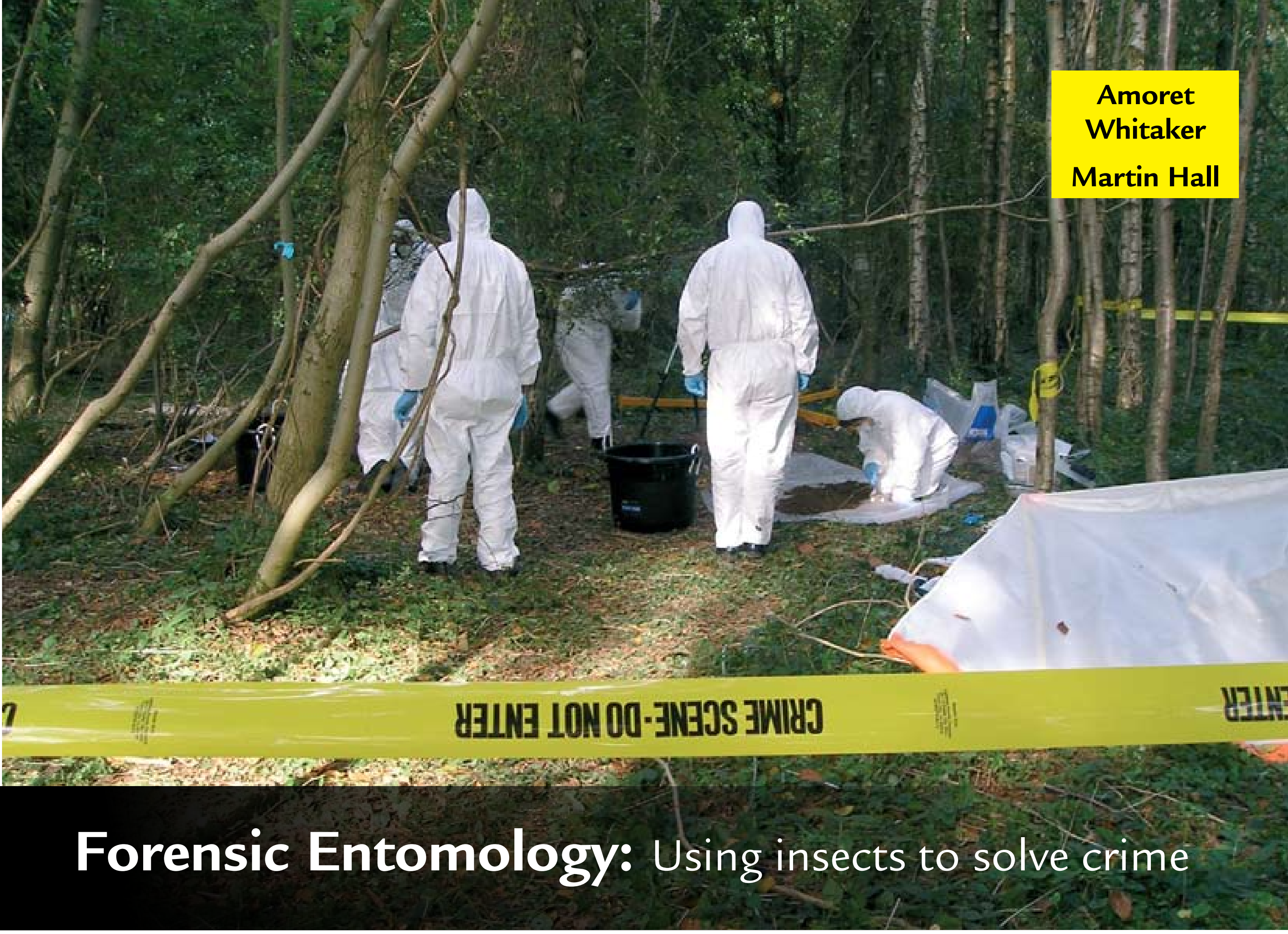

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Forensic Entomology: Using insects to solve crime

Most people avoid contact with insects and are repulsed by the sight of maggots. In this article, Amoret Whitaker and Martin Hall of the Natural History Museum in London look at the positive way in which insects can be used as evidence in criminal investigations.

Working in the Entomology Department at the Natural History Museum is not just about identifying and sorting our 28 million preserved insect specimens. We regularly receive telephone calls from Crime Scene Managers when a body has been found in suspicious circumstances, asking if we can collect the live insects and work out how long the body has been dead.

Forensic entomology is the study of insects and other **arthropods** in a legal context. It covers many different areas, such as pests in stored food products and insect infestations in human habitations. However, the most high-profile use of forensic entomology is in estimating the time since death, or post-mortem interval (PMI), in cases of unexplained or sudden death.

Succession of insects

When a person or animal dies, the body starts to decompose immediately and gives off odours. The chemical composition of these odours changes over time, as does the physical state of the body, which goes from fresh to active decomposition, through to dry and finally skeletal. At different stages during the decomposition process, different types of insect are attracted to the body to feed and lay eggs or larvae on it, so their offspring can also feed. The type of insects follow a predictable pattern, with blowflies (Figure 1) coming in at the earliest stage, followed by many other groups of arthropod such as carrion beetles, ants, mites and moths.

Figure 1 *The blue-blottle blowfly,* Calliphora vicina, *feeding on a dead animal, with larvae.*

Key words
forensic entomology
insects
decomposition
succession

Arthropod: Any animal which has an exoskeleton, a segmented body and jointed limbs, such as crabs, spiders, insects and woodlice.

Blowfly life cycle

Because the blowflies (blue- and green-bottles) are the first insects to be attracted to a body, within hours or sometimes minutes of death, they are the most useful insects for estimating PMI. The adult flies will come to feed on the body and the females will **oviposit**, laying batches of 50-100 eggs in a single egg mass. These eggs hatch out into tiny larvae, called 1st instars, which as they feed and grow, will moult and go through two more stages, called the 2nd and 3rd instars. At the end of the 3rd instar stage, the larvae finish feeding and usually move away from the body to pupate, at which stage they are called post-feeding larvae. Once a suitable place has been found to pupate, the outer skin of the larva constricts and hardens, becoming the pupal case, or puparium. Inside the case the larva metamorphoses into an adult fly, which eventually breaks out of the pupal case, completing the life cycle (Figure 2).

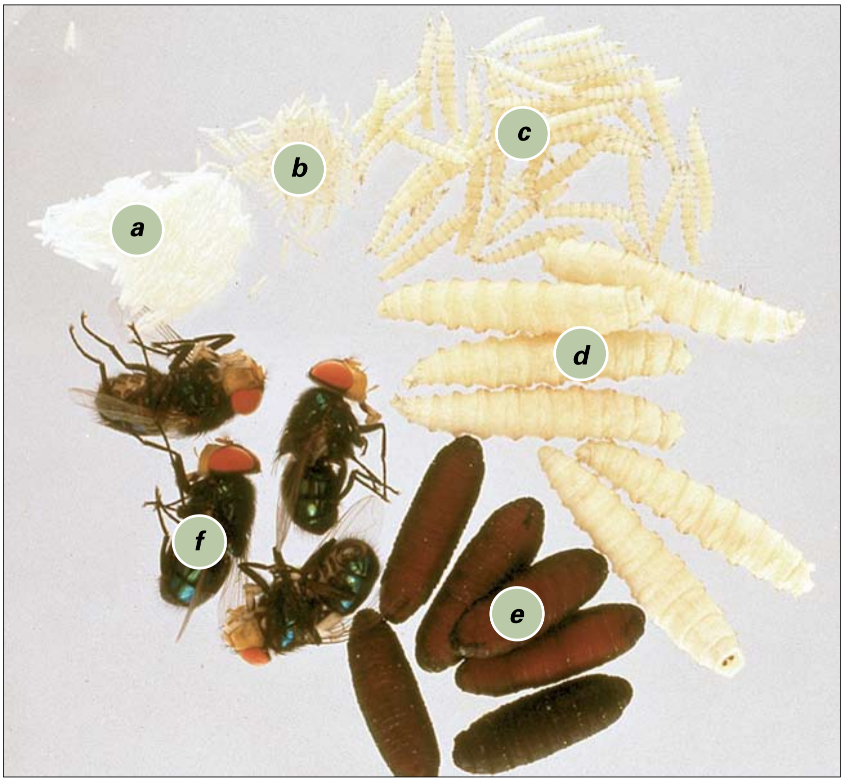

Figure 2. *Stages of blowfly development:* ***a*** *eggs,* ***b*** *1st instar larvae,* ***c*** *2nd instar larvae,* ***d*** *3rd instar larvae,* ***e*** *puparia containing pupae,* ***f*** *adults.*

Effect of temperature

The rate of development of insects is almost entirely dependent upon the temperature at which they develop, i.e. the warmer it is the faster they will develop, and the colder it is the slower they will develop. Therefore in a typical UK summer, when the temperatures are averaging 15°C, blowflies will develop from egg through the larval and pupal stages to adult flies in approximately 15 days. In a typical UK winter, when the temperatures are well below 10°C, dropping to below 0°C at night, it may take many weeks for blowflies to develop.

Estimation of post-mortem interval

It follows that, if blowflies are found associated with a body, you can estimate the post-mortem interval if you can find out: a) what the species of blowfly is, b) what stage the blowflies are at, and c) under what temperatures they developed. It is important to know the exact species of blowfly as different species, even closely related ones, may develop at different rates. The stage may be fairly easy to recognise, e.g. eggs, instar stage, post-feeding or pupal, but the length of the larvae can also be measured to gain greater accuracy, and pupae can be dissected or X-rayed to gauge the stage of development (Figure 3). Finally, the temperature at which they developed can be estimated by obtaining the weather data from the nearest meteorological station to where the body was found.

A more accurate estimation can be made by placing an electronic datalogger at the place where the body was found for a period of time (typically 7-10 days) and comparing these temperatures with those of the local meteorological station over the same period of time. This is called a regression analysis, and the resulting equation can then be used to estimate what the temperatures at the deposition site would have been in the period before the body was found, i.e. during the time when the blowflies were developing on it.

Figure 3 *Pupa of the bluebottle fly,* Calliphora vicina, *dissected from its puparium.*

Larval (or maggot) masses

When the larvae reach the end of the 2nd instar, and throughout the 3rd instar stage, they congregate together to feed in large masses (Figure 4). Their combined feeding activity generates heat, so the larval mass may be many degrees higher than the ambient (surrounding) temperature (Figure 5). In colder climates, the larval mass temperature can be up to 20°C or more above the ambient temperature, resulting in a faster rate of development of the insects. However, there is an upper temperature threshold of about 42°C, above which the larvae will die. If the blowflies found on the body have reached, or gone beyond, the late 2nd instar stage of development, then larval mass temperatures must be taken into consideration, or the PMI is likely to be overestimated. before the body was found, i.e. during the time when the blowflies were developing on it.

Figure 4 *Larval mass, feeding on a body.*

Other factors to be considered

When we estimate PMI, we are actually estimating the time when flies oviposit on the body and, therefore, the minimum PMI. In other words, we estimate the minimum amount of time since the person has died, because the blowflies would not have been present prior to death, and as we don't know exactly when the eggs were laid, we cannot give an actual PMI.

There are many other circumstances within which the body is deposited, which will also affect the speed of oviposition and the speed of development of the insects. For instance, if a body is buried, submerged, wrapped or enclosed in some way, it may be either totally or partially inaccessible to adult flies which may delay or inhibit their ability to oviposit. If a body is found with no insects on it, where they would normally be expected, this can give some indication of the manner in which the body was deposited, for instance whether it was buried immediately or kept in an enclosed fly-free space. Bodies found indoors may decompose at a different rate from those outside, depending on factors such as whether the windows were open and if the heating was turned on.

Forensic entomologist at the crime scene

Sometimes a crime scene manager or pathologist will collect the insect evidence themselves, which is fine, as long as they have been adequately trained to do so. Ideally, though, the forensic entomologist will attend the crime scene themselves, prior to removal of the body to the morgue. Firstly, this enables the entomologist to get a full picture of the scene, firsthand. Secondly, insect evidence may not always be conspicuous and can easily be overlooked by the untrained eye, e.g. fly eggs may be hidden from view and difficult to identify, or if the larvae have already left the body to pupate, the oldest insects may not even be on the body itself, but in the surrounding environment. In addition, if only eggs or pupae are present, they may not be recognised as being insects because they do not move. Thirdly, if the insect evidence is not preserved and/or labelled correctly (Figure 6), it may not be possible to use it in the analysis.

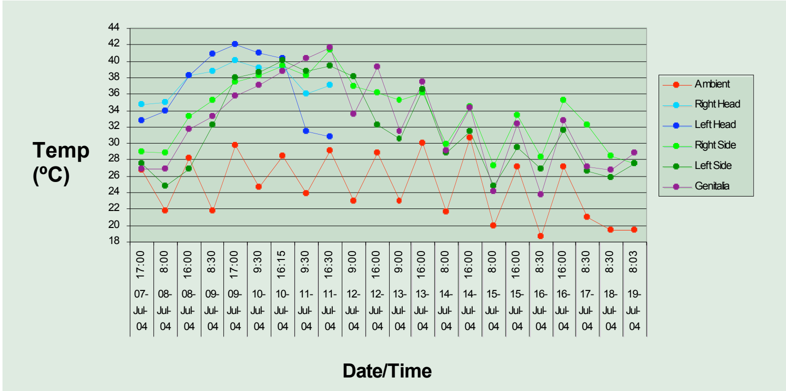

Figure 5 *Larval mass surface temperatures recorded on a human cadaver used during research study. Compare the blue, green and brown lines (larval masses) with the red line (ambient temperature). The difference between ambient and larval mass temperatures is greatest at 8:30am on 09-Jul-04.*

Figure 6 *Insect evidence in sealed forensic evidence bags.*

Forensic entomology as evidence

Any estimation of PMI can never be exact (unless the death has actually been witnessed!), so a forensic entomologist should not be tempted into giving an exact PMI, but more realistically a likely range of dates/times will be suggested, which is typically wider, the more decomposed a body is. If the time of death becomes an important factor in the investigation, or if no other evidence can be found to support it, the forensic entomologist may be required to attend court, to explain their findings and to answer any questions. More often, though, the estimation of time of death given by the forensic entomologist will enable the investigating team to focus their enquiries within the suggested timeframe, thus maximising financial and personnel resources.

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Look here!

These two sites explain more about forensic entomology:
www.forensic-entomology.com
www.research.missouri.edu/entomology/
To watch a talk by Martin Hall, go to:
www.nhm.ac.uk/nature-online/life/insects-spiders/webcast-forensicentomology/forensic-entomology.html