FORENSIC ENTOMOLOGY FOR THE INVESTIGATOR

JASON H. BYRD, Ph.D.
DIPLOMATE, AMERICAN BOARD OF FORENSIC ENTOMOLOGY
HUME HONORS COLLEGE

ASSOCIATE DIRECTOR
WILLIAM R. MAPLES CENTER
FOR FORENSIC MEDICINE
COLLEGE OF MEDICINE
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA
What is Entomology?

The word “entomology” is derived from the Greek words “entomon” = insect and “logia” = study of.

Entomon is derived from “entomos” which means “having a notch or cut at the waist,” referring to the segmentation commonly seen as a characteristic of arthropods.
Forensic entomology is a subfield of entomology dedicated to the application, analysis and study of insects and other arthropod biology as it related to legal matters.
The 13th Century death investigator Sung Ts’u reports on a murder in a Chinese village (1247AD) in which the victim was killed with a sickle. All men in the village were ordered to assemble with their sickles, and flies were only observed to be attracted to one blade. The owner confessed.
It was not until 1668 that the link between fly eggs and maggots was discovered in western society.

Francisco Redi studied meat exposed to flies and meat protected from flies.
Prior to the Redi study, people in western society did not realize maggots were produced from fly eggs. It was believed they arose spontaneously from rotting meat.

First case of forensic entomology from western society was in 1855 (Paris, France).
“Professor LaVonne had many enemies in the entomological world, detective, but if you examine that data label, you’ll find exactly when and where he was—shall we say—‘collected.’”
### Biological/Ecological Processes of Carrion Decomposition

**An Entomological Perspective**

<table>
<thead>
<tr>
<th>Pre-colonization Interval</th>
<th>Post-Colonization Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Exposure Phase</td>
<td><strong>4</strong> Consumption Phase</td>
</tr>
<tr>
<td><strong>2</strong> Activation Phase</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong> Acceptance Phase</td>
<td></td>
</tr>
<tr>
<td><strong>Death</strong></td>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Detection</strong></td>
<td><strong>Colonization</strong></td>
</tr>
<tr>
<td><strong>Behavioral Stage</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Physical Stage</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### Physical Stage

1. **Exposure Phase**
   - Insects cannot detect presence of resource.
   - Few, if any, insects present in area.
   - Not estimable based on entomologic data/evidence.
   - Estimable from microbial data/evidence.

2. **Activation Phase**
   - Insect chemosensory detection of resource induces physiological and behavioral activation.
   - Governed by volatile odor production from microbial community.
   - Estimable based on neurophysiology data.

3. **Acceptance Phase**
   - Insects first physical contact with resource – initial, but negligible?, detection of physical activity.
   - Evaluation of resource.
   - Increased search activity for oviposition locations.
   - Estimable based on innate and/or conditioned behavior.

4. **Consumption Phase**
   - Extensive insect physical contact and oviposition - obvious detection of activity.
   - Growth, development and use of resource.
   - Faunal succession dynamics (biotic interactions)
   - Estimable based on physical entomologic data/evidence.
Entomology and Time of Death

- Temperature Dependent Development
  - Days to first few months
- Insect Fauna / Succession
  - After six months; up to several years

More Accurate than Decomposition Stages
The Female Fly

- Key in on chemical signals emitted from body
  - Female starts biological clock
- Visual clues
  - Find body
  - Land on natural opening or wound
- Female releases chemical signals
  - Attract more flies
  - Safety in numbers
The blow fly life cycle has six parts: the egg, three larval stages, the pupa, and adult.

At 70 degrees F, each stage in a blow fly’s life takes a known amount of time to complete...

- 130 hours
- 143 hours
- 22 hours
- 27 hours
- 23 hours
Colonization occurs head down pattern
- Eyes, nostrils and mouth
- Laying eggs is common in long hair
- Folds of skin

Excrement feeders are not the same as carrion feeders

Exception: Trauma
- Attracted to blood
  - Sugar & moisture
Flies

- **Families**
  - Calliphoridae – Blow flies
  - Sarcophagidae – Flesh flies
  - Muscidae – House flies

- 60% Life cycle **OFF** body
- Most abundant
- Location:
  - Sun vs. Shade
  - Inside vs. Out
- Food source for other insects and animals
Beetles

- Families:
  - Staphylinidae – Rove beetle
  - Silphidae – Carrion beetle
  - Cleridae – Checkered beetle

- Adults early visitors
- Fast larval development
- Feed on maggots and some carrion
- Wandering around and under remains
Flies

- Families:
  - Fanniidae – Lesser house fly
  - Phoridae – Coffin fly
  - Piophilidae – Cheese skipper
  - Stratiomyidae – Soldier fly
  - Sepsidae

- Prefer drier remains
Beetles & Moths

- **Families:**
  - Dermestidae – Carpet beetles
  - Tenebrionidae
  - Trogidae - Carcass beetles
  - Histeridae
  - Tineidae – Clothes moth

- Feed on dry remains
- Not predaceous
- Contain enzymes for breaking down keratin protein
**Commonly Seen**

**Chalcididae – Parasitoid wasps**

- Oviposit in maggot or pupa
- Larvae develop inside maggot, killing it
- Pupate in shell of maggot – adults emerge

**Macrochelidae – Mites**

- Feed on remains, fly eggs, and early instar maggots
Less Common Incidentals

- Wheel or Assassin Bug
- Butterflies
- Bees
- Wasps
- Ants
- Roaches
Invertebrate Feeding

- Tissue decomposition
- Maggot distribution should not be patchy
  - Feed between epidermal and dermal layers
  - Escape through the skin
- Insect Artifacts
  - Fly Specks
  - Roaches & Ants: Feed on epidermis
  - Hornets & Yellow Jackets: Feed on tissue
Entomology Scene

Death Scene Form:  www.forensicentomology/Dform.htm

Document and Photograph:

- Location:
  - Shady/Sunny
  - Inside/Outside
- Canopy over body
- Direction of body
- Trauma
- Photograph before & after collection
- Presence of insects
  - Life stages
  - Distribution
- Area surrounding body
*Temperature*

- Ambient Temperature
  - Certified for court
    - State Climatologist or Regional Climate Data (http://www.sercc.com)
- Above Body Surface
- Body Surface
  - Radiant Temperature
- Anywhere Insects are to be Collected
  - Maggot Mass
  - Soil
  - Under body
Death Scene Reference Temperatures

1. Ambient air temperature (approximately 4.5 feet off the ground)
2. Upper corpse surface temperature
3. Maggot mass temperature
4. Ground-body interface temperature
5. Soil surface temperature
6. Sub-soil temperature (approximately 5 inches below soil surface)
Collection of Insects

- Collect before moving body
  - Adults and immatures
- Concentrate on a representative sample
- Make comparison sample; alive & dead
- Collect from mass
  - 50 to 60 from each colonized area
Specimen Collection

1. Adult insects flying over body
2. Maggots in open wounds, head/orifices, & at ground line
3. Post-feeding maggots leaving corpse to pupate
4. Pupae under objects within 10 meters
5. Other insects in, on, or around corpse
Collection & Preservation

- **Adults**
  - Sweep Net Collections
    - Preserve ALL adults
      - 80% ETOH
- **Maggots and Soft Body Insects**
  - Soft-tip Forceps
    - Preserved Sample
      - **KAA** (10% Kerosene, 10% Acetic Acid, 80% ETOH)
    - Living Sample
      - Soup cup & beef liver
Proper Labeling

- Provide details
  - Where?
  - What?
  - When?
  - How?
- Collect and label separately
Specialized Collections

- Toxicology and DNA analysis
  - Keep separate
  - Document thoroughly

- Storage
  - Freeze (Best method)
  - 80% ETOH (Acceptable method)
Entomotoxicology

- Detection of drugs and toxins
  - Amphetamines, Barbiturates, Opiates, Cocaine, TCA’s, Heavy Metals and Organophosphates
- Change in Insect Life Cycle
  - Variation by stage and species
  - Cocaine & Heroin shorten larval stage
  - TCA longer pupal stage
- Toxicology report to Entomologist
  - Development can be altered 18-38 hrs
Use of Insect DNA

- **Identify insect species**
  - Species are difficult to identify morphologically
- **Associate insect with a body**
  - Maggots found, but no body
  - Maggots found, body found, but not in contact
  - Multiple homicides
  - Mass burial
- **Identify victim or suspect**
  - Transfer of parasites, blood engorged insects
  - Possible identification of victim
Gut Content of Blow Fly Maggots

Zehner et al. (2004) – STR and mtDNA
Wells et al. (2001) – mtDNA from gut content and gut itself
Introna et al. (1999) – mtDNA
Gut Content of Beetle

Sap Beetle
Family Nitidulidae

DiZinno et al. (2002) – mtDNA
The Entomologist

Analysis of Insects

- How is the analysis done?
- What information can it provide?
  - Toxicology
  - DNA
## Calculating Accumulated Degree Hours from the Insect Life Cycle

<table>
<thead>
<tr>
<th>TO</th>
<th>From</th>
<th>Temp</th>
<th>Hours</th>
<th>Degree Hours</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>23</td>
<td>23 x 70 = 1610</td>
<td>1610</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Instar</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>27</td>
<td>27 x 70 = 1890</td>
<td>1610+1890 = 3500</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Instar</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>22</td>
<td>22 x 70 = 1540</td>
<td>1610+1890+1540 = 5040</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Instar</td>
<td>Pupa</td>
<td>70°F</td>
<td>130</td>
<td>130 x 70 = 9100</td>
<td>1610+1890+1540+9100 = 14140</td>
</tr>
<tr>
<td>Pupa</td>
<td>Adult</td>
<td>70°F</td>
<td>143</td>
<td>143 x 70 = 10010</td>
<td>1610+1890+1540+9100+10010 = 24150</td>
</tr>
</tbody>
</table>
Calculating Accumulated Degree Hours from Climate data

Station: GAINESVILLE RGNL AP  
State: FL  
ID: 083326  
Latitude: 29.69 degrees  
Longitude: -82.28 degrees  
Elevation: 123 feet  
Station period of record: 05/01/1960 - 07/11/2011  
CLIMOD product: Daily Data for a Month  
Creation Time: 07/12/2011 22:47 EDT  
Month: June 2011

<table>
<thead>
<tr>
<th>Day</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Avg Temp</th>
<th>Departure</th>
<th>HDD</th>
<th>CDD</th>
<th>GDD</th>
<th>Precipitation</th>
<th>Snowfall</th>
<th>Snow Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>68</td>
<td>83</td>
<td>6</td>
<td>18</td>
<td>33</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>66</td>
<td>81</td>
<td>3</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>65</td>
<td>81</td>
<td>3</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>98</td>
<td>69</td>
<td>84</td>
<td>6</td>
<td>19</td>
<td>34</td>
<td>0.00</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Calculating Accumulated Degree Hours from Climate Data

<table>
<thead>
<tr>
<th>Day</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Avg Temp</th>
<th>Departure</th>
<th>HDD</th>
<th>CDD</th>
<th>GDD</th>
<th>Precipitation</th>
<th>Snowfall</th>
<th>Snow Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>68</td>
<td>83</td>
<td>6</td>
<td>0</td>
<td>18</td>
<td>33</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>66</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>65</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>98</td>
<td>69</td>
<td>84</td>
<td>6</td>
<td>0</td>
<td>19</td>
<td>34</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Calculating Accumulated Degree Hours from Climate Data

<table>
<thead>
<tr>
<th>Day</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Avg Temp</th>
<th>Departure</th>
<th>HDD</th>
<th>CDD</th>
<th>GDD</th>
<th>Precipitation</th>
<th>Snowfall</th>
<th>Snow Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>68</td>
<td>83</td>
<td>6</td>
<td>0</td>
<td>18</td>
<td>33</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>66</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>65</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>98</td>
<td>69</td>
<td>84</td>
<td>6</td>
<td>0</td>
<td>19</td>
<td>34</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Avg Temp</th>
<th>Hours</th>
<th>Daily Ambient Thermal Energy</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 3 (found)</td>
<td>81</td>
<td>12*</td>
<td>972</td>
<td>972</td>
</tr>
<tr>
<td>June 2</td>
<td>81</td>
<td>24</td>
<td>1944</td>
<td>2916</td>
</tr>
<tr>
<td>June 1</td>
<td>83</td>
<td>24</td>
<td>1992</td>
<td>4908</td>
</tr>
</tbody>
</table>

*investigator must account for the time of collection
## Calculating Accumulated Degree Hours from the Insect Life Cycle

<table>
<thead>
<tr>
<th>TO</th>
<th>From</th>
<th>Temp</th>
<th>Hours</th>
<th>Degree Hours</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>23</td>
<td>23 x 70 = 1610</td>
<td>1610</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Instar</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>27</td>
<td>27 x 70 = 1890</td>
<td>1610+1890 = 3500</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Instar</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Instar</td>
<td>70°F</td>
<td>22</td>
<td>22 x 70 = 1540</td>
<td>1610+1890+1540 = 5040</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Instar</td>
<td>Pupa</td>
<td>70°F</td>
<td>130</td>
<td>130 x 70 = 9100</td>
<td>1610+1890+1540+9100 = 14140</td>
</tr>
<tr>
<td>Pupa</td>
<td>Adult</td>
<td>70°F</td>
<td>143</td>
<td>143 x 70 = 10010</td>
<td>1610+1890+1540+9100+10010 = 24150</td>
</tr>
</tbody>
</table>
Calculating Accumulated Degree Hours from Climate Data

<table>
<thead>
<tr>
<th>Day</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Avg Temp</th>
<th>Departure</th>
<th>HDD</th>
<th>CDD</th>
<th>GDD</th>
<th>Precipitation</th>
<th>Snowfall</th>
<th>Snow Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98</td>
<td>68</td>
<td>83</td>
<td>6</td>
<td>0</td>
<td>18</td>
<td>33</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>66</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>65</td>
<td>81</td>
<td>3</td>
<td>0</td>
<td>16</td>
<td>31</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>98</td>
<td>69</td>
<td>84</td>
<td>6</td>
<td>0</td>
<td>19</td>
<td>34</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Avg Temp</th>
<th>Hours</th>
<th>Daily Ambient Thermal Energy</th>
<th>ADH</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 3</td>
<td>81</td>
<td>12*</td>
<td>972</td>
<td>972</td>
</tr>
<tr>
<td>June 2</td>
<td>81</td>
<td>24</td>
<td>1944</td>
<td>2916</td>
</tr>
<tr>
<td>June 1</td>
<td>83</td>
<td>24</td>
<td>1992</td>
<td>4908</td>
</tr>
</tbody>
</table>

*investigator must account for the time of collection*
Forensic Entomologists
Forensic Entomologists
13 individuals in North America are Board Certified by the ABFE.

57 individuals are listed by the Entomological Society of America with a specialty in Forensic Entomology.

120 (approximately) world-wide who do casework or research.
How to Find an Entomologist

Cooperative Extension System

Each U.S. state and territory has a state office at its land-grant university and a network of local or regional offices.

These offices are staffed by one or more experts who provide useful, practical, and research-based information to agricultural producers, small business owners, youth, consumers, and others in rural areas and communities of all sizes.

http://www.csrees.usda.gov/Extension/
Questions?

Contact Information:
Jason H. Byrd, Ph.D.
Maples Center for Forensic Medicine
Department of Pathology
College of Medicine
University of Florida
Gainesville, FL

E-mail: jhbyrd@ufl.edu

Office: (352) 294-4091