10.5. Forensic Zoology

Introduction

Zoology relates to the study of the structures, biological functions, and behavior of animals. Animals and their actions can play important roles in forensic investigations, ranging from providing information about how and when a crime was committed to the results of their actions in changing and disturbing a crime scene or evidence (taphonomy), to being the victims of crimes themselves. Many aspects of zoology as it relates to forensic science have already been covered in previous sections. A few topics, however, that focus on animals in criminal investigations require discussion.

Forensic Veterinary Medicine

A relatively new discipline has arisen that deals with animals in forensic settings: Forensic Veterinary Medicine. This specialty of animal medicine deals specifically with legal cases involving animal health and welfare, causes of animal death, age and parentage of a particular animal, and where the animal originally came from (e.g., ownership, importation, etc.). In many ways, the forensic veterinarian acts as a medical examiner but only in animal medicine. The main work involves investigating cases of animal cruelty, neglect and violations of animal conservation/importation laws.

Forensic Animal Cruelty Investigations

Unfortunately, animals are frequently the victims of careless neglect, intentional injury, and even death as the result of human actions. Laws are becoming stricter regarding the ethical treatment of animals and severe penalties may now result from animal cruelty charges.

The investigations leading to criminal charges against a person for animal cruelty-related crimes require the same degree to careful analysis, proper procedures, and attention to detail as are employed in human-related forensic cases. Animal crime investigators are often called upon to employ the tools of forensic pathology, ballistics, chemical trace analysis, DNA, and other forensic disciplines just as are used in human cases to solve animal-related crimes and bring criminals to justice.

One problem, however, is that there are typically not enough regulators and inspectors to investigate such cases. The USDA has only 90 inspectors who oversee and inspect more than 30,000 breeders, dealers and exhibitors of wildlife.

Forensic Wildlife Investigations

Most countries in the world have strict laws dealing with the capture, sale and transportation of animals or animal products. This is especially critical in efforts to protect endangered species from extinction by over-hunting, mistreatment, and capture. Many animal species are highly prized “pets” and some are hunted solely for some of their parts. For example, tiger pelts, rhinoceros horn, bear gall-bladders, and whale products bring large sums of money in some places of the world. Ivory from elephants and exotic feathers that we buy may possibly have come from a protected animal illegally (Figure 10.5.2).

Figure 10.5.1. USFWS Wildlife Forensic Laboratory investigating suspicious animal deaths
Introduction to Forensic Science

Chapt. 10.51

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J. T. Spencer

– some are more valuable, ounce-per-ounce than gold. Nearly 20 million Americans alone own exotic pets amounting to an annual $20B market (third only to weapons and drugs), according to a recent National Pet Owners Survey.

It can be very difficult to determine if an animal or their products come from legal or illegal sources. For example, bear gall bladder may be ground and used as a “medicine” or dietary supplement. From this ground sample, it is nearly impossible to determine whether it was derived legally or illegally. Legal caviar looks a great deal like illegal caviar in many instances – and in some places legal caviar is even labeled as illegal caviar to increase the price for it! All of this makes the work of forensic animal investigators very difficult.

In the United States, the US Fish and Wildlife Services runs a forensics laboratory, the first in the world, dedicated to bringing progressive forensic tools to criminal investigations involving animals. This laboratory assists in investigations around the world and helps determine cause of death of animals and works to link animal-related crimes to suspects. The analyses can include bones, fur, tissue and any other parts of an animal that is available. These investigations are very similar to those described in previous chapters for human victims.

Animal Parentage and Behavior

In some cases, it is especially important to determine the ancestry of a living animal. For example, thoroughbred horses and certain breeds of dogs and cats may be particularly valuable based upon their parentage. DNA has been used successfully in many instances to verify or refute the claimed provenance (ancestry) of an animal.

Animal behavior may also provide important clues as to how the animal was treated in the past and even where it originally came from. Occasionally, knowledge of an animal’s behavior patterns is important in deciding whether injuries caused by an animal to either another animal or a human were caused by negligence or were provoked. Forensic animal behavior is a new field that is just beginning to be employed in legal settings.

Human Fauna Possibilities

Our bodies are typically teeming with microscopic animal species, from tiny eyelash mites (Figure 10.5.3) to harmless (or sometimes harmful) parasites in our intestinal tracts, not to mention microbial “riders” on and in us. Someday it may be possible to use the array of these

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**Figure 10.5.2.** Elephants killed by poachers for their ivory (news.bbc.co.uk/2/hi/africa/8433750.stm).

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**Figure 10.5.3.** Tiny, harmless eyelash mites (*Demodex folliculorum*) infesting human hair follicles – as many as 25 per follicle. They feed off of oil secretions and dead cells. (www.sciencephoto.com: Z445/312).
person-specific indicators to identify a particular human’s involvement in a crime, although, at this point, this is largely speculation.

**The Case of Sliver Blaze and the Silent Dog**

One of the most famous of Sir Arthur Conan Doyle’s novels about his great detective duo, Mr. Sherlock Holmes and Dr. John Watson, spins the tale of the mysterious disappearance of the thoroughbred racehorse Silver Blaze and the murder of his handler, John Straker. In this story, the favorite at the upcoming Wessex Cup race disappears in the middle of the night and the body of his trainer, Straker, is found on the moors of Dartmoor dead from blunt force trauma to the head. Apparently, the stable boy had been drugged with opium in his food and the horse was led out in the middle of the night, presumably to be killed or injured. It was suspected that Straker, discovering the plot as it unfolded, was killed and was a victim of the crime. Two curious features of the case relating to animals, other than Silver Blaze, led Holmes to a different solution. First, the watchdog at the stable did not bark during the night that Silver Blaze was taken – presumably by a stranger. Second, three sheep have recently gone lame unexpectedly at the farm.

As it turns out, these animal behavioral clues were key. The reason that the dog didn’t bark was that Straker himself, well known to the dog, took Silver Blaze from his stall and led him to the moor. In Holmes words “I had grasped the significance of the silence of the dog, for one true inference invariably suggests others... Obviously the midnight visitor was someone whom the dog knew well. It was Straker who removed Silver Blaze from his stall and led him out on to the moor.”

Straker’s motive was to subtly injure the horse, in such a way that could not be detected but yet was severe enough to cause him to lose the race – by nicking a tendon in the horse’s leg. Straker was deeply in debt and had gambled everything he had on Silver Blaze’s rival - a long shot who was sure to win if Silver Blaze was out of the running. However, during the attempt to injure his tendon, Silver Blaze sensed something was wrong and lashed out with his hoof, striking Straker in the head and killing him instantly. The murderer was, therefore, Silver Blaze acting in “self-defense”.

The importance of the lame sheep, of course, was that Straker needed to practice the delicate process of laming Silver Blaze. He did this by practicing the operation on the sheep until he had the procedure perfected.

[Photo from "The Adventure of Silver Blaze" By Sir Arthur Conan Doyle, Published in Strand Magazine in 1892 Sidney Paget (1860-1908 English)]
Patricia Wiltshire is internationally renowned for her research and expertise in the area of archaeological palynology and for her contributions toward establishing the new discipline of forensic mycology. She is actively engaged in forensic botany and palynology, and environmental/ecological profiling. She is a consultant for a number of police forces in England, Wales, Ireland, and Scotland, applying her expertise to cases involving theft, murder, rape, and abduction. She specializes in locating clandestine burials and estimating time of deposition of corpses, as well as linking objects to places, using palynological, ecological, and botanical methods.

Wiltshire works with scientists from the Forensic Science Service, Forensic Science Service Specialist Advisors, and Specialist Advisors of the National Police Improvement Agency (NPIA) in the United Kingdom and is a member of the International Homicide Investigators Association. She has taught at King’s College, London University; the Institute of Archaeology, University College London, where she established the institute’s master of science program in forensic science; and is currently a Research Fellow at the University of Aberdeen and a Research Associate at the University of Gloucestershire.

**Education:** Ph.D. in botany, Kings College, London University
Honorary higher doctorate (D.Sc.), Gloucestershire University

**Why did you decide to go into this field?**

As a palynologist (study of pollen and spores) botanist, I have worked on high-profile archaeology digs in the area of environmental reconstruction. I examine soils and sediments that contain pre-historical, and historical evidence. This evidence mainly includes pollen grains and plant spores, although fungal spores are also valuable.

One day, a criminal investigator asked me to apply my expertise to a murder case. I used my skills to produce sufficient evidence for the police to arrest and convict a gang of criminals. Since that first case, I have worked to develop the discipline of forensic palynology in Great Britain.

**What background, training, experience, and/or certification does someone typically need to become an expert in your field?**

A Ph.D and experience in routine palynology. Also study botany and ecology, with special emphasis on soils. Fieldwork in the area of paleoecology (environmental reconstruction) and...
archaeology helps one acquire basic techniques and learn to cope with difficult samples. It is also essential to be familiar with plants exotic to one’s own country or research area.

**Are there professional organizations in your field?**

The Forensic Science Society and the American Association of Sedimentary Palynologists are two organizations that lend credibility to one’s expertise in this area. But there are so few of us in the field of forensic palynology, it would be difficult to have a professional organization just for this discipline.

**What was your most interesting case?**

One of the most satisfying cases was where I was able to prove who put a baby’s body in a bag and deposited it in a dirty stream. It turned out the culprit was boyfriend of the child’s mother. They lived in a very poor part of Birmingham (UK). The range of exotic pollen I obtained from the suspect matched that which was found around the stream. The results were quite bizarre because the vegetation around the stream was poor. However, I found split plastic bags of rotting plant material at the site, garden waste that had been dumped along the stream. The “compost” had spread over the site and it was rich in pollen. The suspect had walked through this on his way to the stream.

**What do you especially like about working in this field?**

I like the fact that I can apply my training, and the wealth of experience I have accumulated over the years, to a good use for society. It is also satisfying that every single case is unique and challenging. The actual work of processing samples, and identifying and counting pollen grains and spores, is very tedious. But, interpreting the results and realizing that they are meaningful to a case, is very exciting.

**What is the most difficult part of your profession?**

There are no written instructions to help with what I do, and much of the information in the literature is not helpful. Another problem is dealing with police, pathologists, and other (more conventional) forensic scientists who find it difficult to understand or accept that something as old-fashioned as botany can help solve cases. It is also very difficult dealing with rotting corpses, gut contents, feces, and other items that most people would never encounter. One needs to have a robust character and a strong stomach.

**What advice would you give to someone who is considering pursuing this field?**

Obtain a degree in botany and study as much ecology—plants, microbes, and animals—as possible. The knowledge will help one interpret complex patterns at crime scenes, in the mortuary, and under the microscope. It is utterly imperative to be a good field ecologist. In order to identify anomalies at crime scenes and other places, one must know what is normal.

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**Mycology and forensics**

David Hawksworth, scientific associate for the National Museum in London, is a biologist who has applied his expertise in mycology (study of fungi) to forensics investigations, including the use of fungal growth and spores to estimate post-mortem interval, field evaluation and identification of fungi and spores (including lichens), and differentiation of poisonous and hallucinogenic fungi. He has taught at the University of Gloucestershire and served 14 years as director of the International...
Mycological Institute in Kew and Egham. He is the recipient of numerous awards, including Commander of the British Empire (1996) for services to science.

Education: Honorary Higher Doctorate Umeå University, Sweden.
DSc, Ph.D., and BS from Leicester University

Why did you decide to go into this field?
I became involved in forensics investigations in 2006 when I was asked to identify fungal spores found in palynological preparations made in connection with a murder case. Since then, I have assisted in about 15 cases in the United Kingdom.

What background, training, experience, and/or certification does someone typically need to become an expert in your field?
A Ph.D. in some aspect of systematic mycology followed by decades of fieldwork to identify fungi from diverse habitats around the world.

Are there professional organizations in your field?
Many countries have mycological societies, though these tend to concentrate on larger fungi. There are also international associations concerned with various aspects of the subject, however, none issue any formal qualification or certifications.

What was your most interesting case?
There are really two. One case involved an alleged rape. We used fungal spores along with trace evidence of pollen to identify the sites where the alleged crime occurred. The findings led to a confession. The second case involved the growth of fungi on carpet soaked with body fluids following a murder. Through experiments, it was possible to estimate the time and day of death.

What do you especially like about working in this field?
I enjoy applying knowledge I’ve accumulated over many years to resolve serious crimes and obtain convictions of those responsible. It is a contribution to society that I had never contemplated as something that I could do with my expertise.

What is the most difficult part of your profession?
Getting to know the fungi and their ecological requirements. It is also difficult to keep up with the growing amount of literature available in the field. I continue to find spores that I have never encountered. We probably have only named about 5 to 6 percent of all the fungi on Earth.

What advise would you give someone who is considering pursuing this field?
First, obtain a Ph.D. in some aspect of fungal taxonomy that involves the study of microscopic features, and then spend decades learning about the fungi that occur in the region where you expect to work through fieldwork and by working alongside other mycologists.
Chapter 10: References and Bibliography

Forensic Ecology, Botany, Palynology and Mycology


Forensic Entomology


GLOSSARY OF TERMS

Adventive species – Insect species that use the dead remains as part of their habitat.
Algor mortis – The cooling of the body to eventually match the temperature of its surroundings.
Animals - Multi-cellular organisms that are members of the kingdom Animalia.
Anther – The part of the flower’s stamen that produces pollen.
Beetle - An insect with a hard exoskeleton, hard forewing covers that protect the flight wings, and belonging to the order Coleoptera.
Biome – A large community of plants and animals that occupy a habitat in the natural world.
Biosphere - The living part of the earth.
Botany – The scientific study of plants.
Blow fly - An insect from the family Calliphoridae with two sets of wings and depositing their eggs on the remains; one of the most important species in forensic entomology.
Chitin – A hard material composed of a polymeric sugar molecule from which the exoskeleton insects is formed.
Ecosystem - A complex system of interrelated living organisms and their environment.
Entomology - The scientific study of insects.
Exoskeleton - The external covering, typically hard, that supports and protects an insect.
Faunal succession - The concept that different plants and animals follow each other in a predictable sequence. For example, blow flies arrive first at decaying remains, followed by beetles.
Fungi – The group of living organisms, belonging to the kingdom Fungi, that live by decomposing and absorbing nutrients (e.g., mushrooms, molds, yeast).
Insect - An animal, belonging to the class Insecta, that have bodies divided into three parts (head, thorax, and abdomen), three sets of legs, usually two sets of wings, and an exoskeleton.
Instar - A larval stage in the development of an insect.
Isomegalen diagram – A plot that shows the relationship between temperature and the time necessary for a larva to grow to a given size.
Maggot mass - A collection of very large numbers of feeding maggots in one place.
Medicolegal entomology - The branch of forensic entomology that deals with the juncture of medicine and the law.
Monerans - Prokaryotic organisms, belonging to the kingdom Monera, that includes bacteria, blue-green algae, and other primitive species.
Mycology – The scientific study of fungi.
Myiasis – The disease arising from blow flies feeding directly on a living host's tissues.
Necrophagous insects - Insects that feed directly upon human remains.
Omnivorous species - Insects that feed both on the remains and resident species.
Oviposition - The deposition of eggs by an insect.
Palynology – The study of pollen, spores and similar very small materials.
Palynomorph – A very small particle, typically between 5 and 500 µm, such as pollen, microfossils or similar.
Parasite - An organism that lives off of another organism (host) without providing any advantage to the host.
Phylum - The second most general biological subdivision, just below the kingdom level, and includes organisms with similar body organizations.
**Plants** - Organisms belonging to the kingdom Plantae that produce their nutrition by photosynthesis and have rigid cell walls.

**Pollen** – The fine material discharged from the male part of a flower or cone.

**Post mortem interval (PMI)** – The length of time from the death of the organism to the time that the remains are found.

**Protists** - Simple one-celled organisms belonging to the kingdom Protista.

**Proxy Indicator** – Evidence that points to a particular biological organism, habitat or similar.

**Puparia** – The larvae insect form in which the outer skin of the pre-pupae larvae hardens and darkens to form the outer pupal case.

**Rigor mortis** – The muscle stiffening that occurs after death caused by the chemical decomposition of glycogen and the formation of lactic acid.

**Segmented body** - The divisions of an insect’s body into the head, thorax, and abdomen.

**Sinking rate** – The rate at which pollen falls under the influence of gravity.

**Spiracles** - A respiratory opening in the body of an insect larvae or through the exoskeleton of an adult insect.

**Spore** – The minute reproductive unit that can grow into a new organism.

**Taxonomy** - The science of description and classification of living organisms based upon their similarities.
QUESTIONS FOR FURTHER PRACTICE AND MASTERY

10.1. Forensic entomology **typically** can be used for ________________.

10.2. The most important forensic insects in PMI determination are the ________.

10.3. Describe the most important stages and the events associated with each stage in the decomposition of a body. ________________

10.4. Using the plot below for *Lucilia sericata*, the largest larva removed from a body was found to be 4 mm. If the temperature for the previous week was at 60° F, what would be the age of this larva? What would happen if the temperature during this period were 70° F instead of 60° F?

10.5. Describe the life cycle of a blow fly and how this might be used to determine a PMI. ________________

10.6. Describe the first insect species to typically arrive at a body after death and what subsequently arrive. What is faunal succession?

10.7. What are the factor(s) that affect rate of maggot growth and development on a body the most?

10.8. Using the blowfly development plot above, how long would you expect it to take for a maggot to grow to 8 mm at 15°C?

10.9. What are the most important factors in determining the PMI from blowfly maggot growth and development?

10.10. When and where do blow files usually lay their eggs?

10.11. Briefly describe how pollen and fungi can be used in a forensic investigation.

10.12. What is meant by the term biome?

10.13. What are some of the limitation of palynology in a forensic investigation?

*Introduction to Forensic Science*  
*Chapt. 10.60*  
*Draft 2/17/12*  
*J. T. Spencer*
10.14. Cite on case (from the web) where forensic zoology was an important aspect of the case.
10.15. What is ecology?
10.16. What are proxy indicators?
10.17. What is taxonomy?
10.18. On which phylum does entomology focus?
10.19. What defines an insect?
10.20. What is a necrophageous insect?
10.21. What are the four classifications of arthropods associated with the ecosystem of a dead animal?
10.22. How quickly after the death of an animal will blow flies deposit their eggs?
10.23. How long does the bloated stage typically last? What is primarily responsible for the bloating?
10.24. What signals the onset of the decay stage?
10.25. What effect can the maggot mass have on the remains?
10.26. What parts of the animal are typically left at the end of the decay stage?
10.27. How long does the post decay stage last?
10.28. How does burial impact the decay process?
10.29. How might vertebrate scavengers impact the decay process?
10.30. When using insect cycles to set PMI, what factors must be considered?
10.31. What is myiasis?
10.32. What is the important underlying principle of forensic botany?
10.33. How does a forensic botanist link evidence to a particular site?
10.34. What factors go into a botanical survey of a location?
10.35. What are some of the difficulties in using DNA to track particular plant species?
10.36. What identification difficulties and advantages are presented by plant cloning and plant hybridization?
10.37. What is the most abundant palynomorph?
10.38. What is the difference between pollen and spores?
10.39. How can the presence of pollen or spores found on a victim or on a suspect help a forensic botanist in an investigation?
10.40. What are the differences between anemogamous plants, zoogamous plants and autogamous plants?
10.41. What is “sinking rate”?
10.42. Fungi have well known growth cycles. Explain how this can help in determining PMI.
10.43. What are some of the responsibilities of a forensic zoologist?

EXTENSIVE QUESTIONS

10.44. Explain what each of the following areas of ecology study: entomology, botany, zoology, palynology and mycology.
10.45. List the scientific classifications of life from the broadest category to the narrowest.
10.46. Explain the five decay stages of an animal. What factors can affect the timeline of this process?
10.47. A forensic entomologist identifies the presence of eggs from a Green Bottle fly in human remains found in a shady cove. What conclusion can be drawn about the remains?
10.48. Describe how the type of plant life and its condition at a crime scene can help determine PMI (postmortem interval).
10.49. A forensic entomologist removes the largest maggot from some remains found in the woods. The maggot measures 10mm. The temperature over the past week has had a high of 80°F and a low of 65°F? Using the Isomegalon chart above, what is the range of days that have transpired to produce the maggot?