Review Article

The use of insects in forensic investigations: An overview on the scope of forensic entomology

Isaac Joseph,
Deepu G Mathew,
Pradeesh Sathyan,
Geetha Vargheese
Department of Oral and Maxillofacial Pathology, Sree Mookambika Institute of Dental Sciences, Kulashekhram, Kanyakumari, Tamil Nadu, India

Address for correspondence:
Dr. T. Isaac Joseph, Department of Oral and Maxillofacial Pathology, Sree Mookambika Institute of Dental Sciences, Padanilam, Kulashekhram, Kanyakumari – 629161, Tamil Nadu, India.
E-mail: drisaacj@gmail.com

Abstract

Forensic entomology is the study of insects/arthropods in criminal investigation. Right from the early stages insects are attracted to the decomposing body and may lay eggs in it. By studying the insect population and the developing larval stages, forensic scientists can estimate the postmortem index, any change in position of the corpse as well as the cause of death. Forensic odontologists are called upon more frequently to collaborate in criminal investigations and hence should be aware of the possibilities that forensic entomology have to offer and use it as an adjunct to the conventional means of forensic investigation.

Key words: Insects, larvae, maggots, postmortem index

Introduction

Forensic entomology is the study of the application of insects and other arthropods in criminal investigation.[1] Insects or arthropods are found in a decomposing vertebrate corpse or carrion.[2] These insect colonizers can be used to estimate the time of death i.e., time interval between death and corpse discovery, also called postmortem index (PMI), movement of the corpse, manner and cause of death and association of suspects at the death scene.[3] This review is aimed at providing an overview to forensic odontologists on the possibilities of using forensic data based on insects and their larvae morphology, growth histories, species distribution and toxic contents in their tissue in criminal investigation.

Access this article online	
Website: www.jfds.org	Quick Response Code
DOI: 10.4103/0975-1475.92154	

History

The first recorded incident where insects were used in a criminal investigation was in 13th-century China as described in Sung Tzu's book called *The washing away of wrongs*. When a farmer was found murdered in a field with a sharp weapon, all the suspects were told to place their sickles on the ground. Only one sickle attracted blow flies to the trace amount of blood hidden to the naked eye which resulted in the confession by the murderer.[1] The first application of forensic entomology in a modern court house was in 18th-century France where entomological data was admitted as proof for acquitting the current occupants of the residence from where the skeletonized remains of a child were found. In the 18th century Yovanovich and Megnin's evaluation of the insect succession on corpses established the science of forensic entomology.[2]

Arthropodes and their association with postmortem changes of the human body

As soon as death occurs, cells start dying and enzymes start digesting the cells inside out in a process called autolysis. The body starts decomposing. Bacteria present in the gastrointestinal tract start destroying the soft tissue producing liquids and gases like hydrogen sulphide, carbon dioxide, methane, ammonia, sulfur dioxide and hydrogen. The volatile molecules called apeneumones escaping from the decomposing body attract insects. Researchers are able to isolate the volatile chemicals released at different stages of decomposition of the body. The volatile molecules released during each stage can modify the insect behavior.[4] Based on the studies done by Crag *et al*., in 1950 it was found that putrative sulfur-based compounds were responsible for initially attracting the flies to the decomposing carcass but egg laying or oviposition of the flies are induced by ammonium-rich compounds present on the carrion.[5]

According to Smith (1986) four categories of insects can be found on decomposing carrion: i) Necrophagous species feeding on the carrion; ii) Predators and parasites feeding on the necrophagous species: this group also contains schizophagous species which feed on the body first and which become predaceous on the later stages; iii) Omnivorous species feeding on the carrion and other arthropods like ants, wasps and some beetles; iv) Other species like springtails and spiders which use the corpse as an extension of their environment. The first two groups are found to be more important for the purpose of forensic entomology. They are mainly from the species of the order Diptera (flies) and Coleoptera (beetles). The succession waves in which the arthropods colonize the carrion depends on the state of decomposition of the carrion.[2]

Insects mostly involved in the forensic investigations are true flies or Diptera. The predominant species in this order are Calliphoridae (blow flies), Sacrophagidae (flesh flies) and Muscidae (house flies). Calliphoridae (blow flies), Sacrophagidae (flesh flies) may arrive within minutes following death. Muscidae (house flies) delay colonization until the body reaches bloat stages of decomposition. Calliphoridae adults are commonly shiny with metallic coloring, often with blue, green, or black thoraxes and abdomen. Sarcophagidae are medium-sized flies with black and gray longitudinal stripes on the thorax and checkering on the abdomen. The adult Muscidae are 8-12 mm long. Their thorax is gray, with four longitudinal dark lines on the back. The whole body is covered with hair-like projections. Usual areas of oviposition or egg laying are the natural body openings and wounds. When they hatch, they produce a larva called maggot. They are small peg-shaped organisms with a pair of mouth hooks on the anterior end for feeding. Maggots grow rapidly passing through the three stages or instars, reaching the full size. Once the full size is reached feeding stops and they migrate to drier areas and they begin pupariation (pupa formation). At this stage the outer skin of the maggot becomes hardened and forms a protective encasement eventually emerging as a fly.[6]

According to the studies done by K. Tullies and M. L Goff on exposed carrion in a tropical rainforest, it was found that the decomposition process was best divided into five stages on the basis of physical appearance of carcasses, internal temperatures and characteristic insect populations:

i. Fresh stage (Days 1-2): which begins at the moment of death and ends when the bloating of the carcass is observed. Even though autolysis occurs at this stage gross morphological changes do not occur at this point. The estimation of the time of death by entomological data after 24 hrs is more accurate than medical examiner's estimation based on the soft tissue examination. Insects were seen attracted within the first 10 min of death to the carcass but no egg laying (oviposition) was found during this state. Cellular breakdown occurs during this stage without morphologic alterations. Even though morphological changes and odors are not obvious to humans, the chemicals released from the cellular breakdown attracts insects even in this early stage.[4]
ii. Bloated stage (Days 2-7): Putrefaction begins at this stage. Gases produced by the metabolic activities of anaerobic bacteria cause an inflation of the abdomen and the carcass forming a balloon-like appearance during the later part. Arthropod activities combined with the putrefaction processes cause internal temperatures of the carcass to rise. The greatest numbers of adult Diptera were attracted to the carcasses during this stage. By the fourth day, first- and early second-instar or larval stages Diptera were present. By the beginning of Day 2, several predators of Diptera larvae were also recovered from the carcasses.
iii. Decay stage (Days 5-13): Abdominal wall is penetrated, resulting in the deflation of the carcass and ending the bloated stage, the internal temperature rises to 14 degrees above the ambient temperature followed by a drop signifying the end of the decay stage. Decaying odors are high during increased temperatures and drop with a fall in temperature. There is a steady decrease in the weight of the carcass by 10th day. There is a conversion of carcass biomass to dipteran larval biomass. The larvae subsequently depart from the carcass to pupate.
iv. Post-decay stage (Days 10-23): The post-decay stage begins when most of the Diptera larvae leave the carcass, leaving behind bones, cartilage, hair, small portions of tissue, and a large amount of wet, viscous material known as byproducts of decay (BOD). The BOD is the major site of arthropod activity during this stage.
v. Remains stage (Days 18-90+): This stage is characterized by bones with little cartilage remaining and the BOD

has dried up. The transition from post-decay to remains stage is gradual, with declining adult and larval Diptera populations.[7]

Steps in estimating the postmortem index with insect larvae

The insect larvae present on the dead body can provide evidence for the estimation of PMI up to one month.[2] Correct species identification is the initial step. Different species differ in their growth rates and maturation. For estimating the PMI, age of the larvae has to be determined. By measuring the length or dry weight of the oldest larvae and comparing it with the reference data, age of the larvae can be estimated. The rate of development of the larvae is dependent on the surrounding ambient temperatures. Each stage of development has its temperature requirement hence each species has its own defined number of accumulated degree days or accumulated degree hours to complete its development. Once the thermal history of the larvae is obtained, it can be compared with temperatures at the death scene and PMI can be estimated. The first-generation adult flies can also be used to determine the age. They can be identified by the shriveled wings, and tiny abdomen with dull grey colour.[7] When insects colonizing the carrion in a particular area is known, an insect colonizing succession model can also be used to estimate the PMI.[8,9]

Using insect data for determining the site of crime

There are reported differences in the species of insects involved with the decomposing corpse in different habitats and environments. A careful examination can reveal species variation, as species associated with one type of habitat present on a corpse is found to be different from those when the corpse is transported after death.

DNA analysis for species identification

Identifying the correct species is the important initial step for estimating the age of the larvae. Morphological comparison is usually used for species identification which requires special expertise and is often time-consuming. In order to overcome this difficulty species identification can be done by polymerized chain reaction amplification suitable regions of the larvae genomes and comparing it with reference data.[10]

Entomotoxicology

The larvae of the flies which feed on the carrion can accumulate drugs ingested by the deceased person. Bodies which are in advanced stages of decomposition or which are skeletonized are difficult to examine for toxicological substances. In these instances, the larvae feeding on this body can be macerated and analyzed with techniques like thin-layer chromatography, gas chromatography and/or mass spectrometry. Toxins can influence the stages of development of the larvae. Cocaine and heroin in the carcass can accelerate the larval development. Poisons like malthione in the carrion can delay the insect colonization.[10]

Conclusion

Forensic entomology is an emerging field in forensic sciences, where the insects feeding on corpses are studied. It has become an important tool in criminal investigations. In the present scenario, the role of forensic odontologists is not confined to hard tissue examination alone. Increased instances of forensic odontologists being involved in criminal investigations, as part of the forensic team, have necessitated the need for an increase in awareness of emerging sciences like forensic entomology and its applications in forensics.

References

1. Catts EP, Goff ML. Forensic entomology in criminal investigations. Annu Rev Entomol 1992;37:253-72.
2. Amendt J, Krettek R, Zehner R. Forensic entomology. Naturwissenschaften 2004;91:51-65.
3. Sukontason K, Narongchai P, Kanchai C, Vichairat K, Sribanditmongkol P, Bhoopat T, *et al.* Forensic entomology cases in Thailand: a review of cases from 2000 to 2006. Parasitol Res 2007;101:1417-23.
4. LeBlanc HN, Logan JG. Exploiting Insect Olfaction in Forensic Entomology. In: Amendt J, Goff ML, Campobasso CP, Grassberger M, editors. Current Concepts in Forensic Entomology. Netherlands: Springer; 2010. p. 205-21
5. Ashworth JR, Wall R. Responses of the sheep blowflies Lucilia sericata and Lxuprina to odour and the development ofsemiochemical baits. Med Vet Entomol 1994;8:303-9.
6. Goff ML, Lord WD. Entamotoxicology;a new area of forensic investigation. Amer J foren med pathol 1994;15:51-7.
7. Tullis K and Goff M L. Arthropod succession in exposed carrion in a tropical rainforest on O'ahu Island, Hawai. J. Med. Entomol 1987; 24: 332-9.
8. Schoenly K, Reid W. Dynamics of heterotrophic succession in carrion arthropod assemblages: discrete series or a continuum of change? Oecologia (Berlin) 1987;73:192-202.
9. Davies L. Species composition and larval habitats of blowfly (Calliphoridae) populations in upland areas in England and Wales. Med Vet Entomol 1990;4:61-8.
10. Chen WY, Hung TH, Shiao SF. Molecular identification of forensically important blow fly species (Diptera: Calliphoridae) in Taiwan. J Med Entomol 2004;41:47-57.

How to cite this article: Joseph I, Mathew DG, Sathyan P, Vargheese G. The use of insects in forensic investigations: An overview on the scope of forensic entomology. J Forensic Dent Sci 2011;3:89-91.

Source of Support: Nil, **Conflict of Interest:** None declared