

“The horses in the pasture fidgeted with anticipation when they heard Mr. Johnson’s lawn mower nearby. Little did anyone know that soon one of them would end up dead as a result.”

Crime Solving Insects



**By Lisa Carloye, Washington State University
Stephen Bambara, NC State University**
(Adapted by S. Bambara from “Of Maggots and Murder” by L. Carloye)



This is a hands-on lesson in which 4-H’ers evaluate evidence from four animal death scenarios. For each scenario, they are given a sample of simulated maggots that were collected from a fictional corpse and are asked to figure out the postmortem interval in which the insects developed and determine whether foul play was involved in the death. This exercise is adapted from a lesson used by college biology teachers.



Life Skills:

Critical thinking, problem solving, teamwork, communicating, learning to learn.

Purposes:

1. To appreciate the practical application of entomology in society.
2. To learn the concept of “succession” of insect life in the role of decomposition.

Time:

Four lessons requiring approximately 20 minutes each.

Also included at the end is an optional, related activity involving monitoring insect succession in a decaying chicken gizzard over several weeks. Review the activity to see if it can be useful or applicable to your program.



Flies around the corpse of a cardinal.



Materials You'll Need:

- Life history of flies sheet (provided, Table 1, page 13, one for each team)
- Ecological information sheet (Table 2, page14, one for each team)
- Police report information sheets for Cases 1-4 (provided, one set for each team, pages 9-12)
- Rulers measuring millimeters (one for each team)
- Colored pipe cleaners—white, blue, yellow, pink, and brown
- Plastic sandwich bags filled with appropriately measured lengths of colored pipe cleaners (1 for each case, 4 for each team)
- Scissors (one) to cut pipe cleaners
- Forceps or tweezers for each team (optional)
- Plastic or latex gloves (optional)

Before the Meeting:

Prepare a Crime Report Pack for each team of 4-H'ers.

The Crime Report Pack contains:

- Maggot bag of cut pipe cleaners (4, one for each case using Table 3, page15). (Label each bag with a case number.)
- Police report information sheets (one for each case)
- Life history sheet (Table 1, page13)
- Ecological information sheet (Table 2, page14)
- Ruler measuring millimeters
- Four Common Flies Used in Forensic Investigation (photos, provided, one for each team of 2 or 3 4-H'ers, page 8) (optional)
- Forceps and gloves (optional)

Background:

The ordered development of flies on a dead animal is predictable. Because of that, the flies can be used to help determine the time of death or other factors that may have legal implications. This interactive learning activity was originally developed for use in a college general biology class to illustrate principles of community ecology and ecological succession, the idea of an ecological niche, and the role of life history, and to illustrate how basic biology can have an unexpected practical use.

This activity is of minimal cost and may be conducted without the need of a strong biological background, either in a classroom or at tables. Each of the four death scenarios features a slightly different twist and takes about 20 minutes to complete. Each case can stand alone, or all can be worked through sequentially, as time permits.



Lead In:

When an animal dies, flies are among the first to find and colonize the carcass, usually arriving within 10 minutes of death. As the carcass decays, the environmental conditions within it change. It becomes drier, the temperature rises, and tissues break down. In fact, the process of decay is one of **ecological succession** whereby a series of predictable changes occur, in succession, as the carcass progresses from the “fresh” stage, where the body is intact and decay has barely begun, to the “skeletal” stage, when all that is left is indigestible hair and bone. This process is an example of what is known as **secondary succession**, whereby an ecological community begins with the death of an animal and its body represents an isolated, rich source of resources that is colonized by particular groups of insects as the body undergoes

changes. The process of colonization and utilization of the body continues until decomposition is complete.

The progression of insect life follows a pattern, and the developmental rates of flies are relatively predictable.

Therefore, if enough information is known regarding the temperature of the microclimate in which insects occur, the insect community associated with a corpse may be investigated by forensic scientists to estimate the postmortem interval—the time between death and discovery of the corpse. When this type of information is used in our legal system, it falls into the category called **forensic entomology**.

[Now have several 4-H'ers take turns reading the following paragraphs aloud, one at a time, in order, to the rest of the group.]



The four development stages through which flies and many other insects pass is called **complete metamorphosis**. Here, the insect hatches from an **egg** into a white grub, called a **larva** or a **maggot**, which crawls like a caterpillar and actively consumes food to grow quickly. The insect will pass through several **instars** or stages during this process. Every time it completes a stage, it must shed a tough or hard **exoskeleton** and thus **molt**. Upon reaching larval maturity, the maggot will darken and turn into an immobile **pupa**. The pupa may look inactive, but many changes are occurring inside the casing. Soon, a winged **adult fly** emerges. The adults will then mate, and the females will lay more eggs onto corpses. The adult females often search out the natural body openings for this. This means that eggs and larvae begin feeding in the head region first (mouth, nostrils, eyes, ears), followed by the excretory and reproductive openings. The trunk of the body is invaded much later in the process.

The rate of insect development is influenced by temperature because insects are **ectothermic** (“cold blooded”). That means their body temperatures are largely dictated by the outside temperature. Only when the outside temperature warms an insect’s internal body temperature to its critical level can the insect become active (and eat and grow).

Any drugs present in the corpse at the time of death can affect the rate of maggot development, as they ingest the drug along with the tissue. A drug like cocaine speeds up development, while some poisons, such as arsenic and glycosides, slow it down. This fact can

make estimating the time of death difficult. Sometimes investigators may find large maggots on relatively young corpses and small maggots on relatively old corpses, which is the opposite of what would usually be expected.

These stages of insect growth, as well as the order in which certain insect species invade the corpse, are predictable. For this reason, the insects can be used to estimate time of death and, in some cases, cause of death. The process of decay of the corpse begins at the moment of death. This is the **fresh stage**, and it lasts until the body becomes bloated. At this fresh stage, the body looks relatively normal—much as if it were sleeping. **Blow flies** and **flesh flies** are among the first to find the body, and they can arrive within 10 minutes of death. They lay their eggs, from which the maggots hatch quickly and begin to feed on the tissues. (Flesh flies do not lay eggs, but deposit newly hatched maggots directly onto the corpse.) Not all fly species are found everywhere, and this can provide important information also. For example, the skipper fly, *Piophilina nigriceps* (pie-oh-FEEL-ah NYE-greh-cehps), is found only in urban settings. **Predatory wasps, beetles,** or both may arrive later to feed on the maggots (but not the corpse).



The **bloated stage** begins when the body becomes visibly inflated due to the production of gases from bacteria that begin to **putrefy** the body or cause it to decompose. **House flies** now join the other flies, and their maggots form feeding masses that help to liquefy the tissues of the body. At this point many maggots feed on the body and competition increases, as do the number and variety of predators that come to feed on the maggots.

The **decay stage** begins when the skin breaks and the gases escape, giving the corpse a deflated look. The maggot masses are large and very active as they continue in their development, growing older and larger. This is the stage of decomposition that smells bad. By the end of this stage, most of the maggots have finished development (typically they molt three times before pupating), and they begin to leave the corpse in search of a place to pupate in the soil. Most of the flesh is gone from the corpse, with only cartilage, bone, and skin remaining. At this point the postdecay stage begins. This stage is devoid of flies, although some beetles continue to feed on the highly desiccated or dried remains.



Procedure:

Divide the group into teams of two or three. Hand out a Crime Report Pack to each group. Have them start with Investigation #1. They will measure the maggot and pupal evidence (the cut-up, colored pipe cleaners) to determine the life stages and species found at the scene. Using the life history chart and ecological information (Tables 1 and 2), they can work on the answers to the questions of each investigation. Each investigation can be done separately or in progression, as time allows. Consult your **answer key** to work through the questions with the 4-H teams when the assignments are completed.

At the end of the activity, lead the group through the “Let’s Talk About It” questions.



Crime report pack containing pipe cleaner “maggots” and ruler.

Four Common Flies Used in Forensic Investigation



House Fly Live Stages (eggs, larva, pupa, adult)



Blow Fly



Flesh Fly



Skipper Fly



INVESTIGATION #1

Police Report: The body of a female deer was found behind a fence along a busy two-lane road on the edge of the city limits of Charlotte. Animal Control was called and reported no apparent wounds on the body. It was not hunting season.

Weather Report: Daytime temperatures have been fairly consistent for the past three weeks, ranging from 70 to 74° F.

Questions:

1. Approximately how long has this animal been dead?
2. Why are maggots of different ages found in the body?
3. Other than temperature, what **abiotic** (external to the corpse) conditions would you want to obtain from the weather station to help you to be more confident of your time of death estimation?





INVESTIGATION #2

Police Report: The body of a large pit bull terrier was found inside a walk-in basement at a home in Cary. Maggots were found concentrated in the head and region behind the shoulder. The windows were closed, although the open curtains allowed sunlight to enter, and the air conditioner was set at 72° F.

Weather Report: Daytime temperatures have been variable over the past three weeks, ranging from 75 to 94° F. Skies have been sunny.

Questions:

1. Approximately how long has this animal been dead?
2. What effect, if any, do the outside temperatures have on your estimation of time of death?
3. How does the fact that the windows were closed relate to the populations of flies you observed in and around the corpse? (Is there something different about this population than the population in Investigation #1?) How do you explain the absence of the blow fly, *Calliphora vomitoria*?
4. Do you suspect foul play? Explain.



INVESTIGATION #3

Police Report: The body of a young male horse was found in a pasture in a small town near Wilmington. The autopsy from the vet school reveals that the cardiac glycoside, oleandrin (similar to digitalis, a powerful heart stimulant), was present in the body. Oleandrin is found in the oleander plant. Oleander is a common ornamental shrub in this area, but none grows within 200 feet of the pasture.

Weather Report: Daytime temperatures have been unusually warm over the past three weeks, ranging from 84 to 86° F.

Questions:

1. Approximately how long has this animal been dead?
2. What effect, if any, does oleandrin have on your estimation of time of death? Explain how you used this information in calculating the postmortem interval.
3. What effect, if any, does temperature have on your estimation of time of death? Explain how you used this information in determining the postmortem interval.
4. Does the location of the body, coupled with the insects recovered from it, suggest foul play, or can you tell from the information given? Explain.





INVESTIGATION #4

Police Report: The body of a large pot-bellied pig was found in a dense stand of evergreen trees far from any urban area in Buncombe County. Hairs around the pig's neck were worn away in a band pattern.

Weather Report: Daytime temperatures have been average over the past three weeks, ranging from 70 to 73° F. Temperatures in the woods would be approximately 5 degrees cooler due to the lack of sun in the shady environment.

Questions:

1. Approximately how long has this animal been dead?
2. What effect, if any, does temperature have on your estimation of time of death?
3. Does the location of the body, coupled with the insects recovered from it, suggest foul play, or can you tell from the information given? Explain.



Table 1: Life History of Flies. The development of body length (in millimeters) of some fly species during their metamorphosis at 72° F (L = Larvae, P = Pupae, A = Adult Fly).

Days after Death	Species			
	<i>Musca domestica</i> House fly	<i>Calliphora vomitoria</i> Blow fly	<i>Sarcophaga carnaria</i> Flesh fly	<i>Piophilina nigriceps</i> Skipper fly
1		Egg	L 9-11	
2	Egg	L 9-11	L 12-16	
3	Egg	L 9-11	L 17-20	
4	L 6	L 12-16	L 21-25	
5	L 6	L 12-16	L 26-30	Egg
6	L 7-11	L 17-20	L 31-35	Egg
7	L 12-16	L 17-20	L 36-40	L 3
8	L 17-20	L 21-25	L 41-44	L 3
9	L 21-25	L 21-25	L 44-46	L 4-6
10	L 26-30	L 26-30	L 44-46	L 7-9
11	L 31-35	L 26-30	P 38-40	L 10-13
12	P 26-29	L 31-35	P 38-40	L 14-16
13	P 26-29	L 31-35	P 38-40	P 13-15
14	P 26-29	P 31-34	P 38-40	P 13-15
15	P 26-29	P 31-34	P 38-40	P 13-15
16	P 26-29	P 31-34	P 38-40	P 13-15
17	P 26-29	P 31-34	P 38-40	P 13-15
18	A 30-32	P 31-34	P 38-40	P 13-15
19		P 31-34	A 42-45	A 16-18
20		P 31-34		
21		A 36-38		

Color Key: *Musca domestica* (house fly) Blue 

Calliphora vomitoria (blow fly) Yellow 

Sarcophaga carnaria (flesh fly) White 

Piophilina nigriceps (skipper fly) Pink 

Pupae Brown 
(species of pupae can't be determined except by size)

Table 2: Ecological information for certain species of flies. The developmental delays/accelerations are given in number of days relative to the developmental schedule in Table 1 above.

		<i>Musca domestica</i> House fly	<i>Calliphora vomitoria</i> Blow fly	<i>Sarcophaga carnaria</i> Flesh fly	<i>Piophilina nigriceps</i> Skipper fly
Temperature (°F)	55°	delayed 4	delayed 4.5	delayed 4	delayed 3
	65°	delayed 4	delayed 3	delayed 2	delayed 1
	80°	accelerated 1	accelerated 2	accelerated 1.5	accelerated 1
	85°	accelerated 3	accelerated 4	accelerated 3	accelerated 2
Ecological Traits	Habitat	urban and rural	urban and rural	urban and rural	urban
	Lighting	full to partial sun	partial sun to shady	prefers sunny	prefers sunny
	Drugs	no effect	sensitive to effects	no effect	no effect

Modified from Smith (1986)



Table 3. Maggot pack contents. Cut pipe cleaners in lengths (in mm) to represent maggots and pupae collected from each body in each case. Cut several of each length to make up the “sample” collected from the body. (Remember, all pupae are brown, and the fly species can’t be determined except by size.)

	<i>Musca</i> House fly (blue) (mm)	<i>Calliphora</i> Blow fly (yellow) (mm)	<i>Sarcophaga</i> Flesh fly (white) (mm)	<i>Piophil</i> a Skipper fly (pink)(mm)	<i>Pupae</i> (brown) (mm)
Case# 1	29 & 20	25 & 29	29	9	39 (<i>Sarcophaga</i>)
Case #2	6	—	15	—	—
Case #3	28	35	45	—	33 (<i>Calliphora</i>)
Case #4	6 & 19	18	9 & 15	5	—



Answer Key



INVESTIGATION #1

Police Report: The body of a female deer was found beside a fence on the edge of the Charlotte city limits. Animal Control was called and reported no apparent wounds on the body. It was not hunting season.

Weather Report: Daytime temperatures have been fairly consistent for the past three weeks, ranging from 70 to 74° F.

Questions:

1. Approximately how long has this animal been dead? 11 days
2. Why are maggots of different ages found in the body? Adults of the same species will arrive at the body at different times. Adults of different species may also arrive at different times or they may colonize the corpse in different stages of succession.
3. Other than temperature, what abiotic (external to the body) conditions would you want to obtain from the weather station to help you to be more confident of your time of death estimation? Humidity, rain, cloud cover (for estimating microclimate differences), and wind.

Remarks: The first case is straightforward. This helps 4-H'ers become used to the procedure and to interacting with each other. One might conclude that the deer was hit by a car and not illegally shot.

INVESTIGATION #2

Police Report: The body of a large pit bull terrier was found inside a walk-in basement at a

home in Cary. Maggots were found concentrated in the head and region behind the shoulder. The windows were closed, although the open curtains allowed sunlight to enter, and the air conditioner was set at 72° F.

Weather Report: Daytime temperatures have been variable over the past three weeks, ranging from 75 to 94° F. Skies have been sunny.

Questions:

1. Approximately how long has this animal been dead? 5 days
2. What effect, if any, do the outside temperatures have on your estimation of time of death? The outside temperature has no effect on larval development. That's because the windows were closed and the inside temperature was 72 degrees.
3. How does the fact that the windows were closed relate to the populations of flies you observed in and around the corpse? (I.e., is there something different about this population than the population in Investigation #1?) How do you explain the absence of the blow fly, *Calliphora vomitoria*? Because the windows were closed, the only flies that could have laid eggs on the body were those that were already present at the time of death. Thus, *C. vomitoria* must not have been present, even though we would expect to see it as an early colonizer.
4. Do you suspect foul play? Explain. YES. The pattern of colonization indicates that an orifice was present behind the shoulder (more maggots there than would be expected). A puncture wound or bullet hole would be consistent with the evidence.

INVESTIGATION #3

Police Report: The body of a young male horse was found in a pasture in a small town near Wilmington. The autopsy from the vet school reveals that the cardiac glycoside, oleandrin



(similar to digitalis, a powerful heart stimulant), was present in the body. Oleander is a common ornamental shrub in the area, but none grows within 200 feet of the pasture.

Weather Report: Daytime temperatures have been unusually warm over the past three weeks, ranging from 84 to 86° F.

Questions:

1. Approximately how long has this animal been dead? 7 days (4-H'ers must account for both temperature and drugs when calculating this).
2. What effect, if any, does oleandrin have on your estimation of time of death?
Explain how you used this information in calculating the postmortem interval.
Oleandrin speeds up development of *Calliphora vomitoria* (blow fly) by 2 to 3 days.
3. What effect, if any, does temperature have on your estimation of time of death? Explain how you used this information in determining the postmortem interval.
Temperature speeds up development, thus we must subtract the number of days that accumulated due to temperature rather than the passage of time.
4. Does the location of the body, coupled with the insects recovered from it, suggest foul play, or can you tell from the information given? Explain. No. The fact that *Prophila nigriceps* (skipper) was not found on the body is consistent with the location in which the body was found. However, the presence of oleandrin raised suspicions. It was later determined that a neighbor, Mr. Johnson, usually fed the horses his lawn clippings. The horses knew of the upcoming treat by the sound of the mower. Unfortunately, some clippings from Mr. Johnson's recently pruned oleander bush were left on the ground in his yard and became mixed with the grass clippings.

INVESTIGATION #4

Police Report: The body of a large pot-bellied pig was found in a dense stand of evergreen trees far from any urban area in Buncombe County. Hairs around the pig's neck were worn away in a band pattern.

Weather Report: Daytime temperatures have been average over the past three weeks, ranging from 70 to 73° F. Temperatures in the woods would be approximately 5 degrees cooler due to the lack of sun in the shady environment.

Questions:

1. Approximately how long has this animal been dead? 10 days
2. What effect, if any, does temperature have on your estimation of time of death?
Because it is cooler in the forest, maggot development is slowed; thus you must add days to the number of days it appears the maggots have been developing.
Cooler temperature slows the growth about 2 to 3 days, depending on the species.
3. Does the location of the body, coupled with the insects recovered from it, suggest foul play, or can you tell from the information given? Explain. Because the *Piophila nigriceps* skipper occurs only in urban habitats, its presence indicates the pig died in an urban habitat and was moved to the woods at least five days after death. The missing-hair pattern on the neck suggests a pet's collar.



Let's Talk About It:

Sharing: How do you feel about this topic? What was the hardest aspect of this activity? Do other insects appear on corpses? Which kind? [**Example:** Silphid beetles prey on the maggots.] Is it “good” or “bad” that insects eat an animal corpse? What are some of the challenges of working with team members?

Processing: What different species of flies did we use to determine the ages of the corpses? What does the order of insect arrival mean to a forensic entomologist? What might you find if an animal had been left dead for six months? What other types of data might police look for at the scene or in a laboratory? [**Example:** Footprints, tire tracks, chemicals in blood, DNA.] Why is it important to know about insects?

Generalizing: What other situations like this have you experienced in which you make observations and try to solve a puzzle? When have you used data to prove a point? Why is it important to collect all the information about the case before making a judgment? [Early conclusions may be different or wrong.] What are some other examples of succession that involve species other than insects? [Plant species vary in different aged fields and forests.]

Applying:

Can you think of any other situations where entomology expertise could be used in legal matters? [**Example:** If someone was sold infested products, such as grain (flour) or even baked goods, determining if the infestation came during or after production might help assign liability.] Would this type of information apply to humans? Assigning liability in the cause of a dead tree? What if you found insects on recently purchased shrubs? What if you have termites in the house you purchased 6 months ago?

How can you apply this thinking process to evaluation of issues at home or school? What would you do differently if you conducted this activity again? When have you had to make an educated guess, and how did it turn out?



Optional Activity

For this activity, 4-H'ers may work in teams or separately with parents. Results may be reported and compared at subsequent meetings. Alternatively, this could be conducted as part-activity and part-demonstration. This might be useful at a “camp” setting where ahead of time the leader exposes fresh chicken gizzards or livers to the outdoors at one-week intervals and labels them so that the succession process can be observed on the spot.

1. Obtain a chicken gizzard or liver from the leader. Place the gizzard in an open plastic container and use a permanent marker to identify your container.
2. Place the container outdoors for about 30 minutes. Flies will find the “corpse” and lay eggs on it. Reasonably nice weather and temperature are important.
3. Return the container indoors. Cover it with a lid that allows a little ventilation, but not access by other insects. Check your corpse for the next three weeks or until the next meeting. Using the Data Sheet at the end of this unit, take note of what you see and when, and indicate the organisms you find and the condition of the corpse.



Container with “corpse” exposed to flies.



Table 4. Data Sheet for Recording “Corpse” Observations.

Day	Insects Found & Stage of Insect (e.g., larvae, pupae, adult)	Condition & Appearance of “Corpse”	Odor Detected (try to describe as objectively as possible)	Any Other Characteristics Noticed (e.g., location of insects)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Useful Reading

- Carloye, L. 2003. [Of Maggots and Murder: Forensic Entomology in the Classroom.](#) *The American Biology Teacher* 65:360-366.
- Deavers, S., J. P. Rosborough, and J. D. McCrady. 1979. [The effects of oleandrin on cardiac contractility in the normal dog.](#) *Arch Int Pharmacodyn Ther.* June, Vol.239 (2):283-95.
- Lamm, W. 1997. [Poisonous Plants.](#) *TrailBlazer* magazine. <http://www.horsetrails.com/>
- Sachs, J. S. 1998. [A maggot for the prosecution.](#) *Discover* 19 (11):102-109.

Web Sites of Interest

- http://folk.uio.no/mostarke/forens_ent/forensic_entomology.html (A readable and thorough site with good information and pictures of maggots.)
- <http://www.forensic-entomology.com/> (Background information and good compilation of literature, along with pictures of maggots and adult flies.)
- <http://www.research.missouri.edu/entomology/casestudies.html> (A good history of the science of forensic entomology and a few case studies.)
- <http://www.benecke.com/nextwave.html> (A personal perspective on being a forensic entomologist.)

Works Cited

- Al-Rajhy, D. H., A. M. Alahmed, H. I. Hussein, and S. M. Kheir. 2003. Acaricidal effects of cardiac glycosides, azadirachtin, and neem oil against the camel tick, *Hyalomma dromedarii* (Acari: Ixodidae). *Pest Management Science* 59(11):1250-1254.
- Catts, E. P., and M. L. Goff. 1992. Forensic entomology in criminal investigations. *Annual Review of Entomology* 37:253-272.
- Catts, E. P., and N. H. Haskell, eds. 1990. *Entomology and Death: A Procedural Guide.* Clemson, S.C.: Forensic Entomology Associates.
- Goff, M. L. 2000. [A Fly for the Prosecution: How Insect Evidence Helps Solve Crimes.](#) Cambridge, Mass.: Harvard University Press.
- Purves, W. K., D. Sadava, G. H. Orians, and H. C. Heller. 2001. *Life: The Science of Biology*, 6th ed. Sunderland, Mass.: Sinauer Associates, Inc.
- Smith, K. G. V. 1986. *A Manual of Forensic Entomology.* Ithaca, N.Y.: Cornell University Press.



Acknowledgments

The authors wish to thank Ed Maxa for his suggestions and advice, Carol Sheppherd, John Wallace, and Sarah Vortriede for field testing and suggestions to the original manuscript, June Lioret for her editing and Sonja Swiger.

Cover photo: Blow fly, Joseph Berger, forestryimages.org

Other photos: Dave Powell, U.S. Department of Agriculture-Forest Service; Jim Kalish, University of Nebraska; Joseph Berger, insectimages.org; Bob Blinn, North Carolina State University; Stephen Bambara, North Carolina State University; Lisa Carloye, Washington State University

*Copyright © 2006 Stephen Bambara and Lisa Carloye
Last reviewed on the Web, March 2006*

Published by
North Carolina Cooperative Extension Service

Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. North Carolina State University and North Carolina A&T State University commit themselves to positive action to secure equal opportunity regardless of race, color, creed, national origin, religion, sex, age, or disability. In addition, the two Universities welcome all persons without regard to sexual orientation. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.

3/06—JL
E06-45796

4H-9-01

