ANIL AGGRAWAL'S
Internet Journal of Forensic Medicine and Toxicology
The world's first online journal devoted entirely to forensic medicine and toxicology · Published 1 January and 1 July

VOL. 5, NO. 1 · JANUARY – JUNE 2004
Downloaded from www.anilaggrawal.com · ISSN 0972-8074 (Online) · https://www.anilaggrawal.com/ij/vol_005_no_001/papers/paper010.html

Forensic Entomology – Past, Present and Future

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CITE THIS ARTICLE

Gupta A, Setia P. Forensic Entomology – Past, Present and Future. *Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology* [serial online], 2004; Vol. 5, No. 1 (January – June 2004): [p. 50-53]. Available from: https://www.anilaggrawal.com/ij/vol_005_no_001/papers/paper010.html

ABSTRACT

Entomology is derived from the Greek word *entomon* (insect) +*logos* (word, reason) meaning the study of insects. Forensic entomology is probably one of the oldest branches of forensic sciences. It has developed over the years from being used only for finding post mortem interval to being used for season of death, geographical location of death, movement or storage of remains after death etc. The development of entomotoxicology has further diversified and enhanced the role of entomology in forensic sciences. The use of DNA for identification of new species has opened a new chapter in the field. These are some of the aspects that we have to work on for future research.

Introduction

Entomology is derived from the Greek word *entomon* (insect) +*logos* (word, reason) meaning the study of insects. When we were asked to write an article on forensic entomology the first question that came to our mind was not how it is done or what are its uses and utilities but when it was started, how it has progressed over the years and what is its scope for future. This made us to search for the history of forensic entomology. In our search we found that the best work done about the history of forensic entomology was by Mark Benecke [1]. With full respect to him, we have not dealt with the history of entomology in great detail and recommend the readers to refer to his articles for any further details on the history of forensic entomology.

In this article we have tried to keep the use of medical and technical terms to the bare minimum. This is a deliberate attempt on our part as we wanted to keep the language of this article as simple as possible. We have done this so that someone who is not well versed in medical terminology is not disheartened by the complex and new-fangled expressions. Forensic entomology is a branch that has developed due to the dedicated work of a relatively less number of scientists as compared

to other medical and paramedical fields. This field has developed as a continuum and there have been very few, if any, radical discoveries. As a result it was very difficult for us to differentiate the past from the present. Still we have arbitrarily labeled the period of the last couple of decades as present. Anything before that has been taken as past and the period taken as future is quite obvious.

The Past

The first instance of forensic entomology can be seen in the Chinese literature. In his book "Hsi yuan chi lu", the Chinese lawyer and death investigator Sung Tzu, in the 13_{th} century has mentioned possibly the first case in which insects led to the murder culprit. In that case there was a stabbing near a rice field. A day after the incidence, the investigator made all the laborers to lay down their sickles. The presence of invisible bloodstains led insects (possibly blow flies) to one of the sickles. Thus the culprit was apprehended and he confessed to the crime [1].

Other instances of the presence of insects on corpses can be seen in the writings of the medieval times. There are documents dating as far back as the 15_{th} and 16_{th} century that clearly indicate the importance of insects in the decomposition of human bodies. They tell about the pattern of the destruction and skeletonisation of the bodies by the insects that have been reproduced by the modern research. The biologist Carl von Linné in 1767 said that three flies would destroy a horse as fast as a lion would [1].

Having seen the role of entomology in the medieval times let us now move on to the modern times. The credit for the first modern forensic entomology case goes to French doctor Bergeret [1]. He used forensic entomology to detect the post-mortem interval (PMI) in 1855. In that case the corpse of a child was found in a house. Bergeret was called to detect the PMI. In finding the PMI he assumed that metamorphosis involves one year and also that females lay eggs in summer so that the larvae would transform to pupae the next spring and hatch in summer. He found the eggs of *Musca carnaria L.* on the corpse that lays eggs before the body dries out. Using these findings he calculated that the body must have been left there at least a couple of years back. Thus we can see that in spite of limited knowledge and resources entomology could be of great use even in those times.

Pierre Mégnin can be regarded as the first person who undertook a scientific research on forensic entomology[1]. He worked on the subject for almost a couple of decades and compiled his findings in the form of a book titled *La faune des Cadavres* in 1894. In this book he gave the theory of eight successional waves of insects on bodies left in the open. He also mentioned that on buried bodies insects came in two waves. He also described the morphological features of various classes of insects that helped in their identification. His contribution in popularizing the subject remains unparalleled. As the reports started pouring in that Mégnin's work involved a lot of guesswork, people began modifying his findings to go with the flora and fauna prevelant at their places. This process started at the end of nineteenth century and has been continuing since.

The importance of ants and cockroaches in causing post-mortem artifacts was shown by German doctors Klingelhöffer and Maschka and the forensic pathologist from Poland (then Austria) Stefan von Horoskiewicz [1]. Both Horoskiewicz and Maschka have reported cases in which there were bites by ants or cockroaches that resembled ante-mortem abrasions or bruises. In all those cases, but for the findings and testimony of these renowned scientists, innocent people would have been

punished [1]. During this time (the beginning of twentieth century) France and Germany were the main centers for the work on entomology. This is evident from the following two books of that time *Thierleben (Life of The Animals)* by Alfred Brehm and *Souvenirs entomologiques (Souvenirs of Insect Life)* by Jean Henri Fabre [1]. These books specifically dealt with carrion beetles and blowflies and went a long way in popularizing entomology among the people.

During the next few decades a lot of scientists worked on the subject and the database on the properties of insects increased. Although the amount of research increased in the field, there was no great increase in the popularity of the subject. Only a few scientists across the globe worked on insects. The main aim of this research was to prepare a database for their own geographic area and environmental conditions. All this changed in the mid 1960s. When Watson and Crick discovered DNA in 1953, even they would not have thought about its potential in forensic sciences especially forensic entomology. The use of DNA brought in a new era in the identification of the invertebrates. Soon DNA was being used to identify the insects at the scene of crime. This method was billed as more advanced and scientific than morphological features. Here we would not go into the details of the relative advantages and disadvantages of the use of DNA for identification, but would just state that because of the enormous number of species and diversity present in the invertebrates, the use of DNA is definitely a step in the right direction.

The late 1970s saw the emergence of entomotoxicology as a new branch of forensic entomology. In this the presence of toxins in the invertebrate decomposers was detected and was used as a method of finding the cause of death. So now the use of forensic entomology was graduating from finding only PMI to finding the cause of death.

The Present

In this section we would discuss the things that are currently being done in forensic entomology and their shortcomings. That is going to the basis of our next section viz. the future as the future is determined by the present. For the sake of continuity, we would start this section by discussing entomotoxicology. From detecting metals, in late 1970s it has graduated to detecting various drugs and their metabolites. Beyer et al[2]have reported a case in 1980 about a woman who was found in the stage of early skeletonisation, about 14 days after her death. They analyzed the larvae of *Cochliomyia macellaria* (Fabricius) (Calliphoridae) using Gas Chromatography (GC) and Thin Layer Chromatography (TLC); the results revealed the presence of Phenobarbital. Since then various scientists have detected the presence of quite a large number of drugs like benzodiapines, barbiturates, tricyclic antidepressants, various narcotics etc. etc. (the list is endless). The method of extraction has also improved from GC and TLC to the more advanced techniques like RIA, MS, HPLC etc. All this indicates that today virtually any drug can be detected in even minute quantities in the insect adults and larvae alike.

Newton's third law of motion states "every action has an equal and opposite reaction". This is also applicable for every new discovery. Although the use of entomotoxicology has increased and has brought in new avenues, it has also got some inherent problems that have to be solved before it can be used as an effective forensic tool. At present we don't know about the drugs that are accumulated by the insects. We are also unaware of the level upto which the various drugs are concentrated. It has been seen that various drugs alter the rate of growth of the insects. Some drugs increase the rate of growth while some others reduce it. Inability to recognize this fact can lead to an error in estimating the PMI by upto about 18 hours and sometimes even more [3-7].

Now let us come to the more orthodox use of forensic entomology i.e. for finding PMI. It has been noted that with changing times, the flora and fauna of various ecological regions of the world keeps changing. This includes the insect population also. As a result the current research is going on to note these changing patterns and update our knowledge accordingly. As has been already mentioned, the invertebrates constitute the maximum number of species on this planet. The number of species that we are aware of is still far away from being complete. This is more so in the tropical regions of the world like India. As a result the requirement for renewed research in finding as many species as possible is being felt all over the world. This is one of the most important activities going on in all parts of the world. The use of DNA for the identification and classification of species is going on in a big way. The advantages of this method are quite obvious and don't require any reiteration here.

One aspect of the use of forensic entomology that can be hard to believe and even harder to prove is in child abuse and sexual abuse cases. Its use in child abuse can be seen from the case described by Mark Benecke [8]. He has described a case in which a child's body was found. The use of forensic entomology put the time since death at about 6-8 days. But the examination of insects present in the ano-genital area of the child suggested that it had not been cleaned for about 14 days prior to the child's death. This case marked a landmark in the use of entomology in child abuse. Studies have shown that post mortem insect activity, particularly maggot masses, combined with natural decompositional changes can produce changes to clothing which mirror those seen in cases of sexual assault. This is again relevant in cases in which advanced decomposition has set in [9]. Today forensic entomology is not limited to finding PMI only. A forensic entomologist has acquired an important role in death investigation. He is required to do all sorts of works like finding time since death, season of death, geographical location of death, movement or storage of remains after death, time of decapitation and/or dismemberment, submersion interval, specific sites of injury on the body, postmortem artifacts on the body and the crime scene, use of drugs, linking a suspect to scene of crime, in child neglect, sexual molestation, identification of suspects etc [10].

The Future

Finally we come to the question: what does the future has in store for us? In which direction should the future research be directed? These are the questions one has to answer today. Before taking up these questions we should first discuss the shortcomings of the present methods.

First and foremost is the identification of correct species. Even today we are not aware of all the species of the insects. So to complete our list should be our utmost priority. The method of species identification can change e.g. from morphological features to DNA analysis, but the priority should not. Along with species identification the next thing that is to be done is to identify species in various ecosystems. For this the research has to be carried out in that particular geographical area for which we are finding the species. Not only the geographical area, the species also change with the time of the day, the season etc. So one has to take into account all these factors when conducting research on this topic.

Here we would like to mention a couple of special circumstances that can make our point clear. The first is the situation in which a corpse is found in a car. Now a car can be regarded as a special ecosystem as the points of entry in a car are bare minimum and sometimes are not present at all. As a result we are not aware what all species gain entry to this closed ecosystem and after how much time. Another case of point is the type of insects present in the water bodies viz. the lakes,

rivers, oceans etc. This is important in cases where the bodies are found in water. In those cases it becomes very difficult to know the time since death as the body is usually decomposed beyond recognition. So the entomologist can help in such cases when everyone else has failed.

The next thing that we are going to talk about is entomotoxicology. Although it has made great progress in recent years, a great deal of work still has to be done in it. As we have already mentioned in the preceding section, this science has not yet developed to the level that it can be used in routine practice. The use of entomotoxicology can also be used for identification. This can be done by extracting the deceased's DNA from the invertebrates. When the insects feed on the human remains, they ingest human cells. These cells can provide the necessary sample for the sampling. Although one may say that if the DNA is present it will be present in the available sample of the human remains. But here we can say that we had come across a case in which we got a totally charred body. The sample that we sent for DNA came negative for any DNA sample present in the remains. There were maggots present on the corpse. Although we did not send any maggots for DNA analysis, we feel that we may have been successful in getting a positive response especially because the maggots are present only on the live tissue. So we feel that this is one area on which the future research can be directed. It can be seen that DiZinno et al [11] have already done some work on this subject. They have used mitochondrial DNA to match the human DNA found in the blood in the insect's gut to that of the deceased's bone. In this case the deceased's DNA was available to match. This can be taken as a guide that in badly decomposed bodies forensic entomology can be used for the identification of the deceased.

An important thing that we must remember is that the future is in the hands of the youth. And the youth will take up the field only if we make it good enough for them to take it as a career. This is our responsibility i.e. those who are already in the field. We are saying this because forensic entomology has not progressed at the rate at which it should have. So the popularisation of the field should be one of the topmost priority of all forensic entomologists all around the globe. With more people joining the field will lead to more development paving the way for further research. This will lead to a cycle that can have only one effect, that of popularising the branch. So this should be one of the most important aspect of future development that we should strive for.

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