Bugs Don’t Lie!

The first ever-recorded case involving forensic entomology is described in a book titled *His Yuan Lu*, which means “The Washing Away of Wrongs”. The Chinese book describes a murder investigation in a rice paddy involving workers. To solve the case, the investigator had the workers line up and lay down their sickles on the ground and observed the blowflies landing on the murderer’s sickle. (Blowflies are attracted to the smallest traces of the scent of blood.) The criminal was caught in this way – using entomology.

Forensic entomology is the study of arthropods, including insects, arachnids, centipedes, millipedes and crustaceans for criminal or legal purposes. This concentration of study can be divided into three topics, urban entomology, stored products entomology, and medicolegal entomology. By examining insects’ lifecycles, a forensic entomologist can determine the PMI, or postmortem interval. Insects contribute to more than the PMI, they also help investigators determine if the body has been moved, in cases where there is no body at all, and when the body is present. Insects are fascinating organisms and are found in nearly every habitat. For this reason, flies in particular play a major role in “recycling” the remains of living organisms. Because insects develop in particular patterns, a forensic entomologist can work backwards after collecting insect specimens and stages to determine the time interval at which the person died. Insects are often ignored as evidence and treated as a nuisance; but they could be the best resource in solving the case.

The lifecycle of insects is important knowledge for a forensic entomologist. As an insect grows, it passes through a series of maturation phases, and with each phase its appearance may drastically change. Holometabolous (complete) metamorphosis is one of three types of metamorphosis among organisms. This type of development is the most complex form and is how a common fly, a blow fly for example, metamorphizes. It begins by an adult depositing an egg (oviposition) onto the food source in moisture rich areas (mouth, nose, eyes, or open wounds). Egg laying typically occurs during the day, so if death occurs during the night, the egg laying will be delayed. One blowfly can lay hundreds of eggs in a short amount of time.

The larvae start eating, or hatch and then start eating immediately; increasing in size by molting through three instars. (Each instar larvae will appear darker in color as it’s up-taking food.) Upon completion of the instars, the larvae (maggots) transition to an inactive phase called the pupal stage. The pupa is a hardened outer shell (for protection) that is darker in color than the larvae. Typically these are found underground and a forensic entomologist will dig to find them. Below is a timeline of instar development under moderate dry conditions.

- **1st Instar**: Oviposition to about 8 hours
- **2nd Instar**: Forms around 20 hours later
- **3rd Instar**: 20 Hours after the 2nd instar

**After about 5 days, the larvae stop feeding and rest. After a few more days, the larva become pupa. The adult fly emerges about 3 weeks after the eggs.**

**Remember, climate conditions vary each case.**

Forensic Science
~Forensic Entomology
It may seem that the time it takes from egg to adult could be calculated and used on every crime scene case. However, many factors are involved when dealing with necrophilious (“dead loving”) including temperature, humidity, land, water, soil, etc.

Each of the conditions mentioned will influence the timing of the instars and stages of a fly’s lifecycle. Research has shown that necrophilious insects are very sensitive to even the slightest changes in a dead body and can detect the initial decomposition of a body within minutes of death, up to a couple miles away.

When a body decomposes, it begins to break down almost immediately. Visibly from the outside, it may not seem so. Bacteria in the body, and outside the body carry out much of the decomposition. There are four types of visitors that may arrive at a body which aid in the decaying process. Necrophages are insects that actually feed on the tissue of the corpse (Ex: flies). Forensic entomologists study the life cycles of these organisms to investigate the PMI. Omnivores feed not only on the body but also the other insects that at the corpse (Ex: wasps and beetles). Keep in mind that if many omnivores are present, they may have diminished the amount of necrophages, thus slowing the decomposition process. Predators and parasites act on other insects. Some may start out as necrophages and then become predators of other insects at later stages (Ex: some flies and mites). Finally, incidental organisms such as spiders and centipedes use the corpse as part of their normal habitat.

The number, type and distribution of insects at the site of a corpse will vary by the environmental conditions, time since death, location, geography, and other variables. It is important that a forensic entomologist visually observes the scene before collecting specimens. He/she will record notes, approximately the number and kinds of insects, identify the major locations of insect infestations, noting immature stages, documenting the exact location of the body, and record any trauma to the body that is visible. The forensic entomologist will also need the climatological data from the scene; the ambient (air) temperature, ambient humidity, ground surface temperature, below surface temperature, below-body surface temperatures, and maggot-mass temperatures. The forensic entomologist will also want to record the temperature of the sub-soil once the body is removed. All of the climatological information is critically important for calculating the PMI, since insects feed and mature at different rates for different conditions. No two entomological cases are the same!

Necrophilius insects, particularly flies, are attracted to dark moist areas. Thus, it is expected that on fresh bodies the nostrils, mouth and eyes will likely be very infested. Any open wounds will also be infested, which can help investigators. The pattern of the ovipositing should be noted with drawings for a precise conclusion. The forensic entomologist will collect specimens from the scene to take some back to the lab for examination. Collection can be done in various ways from using forceps for the instar larvae to a collection net for adult flies. It is important not only to collect a representative sample size, but also different sizes of the larvae in various stages. A forensic entomologist will place the some of the collected larvae, if present, on some liver to feed them and raise them to ensure they grow to adult like the collected adult fly. Other larvae are preserved in small vials of ETOH.
Buried or enclosed remains present another obstacle for forensic entomologists because the access to the body is limited. Fewer bacteria inhabit the body because the body is kept at a more constant temperature when buried. Each of these factors plays a role in determining the PMI.

Being able to provide the PMI is the forensic entomologists goal. If the victim is unidentified, it may limit the potential number of missing persons. It also may limit the number of suspects in question. The PMI sets a minimum and maximum time since death based on evidence collection. The maximum limit is set by the insects present on and around the body at the time of collection. Weather conditions are taken into account when setting the maximum time since death. The minimum PMI is estimated by the developing insects and the time needed for them to grow to adulthood. A baseline reference is utilized in many cases with experimental samples (pigs) to repeat their research for accuracy.

So, how exactly do the bugs determine the PMI? The faunal succession on carrion is directly linked to the body’s decay. After death, the body temperature falls to that of the ambient temperature, and cellular breakdown beings resulting in the release of gases (NH₃, H₂S, CO₂, N₂). Putrefaction follows as a result of the activity of microbes, especially those found in the intestines. The chemical and biological factors up until this point tend to be the most accurate determination of the time of the death. Necrophagous insects appear almost immediately as the cellular breakdown begins; some flies appear within minutes! Collection, preservation and raising of the larvae then help determine the maximum and minimum time of death.

*Forensic anthropologists generally identify five stages of decomposition of a body. The stages are listed below.*

**Fresh (1-2 days):** adult blow flies, flesh flies, and yellow jackets  
**Bloated (2-6 days):** blowflies, and other flies, some beetles and yellow jackets  
**Decay (5-11 days):** some flies and beetles, and cockroaches  
- Once the body has completed the stages above, the maggots leave the body and the decomposition fluids have mostly seeped away.  
**Postdecay (10-24 days):** fruitflies, gnats and some beetles and flies  
**Dry Stage (24+ days):** ants, flies, and some beetles

In some cases, no data is present, thus the forensic entomologist must experiment. The conditions in which the body is found must be replicated to those of the crime scene.
One of the most influential factors when determining the PMI is temperature. A body found in the shade versus an open field will yield very different results. A maggot is an “eating machine”, with a very high metabolism. When the maggots are eating and moving around the temperature can greatly increase. This is called the maggot mass effect. The temperature of the center of the maggot mass effect at an experimentation site that I visited was $107.6^\circ F$; in the meantime, the ambient temperature was about $87^\circ F$.

Surprisingly, insects can also be used in determining poison cases, and drug use of a corpse. Because the insects ingest the body, they also intake the poisons or drugs which then can be analyzed. In a case that Dr. Richard Merritt (chair of the Department of Entomology at Michigan State University) worked on, the maggots were supermaggots, very large in size. This caused the entomologists to estimate the PMI to be much longer than that it actually was. In reality, the victim died of a cocaine overdose, and the maggots ingested some of the cocaine. This stimulant caused the maggots’ metabolism to speed up resulting in their feeding frenzy growing to abnormal sizes.

Insects also live in certain habitats, and some are geographically specific. For example, insects found on the grill of a car can be analyzed which can prove that the suspect in a case was indeed in California, when he/she said they went to Michigan. It’s amazing what evidence can be uncovered from bugs….and they don’t lie!

http://www.kathyreichs.com/images/blowflydev.jpg