Forensic Entomology

**Definition:** Forensic Entomology is the application of the study of insects and other arthropods to legal issues. It is divided into three areas: 1) urban, 2) stored products, and 3) medico-legal. It is the medico-legal area that receives the most attention (and is the most interesting).

In the medico-legal field insects have been used to 1) locate bodies or body parts, 2) estimate the time of death or postmortem interval (PMI), 3) determine the cause of death, 4) determine whether the body has been moved after death, 5) identify a criminal suspect, and 6) identify the geographic origin of contraband.

In this lecture we will discuss the kind of entomological data collected in forensic cases and how these data are used as evidence in criminal proceedings. Case studies will be used to illustrate the use of entomological data.
Evidence Used in Forensic Entomology

• **Presence of suspicious insects in the environment or on a criminal suspect.** Adults of carrion-feeding insects are usually found in a restricted set of habitats: 1) around adult feeding sites (i.e., flowers), or 2) around oviposition sites (i.e., carrion). Insects, insect body parts or insect bites on criminal suspects can be used to place them at scene of a crime or elsewhere.

• **Developmental stages of insects at crime scene.** Detailed information on the developmental stages of insects on a corpse can be used to estimate the time of colonization.

• **Succession of insect species at the crime scene.** Different insect species arrive at corpses at different times in the decompositional process. Blowflies and flesh flies usually arrive first, followed by staphylinid beetles, followed by hesterid beetles, etc. However successional sequence is strongly affected by environmental conditions, including biogeographic region, season, placement of the corpse (e.g., sun vs. shade), and exposure of the corpse (covered vs. uncovered). Even a light covering of vegetation can prevent oviposition by blowflies, for example.

• **Environmental data:** 1) habitat (vegetation type, open or closed canopy), 2) time of day, 3) temperatures (ambient, substrate, body, centralized mass of larvae), 4) relative humidity.
Major Players in Forensic Entomology

Flies - Order Diptera

Most flies arrive early and feed on the flesh of the cadaver.

The blow fly life cycle has six parts: the egg, three larval stages, the pupa, and adult.

Blowflies - Family Calliphoridae

Flesh flies
Family Sarcophagidae

Cheese flies
Family Piophilidae

At 70 degrees F, each stage in a blow fly's life takes a known amount of time to complete...
Major Players in Forensic Entomology

Beetles - Order Coleoptera

Beetles typically arrive after the flies. The earliest arriving beetles (rove and carrion beetles) are predators and feed on fly larvae and pupae. Late arriving beetles (hide beetles) feed in the dried flesh of the cadaver.
Quantitative Entomological Data

Rate of insect development varies with temperature. Knowledge of temperature at the crime scene can be used to predict rate of insect development and time of death.

Development rate of *Lucilia sericata* (in hours) at three different temperatures

<table>
<thead>
<tr>
<th>Temp(°C)</th>
<th>Egg</th>
<th>Larva 1st Instar</th>
<th>Larva 2nd Instar</th>
<th>Larva 3rd Instar</th>
<th>Pre-pupa</th>
<th>Pupa</th>
<th>Total time (days)</th>
</tr>
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<tr>
<td>16</td>
<td>41</td>
<td>53</td>
<td>42</td>
<td>98</td>
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<td>27</td>
<td>18</td>
<td>20</td>
<td>12</td>
<td>40</td>
<td>90</td>
<td>168</td>
<td>14</td>
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</tbody>
</table>
Rates of insect development varies among species. Knowledge of species identities at the crime scene can be used to predict rate of insect development and time of death.

### Development times of particular fly species - in hours

<table>
<thead>
<tr>
<th>Temp (21°C)</th>
<th>Egg</th>
<th>Larva 1st Instar</th>
<th>Larva 2nd Instar</th>
<th>Larva 3rd Instar</th>
<th>Prepupa</th>
<th>Pupa</th>
<th>Total time (days)</th>
</tr>
</thead>
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<tr>
<td>Lucilia sericata</td>
<td>21</td>
<td>31</td>
<td>26</td>
<td>50</td>
<td>118</td>
<td>240</td>
<td>20</td>
</tr>
<tr>
<td>Lucilia cuprina</td>
<td>26</td>
<td>33*</td>
<td>33*</td>
<td>24</td>
<td>114</td>
<td>324</td>
<td>23</td>
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<tr>
<td>Calliphora stygia</td>
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<td>48</td>
<td>24</td>
<td>48</td>
<td>96</td>
<td>324</td>
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<tr>
<td>Calliphora augur</td>
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<td>24</td>
<td>60</td>
<td>96</td>
<td>336</td>
<td>23</td>
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<tr>
<td>Chrysomya rufifacies</td>
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<td>36</td>
<td>36</td>
<td>72?</td>
<td>72?</td>
<td>168</td>
<td>17**</td>
</tr>
<tr>
<td>Hydrotaea rostrata</td>
<td>48*</td>
<td>60*</td>
<td>60*</td>
<td>36*</td>
<td>144</td>
<td>324</td>
<td>28</td>
</tr>
</tbody>
</table>
Quantitative Entomological Data

• Presence and absence of entomological material on corpses have been used as evidence for many years.

• Quantitative studies of insect development and species succession on corpses is relatively recent (last 35 years).

• Quantitative studies were first started at The Body Farm in Knoxville, Tennessee.
The Body Farm
Finding Bodies or Body Parts

- Large aggregations of carrion-feeding adult insects such as blowflies, flesh flies, blue bottle flies and secondary screwworm flies usually indicate the presence of carrion.

- **Case Study.** The remains of a murder victim were reportedly thrown down an open well on a small farm in a rural area in south-central Indiana. Then the well was completely filled with junk, tires, and rocks. The exact location of the well where the remains were deposited was unknown, but as the investigators drove into one of several wooded farm yard sites being investigated, it was obvious they had found the right location. Several thousand flies were hovering over a pile of old tires. The remains were found at the bottom of the well under the debris. Decomposition was advancing in the body, but there were no insects found on it. Access to the body by the blow flies was prevented by the intervening material, but odors were still capable of attracting multitudes of insects.
Estimate Time of Death and Postmortem Interval Case Study 1

- Information on the developmental stages of insects present at the crime scene can be used to estimate the postmortem interval (PMI) for relatively recent crimes. Environmental data (time, of day, temperature and relative humidity) are essential to properly estimate PMI, since insect development is strongly dependent on temperature and relative humidity. Insect successional sequence can be used to estimate PMI of relatively older crimes.

- **Case Study 1.** In early Spring, the fully-clothed body of a young, white male was found in a sandy, shrub habitat, in the southwestern United States. The victim had died of multiple small caliber bullet wounds to the chest and back. There was little external evidence of decomposition. A small amount of blood was observed to have oozed from the victim’s left nostril, partially coating his left eye. A small irregular granular mass was collected from the surface of the victim’s left eye. Closer examination of this substance revealed it to be a small mass of blow fly eggs. Several eggs had hatched already. These maggots were reared to adults and were subsequently identified as *Cochliomyia macellaria*, the secondary screw worm. Based on the climatic conditions and knowledge of the developmental biology of this fly, it was determined that the eggs most likely had been laid on the corpse 24 to 36 hours prior to the time the corpse was found. Subsequent investigation determined the identity of the victim. He had last been seen alive in the company of a male companion approximately 36 hours prior to the time his corpse was found. It was later determined that the victim had been murdered by his companion approximately 36 hours prior to discovery of the remains.
Case Study 2. In the southeastern United States during mid-November, police were called to investigate a foul smelling odor which was emanating from a small single family home in an impoverished section of town. Investigating officers soon discovered the badly decomposed body of a young, black female in a shallow grave in the dirt basement of the dwelling. The victim had died of a single bullet wound to the head inflicted with a small caliber rifle. Subsequently, a careful examination of the corpse and a detailed excavation of the soil in and around the grave site revealed the presence of numerous larvae of *Calliphora vicina* and larvae and pupae of a relative of the house fly, *Synthesiomyia nudesita*. Specimens collected from the scene were reared in the laboratory. Supplemental information including climatic data and soil temperatures were reviewed in an effort to determine the intervening climatic conditions. Using information on the developmental biology of both of these species of flies, an estimate was made that the victim had died and was colonized by flies approximately 28 days prior to the time of discovery. Investigators were able to target their investigation in and around the estimated time of death. Shortly thereafter a suspect was identified. This individual eventually confessed to having killed the victim 28 days prior to the time the body was found. She had attempted to bury the victim in a shallow grave located in the basement of the house shortly after committing the homicide. In this case, larvae of multiple species of flies provided investigators with the only scientifically reliable method of estimating the time of the victim’s death.
Determine Cause of Death

- The presence and position of wounds, decomposition may obscure wounds. Insects colonize remains in a specific pattern, usually laying eggs first in the facial orifices, unless there are wounds, in which case they will colonize these first, then proceed down the body. If the maggot activity is centered away from the natural orifices, then it is likely that this is the site of a wound. For example, maggot activity on the palm of the hands indicates the probable presence of defensive wounds. The presence of drugs can also be determined using insect evidence. There is often not enough flesh left to determine drug presence, but maggots bioaccumulate so can be analyzed to determine type of drugs present.

- **Case Study 1: Stabbing death.** The body of a young woman was discovered in such an advanced state of decomposition that the coroner could not determine the cause and manner of death. However, investigators note that there were peculiar patterns of insect invasion in the chest and on the palms of the hands. Entomologists determined that the insects were attracted to open wounds in the chest and on the hands which is consistent with stab wounds to the chest and defensive wounds to the palms of the hands as the victim tried to fight off her attacker.
Determine Cause of Death

- **Case Study 2: Drug overdose.** A nearly skeletonized corpse was of a 22-year-old woman was found along a creek. The soft tissue was gone and only shreds of skin clung to the posterior part of the body. Numerous maggots of the secondary screwworm was found associated with the body. With the remains were found a pocketbook containing identification and an empty bottle with a prescription label. During the autopsy, maggots had been collected for use in estimating PMI. These maggots were substituted for soft tissue of the victim and analyzed for drugs. Analysis showed the maggots were full of Phenobarbital and it was concluded that the victim committed suicide.
Determine If a Body Has Been Moved or Disturbed After Death

- The body may have been moved after death, from the scene of the killing to a hiding place. Some of the insects on the body may be native to the first habitat and not the second. This will show that not only was the body moved, but it will also give an indication of the type of area where the murder actually took place. The body may have been disturbed after death, by the killer returning to the scene of the crime. This may disturb the lifecycle or successional cycle of insects on and around the body, so that the entomologist may be able to determine not only the date of death, but also the date of the return of the killer.

- **Case Study.** In September 1983 the headless body of a young woman was found hidden in gorse and bracken in Devon. Many full-grown larvae and puparia of *Ophyra* were found in clothing from the body, but only a few larvae and puparia of *Calliphora*. The absence of significant numbers of blowfly larvae and lack of evidence of their feeding in the natural orifices or gunshot wounds on the corpse suggested that the body had been kept elsewhere, probably indoors, for several months and only recently placed on the site it was found. The good state of preservation of the internal organs (which misled the pathologist to estimate the time of death as 7-10 days), coupled with the presence of *Ophyra*, suggested that the storage place was warm and dry. The presence of the few *Calliphora* larvae and puparia suggested either that the body had been on site for some 20 days or so and being in a dry state had only attracted a few blowflies, or that the head perhaps been exposed and available to blowflies wherever it was stored, and removed on site when a few larvae had crawled off onto the body. When the head was subsequently found it contained several larvae and puparia of *Calliphora*, but only one *Ophyra*, which suggested exposure and subsequent detachment when the differing maggot populations of head and body were then established. Subsequent confession by the murderer established that the victim had been shot and kept in a sauna room for five months, then dumped at the edge of the wood where the body was found. The head had been removed on site and then brought back and kept in a plastic bag in the trunk of a car.
Identify or Exclude Criminal Suspects
Case Study 1

- Insects and/or insect bites can be used to place a suspect at the scene of a crime, and in some cases exonerate criminal suspects.

- **Case Study 1: The cockleburs on a skimask.** One midnight in midsummer in a suburb of Chicago a woman parked her car and walked toward her apartment building. Suddenly a man wearing a ski mask leaped from the shrubbery, attacked her, and then disappeared. The police began to suspect one man in the building, and with a warrant they searched his apartment and found a ski mask, which he claimed he had not used since the previous winter. The victim identified the man in a voice lineup, but this was not enough for a conviction. There were two cockleburs stucked to the ski mask and the detectives sent them to forensic entomologist Bernhard Greenberg for examination. Within the cockleburs were live weevil larvae. Examination of the cockleburs found on the crime scene proved to be of the same species as the weevil found on the ski mask. The species was identified as *Rhodobaenus 13-punctatus*, and is also known as the billbug. This species has a 1-year life cycle, and the larvae pupate in the cocklebur and emerge in the latter part of the summer, and then hibernate. Larvae do not overwinter, and they would not survive the winter within a dessicated cocklebur in a heated apartment. The suspect was then caught in a lie. The court trusted this evidence, and the rapist was convicted.
Identify or Exclude Criminal Suspects
Case Study 2

Case Study 2: Chigger bites in Ventura County. In 1982, deputies of the Ventura County Sheriff office noticed that a murder suspect had chigger bites similar to the ones investigators at the crime scene had on their wastelines, ankles and behind the knees. The entomologist Jim Webb was contacted, and by analyzing the bites, Webb connected the suspect to the crime scene where the naked body of a 24-year-old woman was found on August 5, 1982. She had been strangled with her own blouse. They did several tests at different places, but the only place they found chiggers in was a narrow strip near a eucalyptus tree under which the woman had been found. This meant that the suspect had to be at the crime scene at some point, which did not correlate with his testimony. The suspect claimed to have seen the woman the last time at a bar. The suspect was convicted for first-degree murder and sentenced to life without parole.
Case Study 3: The erroneously condemned Hungarian ferry skipper. A ferry skipper had been condemned to life imprisonment for the murder of a postmaster, whose knifed body had been found one evening in September on the ferry. The ferry skipper had arrived at 1800 on that day, and the body of the murdered postmaster had been found some hours later. The autopsy was performed the next day at 1600. Masses of yellowish fly eggs and numerous newly hatched larvae of 1 to 2 mm in length were present, and the finding was recorded in the autopsy report. No attention was paid to this observation at the trial, however. On assumed evidence, the ferry skipper was condemned to life imprisonment in spite of his swearing that he was innocent. Eight years later the case was reopened. At the new trial, an entomologist for the defense pointed out that no sarcophagous flies are active in Hungary after 1800 in the month of September. He also recalled some of his experiments indicating that, at a temperature of 26 degrees Celsius, the yellowish eggs of *Lucilia caesar* hatch after 13 hours, those of *L. sericata* hatch after 10-11 hours, and those of *Phormia terranovae* hatch 14-16 hours after oviposition. These data, applied to the case of the ferry skipper, led to the conclusion that it was not possible that the eggs could have hatched if they had been laid during the day the autopsy was performed, and that they must have been laid during the previous day before 1800 since the flies are not active after this time. The entomologist’s data on oviposition was verified and, on the basis of this and other evidence, the ferry skipper was released from prison.
Identifying the Origin of Contraband

- Insect have different geographic distributions and information on these distributions can be used to determine the origin of contraband in a similar way in which it can be determined whether a body has been moved.

- **Case Study: Cannabis seizures in New Zealand.** 60 specimens of insects were in two separate seizures of cannabis in New Zealand. Of these, only the rice weevil (*Oryzaephilus surinamensis*) was known to occur in New Zealand, but eight other species were native only to Asia and yielded sufficient information to indicate the precise geographical areas. By plotting the distribution of these species, and studying the degree of overlap, it was possible to determine that the Cannabis originated in the Tenasserim region between the Andaman Sea to the west and Thailand in the east. From the known habits of the insects it was surmised that the Cannabis was harvested near a stream or lake with fig trees and termite nests nearby. Following presentation of this evidence one of the suspects in this case changed his plea from not guilty to guilty.
Identify Child or Senior Abuse/Neglect

- Some insects will colonize wounds or unclean areas on a living person. This is called cutaneous myiasis. In these cases, the victim is still alive, but maggot infested. A forensic entomologist will be able to tell when the wound or abuse occurred. For instance, in the case of neglected children, the onset of maggot infestation will give a minimum time interval since the child last had a diaper change. Such cases occur particularly in young children and seniors.