Popular television series such as *CSI* and *Bones* have brought the practice of forensic entomology into the public consciousness. Forensic entomology is the use of insect evidence to aid in criminal investigations. By examining the variety of species and the development stages of insects present on a human body, information on the corpse’s location and time spent outdoors can be determined. In some regards, the accuracy with which a forensic entomologist may determine the time a corpse has spent exposed to insects matches that of the forensic wizardry on display in popular depictions. In particular, fly larvae, more commonly called maggots, undergo several life stages, known as *instars*, which occur after a specific number of *heat-hours*. A forensic entomologist can quickly determine the age of a maggot from just a few key pieces of information: average temperature, species of fly, and instar stage. The age of a maggot found on a body is a minimum time of death. Forensic entomology, therefore, is a powerful tool for law enforcement.

Unfortunately, while entomological information such as instar developmental timetables are quite accurate, there are often additional variables that can make the job of the forensic entomologist more complex. Consulting instar development can at best determine a minimum time of exposure as the individual may have died before insects had access to the body. Even with access to human remains, insects do not colonize immediately. The smell of the putrefying flesh must have time enough to diffuse into the environment and reach the insects. The insects must then travel to the body, often no easy task for a creature only millimeters long. Additionally, there is the complex issue of insect succession. *Succession* in biology refers to the several stages of a developing ecosystem. For example, consider a forest after a devastating fire. Some plant species will recover quickly and attract the first wave of animals to recolonize the forest. Over time, larger plants will grow and provide the structure needed for more animal species. Finally the forest will return to a mature state and feature its full complement of animal and plant species. Each of these steps is a *successional stage*. A body, from an entomological standpoint, represents such a huge new source of nutrients and a variety of habitats for insects that it is an ecosystem unto itself and undergoes successional stages. Rapidly moving flies colonize first, followed by slower moving beetles and other terrestrial insects. As larvae begin to hatch, they attract predators. When the larvae mature, they emerge from the body as a new generation of adult insects, representing a further stage of succession. Tying together all of the above information into a form useable by law enforcement is a daunting task, but methods have been developed to do just that.

When a law enforcement officer or forensic entomologist is faced with the task of indentifying the age of a corpse using entomological data, one of several authoritative manuals on the subject is consulted. These manuals contain information on the makeup of the insect community on bodies based on time of exposure. For example, the manual might explain that maggots of a particular genus appear around 24 hours after exposure, or that a certain predator beetle will be found in high number after 72 hours. These manuals summarize the entomological data rather than forcing the investigator to consider a
multitude of variables. The data in these manuals are not determined by simply theory or conjecture; rather, studies are undertaken in which cadavers are exposed to insect colonization, and the insect community at each time interval is examined, described, and recorded.

Certain basic principles guide the experiments that form the bulk of data in forensic entomology guides. Foremost, there is a tradeoff between maximizing the comprehensiveness of the study and minimizing the disturbance to the study site. Researchers attempt to maximize the comprehensiveness of the study by capturing a large number of insects. The goal is to determine exactly when a species becomes present on a body and how that insect population changes over time. Researchers are more confident they have collected a representative sample as the number of insects collected increases. However, a body left at a crime scene is different than one found in a field study as a body left alone will not have any insects removed from it during its successional development. The removal of insects from a cadaver being studied is a form of disturbance, sometimes referred to as the observer effect. The method of data collection, in this case collecting insects interacts with the subject rather than passively observing it and actually alters the subject’s state. Only by not collecting any insects at all could disturbance be completely avoided. Researchers, therefore, must choose a methodology that achieves some balance between these two extremes.

The traditional method of the forensic entomology researcher involves a caged cadaver and hand or net collecting. The cadaver is placed into the field, and a barrier is erected to keep out large, non-insect scavengers, such as rats or coyotes. At regular timed intervals, researchers collect insects off the body using a variety of tools. Sweep nets are used to capture flying insects, while terrestrial insects or insects on the body are captured using forceps, aspirators (a device that uses the researcher’s intake of breath to create a vacuum and draw insects into a sample container), or even by hand.

An alternative to the traditional cage method is the Schoenly trap. A Schoenly trap allows for greater numbers of insects to be collected than the traditional cage method.

BACKGROUND

The Schoenly trap first appeared in publication in Schoenly, 1981. The Schoenly trap was designed to capture both outgoing and incoming insects to and from a baited location. This novel trapping method was able to capture both of these insect groups.

Since its initial publication, the Schoenly trap has been used by many other forensic entomologists. In Portugal, for example, a series of experiments by Prado e Castro (2010, 2011) used the Schoenly trap to greatly increase the knowledge of forensically-important insects for Portuguese researchers and law enforcement.

An analysis of the usefulness of the Schoenly trap in collecting insects was undertaken by Ordóñez, 2008. Ordóñez compared the Schoenly trap to traditional cage methods. Traditional cage methods involve the placement of insect bait, usually a pig carcass, inside of a wire cage to prevent disturbance of the carcass by non-insect scavengers. Insects are collected from the carcass either by hand or with a net. Ordóñez concluded that the Schoenly trap was more effective than these traditional methods for forensic entomology studies.

PURPOSE

While the effectiveness of the Schoenly trap versus traditional cage methods has
been established by prior research, there are still possible improvements to be made. Schoenly traps feature underground collecting devices to capture incoming insects (these devices are referred to as baffles in this paper). However, no attempt has been made so far to analyze how the presence of these baffles affects the results of an entomological study using a Schoenly trap. Therefore, this experiment will examine the differences between Schoenly traps with no baffles, two baffles, or four baffles. From the information gathered during this study, the most effective form of the Schoenly trap can be determined.

**PREPARATION**

An unused plot on the west side of the CSUS campus was selected to be the study site, and a 90 by 120 m area was cordoned off (Picture 1). Twelve points inside the study site in a three by four grid were selected to be the location of the traps and cages. The trap and cage locations were chosen to maximize distance between each trap to prevent contamination. This contamination would be insects feeding at one trap, then escaping and feeding at another trap. A backhoe was used to break up the soil at each location to house a trap or cage.

The Schoenly traps were constructed according to the specifications of Prado e Castro, 2009 (Picture 2). Several features should be noted (Picture 3). On top of each trap was installed a u-bend pipe leading to a collection jar. This top pipe also featured a small hole to allow a rope to reach into the central chamber and attached to the carcass cradle. This rope would allow researchers to weigh the carcass without opening the trap.

Of the twelve sides of each trap, four allowed access by insects into the central chamber with the carcass. Four of the sides featured exits that lead into collecting jars. Of the remaining four sides, either zero, two, or four featured interior immigrant collection jars. These interior collection jars were accessible to researchers via PVC pipe “baffles” that extended from under the trap to ground level (the bottom plane of the trap). These baffles are the novel addition to the standard construction that this experiment was designed to study.

Both the top and bottom of the structure allowed some exchange between the interior of the trap and the outside environment. The top “pyramidal” portion of the trap was made of a permeable screen, which allowed sunlight and air into the trap while preventing the loss of insects. The bottom of the trap featured a wire screen that allowed a soil-carcass interface to form. In a natural environment, the carcass would likely have contact with the ground, so soil contact is allowed to take place to ensure a decomposition process that is as natural as possible.

The cages for the traditional treatment were also constructed by the researchers (Picture 4). (In scientific research, a treatment is an independent variable that is manipulated by the researcher. The cages, and each version of the Schoenly trap, with zero, two and four baffles, are treatments in this study.) A chicken wire mesh was used to form five sides of a rectangular cube. Rebar poles were used to stabilize the cage, and the mesh fastened down with stakes and rubber straps.

A weighing tripod was constructed to allow measurement of the mass of the pig carcasses (Picture 5). The tripod could be used to attach an electronic scale. A rope would be attached to the carcass cradle and lifted to the electronic scale to allow weighing.

Four temperature and moisture data collectors were also installed at the study site (Picture 6). One data collector was placed out in the open in the center of the study site to allow monitoring of the ambient environment. One additional data
collector was placed in a trap of each of the three treatments (no baffles, two baffles, and four baffles). These will allow the researchers to examine the effect of the baffle treatments on the environment inside the Schoenly trap.

After construction and installation of the traps and cages, the study site was left alone for one week to settle. At this time, the collection jars were not filled with collecting fluid. This period of time ensures that the normal insect population returns to the study site after being disturbed by the installation process.

After the traps and cages were allowed to settle, the collection jars were “armed.” A mixture of water, ethylene glycol, and detergent was placed into each collection jar. This liquid, Morrill’s solution (Morrill 1975), is used to kill the insects that fall into the collecting jars.

The armed traps were allowed to collect insects for one week without pig carcasses. The insects collected during this time form the background fauna. The background fauna are the insects that wandered into the trap accidentally and were not attracted by the pig carcass. By establishing what species of insects make up the background fauna, these species can be ignored when determining which species were attracted to the pig carcass during the study.

After collecting background fauna, twelve pig carcasses were obtained and installed into the traps and cages (Picture 7). The pigs were obtained from a local vendor and treated in accordance with the CSU Stanislaus animal welfare regulations (CSU Stanislaus Policy, 2011). Each pig had a starting weight of 10-13 kg. The carcasses were placed into wire “carcass cradles.” These cradles allowed the pigs to be lifted up and weighed during the study. Finally, the pigs were placed inside each trap or cage. In the case of traps, the top portion was securely attached and not opened again until the conclusion of the study.

**METHODOLOGY**

Each day of the study, the pig carcasses in each cage and trap were weighed. A cage would be opened and the weighing tripod placed over the carcass. The rope attached to the cradle under the carcass would be lifted and attached to the scale and a weight recorded. In the case of pig bodies in traps, the rope would be lifted through the top hole to avoid opening the traps and allowing insects to escape.

Collection vessels would be prepared each day for each trap and cage. Each vessel would be labeled with the day of the study, the unique trap or cage identification, whether the insects were immigrating or emigrating in the case of traps, or whether the insects were collected by hand or by sweep net in the case of cages.

Insect specimens from Schoenly traps were gathered from two types of sites: the five outgoing emigrant traps found on each trap, and the two or four underground immigrant traps found under treatments with baffles (Picture 8). Emigrant and immigrant insects would be collected from these sites and placed into separate collection vessels.

Insect specimens from traditional cages were collected both by hand and by sweep netting (Picture 9). In either case, one researcher would undertake collection for one minute, attempting to capture as many individuals as possible. A one-minute interval without collection would then occur, to allow disturbed insects to return to the carcass. A second minute of collection would then be undertaken, and this process continued until five minutes of both sweep netting and hand collection had occurred.

**Preliminary Data and Analysis**

The weight of the pig carcass in each trap was measured daily. The average carcass
mass for each treatment is summarized below in Graph 1. From this preliminary data, several observations are possible. The graph of average carcass mass for each treatment can roughly be divided into two major stages: a stage of exponential loss of mass, from day 2 to about day 15, to a static area of almost no change in mass, from about day 15 to day 30. There are differences between the three treatments of Schoenly traps. However, more statistical analysis is necessary to determine if the variation in mass loss is significant or within normal random variance.

The loss of mass for the cages was initially more rapid than the loss of mass for the Schoenly traps; however, the final total weight for the traps was ultimately lower than the weight of the caged carcasses. A hypothesis can be ventured for these results. The caged carcasses were more exposed to the elements, while the carcasses in traps were more insulated. The rapid initial weight loss seen in the caged pigs could be due to an initial loss of moisture from the carcass, while the trapped pigs retained more of that moisture longer. This is only speculative, however; further analysis is required to determine a cause conclusively.

Some of that further analysis will include the examination of the temperature and moisture data collectors placed outside the traps and within one of each trap treatment. The information collected from these data collectors will reveal if the traps did in fact retain more moisture than the exposed carcasses in the cages. In addition, differences in temperature and moisture can be compared between the three treatments of traps. It remains to be determined if statistically meaningful differences in temperature and moisture will be found in the different trap treatments. If such differences are found, it will be possible to examine them for correlation with weight loss rates.

The last variable to be examined is the diversity of insects collected by the traps. Insect diversity is a measure of the number of difference species found. Each collection vessel will be examined and the insects collected will be identified. Results from the
traps are expected to include much higher insect diversity than traditional collecting methods based on prior literature. However, it is unknown whether different trap treatments will have an effect on insect diversity collected. In addition, insect succession may have been affected by different trap treatments, with certain insect species appearing sooner or later in the time table depending on the treatment used on the trap. It is the subject of insect diversity in the collected samples where the most work remains in analyzing and interpreting the data from this project.
Picture 2. The Schoenly Trap.
Picture 3. Completed Trap.

Picture 4. Traditional Cage.
Picture 5. Weighing Tripod.

Picture 6. Interior Temperature/Moisture Data Collector.
Picture 7. Pig Carcass Inside Schoenley Trap.

Picture 8. Collecting Jars from Baffles.

Works Cited


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