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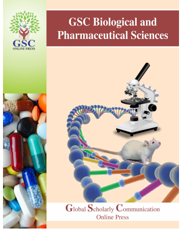

(REVIEW ARTICLE)

Now a day's forensic entomology is considered as important tool in medico-legal cases

Sadek Ahmad [1,*] and Khan Nashid Tabassum [2]

[1] *Department of Forensic Medicine and Toxicology, Army medical college, Chittagong, Bangladesh.*
[2] *Department of Forensic Medicine and Toxicology, Z H Sikder womens Medical College, Dhaka, Bangladesh.*

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Abstract

Forensic entomology is the use of arthropod evidence in legal investigations is becoming increasingly more important in such investigations. Most often, forensic entomologists assist homicide investigations by estimating the time of death using information on the biology and ecology of arthropods. In murder investigations it deals with which insect's eggs appear, their location on the body and in what order they appear. In medico-legal death investigations one of the most critical question is, ''When did the death take place?'' An accurate estimation of the post mortem interval has special relevance in a homicide case because this information can narrow the field of possible suspects in a crime. Forensic entomology helpful in determining a post mortem interval (PMI) and location of a death in question. Since many insects exhibit a degree of endemism (occurring only in certain places), or have a well-defined phenology (active only at a certain season, or time of day), their presence in association with other evidence can demonstrate potential links to times and locations where other events may have occurred. Another area covered by medico legal forensic entomology is the relatively new field of entomotoxicology. This particular branch involves the utilization of entomological specimens found at a scene in order to test for different drugs that may have possibly played a role in the death of the victim. Forensic entomology is recognized in many countries as an important tool for legal investigations. Unfortunately, it has not received much attention in Bangladesh as an important investigative tool. This paper reviews the various types of insect's behavior on corpse also important information we will find from them. This is helpful for the investigators, law personnel and researchers aware of the importance of entomology in criminal investigations. Correct estimation of the post mortem interval is one of the most important aspects of legal medicine.

Keywords: Forensic entomology; Post mortem interval; Legal medicine; Homicide; Arthropods

1. Introduction

Forensic entomology is now an integral part of a death investigation when estimating the time since death beyond 72 h. Forensic entomology is considered the most accurate method for estimating the elapsed time since death, particularly when more than 3 days have elapsed [1]. Forensic entomology was successfully utilized in the most famous Buck Ruxton case in 1935 in UK [2]. Since then, the importance of forensic entomology has increased dramatically. The credit for the first entomology case goes to the French doctor Bergeret, who used forensic entomology to estimate time since death in 1855 [3]. Probably the best study on insects and their relationships with decay rates was reported in 1958 by Reed [4]. The objective of this review is various types of insect's behaviour on corpse also important information we will find from them. This is helpful for the investigators, law personnel and researchers aware of the importance of entomology in criminal investigations. Correct estimation of the post mortem interval is one of the most important aspects of legal medicine.

* Corresponding author
E-mail address: dr.sadek555@gmail.com

2. 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 [5].

3. Decomposition attracts various types of flies

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 [6]. Based on the studies done by Crag et al., in 1950 it was found that putrativesulfur-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 [7]. 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 [8]. 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.

3.1. Blow flies

Figure 1 Blow fly feeding human flesh

The Calliphoridae (commonly known as blow flies, blow-flies, carrion flies, bluebottles, greenbottles, or cluster flies) are a family of insects in the order Diptera, with 1,100 known species [9]. The name blow fly comes from an older English term for meat that had eggs laid on it, which was said to be fly blown. Calliphoridae adults are commonly shiny with metallic colouring, often with blue, green, or black thoraces and abdomens. Antennae are three segmented and aristate. The arista are plumose the entire length, and the second antennal segment is distinctly grooved. Members of Calliphoridae have branched Rs 2 veins, frontal sutures are present, and calypters are well developed. The forensic importance of this fly is that it is the first insect to come in contact with carrion because they have the ability to smell death from up to ten miles (16 km) away [10]. Adult female blow flies arrive within minutes to lay eggs on a cadaver. Each deposits about 250 eggs in the natural openings of the body and open wounds. The eggs hatch into first-stage maggots within 24 hours. These feed and then molt into second-stage maggots, which feed for several hours, and then molt into third-stage maggots. Masses of third-stage maggots may produce heat, which can raise the temperature around them more than 10 °C. After more feeding, the third-stage maggots move away from the body and metamorphize into adult flies. Blow flies rapidly discover a body and their development times are predictable under particular environmental conditions, the time of death can be calculated by counting back the days from the state of development of flies living on the corpse, which was shown figure 2 [11].

A B

Figure 2 (A and B) The face of this dead woman was photographed with flies and maggots covering her

Figure 2 (C) Various parts of corpse infest by flies

The larva, or maggot, is the main feeding stage of the fly. On hatching, first-instar larvae are roughly 2 mm long, growing to about 5 mm before shedding their skin. The second instar larvae grow to around 10 mm before they shed their skins to become third-instar larvae. Third-instar larvae grow to between 15 mm and 20 mm before wandering off as pre-pupae. Apart from the change in size, the overall form of fly larvae varies little between instars. The most distinctive feature for separating larvae of different instars is the structure of the posterior spiracles, though which the larvae respire. Some flies produce predatory maggots that feed on other maggots. The predatory maggots of *Chrysomya rufifacies* are covered with spiny protrusions which deter other predators. Maggots (fly larvae) are remarkable eating machines. Their front ends are armed with mouth hooks with which they rake in decaying flesh, shredded from the corpse. Their rear ends consist of a chamber, in which their anus and posterior spiracles are located. (They also have anterior spiracles). Spiracles are used for breathing, and the possession of spiracles in a posterior location means that maggots can breathe feeding 24 hours a day. Between their heads and their tails is a muscular, segmented body, a simple intestine and a pair of very large salivary glands. They wriggle easily through a corpse, secreting digestive enzymes and spreading putrefying bacteria which help create their soupy environment. Maggots are gregarious animals and travel around in 'maggot masses'. Their digestive activities are so intense that the corpse heats up in the vicinity of a maggot mass, sometimes reaching 53 °C. It can get so hot inside a maggot mass that centrally located maggots have to migrate to the edge to cool down. However, the heat is a bonus, because it increases the rate of putrefaction, and the rate of digestion. Maggots moult twice during their development and can grow from 2 mm to 20 mm in length in four days. Having acquired the necessary nutrients to make a fly, they retire into their puparia where the transformation occurs. In warm weather, conducive to fly growth, maggots can consume 60 per cent of a human body in less than a week.

3.2. Flesh flies

Sarcophagidae are commonly known as flesh flies. They 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 [12].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:

Figure 3 Flesh flies feeding on human flesh

3.2.1. Fresh stage (Days 1-2)

It 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 [6].

3.2.2. 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.

3.2.3. 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.

3.2.4. 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.

3.2.5. 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 [13].

4. Estimating time elapsed since death or post morteminterval [14]

There are two methods to estimate time since death: 1) using successional waves of insects and 2) maggot age and development. Insect succession is used if the individual has been dead for a month or longer. Maggot development is used when death occurred less than a month prior to discovery. Insect succession uses the fact that a body (human or otherwise) supports a rapidly changing ecosystem as it decomposes. As they decay, the remains go through physical, biological and chemical changes, and different stages attract different species of insects. Calliphoridae (blow flies) and Sarcophagidae (flesh flies) may arrive within 24 h of death if the season is suitable or within minutes if blood or other body fluids are present. Other species, like Piophilidae (cheese skippers), are not interested in the fresh corpse, but are attracted to the body at a later stage of decomposition. Some insects do not seek the body directly, but arrive to feed on other insects at the scene. Many species are involved at each decomposition stage and groups of insects may overlap with each other. Knowing the regional insect fauna and times of colonization, a forensic entomologist can determine a period of time in which death took place. They may also be able to establish the season of death (e.g. summer) according to the presence of absence of certain insects that are only seasonally active.

5. Other uses for forensic entomology

Forensic entomology is used most commonly to determine time since death. However, insects can provide other important information about a crime or victim. For example, insects can provide details about a person's life before they died. Because development is predictable depending on specific factors, the use of drugs can change the lifecycle timing of an insect. One such drug is cocaine, which causes the maggots feeding on affected tissues to develop much faster than they normally would. Insect behavior can also offer clues about what happened around the time of death. Flies tend to lay their eggs first in moist places in the body like the eyes and mouth. If eggs or maggots are found on normally dry skin, like the forearms, before these other areas, it suggests that the skin was damaged in some way. This may be because the individual injured themselves in a fall or because they were trying to protect themselves from a weapon. In either case, an important piece of evidence has been discovered. Finally, the species of insect can point to events that occurred after death. For instance, some insects are found only in some areas. If a species that is normally found only in the countryside is found at a scene in the city, it suggests the body has been moved at some point after death. Again, this provides an essential piece of evidence that could help solve a crime [15].

a) The presence of insects on the body that are not found in the area suggests the body was moved, and may indicate the type of area where the murder took place.
b) If the insect cycle is disturbed, it may suggest that the killer returned to the scene of the crime. The entomologist may be able to estimate the date of death and possibly the date of the return of the killer.
c) If maggot activity occurs away from a natural opening, this may indicate a wound. For example, maggots on the palm of the hands suggest defence wounds.
d) If maggots feed on a body with drugs in its system, those chemicals accumulate and may be detected.
e) If an insect is found from a specific site, it may place a suspect at the scene of a crime.
f) If insects are found on a living individual (often young children or seniors), it may indicate neglect or abuse.

6. Limitations of forensic entomology

a) Time of death estimates depend on accurate temperature information, but local weather patterns can be variable and data may come from stations quite distant from the crime scene.
b) Forensic entomology relies on insect abundance. In winter, there are fewer insects and entomology's use is limited.
c) Since it takes time to rear insects, forensic entomology cannot produce immediate results.
d) Treatments (like freezing, burial or wrapping) that exclude insects can affect estimates.
e) Since chemicals can slow or accelerate growth, insect evidence may be affected by the presence of drugs in a corpse's system.

7. Conclusion

In the recent past, several publications have highlighted the important role of quality assurance in medicine in general [16-17] and particularly in forensic science [18-19]. Forensic entomology is still a young science and precisely for this reason, it must maintain rigorous standards among its researches and practitioners, if it is to gain widespread acceptance. There is no substitute for good data nor for well-trained entomologists to interpret and apply them. In general, our knowledge of the biology and ecology of fauna associated with the decomposing corpse must be refined. Then new branch will helps successfully slove many criminal problems.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest exist between both authors.

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