FORENSIC ENTOMOLOGY: BEST PRACTICES

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INTRODUCTION

Forensic entomology is the discipline of using insect evidence to answer questions of interest to the legal system. Primarily it is used in cases of decomposition following human death under mysterious or suspicious circumstances. During these situations, examination of insect adults, immature stages, and trace remains by a qualified entomologist are primarily used to estimate the time between death and body discovery, or *postmortem interval* (PMI). Less often, the evidence is used to determine body movement postmortem.

During decomposition of animal tissue (including humans), various volatile chemicals are released from a body almost immediately after death. A suite of insects are adapted to follow the scent of these chemicals to find the decomposing tissue. Some of the insects lay eggs on the tissue as a means of providing food for their offspring, some arrive at the tissue to feed directly on the putrid remains, and others come specifically to hunt the insects initially attracted.

The most commonly encountered and important insect to the forensic entomologist is the blow fly. These flies constitute the entomological group called the Calliphoridae (kal-i-for'-i-dee). Many of these flies are known as bottle flies because their bodies are a metallic shining blue or green. We have all encountered them when we observed road kill on the side of a road and a cloud of flies buzzed above the carcass. The sense of smell of these creatures is such that they can detect human death within minutes or just a couple hours following death. Being rather rapid responders to decomposing tissue, the winged adult fly will follow the scent to the decomposing animal. Humans decompose the same way as all animals do, and flies do

not discriminate about what kind of dead animal they are attracted to. The flies are there to quickly lay their eggs as the blow fly larvae, or maggots, will quickly hatch and feed on the body. When full grown, the larvae will transform into immobile pupae, which after a given period of time will produce a new adult fly.

The significance of insects on bodies is two-fold. First, the crime scene investigation that yields insects on a decedent should engage an entomologist who can examine the insects and estimate the PMI. This method provides one of the most accurate and useful methods with which to determine how long a body was *in situ* (in position) prior to discovery. The second point is that insects are often restricted in their range or habitat preference. In some cases, analysis of the suite of insects on a body can yield clues to where a victim died if the death scene is not the same as the site of body discovery.

This chapter will give details on 1) The insects that are frequently recovered from bodies, 2) The significance of the blow fly life cycle, 3) PMI estimation, 4) techniques for collecting insects at a crime scene or at the morgue, 5) innovations, and 6) some related issues for consideration by law enforcement.

INSECTS FOUND ON BODIES

The two most commonly encountered types of insects found on bodies are flies and beetles. Other types of insects and related animals (wasps, pill bugs, earthworms, etc.) should still be collected, but the focus of the entomologist's attention will be to the flies and beetles.

FLIES

Many of the flies found around a body generally resemble and behave much like the common house fly we are all exposed to. They can be black, gray, or metallic blue or green. All are very fast flying and can pose a challenge to collect. Many references exist that delve into great detail on the large number of flies, so this document will focus on the most commonly encountered and, arguably, the most important to the forensic entomologist.

Blow flies

Blow flies move to bodies to deposit eggs by day and tend to be inactive at night. The blow fly life cycle is given in Figure 1.

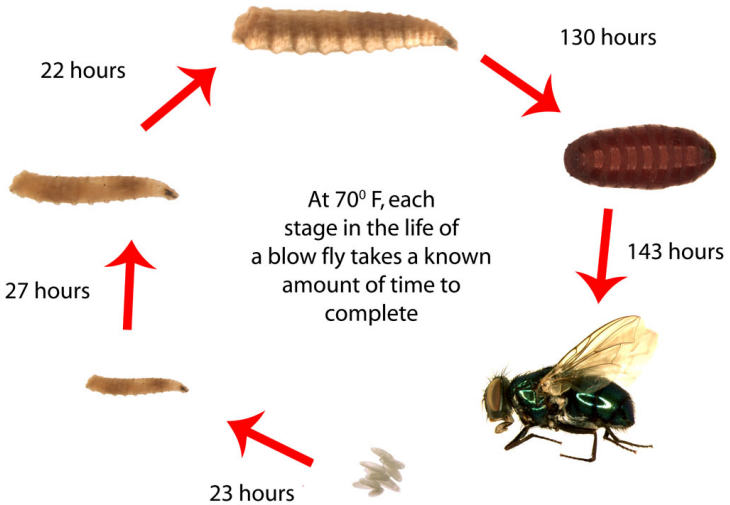

Figure 1. The blow fly life cycle, adapted from Greenberg 1990. This graphic specific to the black blow fly, *Phormia regina*.

Upon arrival at a body, the female fly will begin to search for an appropriate place to lay her eggs, and often does so very quickly. One female lays upwards of 200 eggs and multiple females may cluster their eggs into egg masses, visible to the naked eye.

Insect growth and development is temperature dependent. The warmer it is, the faster they grow. Figure 1 gives data for each stage in the black blow fly life cycle at approximately room temperature. The values given would increase as temperatures cool and decrease as temperatures warm.

After eggs hatch, maggots begin to feed and grow. The maggots grow via 3 static stages of development, simply labeled first, second, and third. Sizes are about 1/8", ¼", and ½", respectively, but size can be variable among different kinds (that is, different species) of blow fly.

Upon reaching the third stage maggot, feeding continues for about a day, and generally a maggot will move off a body to find a safe place to form the immobile pupa. The pupa is the transitional form between the maggot and the winged adult.

Search for eggs and maggots primarily around the head (eyes, ears, nose, mouth), genitals and anus, and open wounds. These are areas where female flies deposit their eggs. Pupae can be found around the body in folds of clothing, under the body, or one to 30 feet from a body about a ½" into the soil. A small shovel is helpful for finding pupae in soil.

Other kinds of flies

Flesh flies, house flies, soldier flies, cheese-skipper flies, and others can be present on a body. None appear to arrive as quickly as blow flies. While collecting maggots and other life stages, you may encounter maggots that look different and that is OK. Give them to the entomologist.

maggo al for t gator to encour s of fly on one body. All can be useful.

BEETLES

A variety of beetles can be present. They tend to arrive at different times. For the sake of simplicity, be prepared to encounter beetles at any stage of decomposition. Whether the body is fresh, decomposing, in a stage of advanced decay, or drying, different kinds of beetles ranging from 1/8” to over an inch long may be encountered. Different species find bodies suitable at different stages of decay, and can offer clues to how long a body has been present. A few examples are given in Figure 2.

Figure 2. A carpet beetle (typically found on dry remains, about 1/8” long), a rove beetle with different species found at different stages of decay (about ¼” to over an inch long), and a carrion beetle, typically found during active decay (about an inch long).

Beetles may breed at decomposing bodies, and the larvae or pupae can be of use. Larvae look like fast moving caterpillars. They should be collected too.

BASIC APPLICATION

Photography

Death scenes are typically photographed. Close up photographs of body openings and wounds can be helpful to the entomologist. In some cold cases, photographs of insects not originally noted at crime scenes have been useful. However, photographs should not be used as a substitute for actual collections of insects.

Collecting insects

Kits are available from a number of online suppliers. These will have everything you need. However, in the absence of a prefabricated kit, the following equipment will be helpful.

1. Forceps (tweezers), or if enough maggots are available use a spoon.
2. Jars, or plastic Ziploc style containers.
3. Paper towels and rubber gloves.
4. Preservative
    - 70% ethanol is best (just dilute with tap water)
    - Isopropyl (rubbing) alcohol is OK
    - 80 proof liquor (bourbon, vodka, gin etc.) will do in a pinch (short term storage)
5. An insect net with fine mesh.
6. Sharpie magic marker to label where/when collection was made.
7. Photos are helpful.
8. Thermometer
    - Take air temp near body (record time of day).
    - Take temp of any maggot mass (stick thermometer in the maggot mass at least 2 inches).
    - Take another air temp before you leave the scene (record time of day).
9. Small shovel or trowel
    - When mature, maggots move off a corpse into the surrounding soil.

- Dig some soil about 3-10 feet from the body and place in a jar. Do this in 4 spots around body, with each shovel-full of dirt in a new jar.

10. Cooler for transport
    - DO NOT LOAD WITH ICE
    - A freezer pack is OK
    - No need to worry if transported in an air conditioned vehicle.

After photography, take notes of the scene. Is the body in sun, shade, or both? Remember, temperature is important to understanding how old insects are and therefore critical to determining the PMI. Is the scene rural or urban? Any notes describing the scene could be helpful. Note time of day observations are made.

Make readings of the air temperature over the body, in shade nearby, and by inserting the thermometer an inch into the ground if possible. These three readings can help determine the environment the maggots and other insects grew in. Also, if a mass of maggots is on the body, stick the thermometer an inch into the maggot mass. Their metabolism can increase the temperature of their environment by as much as 20 degrees. Again, record the date and time your observations are made.

Use your insect net to quickly sweep flying insects that are around the body (primarily flies). Remember, there are possibly lots of different kinds of insects around a body and the entomologist can use all the help he/she can get in identifying them, and the adult flies will help immensely! Swing your net in a figure 8 pattern above the body. It may take several attempts to be successful. If you scare the flies away, they will come back. Shake your insects down into the net and close off the net by grabbing it with your hand. Try to shake them down into a container of alcohol. Don't get frustrated!

Use the alcohol and containers to store insects captured. Scoop up maggots with the forceps or with a spoon and drop directly into the preservative. Maggots can be

numerous, but 100 or so will do. Beetles can be captured with forceps or with a gloved hand. Try to get a representative of all insect types you observe if possible. For maggots, be sure to get the largest ones (as well as other sizes) as they will be the oldest and presumably will have hatched from the first eggs laid on the body.

Search the soil nearby or under the body for any pupae. Place them in preservative as well. Keep all your collections from the body, under the body, and from surrounding soil in separate jars or containers.

Lastly, make a second collection of maggots and pupae, but this time keep them alive in containers with some moist (not dripping wet) paper towels. There is no need to feed any of these live collections if you can get the specimens to an entomologist quickly. Don't let any of the live specimens overheat in the sun.

COMMON ISSUES

Many references with "how to" sections exist (see references below). What is presented in this chapter represent the basic techniques. This entomologist recognizes the many responsibilities law enforcement has at a crime scene. Described above are the basic techniques that will get the job done without the process of obtaining entomological evidence becoming onerous.

As you browse other references, note that many include more detailed and involved techniques for collecting insects. It is OK to augment what is described here with what is learned from other references, workshops, and from simple experience.

Maggots are notoriously difficult to identify. It is important for the entomologist to know exactly what kind of maggot is collected. The development rate for each species is different. In some cases, only a general PMI estimation can be given if only preserved

maggots are provided. While still very useful, PMI estimates made from maggots where identification is fully known are best. The entomologist will take the living material you provide and feed them to obtain adult flies. These are much easier to identify than maggots and help confirms the conclusions drawn. Try your best to provide both live and preserved materials!

If an entomologist is available to visit the crime scene, invite one to visit. The professional can do the work more quickly and more efficiently because of their experience. However, in the end, never hesitate to try your hand at collecting flies, beetles, and other insects!

INNOVATIONS

Work has been done since the 1980s to obtain new information than just PMI or body movement data. One avenue in particular allows researchers to detect the presence of narcotics in maggot tissue. This even applies to the pupal skin left behind after a fly is liberated. Pupal skins are durable and can be found months or even years later. In one case where only skeletal remains of a decedent were present, pupal skins were examined to confirm the presence of narcotics.

Insect evidence can also be leveraged during investigations that do not involve bodies. Marijuana is a plant that is susceptible to consumption by herbivorous insects. Insects and insect remains found in shipments of marijuana have been supplied to entomologists who were then able to give information on the origin of the shipment. Remember, many insects have very restricted ranges and are not universally found across a state, country or continent.

In some instances, the same insects associated with dead bodies are found in cases of elder neglect and abuse. One situation found insects around the trach insertion of an invalid. A lawsuit subsequently occurred, with entomologists giving input on the origins of the insects. Did the patient become colonized while under the care of a particular facility, or did blow flies lay eggs around the trach insertion during ambulance transfer between facilities? Investigators should be prepared to understand the insect life cycle when investigating such cases.

SUMMARY

Insects on bodies can provide important information on the PMI, and also occasionally help determine if a body was found where the victim actually died. Cases include homicide, suicide, and accidental death. Investigators should be prepared to collect insects at death scenes by having a prefabricated kit or at least some basic supplies on hand. As important as the specimens collected are, temperature and habitat data as well as photographs of the victim and scene can be invaluable, even in cold cases.

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