Entomology and the Law

Used particularly when there has been a suspicious death, insect-related evidence is one of the most powerful, but least understood examples of modern forensic science. *Entomology and the Law* provides a detailed roadmap that can be followed from crime scene to courtroom by entomologists, law enforcement personnel and lawyers preparing for trial. Part I focuses on carrion flies as forensic indicators, exploring relevant biology clearly, and concisely illustrated by real-life cases. Flies are usually first on the scene of a death, and knowledge of their habits and lifestyles can help to reveal time of death, weeks or even years later. Part II provides a thorough examination of the law of scientific evidence worldwide, complete with caselaw and applicable code provisions, and legal issues relevant to the admissibility and use of forensic entomology in litigation. It will prepare both scientists and lawyers for real-world forays into the world of forensic entomology.

**BERNARD GREENBERG** is Professor Emeritus in the Department of Biological Sciences at the University of Illinois at Chicago. He is an internationally recognized fly biologist. One of the founding fathers of the modern field of forensic entomology, he has been an expert witness and consultant for many murder trials.

**JOHN CHARLES KUNICH** is a Professor in the Roger Williams University School of Law in Rhode Island. Trained originally as an entomologist, he changed track and gained his Juris Doctor degree cum laude at Harvard Law School, followed by a Master of Laws degree summa cum laude from George Washington University School of Law. He now teaches and publishes in the areas of scientific evidence, trial advocacy, law and science, environmental law, and natural resources law.
Entomology and the Law
Flies as Forensic Indicators

Bernard Greenberg
*University of Illinois, Chicago*

AND

John Charles Kunich
*Roger Williams University School of Law, Rhode Island*
Dedication

To all my grandchildren and those to be.
Bernard Greenberg

and

To my wife and daughters Christina Laurel and Julie-Kate, from whom all that is good in my life flows
John Charles Kunich
Contents

Glossary viii

PART 1
Preface to Part 1 1
1 A History of Flies 3
2 Forensic Biology of Flies 16
3 Keys to the Eggs, Larvae, Pupae and Adults of Some Forensically Important Flies 54
4 Problems Estimating Time of Death 154
5 The Fly in Court 168

Entomological References 194

PART 2
Preface to Part 2 213
6 The Law of Scientific Evidence 215
7 The Admissibility of Forensic Entomology Evidence 249
8 The Introduction and Optimal Use of Forensic Entomology Evidence at Trial 284

Conclusion 302
Index 304

Colour plates between pages 50 and 51
Glossary

ADH – accumulated degree hours: the number of heat units × time required for a specific development to occur.

alpine – a biotic zone occurring roughly at 3500–4800 m.

anautogetic – requiring a protein meal to develop the ovaries and eggs.

apodeme – an invagination of the body wall in arthropods that serves for muscle attachment or for strengthening the body wall.

apophasis – separation of the new skin from the old one, as in the fly when the pupa is no longer attached to the inside of the puparium.

asynanthropic – flies and other organisms that live entirely independently of the human environment.

autogenous – the ovaries and eggs mature without a prior protein meal.

bionomics – the habits, breeding and adaptations of organisms.

blowflies – see Calliphoridae.

Calliphoridae – a family of large, generally metallic blue or green carrion-feeding flies commonly called blowflies, bluebottles, and greenbottles; some species are parasitic.

carbohydrase – an enzyme that splits carbohydrates.

carrion flies – sarcosaprophagous flies (feeding on dead animals) belonging to various families including Calliphoridae, Sarcophagidae, Muscidae, Phoridae, and Piophilidae.

cephalic – toward or referring to the head.

chorion – the outer shell of the insect egg.

chrysalis – the pupa in moths and butterflies.

chymotrypsin – an enzyme from the mammalian pancreas that digests proteins in alkaline solution.

cicatrization – formation of a scar at the site of a healing wound.

circadian rhythm – an organism’s behavior/physiology closely tied to a 24-hour cycle.

collagenase – an enzyme in blowflies that splits collagen, the main constituent of fibrous tissue, in alkaline solution.

corroboration – additional evidence that supports some other item of evidence.

crop – an inflated part of the foregut of insects, functioning as a temporary storage organ for excess food in fly larvae; also present in many adult flies.

cross examination – the process by which the opposing party’s attorney asks questions of the other side’s witness in court. Leading questions are generally permitted during cross examination.
cryptocephalic pupa – the stage following larval-pupal apolysis within the fly puparium; adult structures are not yet visible.
demonstrative evidence – evidence other than actual testimony of witnesses, which relates to the senses. Examples include photographs, charts, diagrams, maps, models, computer-aided animation, etc.
derponent – a person who gives testimony in a deposition.
deposition – the testimony of a witness taken not in open court, but in advance of the in-court phase of a trial; a discovery device in which the attorney for one party asks questions of the other party or the other party's witnesses. The questions and answers can be written or oral. If oral, a verbatim transcript is made of the deposition.
Dermetidiae – a family of beetles the larvae of which attack a wide variety of dead animal substances, usually exploiting middle- or late-stage carcasses.
diapause – arrested development in the egg, larvae, or pupa, or dormant period in the adult.
direct examination – the process by which the attorney who called a witness to testify asks questions of that witness in court. Generally attorneys may not ask leading questions during direct examination.
dura mater – the outermost and toughest of three membranes which envelope the brain and spinal cord; closely applied to the bone in the cranium.
edysone – hormone from the prothoracic gland that initiates new cuticle formation. In maggots, it stimulates the growth of the imaginal discs which produce adult structures, e.g. legs, wings, and antennae.
ecllosion – the process of adult emergence; in flies, from the puparium.
endemic – restricted to, or native to, a particular region or area.
endophily – characterized by a readiness to enter homes, etc.
eschar – dry crust or scab at site of wound.
eurythermal – adapted to a wide range of temperatures. (See stenothermal.)
eusynanthropic – closely tied to and dependant on the human environment.
exophily – preferring the outdoors and characterized by a reluctance to enter homes, etc.
expert witness – a witness qualified by virtue of specialized knowledge, education, training, or experience to offer an opinion in court or in a deposition on some matter in controversy.
exuvium – the cast skin.
facultative imaginal diapause – the adult may or may not exhibit arrested development or prolonged cessation of activity.
fecundity – potential reproductive capacity.
fleshflies – see Sarcophagidae.
forensic – used in or belonging to the courts of justice.
fuscous – dark brown, approaching black.
Gravid – full of eggs.

Hearsay – an out-of-court statement offered in court to prove the truth of the matter asserted in the statement. Some forms of hearsay are admissible as evidence, usually as specific exceptions to the general rule against admissibility of hearsay.

Hemisynanthropic – overlapping the human environment but capable of functioning independently of it.

Hemolymph – the blood of arthropods, which circulates in a system where it is only partly confined to blood vessels.

Holarctic – the northern regions of the Old World (Palaeartctic) and the New World (Nearctic).

Holometabolous – complete metamorphosis, i.e., egg, larva, pupa, adult.

Holoptic – the compound eyes touch, or nearly so, dorsally.

Hypertrophy – abnormal enlargement or excessive development.

Imaginal discs – saucer-shaped embryonic clusters of cells in maggots destined to give rise to adult structures, e.g., legs, wings, antennae.

Instar – the stage between molts in the larva, e.g. the first instar is the stage after hatching from the egg and before the first molt. Flies typically have three larval instars.

Interrogatories – a set or series of written questions used during discovery, pre-trial, to gather information about the case, as in a deposition. The answers are generally given under oath and subject to the penalties for perjury.

Juxta – or apical plate, shovel-like and sclerotized at the apicoposterior part of the phallus.

Larva – the stages subsequent to the egg and before the pupa, which are usually mobile and actively feeding.

Larviparous – eggs hatch within the female.

Larviposit – the female deposits larvae instead of eggs, as in sarcophagids.

Leading question – a question which suggests or implies a particular answer.

Leading questions often begin with such phrases as “Isn’t it true,” “Is it a fact that,” and other words that attempt to lead the witness to agree with the questioner. Generally, leading questions are only permitted to be used during cross examination.

Lipase – an enzyme that splits fats.

Livor mortis – blood circulation ceases after death, blood collects in the lowest regions where a red-purple discoloration appears.

Maculae – spots.

Material – a quality of evidence that tends to influence the trier of fact because of its logical connection with the issues in the case.

Medicolegal – in forensic entomology, pertaining to a homicide, suicide, or accidental death under questionable circumstances.
metabolic heat – heat produced by an organism(s) in excess of the ambient temperature.

metamorphosis – the changes that occur during development to the adult stage. There are three categories: (1) holometabolous – complete metamorphosis (egg, larva, pupa, adult) e.g. flies, bees, beetles; (2) paurometabolous – gradual metamorphosis (egg, nymphal stages and adult, usually winged), e.g., grasshoppers; and (3) ametabolous – as in (2) but with wingless adult, e.g., silverfish.

micropyle – the minute opening at the anterior end of the egg through which sperm enter.

montane – a biotic zone occurring roughly at 2700–3500 m.

Neotropical region – includes South and Central America, the Caribbean, and the coasts and southernmost parts of Mexico. The rest of Mexico is in the Nearctic region.

neuroendocrine system – its input is sensory signals, its output is effector signals and hormones.

nival – a biotic zone occurring roughly at over 4800 m.

non-responsive – an objection to a witness's answer to a question in court on the basis that the answer failed to address the matter at issue in the question. Rambling, discursive, or argumentative answers are often vulnerable to this objection.

objection – a formal legal protest against something in a trial or deposition, used to call the court's attention to improper or illegal evidence or procedure. Objections often must be made at trial to preserve a legal issue for subsequent appeal.

obligate heliophile – showing a strong preference for light and avoiding shade or darkness.

ommatidium – a photosensitive unit of the arthropod eye with a set of lenses, retinal cells and optic nerve fibers.

oocyte – female gamete before maturation.

osteomyelitis – inflammatory disease of bone that may involve the marrow, cortex, or periosteum, caused by an infectious agent.

oviduct – one of the paired tubes through which the egg passes from the ovarian tubules into the vagina.

oviposition – the act of laying eggs.

pepsin – an enzyme that digests proteins in an acid solution (pH 2.5–3.5).

peritrophic membrane – secreted at the anterior of the midgut and envelopes the incoming food.

phanerocephalic pupa – the stage within the fly puparium where head, legs, antennae, and wing buds are everted.

pharate adult – the adult fly prior to emergence from the puparium.

phenotype – the detectable expression of the interaction of an organism's genotype and environment.
GLOSSARY

Phoridae – a family of small flies of widely different habits, including carrion feeders e.g., the coffin fly.

phragma – an invagination of the exoskeleton to which a muscle is attached.

pilose – hairy.

Piophilidae – a family of small dark flies, some of which feed on late-stage carrion, cured hams, and cheese, hence the name ‘cheese skipper’ for the mature larvae of some species which exhibit a remarkable method of propulsion.

Pleistocene – the period on earth from 2 million to 100 000 years ago.

pollen – a dusty, grayish surface on flies.

polymorphism – existence of populations of a species with different forms and/or behaviors.

postfeeding larva – the nonfeeding stage of the fly larva prior to pupariation, during which the gut contents are digested and a single layer of fat cells is deposited on the inner surface of the cuticle.

prepupa – the brief maggot stage within the puparium before larval–pupal apolysis.

probabilistic evidence – evidence that relies on statistics and/or probability estimates. Many courts disfavor such evidence, at least in the absence of corroboration.

protease – an enzyme that splits proteins.

prothoracic gland – endocrine gland generally located in the thorax that secretes ecdysone. It is part of the ring gland in the maggot.

psychrophilic – cold loving.

ptilinum – an ephemeral bladder-like structure between the compound eyes of the emerging adult fly which alternately inflates and deflates.

pupa – in insects with complete metamorphosis the stage between larva and adult, wherein extensive destruction of larval tissues occurs to make the adult structures.

pupariation – the process that shrinks the postfeeding maggot and makes its skin dark, shiny, and brittle.

pupation – formation of the pupa within the puparium of flies (see chrysalis).

respiratory horns – breathing tubes on the fourth segment, only in phanerocephalic pupae, that are accessory to the posterior spiracles.

relevance – a tendency of any evidence to make any fact in issue in a case more or less probable than it would be without that evidence. All evidence, at a minimum, must be relevant to be admissible at trial.

rigor mortis – rigidity of muscles after death.

ring gland – in higher Diptera the corpus allatum, corpus cardiacum, and prothoracic gland form a composite structure which rings the aorta, and is closely associated with the brain toward the rear part of the foregut (see Fig. 2.2).
Glossary

Sarcophagidae – a family of black and grey checkered flies, mostly carrion feeders, thus the common name ‘fleshfly’. Some species are parasitic.

Sarcosaprophagous – consuming dead meat.

Sclerotization – the process that leads to hardening and usually darkening of the arthropod cuticle.

SEM – scanning electron microscope: an electron beam is focused on the gold-coated surface of the object; secondary electrons are emitted from the surface and picked up by a secondary electron detector. The effect is a view of the surface, as in the light dissecting microscope.

Seta – hollow bristle or hair developed from specialized cells in the epidermis of the arthropod cuticle.

Spiracle – an opening in the insect’s body through which air passes into the tracheae or air tubes.

Standard Error – the standard deviation of the sample mean.

Stenothermal – adapted to a narrow range of temperatures (see eurythermal).

Succession – in forensic entomology, the sequence of arthropods visiting and exploiting a carcass.

Testaceous – brownish yellow; bearing a hard covering.

Trachea – a system of ramifying tubes that bring oxygen from the outside to the cells. The maggot has two parallel tubes that run the length of the body and give off branches in each segment.

Trier of fact – the person or persons who determine which facts will be considered to be established as true for purposes of a given case. It is generally the function of the jury to serve as the triers of fact, while the judge determines the law to be applied to those facts.

Trypsin – an enzyme that digests protein in an alkaline solution.

Voir dire – the process of questioning potential jurors prior to their empanelment as the official jury for a given case. Voir dire can also take place with regard to a potential expert witness, out of the presence of the jury, to determine whether he or she can qualify as an expert witness on the relevant subject matter at trial.