Entomotoxicology in forensic science

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ENTOMOTOXICOLOGY: A POWERFUL TOOL FOR FORENSIC SCIENCE

For many years, forensic science have known that insects and their larvae hold answers to deaths that are not quite clear in terms of their actual timeframe or situations surrounding them. Now, a branch called entomotoxicology is helping those who work in forensic science find new answers to the questions that have remained in certain cases. This paper examines the role and science behind the advancing field of entomotoxicology in which toxins and drugs can be measured in the insects and larvae that infest even the most decomposed body.

Before understanding this branch of forensic science, it is important to understand how bodies decompose and how insects become a part of the transformation of a human body once the person has died. It is important to study the decomposition process as part of a crime scene because it helps determine the victim, how they died, and when and where they died (Vass 2001: 192). Other factors, such as the presence of melanin can help investigators find out the race or ethnic background of the victim (Vass 2001: 192). Additionally, " knowledge of any trace amounts of chemicals, drugs, medications or toxins present in decomposed tissue may also be of help to investigators in attempting to determine the cause of death" (Vass 2001: 192). Having said that, it is then important to understand what is generally involved in the decomposition process.

The start of the decomposition process has been clocked down to four minutes after death has occurred (Vass 2001: 190). The putrefaction process is where the body's soft tissues are destroyed by micro-organisms, such as bacteria, fungi and protozoa (Vass 2001: 190). Part of what happens to a decomposing body is a mummification process (Anonymous 2007: 2) that is called adipocere, which is " insoluble fatty acids" that are left behind from " pre-existing fats" that forms within a month of death but can remain as part of the cadaver for literally centuries (Wikipedia 2007: 1).

Created from bacteria that convert a body's fat, adipocere is the formation of soap from this fat is also known as saponification and appears in the form of a " yellowish-white, greasy, wax-like substance" (Voss 2001: 190). This substance can slow the growth of bacteria and can protect the body from further decomposition (Wikipedia 2007: 1). Adipocere also " forms through hydrolysis" so it is more common in humid environments or when a body is found underwater (Wikipedia 2007: 1). It is also interesting to note that adipocere also seems more common on corpses that are clothed in synthetic materials versus natural materials, such as cotton (Anonymous 2007: 3). Additionally, soils that are highly alkaline contribute to adipocere formation (Anonymous 2007: 4). This is because the alkaline source hydrolyses the corpse's fat, turning it into the aforementioned soap-like substance (Anonymous 2007: 4). The deposits of adipocere are beneficial in determining the weight of an individual, which may then lead to the identity of that person (Vass 2001: 192). Insect activity, including laying eggs, eventually becomes part of the process – sometimes as soon as the onslaught of rigor mortis (Anonymous 2007: 2) – and leads to a significant decline in the condition of a corpse (Vass 2001: 190). Injuries, such as wounds and other instances where the dead person previously bled before dying can increase the onset of insects and bacteria (Voss 2001: 1919).

Along with adipocere in a decomposing body comes the infestation by maggots and bugs, which are interrelated due to the amount of adipocere and climate conditions of the area where the decomposing body is located. Insects – especially arthropods – have played a significant role in forensic science because they, including larval and mature forms, like to feed on organic substances (Tuzun and Acikgoz 2007: 1). They feed on wounds and decomposing bodies, subsisting on " the nostrils, sinuses, stomach, bowels, ears, vagina and anus part from the skin" (Tuzun and Acikgoz 2007: 1). Forensic entomology has been used for years to help calculate the time of death of a body as well as " who was the killer, whether a killer had been in a particular spot or not, which was the murder weapon, in what manner a person had been killed and so on" (Aggrawal 2001: 1-2). The exact science really uses an estimate of " the period of insect activity on the dead body" (McKenna 2003: 3). There can be outside factors, such as " weather conditions, placement or concealment of the body, or other factors" that delay the arrival of insects (McKenna 2003: 3). For example, one noted forensic scientist who specialises in studying insects on bodies pointed out that " insects will begin to colonize an exposed body within minutes following death" in warm climates like Hawaii but may take longer to appear in more temperate climates (McKenna 2003: 3).

However, what becomes hard to gauge is the effect of substances, such as heroin and cocaine, play on a person because it can be difficult to measure the toxicity level of these substances in the body once blood and certain tissue is no longer in a form to be accurately analysed (Tuzun and Acikgoz 2007: 1). Sometimes, it is not clear whether or not there might have been an

“ accidental or suicidal consumption of toxic substances” (Tuzun and Acikgoz 2007: 1). For example, in researching the subject of entomotoxicology, it is clear that it is only in recent years has it become a well-utilised facet of forensic science. An article from a 1998 Journal of Forensic Science had a case that described the suicide death of a heroin addict (Benecke 1998: 3). While the body showed signs of masses of eggs that were first and second generation cheese skippers, which helped the forensics team that the woman had been dead about four months, there were other unanswered questions in regards to the level of heroin in her body (Benecke 1998: 3): “ This case indicates that P. caset does not shorten its development significantly under the influence of heroin as was observed for some arthropods. However, the exact concentration of heroin could not be determined because of the severe decomposition” (Benecke 1998: 3). In a similar case with another heroin addict, those investigating the death admitted that the “ influence of drugs in corpses to the insects feeding on them is still in progress” and there was still no conclusive way to indicate the quantity of drugs in the body of the drug user (Benecke 1998: 5).

This is where the relatively new science of entomotoxicology becomes an important and vital way to find solutions to certain cadaver issues related to drugs and toxins. Going beyond just studying the insects found on corpses to gain insights into what may have happened to a person, entomotoxicology includes “ the post-mortem toxicological analysis of carrion-feeding insects in order to identify drugs and toxins present on intoxicated tissues” (Tuzun and Acikgoz 2007: 1). This branch of forensic science “ also investigates the effects caused by drugs and toxins on arthropod development in order to assist the forensic post-mortem interval estimates" (Tuzun and Acikgoz 2007: 1). What happens is that " insect larvae eat the flesh of a person and based on the drug content of the insect, drug intake of descendent can be determined" (DeBoeck, Wood, and Samyn 2007: 14). The drugs or toxins become concentrated in the body of the insect tissue and may stay there based on the level of concentration from the cadaver (McKenna 2003: 4).

As a particularly effective tactic during the autopsy stage, entomotoxicology is an incredible process that puts the amazing powers of insects to work:

Diptera and other arthropods can be reliable alternate specimens for toxicological analyses in the absence of tissues and fluids normally taken for such purposes. Insects can be analysed quite easily after homogenisation by common toxicological procedures such as radio-immune analysis (RIA), gas chromatography (GC), think layer chromatography (TLC), high pressure liquid-mass chromatography (HPLC-MS) and gas-mass analysis (GC-MS). (Tuzun and Acikgoz 2007: 1).

Previously, the methods used were " time-consuming and labor-intensive" (DeBoeck, Wood, and Samyn 2007: 5). The new methods incorporated into entomotoxicology utilise tandem mass spectrometry and multiple reaction monitoring to identify low levels of compounds " in complex biological matrices" (DeBoeck, Wood, and Samyn 2007: 6). Diagnosis allows for an actual analysis of the " metabolites of drugs" and helps differentiate " between prescription and non-prescription derivatives of drugs" (DeBoeck, Wood, and Samyn 2007: 6).

To better understand how insects that have ingested toxic human flesh can help forensic scientists, it is best to examine a specific experiment that utilised the Black Blow Fly which had ingested Carisoprodol, a muscle relaxant sold by prescription only (Monthei 2007: 1):

Even though Carisoprodol had no effect on the fly's life cycle, the experiment is significant because a carbamate like Carisoprodol has not been tested before in this manner. This experiment could be done with another species of fly and have different results. Also, another person doing an independent study could take the maggots that I collected and determine if Carisoprodol accumulated in the maggots or if a metabolite of the drug is present. The presence of Carisoprodol would be significant to a toxicologist because if a body found at a crime scene was devoid of tissue, the toxicologist could use the maggots to determine if the deceased had Carisprodol in his or her system. My study showed that a forensic entomologist would not have to adjust the PMI based on the presence of the drug because this insect's life cycle is not changed due to the drug (Monthei 2007: 1-2).

Similarly, if a person was killed by morphine and the body ended up becoming infested by maggots during the decomposition process, the morphine can now be detected by analysing the maggots and the larvae (Aggrawal 2001: 1). What's interesting is that, as the maggots " metamorphose into pupae, this morphine gets incorporated in their walls (Aggrawal 2001: 1). This means that, even years later, a skeletonised body could be tested and found to have died from morphine by testing pupae shells around the skeleton since morphine is impossible to detect by studying human bones (Aggrawal 2001: 1).

The book entitled, *A Fly for the Prosecution* , goes into great detail explaining how entomotoxicology works. The author describes a paper published in 1990 by Pascal Kintz that describes how he tested for five drugs in both a cadaver’s organs and the maggots that were found and while the organs only tested positive for four of the drugs, the maggots had all five, including an insecticide known as malathion (Aggrawal 2001: 3). Interestingly enough, “ in the case involving malathion, his conclusions regarding the time of death were a bout five days, while other evidence was pointing towards eight days…. Malathion had failed to kill the maggots…but had delayed their maturation by 3 days (Aggrawal 2001: 3). The level of malathion would have killed them if they had been adult flies instead of maggots (Aggrawal 2001: 3).

As forensic science progresses, more advancements have been made, particularly in the areas of DNA technology and entomotoxicology. In terms of DNA advances, this tactic has enabled forensic scientists to more quickly identify “ early instars of the Diptera larvae, eliminating the need for time consuming rearing of the larvae to the adult stage” (McKenna 2003: 5). Additionally, “ the effects of various drugs and toxins on maggots development have demonstrated the need to include these in the estimations of the periods of insects development on a body when estimating the post-mortem interval” (McKenna 2003: 5).

This is just some of the many examples available on how this new area of forensic science is providing more answers for those doing autopsies or studying crimes. While insect evidence as part of forensic study became more credible in the 1980s, it has slowly become more accepted rather than having maggots removed from a body to reach the “ real evidence” (McKenna 2003: 4). Now, the role of entomologists and law enforcement are becoming more comfortable with each other as the number of cases are indicating the amazing finds of both straightforward entomology forensics and entomotoxicology in particular cases. Adding the use of insect toxicology as a scientific tool to their other capabilities allows the forensic scientist to uncover further clues that might have previously gone unnoticed due to their inability to gather the evidence from a badly decomposed corpse or from mummified or skeletal remains.

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