

Forensic entomology – How the tiny insects unravel the mystery of a crime!

Madhurima Vinod¹ and Ishwari G. Hiremath²

¹Assistant Professor, Entomology, Department of Entomology, KLE College of Agricultural Sciences, Tenikolla, Belagavi, Affiliated to University of Agricultural Sciences (UAS), Dharwad, Karnataka.

² Assistant Professor, Plant Pathology, Department of Plant Pathology, KLE College of Agricultural Sciences, Tenikolla, Belagavi, Affiliated to University of Agricultural Sciences (UAS), Dharwad, Karnataka

Insects are the most numerous life forms on the planet with approximately seven out of every eight living species being insects. They are the most diverse group of animals with more than a million described species representing more than half of all animal species. Insects are known for their adaptability and ability to inhabit nearly all terrestrial and freshwater environments. They play vital roles in ecosystems such as pollination, decomposition and pest control. Insects are essential to ecosystems serving as pollinators, decomposers, predators, prey and ecosystem engineers thereby maintaining biodiversity, nutrient cycling and ecological balance.

Insects such as bees, butterflies and flies are critical pollinators facilitating the reproduction of flowering plants and crops. Decomposer insects including beetles, ants and termites break down organic matter such as dead plants, fallen leaves and animal waste. This process recycles nutrients back into the soil, enhancing soil fertility and supporting plant growth. Insects occupy multiple trophic levels acting as both predators and prey. Predatory insects help control populations of crop pests naturally, reducing the need for chemical pesticides. Meanwhile, insects serve as a vital food source for birds, mammals, reptiles, and other wildlife, sustaining complex food webs and maintaining ecosystem stability. Insects are indispensable to ecosystem health, performing multiple roles that sustain biodiversity, regulate populations, recycle nutrient and support food webs. In addition to all these roles played by insects, there is one area where the role of insects is indispensable – forensics!

Forensic entomology is an important branch of forensic science in which the information about insects is utilized to draw inferences in criminal investigations in instances involving both humans and wildlife. Both on land and in water, insects can be utilized to probe a scene of crime. Insects are crucial to the decomposition of bodies and can offer crucial hints in criminal inquiry and examinations. When the post-mortem interval (PMI) is extensive and other procedures are ineffective, entomological findings is very helpful in determining the timing of the death. Additionally, insects supply forensic evidence with geographical or temporal information that is otherwise impossible to get. Forensic entomology relates to death investigations. Numerous forms of forensic investigations can benefit from information of the location, anatomy and conduct of insects

present in areas where carcasses have been located as it can indicate investigators when, at what place and how a crime was perpetrated or how a person died under specific circumstances.

In forensic entomology, insects are not just scavengers- they are timekeepers, location markers and sometimes silent witnesses that help reconstruct what happened around a death. By studying which insects colonize a body, in what sequence and at what developmental stage, forensic entomologists can estimate the time of death, infer whether a body was moved and even detect toxins that might otherwise go unnoticed. Insects are reliable indicators in this regard because their colonization of a body is often predictable. After death, body releases volatile compounds that attract necrophagous (carrion-feeding) insects especially blowflies and beetles in a fairly predictable succession. Also, insect growth rates are strongly influenced by ambient temperature, so by identifying the species and measuring larval size or stage, experts can back-calculate the minimum post-mortem interval. Some of the behavioural clues also help in solving the crime. For example, heavy infestation on non-natural body openings may indicate wounds; unusual species assemblages can suggest the body was moved between environments like indoor to outdoor, urban to rural etc.

Insects like rove beetles, nematodes, blowflies, flesh flies etc can help in forensic entomological examinations. Few species, at their larval stages feed on carrion and eat a dead corpse. In some, both the adult and juvenile phases consume the organism. Other insect groups, however, are drawn to the body only to feast on the necrophagous larvae that are already there. Arthropods samples like Diptera, Coleoptera etc whether maggots or adults should be regarded as forensic proof in the same way as biological materials like hair fibres, fingerprints and blood stains. Both at the postmortem and the scene of the crime inspection, insects should be treated as evidence.

Use of insects in mortality examinations is justified for several factors. Typically, insects are the quickest to discover a dead body. The blow flies frequently lay their eggs on carcasses during the first few moments after a death. This event begins a biological clock, and the age of the growing fly offspring is later determined as the foundation for calculating the PMI. As the decaying process advances, the invertebrate fauna inside and around a body transforms in a reasonably

regular successional manner. A diverse variety of creatures from bacteria to vertebrate decomposers, use the body as a transitory supply. Insects are often the most consistent, diversified and noticeable group of arthropods present. Their roles may be classified into following different categories:

- **Necrophages**- They are the type of organism that eats carcass tissue. This category consists of Coleoptera - E.g: Silphids and Dermestids and Calliphorids, Diptera- particularly Calliphorids and Sarcophagids. Usually, determining the age of these insects serves as the foundation for developing PMI estimates.



Blue bottle flies - Calliphoridae



Burying beetles - Silphidae

- **Generalist Feeders**- Species that consume both the body and the surrounding fauna are known as Omnivores. This includes ants, bees and certain beetles. Massive numbers of these species might slow the rate of body decomposition by reducing necrophagous species populations.
- **Predators**- This category of arthropods was ranked second in significance to necrophages. Numerous Coleoptera - E.g: Histerids, Staphylinids, Silphids, Diptera and those Hymenoptera that infests young flies are all included in this group. Many insects, which are necrophagous in the initial stages of their larval growth, turn predacious in the later stage.

- **Incidentals**- Arthropods that exploit the cadaver as an expansion of their natural home and a rich supply of resources fall under this category. This class of organisms includes centipedes, spiders, springtails and several mites including Lardoglyphidae and Acaridae. Insects from any of these groups may offer valuable evidence for the inquiry to the forensic entomologist.

Insects play a significant part in the decaying mechanism by nibbling on the body mechanically and producing salivary fluids that include proteolytic enzymes to help dissolve stubborn tissues. Additionally, the initiation and acceleration of bacterial degradation is the result of these mechanical and chemical mechanisms. Diptera (fly), whose larvae can survive in a semi-liquid condition, are responsible for the primary and most severe decomposition of the body. Once the carcass has largely desiccated, members of other arthropod families, particularly Coleoptera (beetles) and Lepidoptera (moths) enter and carry on the process further.

When flies arrive at a body, they either start ovipositing nearly immediately or initially eat before doing so. The first insects to approach generally blue bottles (Calliphorids) deposit their eggs at injuries and bodily openings, including the nose, mouth, ears and if accessible, the rectum and genital. Depending upon the weather, the larval stage called maggots develop in 2-3 days. Larval size is a useful characteristic for identification. It is increasingly significant as it gets older. The larvae develop quickly and go through three stages before reaching adulthood. At this phase they creep away from the corpse, bury themselves beneath the ground and undergo metamorphosis. When the adults emerge, it flies away and then again, the life cycle continues. The blue bottles generally land on the corpse first. They are very essential to the forensic entomologist in determining the time of death since they are obviously drawn to meat before it exhibits any indications of deterioration.



Flesh fly - Sarcophagidae



Carrion beetle - Silphidae

The flesh flies (Sarcophagids) are additional category of flies that are drawn to the initial phases of the corpse. They either directly deposit eggs or lay tiny larvae that mature quickly. The larvae are larger than the ones in the blue bottles, but they may be readily differentiated from them through comparing the anatomy of the hind spiracle. Green bottles, another well-known species of flies are drawn to the ammoniac smells of dead bodies and begin to emerge on them after approximately a week. The body is drastically altered over the first few weeks by these principal colonists, and as it dries out, it attracts various more dipterans. When the fats rot and get creamy, it creates the ideal environment for the cheese skipper fly *Piophilidae casei*. This fly's larvae also

inhabit any bodies that get to this point in the decomposition process. Drosophilidae and other closely connected Sepsid flies are also drawn to the body at this time. After another 6 to 12 months, when the body is fully mummified and dried, the coffin flies, also known as the Phoridae, begin to occupy it.

Two more insect types, besides Diptera, are somewhat engaged in the decomposition of a body. Coleoptera, or beetles, are the biggest category of insects, making about 25% of all species. After the first fly species have invaded the body and the residual tissues have dried out, they subsequently infiltrate. The function of beetles on corpses has not received much research. They enter in the late phases of degradation, which may be partly a revelation of how quickly humans have unearthed the bodies.

There is no doubt that insects have a lot to offer in forensic science. Their value can only be realized to the full extent if the investigating officer, technicians, the police, pathologists, technicians and others involved in crime solving are clearly cognizant of the intricate ecology of the decay process, the requirements of the decomposer organisms and the importance of gathering crucial samples and helpful field data. The use of pesticides in autopsy rooms has resulted in the loss of important entomological data or has negatively impacted such data. Every forensic science laboratory should have the resources and knowledge necessary to establish developmental times, which are crucial for determining the time of death.
