Insect Detectives

Forensic Entomology

P K Sumodan

P K Sumodan is working as District Malaria Officer of Wayanad District in Kerala. His area of specialization is entomology. His fields of study, for the last one decade, have been mosquitoes and malaria. He writes popular science articles in English as well as Malayalam. Besides science, English poetry is his area of interest.

Insects are increasingly being used to trace absconding murderers. A fascinating branch of insect science (entomology) – *forensic entomology* – is introduced in this article.

In 1235 AD, a small village in China witnessed a murder by slashing. The local investigator who was deputed to probe the crime inferred a sharp sickle as the weapon used. He asked the villagers to bring their sickles to one spot and lay them out before the crowd. To the surprise of the villagers, flies were attracted to only one, otherwise innocent-looking, sickle. On rigorous interrogation the owner of that sickle confessed to the gruesome crime. It was explained later that the attractants on the sickle were small traces of human flesh invisible to the naked eye. This was the first recorded use of insects in the investigation of a crime, and this use of insects has caught on in the world of forensics only in the past 20 years or so. However, in developed countries like USA, forensic entomology has today gained a prominent place in crime investigation.

Forensic entomology is now considered as a major component of forensic science. It deals primarily with determining the place, time and mode of death in homicide cases by analyzing the insects collected from and around corpses. Insects, along with bacteria and fungi, play a major role in the decomposition of dead animals. Insects use this decomposing material as a food source as well as a place to rear their young ones (egg, larva and pupa). Initially, the insects are attracted to body fluids like urine, saliva and faecal material oozing from natural openings and blood from wounds. Later on, the flesh and other tissues and bones also become attractive. As a body decays, it can be viewed as providing a succession of habitats, each attractive to and supporting a particular group of insects. Although the exact

Keywords
Forensic entomology, Diptera, Calliphoridae, Sarcophagidae

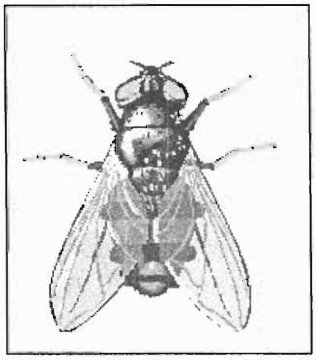

Figure 1. A typical blowfly.

species may differ from country to country, habitat to habitat, and from season to season, the basic pattern and the sequences in which insect decomposers utilize a carcass is remarkably constant around the world. While a wide variety of insects are attracted to the decomposing remains and play an active role in decay process, two groups, the flies and beetles are of major importance from a forensic angle. Flies, whose larvae are capable of living in a semi liquid medium, are the first insects to colonize decomposing remains and the most important in crime investigations. Beetles are attracted at a later stage when the corpse has largely dried out. Their role in forensic entomology is only secondary. Flies belong to a very large insect order called Diptera (*Box* 1). A mong them only the carrion (dead tissue) feeding blowflies (Family: Calliphoridae) (*Figure* 1) and flesh flies (Family: Sarcophagidae) play significant roles in crime investigations.

Methods in Forensic Entomology

When a forensic entomologist reaches a crime scene he collects all life stages of insects from and around the corpse. The collected specimens are subjected to further analysis either in the field itself or in the laboratory. A forensic entomologist has three main objectives in his mind while analyzing the insect data: determination of place, time and mode of death, each of which requires distinct methodologies.

A forensic entomologist has three main objectives in his mind while analyzing the insect data: determination of place, time and mode of death, each of which requires distinct methodologies.

1. ***Place of Death:*** Analysis of insect species collected from and around a dead body may in many cases prove useful in determining the original place of death. Many fly species have specific geographic preferences. One species common in rural areas may not be found in a city and vice versa. Rural species collected from a dead body found in a city may indicate that the actual crime was committed in a rural area and the body shifted to the city at a later time. Some flies prefer to breed indoors while others prefer an outdoor environment. Flies can also exhibit preferences for corpses in shade or sunlit conditions of the outdoor environment. Therefore, a corpse that is recovered

Box 1. About Flies

Flies are two-winged insects (all other flying insects have four wings) belonging to the order Diptera. There are about 120,000 known species of flies all over the world. It is estimated that the actual number of living species could be as high as 1,000,000. There are more foes than friends of human beings among flies. The notorious mosquitoes and houseflies are members of the Diptera. Mosquitoes transmit diseases like malaria, filaria, dengue, Japanese encephalitis and yellow fever (see Tiny Terminators, *Resonance* Vol.6, No.5, 2001). Houseflies transmit intestinal bacteria causing cholera, typhoid and dysentery. Sand flies spread kala azar, and tse tse flies spread African sleeping sickness. Other important disease carriers are black flies, transmitting river blindness and blowflies causing myiasis. Even the latest sensation, anthrax bacteria, could be carried by some biting flies like horse flies. Interestingly blowflies (Calliphoridae) can be seen in the list of fly friends too. They, along with flesh flies (Sarcophagidae) help the forensic entomologist in crime investigations. Besides, some of them are also used as therapeutic agents in the treatment of wounds and are aptly nicknamed 'the smallest surgeons of the world'! Blowflies are small to medium sized flies with a metallic sheen. There are over 1000 species of blowflies all over the world. The common greenbottles and bluebottles belong to this group. Flesh flies do not have the metallic sheen, and are a bigger group than blowflies with over 2000 species worldwide. Apart from these two groups, fruit flies (*Drosophila*) are famous as experimental models in genetic studies. Although most *Drosophila* breed on rotting fruits or mushrooms, a few species (eg. *D. mercatorum*) do utilize rotting carcasses as a food resource.

indoors with the eggs or larvae of flies that typically inhabit sunny outdoor locations would indicate that the murder was committed outdoors. Similarly, an indoor-loving species collected from an outdoor corpse suggests the original place of death as some indoor environment. Identifying insects to species level when they are in pre-adult stages (egg, larva or maggot and pupa, *Figure* 2) is extremely difficult and in some cases impossible. To overcome this difficulty live pre-adult individuals can be collected from the crime scene and reared in the laboratory to adult stage for easy identification.

2. ***Time of Death:*** Time since death provides vital clues in crime investigations. Normally this is done by examining the physical

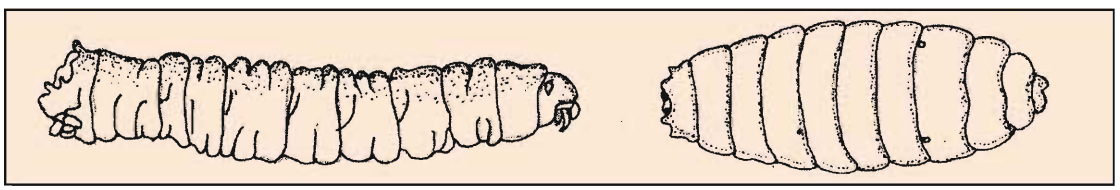

Figure 2. Larva and pupa of a typical blowfly.

The time of colonization of a dead body is species-specific and largely depends on the level of decomposition. Some insects are attracted to the corpse within a few hours while others need a few days.

condition of the corpse. These conventional methods may not always give accurate estimates of the post-mortem interval. In many cases insects provide better results. Flies pass through three distinct developmental stages (egg, larva and pupa) before they become winged adults. The rates at which these stages grow and metamorphose to the next stage largely depend on the environmental conditions, especially temperature and humidity. An expert entomologist can calculate this rate and tell the time of death accurately from the age of the developmental stages collected from the corpse. Under field conditions identifying the exact growth stage of the immature stages is a tough job. Normally samples are preserved in the field at the time of collection and sent to the laboratory for further investigations. As mentioned earlier, the time of colonization of a dead body is species-specific and largely depends on the level of decomposition. Some insects are attracted to the corpse within a few hours while others need a few days. Anything that may have prevented the insects from laying eggs in their normal time frame will alter both the sequence of species and their typical colonization time. This alteration of the normal insect succession and insect species would invite the attention of the forensic entomologist. Such instances suggest the possibility of wrapping or freezing of the body after death.

3. ***Mode of Death:*** Forensic entomology can also throw light on the mode of death in certain circumstances. A dead body having external injuries is more attractive to insects than one having none. So, depending upon the degree of degradation brought about by maggots (larvae of flies), it may be possible to suggest the probable mode of death, i.e. strangulation or mutilation. Another application is in the cases of death due to drugs. When human tissues are not available for chemical analysis, insect maggots collected from the body can be used as alternative sources to reveal the presence of specific drugs or poisons.

Besides the above methods, nowadays forensic entomologists also use genetic technology to generate evidence in certain circumstances. The DNA from human blood can be recovered

from the digestive tract of a blood-feeding insect (like mosquitoes) that has fed on an individual. Since 1985, DNA typing of biological material has become one of the most powerful tools for personal identification in forensic medicine and in criminal investigation. The advantages of using DNA are that it provides a huge amount of diagnostic information compared to some older techniques (such as blood-group typing), it is present in all biological tissues, and it is much more resistant to environmental degradation are than most other biological molecules (e.g., proteins). The presence of DNA of the suspect within the insects at a known location within a definable period of time can establish a link between him and the crime as can be seen in the following example. A murder was committed in a house. Certain circumstantial evidence incriminated a particular person as the main suspect. However no proof such as finger prints, hair, etc. could be collected from the crime scene. But the entomologists collected a few mosquitoes resting in the same house. The blood DNA recovered from one of the mosquitoes was identical to that of the suspect which strengthened the case against that person.

The DNA from human blood can be recovered from the digestive tract of a blood-feeding insect (like mosquitoes) that has fed on an individual. Since 1985, DNA typing of biological material has become one of the most powerful tools for personal identification in forensic medicine and in criminal investigation.

Case Histories

To give a better idea of the procedures of forensic entomology, three case histories published by Wayne D Lord of the Federal Bureau of Investigation, USA, are given below (available on www.missouri.edu/~agwww/entomology/casestudies.html).

1. A few years ago, on 4 June, the body of a girl was found alongside a rural highway in the northwestern United States. An autopsy revealed that she had died of multiple head and neck wounds inflicted by a heavy sharp object. Her brother had reported her missing approximately 4 days prior to the discovery of the corpse. She had last been seen alive on the morning of 31 May in the company of a 30 year old army sergeant, the primary suspect. While considerable circumstantial evidence supported the theory that the victim had been murdered by the sergeant, an accurate estimation of time of death was crucial to

establishing a possible link between the suspect and the victim at the time when death occurred. Several estimates were offered by medical examiners and investigators. These were based largely on the physical appearance of the body and the extent to which decomposition had occurred in various organs. Numerous fly larvae, adult flies and other insects were collected from in and around the victim's wounds. Some of the larvae were collected alive and reared to produce adult flies for species identification. Others were placed immediately into a liquid preservative to identify the developmental stage. Reports describing the condition of the body when found and detailing autopsy procedures and results were reviewed. Weather data, including maximum and minimum temperatures, incidence of rainfall, cloud cover, wind speed and direction, and relative humidity were obtained from a weather station located a short distance from the crime scene. These data indicated the environmental conditions to which the body and its associated insects were exposed. Based on this total array of evidence, entomologists determined that the first insects to colonize the body had arrived on May 31 when the accused was found with the victim. On questioning he admitted to have murdered the girl by striking her six to eight times with a small hatchet sometime around noon on May 31. Subsequently, he entered a plea of guilty to the murder charge and was sentenced to life in prison without parole.

2. Recently, in New England, USA, the body of a young adult woman was found in a parking lot located behind an urban industrial complex. The victim had died from a single 9 mm bullet wound to the right temple, and a substantial pooling of blood was noted beneath the victim's head. The body was discovered at approximately 6:00 a.m. No insect evidence was observed on or around the body during the preliminary crime scene survey. As the investigation proceeded, however, and the body was warmed by the morning sun, small numbers of green bottle flies were observed feeding at the bullet wound. By the time the corpse was removed from the scene, patches of eggs were present in and around the wound. Knowing that the

previous day's climatic conditions were ideal for blowfly activity, that adult blowflies are typically not active at night, and that blowflies would be attracted to the pooled blood, entomologists concluded that the victim had been killed during the hours of darkness preceding the discovery of the body. It was later determined that the young woman had been last seen alive around midnight of the previous day.

3. On a midmorning in August, the body of a young female was discovered, more or less face down, among a group of junk automobiles near Spokane, Washington, USA. The victim had died of multiple stab wounds to the chest and neck, and adult blowflies were observed in and around the wounds. Blowfly eggs were collected from the wounds at autopsy in the late afternoon. Subsequent dissection of the eggs showed no embryonic development suggesting that they had been deposited on the remains less than eight hours earlier. The victim had been last seen alive during the evening two days prior to the discovery of the body. The insect evidence, however, suggested that the young woman had been murdered during the hours of darkness preceding the finding of her remains. Had the victim died any earlier, young fly larvae (maggots) rather than eggs would have been collected from her wounds. Climatic conditions on both days prior to her discovery were suitable for adult blowfly activity and egg laying. A subsequent investigation verified these findings, revealing that the victim had been murdered during the hours of darkness just prior to the morning of the discovery of the body.

Forensic Entomology in India

According to the latest worldwide directory of forensic entomology there are 62 scientists involved in this field of study in the world. However, forensic entomology in our country is still in its infancy. Currently, there are only two researchers who are active in this field in India: Pankaj Kulshrestha of Medico Legal Institute, Bhopal, and Devinder Singh of Punjabi University, Patiala. Kulshrestha pioneered the application of forensic

According to the latest worldwide directory of forensic entomology there are 62 scientists involved in this field of study in the world. However, forensic entomology in our country is still in its infancy.

Suggested Reading

[1] M Lee Goff, *A fly for the prosecution: How Insect evidence helps solve crimes.* Harvard University Press, 2000.

[2] K G V Smith, *A manual of forensic entomology*, British Museum (Natural History), London, 1986.

entomology in India by publishing an article describing the use of insects and larvae to determine the time of death. His main areas of research are: post-mortem interval estimation based on Calliphoridae, Sarcophagidae and Muscidae flies infestating human corpses, and the role of maggots in forensic toxicology. Devinder Singh is running a major research project on forensic entomology sponsored by Department of Science and Technology, Government of India. The main thrust of his project is generating basic data about the carrion-feeding fly fauna in Punjab (the species available in that part of the country, their seasonal prevalence, preferred stage of decomposition, etc.). Considering the vastness of our country, we are yet to go a long way to generate basic data on the taxonomy, geographic distribution, biology and ecology of the insects involved in the decomposition of dead animals.

Conclusion

Forensic entomology may not be the last word in all death investigations. However, the evidence from insects, if investigated by the right person and with right techniques, can certainly complement and supplement other conventional procedures in forensics. Besides, at least in some cases, insects might be the only major sources of information regarding time and place of death. The accuracy of these methods, of course, largely depends on the expertise of the forensic entomologist and also the availability of all required data on the insects concerned. A wrong interpretation of the insect data may even mislead the investigators. Indian courts of justice allow any scientific evidence to prove a case, under article 138 of the Evidence Act. But forensic entomology is yet to find an undisputed place in the legal proceedings in our country due to the absence of sufficient background data on the insects involved in the decomposition of dead animals and also the dearth of professional forensic entomologists. It is hoped that the scenario would change in favour of this important branch of forensic science in India with the initiatives of the scientists working in this field.

Address for Correspondence
P K Sumodan
District Malaria Officer, District Medical Office of Health
Mananthavady, Wayanad
Kerala 670 635, India.
Email:
sumodan@indiatimes.com