Forensic entomology

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ABSTRACT – Forensic entomology is the application of insect biology to the investigation of crime. The subject covers all aspects of insect evidence, but for the purpose of this article the discussion will be restricted to insect evidence from the bodies of persons thought to have been the victims of murder or other unlawful killing.

Time of death

Determining the time of death of a body has been described as one of the most difficult aspects of forensic science, yet it is so often one of the most important problems that has to be resolved in a criminal investigation.

If a post-mortem is held within three or four days after death, in many cases the pathologist's expertise is sufficient to determine the time of death by means of the usual pathological indicators:

- onset and passing away of *rigor mortis*
- the drop of body temperature to the ambient temperature, and
- the order in which the various organs decompose.

However, when the period of time after death is longer, these indicators will have occurred, and no other convenient physical changes remain that could be used to determine time of death with any accuracy.

Entomology can often be of use in time of death estimation in criminal cases. There are two approaches to this problem:

1 Blowfly (bluebottle or greenbottle) maggots are usually present on exposed (ie unburied) bodies in the summer.

2 The succession of species found on a decomposing body varies with time.

Biography of a blowfly

Blowfly biology. A female blowfly can lay up to 300 eggs in one bout of egg laying and can repeat this performance 10 times in its lifetime, resulting in up to 3,000 eggs per fly. The eggs hatch after roughly 24 hours at room temperature, producing what are known as first instar maggots. They moult again about a day later to give rise to second instars, which live for a further day or two. The second instars then moult into third instars, the well-known anglers' maggots, which live for five or six days after which they stop feeding. They then leave the corpse and wander about for two or three days. The maggots' skin darkens, contracts and hardens to form the puparium, within which the maggot pupates. After a week or so, the flies emerge by breaking the front end of the puparium. Puparia are chemically durable structures and may last unchanged for hundreds of years.

The periods of time given above are approximate and vary considerably between species and at different environmental temperatures. It can take a maggot two or three months to complete its development at relatively low temperatures.

Minimum time since death. In principle, if the age of the maggots in a corpse can be determined, a minimum time since death (MTD) can be ascertained, by which is meant the time *after which* death could not have occurred. For example, if the oldest maggots on the body are, say, six days old, death could not have occurred later than six days before the maggots were sampled and killed. It is important to stress that this does not indicate the *actual* time of death, since the age of the maggot cannot indicate when the flies arrived at the body after the victim's death. In this kind of work the oldest maggots are used, for obvious reasons.

The technique is straightforward in theory, but complex in practice. Maggots, like all other living organisms, exhibit both genetic and environmental variation. Two maggots hatching from their eggs at exactly the same moment may develop at different rates. Studies on maggot development show that maggots from the same batch of eggs reach a particular stage of development over a period of time, usually a few hours. In other words, the first maggot to moult may do so at, say, 22 hours after hatching, while another may take 26 hours, although both individuals may have hatched at the same time. Because of this variation, it has to be assumed that a maggot at any particular stage developed at the fastest rate. This allows an estimation of the shortest MTD – or, to put it another way, the 'minimum

† We regret that Dr Erzinçlioglu has died since writing this article.

MTD estimation' – thereby providing a period of time in which it is possible to be almost certain that death did *not* occur.

The age of a maggot and its stage of development are very different things. A maggot developing at a high temperature may be at a more advanced stage of development than another maggot developing at a low temperature. The latter may be chronologically older, yet still be at an earlier stage of development. Therefore, the age of a maggot is based on a consideration of two aspects:

- its stage of development, which is discovered by dissection of the maggot, and
- the temperature at which it was developing.

Microclimate and development

This raises another difficulty, namely, the need to determine the temperature at which the maggots were developing. This is not as easy as it may sound since bodies are usually found lying on the ground, often among vegetation, or indoors, or indeed buried underground. Temperatures near the ground, called by meteorologists the 'boundary layer', can markedly differ from the general weather picture. This 'microclimate' is regarded as a complication by weather forecasters; they are interested in the weather at a higher level, enabling them to predict the arrival of rain fronts etc. This is why weather stations are situated in open countryside, with the grass mown very low. Temperature data obtained from nearby weather stations cannot be applied unthinkingly to the area in which a body was found.

There are ways of dealing with this problem. On arrival at the scene, a series of temperature measurements can be taken of both the body and the surrounding air. There is a fairly well understood relationship between the microclimate and the general weather picture. Although the microclimatic temperatures will differ from those high above the ground, they will nevertheless be a function of those temperatures. Similarly, the temperatures within the body will mirror those of the air surrounding it, although in maggot-infested bodies the temperatures will almost always be higher than the ambient temperatures. By carrying out certain calculations, it is therefore possible to reconstruct the temperatures at the scene and in the body for the days preceding the discovery of the corpse.

There is yet another practical difficulty concerned with temperature. Most insect developmental and physiological studies carried out in the laboratory are conducted at constant temperatures, allowing the researcher to control the conditions of an experiment more easily and enabling easy repetition of the experiment by others. Unfortunately, in nature temperatures are almost always fluctuating. In the past, investigators assumed that a constant temperature equal to the average value of a fluctuating temperature would affect maggot development in the same way. However, this is not true. A constant temperature of, say, 15°C will affect the development of a maggot differently from a fluctuating temperature of 10–20°C (mean 15°C), increasing or decreasing the rate of development depending upon species and stage of development. It is important to bear this in mind when viewing the reconstructed temperatures.

Case History 1

In November 1985, the body of a 14-year-old boy was found inside a thicket that was itself within a woodland. The temperatures in woodlands are usually 'dampened' – in other words, the fluctuations are less extreme than in exposed areas. The maximum temperatures are lower and the minimum temperatures higher than those in adjacent open areas. The fact that the body was lying within a thicket inside the wood had a further 'dampening' effect, with the result that a particularly accurate time of death estimate was obtained (subsequently supported by other evidence).

The faunal succession

The second entomological approach to the matter of time of death estimation is concerned with the general assembly of species found in a corpse. Although blowflies are usually the first to appear on exposed corpses in the summer months, other species will appear after the maggots have gone. Different species will be attracted to the body underground, during cooler times of the year and at different stages of the process of decomposition – a phenomenon known as the 'faunal succession'. Anything that changes with time can be used as a clock.

It is, of course, essential to understand how the clock works before using it. Sadly, our understanding of this clock is rudimentary. It is almost impossible to predict what the faunal succession will be, even under well-controlled field experiments. So many factors affect what species will arrive at what time that, in the present state of knowledge, it is impossible to make any predictions. Tables have been published in the entomological and forensic science literature, asserting that certain species will arrive, say, 10 days after death, others at 20 days and so on. On the basis of the many experimental investigations into this point, it is not possible to accept that such predictions are justified. Season, temperature, rain, cloud cover, habitat, human and animal interference, and many other factors will affect what comes when. However, insect species are active in particular seasons or at particular times of day. If, during the investigation of a murder discovered in October, the remains of empty puparia (see above) are found of a species known to be active only in June, July and August, it can validly be concluded that death took place during those summer months.

Pure chance is also an important factor and, by its very nature, unpredictable. What then is the value of the faunal succession in forensic investigations if it is such a badly understood phenomenon? In answer, it must be kept in mind that forensic science is not concerned with predicting the future but with reconstructing the past.

Manner of death

Determination of the cause of death in murder or suspicious death cases is the province of the forensic pathologist, but in some cases the entomologist can make a contribution to establishing the manner of death.

The cause of death is a medical matter: it may be the severance of an artery or malfunction of the liver. The manner of death is concerned with *how* the cause of death was brought about. For example, the manner of death may have been a stabbing with a knife that brought about the severance of the artery. The manner is the cause of the cause, so-to-speak.

Blowflies usually lay the eggs on those parts of the body most conducive to their development. To avoid excessive heat and dryness, the eggs are laid on or in the natural body cavities that are both most accessible and sheltered. The eyes, nose, ears, mouth and so forth provide such positions. The eggs are hardly ever laid on the exposed general surface of the skin. Once the maggots hatch, they move through the body in a more or less predictable pattern. However, it sometimes happens that this pattern is not followed, and then the entomologist must ask *why.*

Evidence from maggot location

If a stab wound is inflicted, say, in the chest, the wound may mimic the natural body orifices by providing a moist and sheltered place for the flies to lay their eggs – indeed, the wound may be preferable since it may be moister. In such cases, the maggots may have consumed so much of the flesh and internal organs that any original injury may no longer be apparent, but the different pattern of the maggot infestation could suggest where the injury may have been.

In cases of suspected death by poisoning, subjecting the maggots to toxicological analysis may reveal the truth, especially if most of the remains have been consumed by the maggots. Maggots can accumulate certain substances toxic to human beings without any apparent ill effects. Thus, even in the absence of human tissues to test, maggots may reveal that poisoning has taken place. It is in fact better to test the maggots than human tissues because the latter are in active decomposition and may confuse the toxicological analysis.

Place of death

It is often possible to determine the place of death of an individual whose body was moved after death. Many murder victims are moved from the scene of their death to somewhere else. In these circumstances, entomology may be able to shed light on the problem of where death occurred or where the body may have been lying at an earlier time.

The term 'place of death' may be defined in two different ways:

- *geographically,* to mean the actual locality. Was the murder committed in London, the Isle of Wight or the north of Scotland?
- *ecologically,* to mean the kind of locality in which the body had lain. Was it indoors, in a woodland, on top of a mountain or by the sea?

Evidence from maggot species

Insect species are known to have specific geographical ranges and habitat preferences. For example, some may live only in Scotland and only in woodlands. If such an insect species is found on a corpse discovered in, say, Newcastle, it may be validly concluded that the body had been lying in a Scottish forest at some earlier time.

Case History 2

The body of a three-week-old baby was found in a garage with its head bashed in. There was a heavy infestation of maggots and various other insects. It was possible to determine that the MTD was six days prior to discovery, and that the body had lain indoors for a while before being taken outdoors and placed on soil that had recently been dug up. The presence of the different insect species allowed no other reasonable interpretation. Other evidence subsequently supported such a scenario.

There are cases on record in which analysis of environmental pollutants, such as mercury, within maggots from unidentified corpses led the investigators to make enquiries in areas in which high levels of mercury are known to occur, in the belief that the victim may have lived in such a polluted area. At least one such investigation was successful.

Further reading

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