Forensic Entomology
(Postmortem Interval Estimates)

Background

The insects of key forensic interest are the flies (Diptera) and beetles (Coleoptera). Many fly species specialize in living on “carrion”, or carcasses. There are two main families of carrion flies (though there are many minor families): the Blow flies, in the family Calliphoridae, and the Flesh flies, in the family Sarcophagidae. Adult calliphorids are easily identified by their iridescent blue, green, copper, or black bodies. Sarcophagids, on the other hand, are grayish, usually with three distinct longitudinal dark stripes on the thorax. Some species of beetles also live on carrion, but they are less common, and arrive later, than the flies.

Larval development rates help forensic entomologists estimate the minimum postmortem interval (m-PMI), i.e., the minimum amount of time that has elapsed between death and when the body was discovered. This is possible since insects are cold-blooded animals and their larval growth rate increases as the environmental temperature increases, until they reach a lethal point (the developmental maximum). Researchers rear insects at a constant temperature and calculate the time it takes for an insect to develop from one life stage to another.

By comparing growth rates at a variety of temperatures, entomologists calculate the ‘**Degree Days**’ required for the insect to develop from one stage to another.

The number of hours or days to reach a stage is multiplied by the standard rearing temperature, minus the lowest temperature at which an insect will develop (the developmental minimum), during that time period.

When investigators can get accurate weather reports for an area, they calculate the ‘**Accumulated Degree Days**’ needed for the growth stage of insects found on the body, which is an estimate of the **m-PMI**.

The Case

A local detective contacts you to get your assistance with a homicide investigation. A 27 year old female was found beaten to death in the middle of a farmer’s field on Thursday, October 15th at 9:00 AM. The crime scene technicians collected insects off the body at 12 Noon that same day, and preserved them in alcohol. The detective brought the following vials of insects to you that you identify as <u>3rd instar Lucilia sericata</u>.

Try to calculate your m-PMI estimate for the decedent.

Calculation 1

Using the local weather conditions (found on the following Weather table below), fill in the average temperature below [Ave Temp = (Min +Max)/2].

Date	Rain (in)	Max temp (ºC)	Min temp (ºC)	Average Temp (ºC)
Oct 01	0	20.2	4.9	
Oct 02	0	25	5.1	
Oct 03	0	27.7	6.8	
Oct 04	.09	29.2	12.8	
Oct 05	0	19.0	9.6	
Oct 06	.11	11.8	2.9	
Oct 07	0	10.8	2.8	
Oct 08	0	18.3	2.1	
Oct 09	0	21.8	1.2	
Oct 10	0	23.7	3.5	
Oct 11	0	24.1	6.1	
Oct 12	0.09	20.8	11.6	
Oct 13	0	20.8	10.3	
Oct 14	0	11.9	9.1	
Oct 15	0.56	9.8	5.6	

The following data show the time (in hours) individuals of each species spend in each life stage at a specific temperature. For example, it requires 21 hours for Lucilia cuprina to develop from egg to 1st instar, then an additional 21 hours feeding as a 1st instar before it molts to become a 2nd instar. Development times are different for different species, and they differ at different temperatures.

When calculating a m-PMI always use the development temperature that most closely matches the average temperature at which the body was found. Sometimes this is relatively easy (e.g., if a body is found in an air-conditioned house, and the thermostat setting was recorded), or very difficult (e.g., if a body is found in an unventilated attic during a hot summer).

Even though these values are in hours, we will construct a m-PMI in days. So, once you have summed your hours to reach the stage you have identified for a particular species, you then divide this value by 24 (i.e., 24 hours/day).

Cochliomyia sp. (in hours): [Dev. Min. = 10 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	20	27	21	45	101

Lucilia coeruleiviridis (duration, in hours): [Dev. Min. = 10 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	35	62	56	90	158

Lucilia cuprina (duration, in hours): [Dev. Min. = 10 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	21	21	26	50	118

Lucilia sericata (in hours): [Dev. Min. = 6 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	15	40	21	60	124

Phormia regina (in hours): [Dev. Min. = 10 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	15	37	44	35	187

Sarcophaga sp. (in hours): [Dev. Min. = 4 °C]

Temp °C	Egg	1st Instar	2nd Instar	3rd Instar	Pupa
21	22	21	41	40	74

For example, if you find an intact (i.e., non-emerged) Lucilia cuprina pupa, your **Accumulated Degree Hours** (**ADH**) are (21°C [Rearing Temperature] – 10°C [Developmental Minimum Temperature] =) 11°C.

Take 11°C x (21 + 21 + 26 + 50hr =) 118 = 1,298 ADH.

Divide the ADH by 24 to get the **Accumulated Degree Days**. That is, for Lucilia cuprina to reach the pupal stage it requires 1,298 ADH or (1,298 ADH / 24hr/day =) 54.1 ADD.

**NOTE: The data below are completely made up, for simplicity in this lab. If you construct a m-PMI based on these data, you will probably go to jail for incompetence!

Calculation 2

What is the ADH for the <u>3rd instar Lucilia sericata</u> that were collected at the crime scene?

What is the ADD for the <u>3rd instar Lucilia sericata</u> that were collected at the crime scene?

Of course, the most important thing that law enforcement wants to know is the “time of death”, what forensic entomologists refer to as the m-PMI. Once you have identified the species of insects on the body, determined the oldest stage of each species on the body, obtained the local weather conditions for where the body was found, and gathered the development data for each species from previously published literature you are ready to calculate your m-PMI estimate.

To calculate the m-PMI for this case you will be filling out the following table. The table needs to be filled out backwards, start at the date the body was found and move backwards in time

<u>Calculations 3</u>

Date	1 Ave Temp (°C)	Insect Developmental Minimum (°C)	2 Degree Days	3 Proportion of the Day	4 Accumulated Degree Days (ADD)
Oct 15					
Oct 14					
Oct 13					
Oct 12					
Oct 11					
Oct 10					
Oct 9					
Oct 8					
Oct 7					
Oct 6					
Oct 5					
Oct 4					
Oct 3					
Oct 2					
Oct 1					

1. Using the weather data you previously calculated, fill in the **AVG Daily Temperature (C)** (note the dates are backwards).

2. Now, for each date, subtract the ‘Insect Developmental Minimum (C)’ from the ‘AVG Daily Temperature (C)’. This calculated value goes in **Degree Days (DD)**.

3. The ‘**Proportion of Day**’ is 1 for full days. It should be this for most days, except for the first day. That is, a body is rarely found exactly at midnight (making this value 1). Thus, you need to calculate the proportion of the day the insects were feeding on the body prior to being collected,

4. Calculate **Accumulated Degree Days (ADD)** by multiplying the **Degree Days** x **Portion of Day** and add this to the ADD from the row above. This gives you a running total for **ADD**.

5. At this point, you can determine the ‘day’ of death. The ‘day’ of death is that which contains the ADD for the fly species in question.

   For example: If your fly species’ ADD is 85, and June 5th ADD is 72, and June 4th ADD is 90, then your ‘day’ of death is June 4th. This is because the fly ADD of 85 exceeds the temperature units acquired for the day of June 5th and lies somewhere during the day of June 4th.

   What is the day of death for our case?

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6. Now calculate the proportion of the day required to reach the fly species/age ADD, to determine the ‘time’ of death.

   In the same example mentioned above, you know the ‘day’ of death is June 4th, but you don’t know the exact time. To calculate the time, take the DD for June 4th, which is (90 – 72 =) 18. As the fly species/age ADD was 85, and June 5th ADD was 72, that means the proportion of June 4th you need to account for is (13 / 18 =) 0.72 or 72%, or (0.72 x 24hr =) 17 hours. As you are always working backwards, in a 24hr time interval, you start at midnight June 4th and count back 17 hours. As such, your ‘time’ of death is approximately 7AM.

   What is the approximate time of death?

   ADD of insect (i) = __________

   ADD for the first date your insect ADD is past = (a) = __________

   ADD for the date your insect developed to = (b) = __________

   (i-a) / (b-a) x 24 = hours into day of death (counting backwards from midnight)

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