decomposition, observations of time to first oviposition event, and new oviposition events, and collection of samples of insects that had colonized the carcasses. Insect samples included adult and juvenile insects; adults were placed into vials with 70% ethanol and preserved for identification. Samples of eggs and larvae were placed into plastic, 1 quart rearing containers, which contained sand that served as a pupation medium. Larvae were provided with beef liver as a food source during their development. All flies that successfully emerged were sorted and identified to species (Jones et al., 2019) and adult beetles were identified (Castner and Byrd, 2000). The Decomposition rates were quantified using Total Body Scores (TBS) provided by Keough et al. (2016).

Results

Phormia regina was the most abundant blow fly that colonized the fabric softener and distilled water treated carcasses, whereas *Lucilia sericata* was the most abundant blow fly that colonized the bleach treated carcasses. Bleach also attracted beetles (Coleoptera: Staphylinidae) which were the most abundant for bleach treated carcasses (Figure 1)..

Faster decomposition rates occurred in the distilled water treated carcasses, which reached a plateau by day 6 when skeletonization occurred. Fabric softener treated carcasses decomposed slower, but plateaued when skeletonization occurred, whereas bleach treated carcasses had the slowest rate of decomposition (Figure 2, Figure 3). Decomposition progress for each treatment is displayed in Figure 3. Time to first oviposition event, which is the time to first observable egg mass on each treatment, is documented in Figure 4. The control carcasses were colonized first, with a slight delay in colonization for the fabric softener treated carcasses (Figure 4). Carcasses treated with bleach took the longest for colonization to occur, with a mean of 188 hours until oviposition (Figure 4).

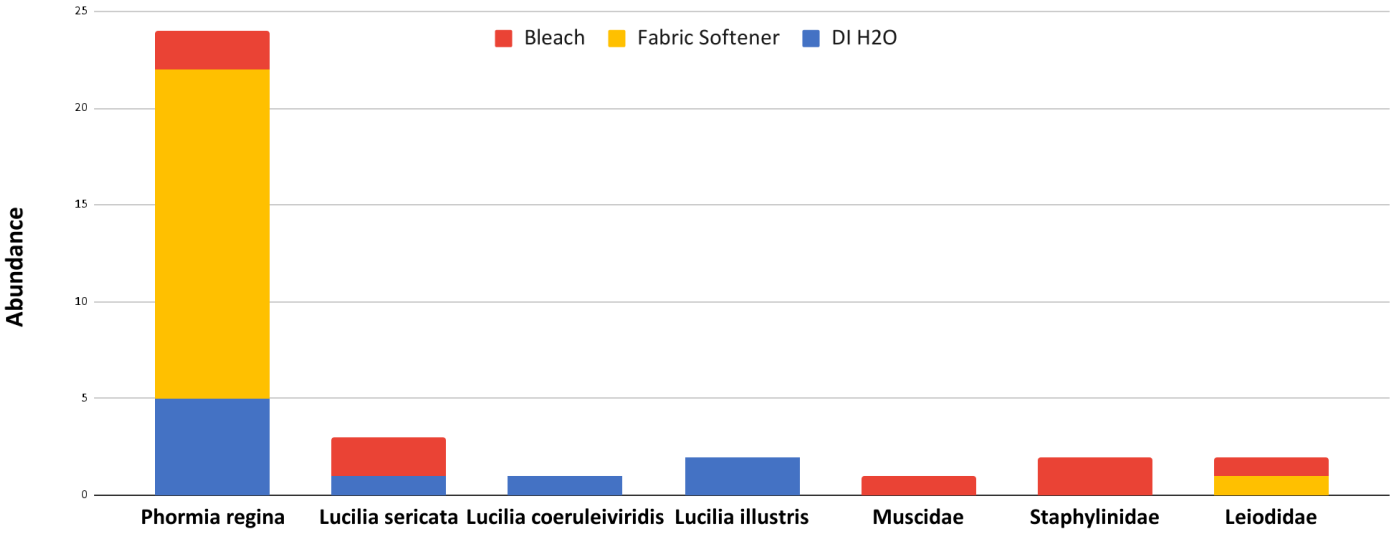

Figure 1. Insect abundance and diversity collected from each treatment, with bleach represented in red, fabric softener in yellow and control (distilled water) in blue.

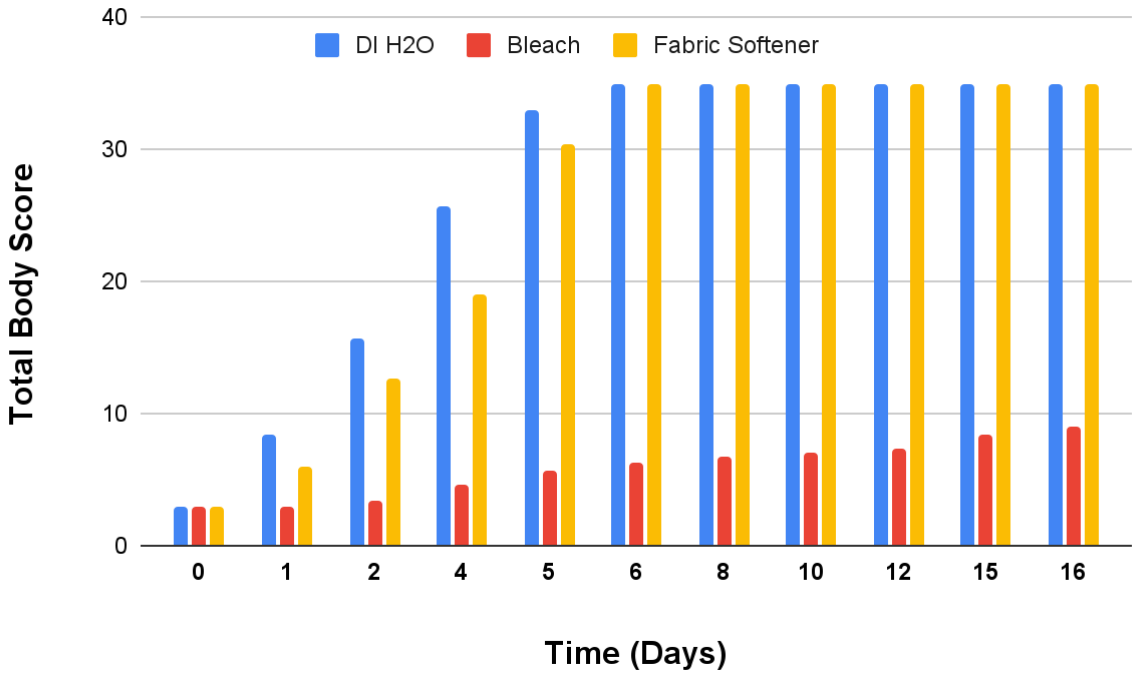

Figure 2. Total body scores of each treatment over the duration of the experiment, bleach represented in red, fabric softener in yellow and control (distilled water) in blue.

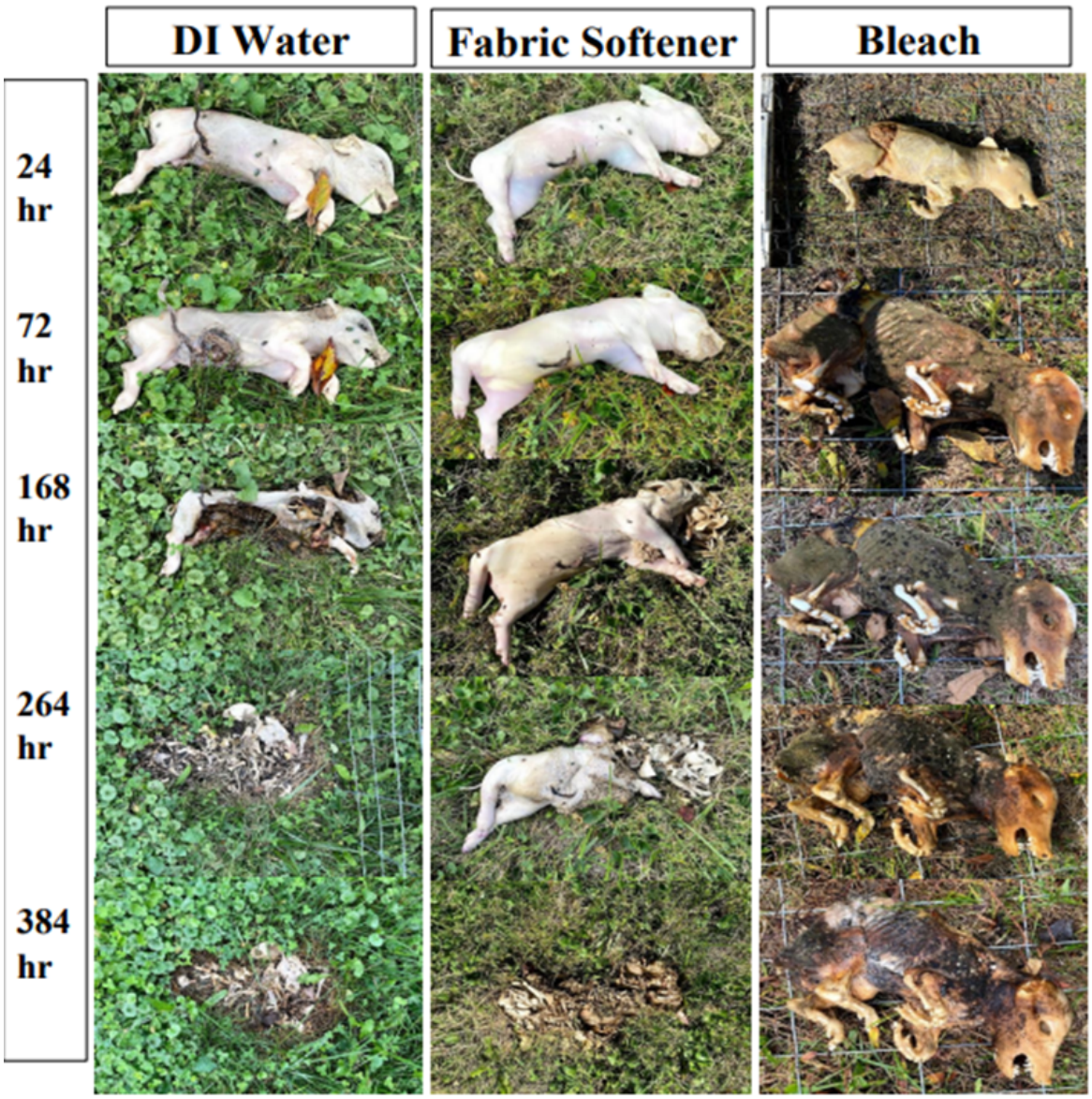

Figure 3. Photos of pig carcasses of each treatment over the duration of the study. Slower decomposition was observed for the bleach treated pigs.

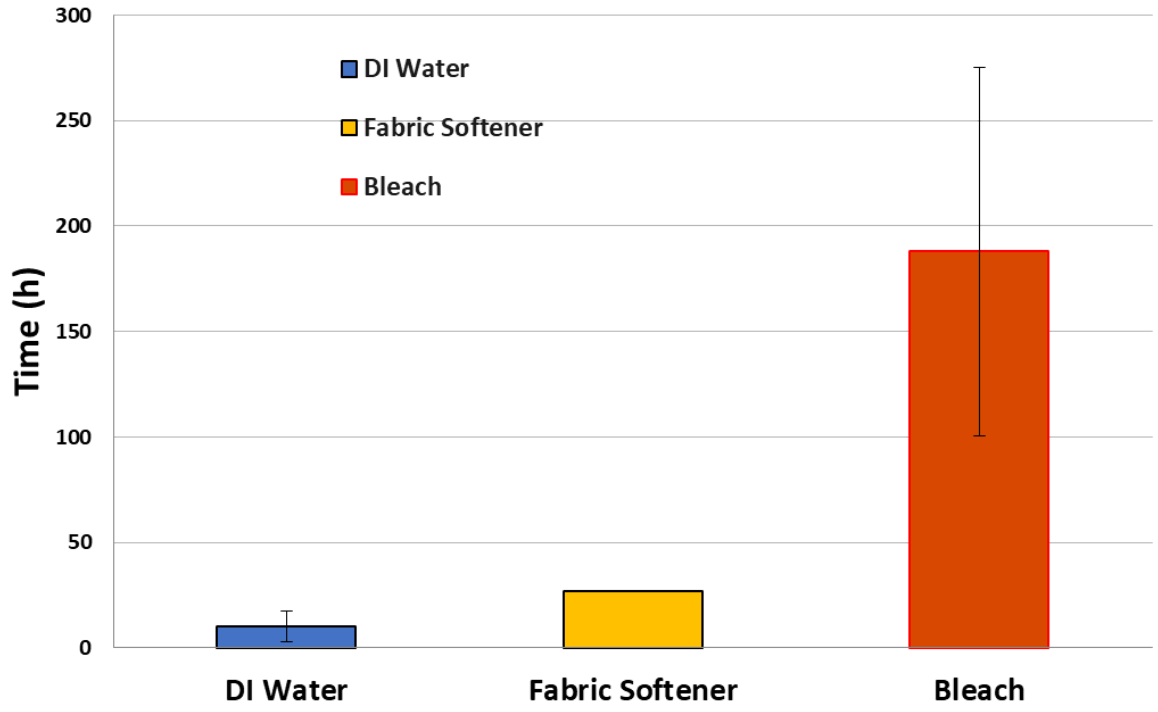

Figure 4. Mean time (hours) to first oviposition event on each treatment, with bleach represented in red, fabric softener in yellow and control (distilled water) in blue.

Discussion

The results from this experiment show us that there was a delay in blow fly activity due to chemical exposure. As predicted, the carcasses that were soaked in bleach had shown the longest delay in blow fly oviposition and decomposition rate.This is because the bleach hardened the pigs skin making it difficult for the maggots to feed on it. The bleach almost mummified the pig bodies, some of the skin and muscle tissue was even deteriorated and the bones were showing. There was also a presence of fungal growth on the pigs soaked in bleach. Some of the maggots may have been killed from feeding on the bleach soaked pigs. This is because the bleach hardened the pigs skin making it difficult for the maggots to feed on it.

Fabric softener showed a slight delay in blow fly oviposition behavior and decomposition compared to the pigs that were soaked in deionized water which were the control pigs. Heavy rain made these pigs make the area around them smell like the fabric softener, which could have deterred the insects. These heavy rains may have changed the results of this study because it removed a lot of the fabric softener from the carcasses. The diptera *Lucilia coeruleiviridis* has a very low survival rate when reared in the lab, so we suspect that the numbers for this species would have been higher if they could have survived.

These findings are important because when forensic entomologists estimate the minimum post-mortem interval (mPMI), time of colonization (ToC), and accumulated degree hours or days (ADH or ADD), they do not take chemicals into consideration. From the findings of this research, it is clear that chemicals do need to be considered because there is a significant delay in blow fly oviposition and decomposition.

These calculations help entomologists determine when the blow flies laid their eggs on the body and how quickly they developed to determine an approximate time of death. Therefore, the results of this study will help to better inform entomologists about the impact of household chemicals. By performing this research, we could get a better understanding of how the chemicals affect the rate of blow fly attraction and that would allow us to create a new calculation to include a delayed response if there are chemicals present.

Future studies could examine carcass exposure to chemicals for a longer period of time or could use different chemicals. Since the bleach treated carcasses had ample fungal growth, another study could determine the fungal community on carcasses. It would also be helpful to conduct this study in different seasons, temperature ranges and precipitation levels.

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