FORENSIC INSIGHTS

Volume 1: Issue 1: 2023

https://doi.org/10.56770/fi2023114

FORENSIC ENTOMOLOGY AS AN ADVANCED TOOL IN CRIME INVESTIGATION

Talha Arshad[1], Muhammad Naeem[2*]

[1]Department of Forensic Science, Islamia University, Bahawalpur, Punjab, Pakistan

[2]Department of Pharmacy, Shah Abdul Latif University, Khairpur, Sindh, Pakistan

Submitted 27th March 2023, Accepted 3rd May 2023

ABSTRACT

The use of research on insects and other arthropods in court proceedings is known as forensic entomology. When forensic insects are discovered on a human body or at the crime scenes, their biodiversity, biology, ecology, and behavior can reveal details about the period since death and occasionally even the reason of the death. The forensic insects have been utilized in criminal investigations from decades, they have only recently become a very well-known and separate field in forensic investigations. Knowledge of local insect assemblages and population dynamics is crucial in medico-legal entomology for a successful criminal investigation when monitoring and analyzing insects on a corpse. Forensic entomology comprises three subspecialties, namely urban, stored goods, and medico-legal. The insects that colonize corpses provide valuable insights into the decomposition process. In cases where traditional methods for determining the time since death are limited, Calliphoridae, a family of flies, provides crucial evidence. Two well-established approaches for estimating the post-mortem interval rely on the development of maggots and the succession patterns of insect species. Forensic entomology has gained significant popularity among criminal investigators and forensic entomologists, leading to the emergence of various related fields.

Keywords: Entomology, Medico-legal entomology; Time since death, Forensics

Corresponding Author. E-mail: naeem.mahar@salu.edu.pk

INTRODUCTION

Entomology is the scientific study of insects. It covers a wide range of topics, including insect taxonomy, morphology, physiology, behavior, ecology, and evolution. Entomologists study insects' roles in ecosystems, their interactions with other organisms, and their impact on agriculture, human health, and the environment. Some key areas of entomology include insect classification, life cycles, feeding habits, and pest management strategies. While insects are commonly perceived as detrimental pests causing harm to humans, crops, livestock, and household items, they also play a pivotal role in producing highly sought-after commercial commodities. For instance, honey is a valuable product derived from bees and silk, hailed as the supreme among textile fibers, showcases the remarkable prowess of insects. Additionally, lac, utilized in sealing wax, cosmetics, and dyes, further exemplifies the significance of insects in producing essential goods. Moreover, the vital process of insect pollination contributes significantly to approximately one-third of agricultural yield. The contribution of insects to genetics is both astoundingly significant and enduring. By serving as a scavenger while decomposing, it also cleans the environment. The academics have used forensic entomology to calculate postmortem times in cases involving human deaths. For this reason, entomology has developed into a well-recognized subject of forensic science, and entomological evidence's admissibility in court proceedings is expanding globally. Forensic entomology is the study of the insect flora found around dead corpses during criminal investigations for legal proceedings. Many forensic entomologists asserted that even beyond 72 hours, the evidence provided by forensically significant insects is frequently the most exact, precise, and perhaps the only way to estimate the amount of duration after death **[1,2].** Traditionally, determining the duration after death has relied on observing the external characteristics of corpses and considering factors like temperature, body cooling, eye changes, rigor mortis, muscle drooping, skin color, and post-mortem discoloration **[3,4].** However, in cases where these features are unobservable due to decomposition or mutilation,

forensic entomology serves as a valuable evidentiary tool. By studying the succession patterns of insects, it becomes possible to calculate the post-mortem interval (PMI). The analysis of legal entomofauna as a forensic method has gained popularity due to the fact that insects arrive in no time at a deceased body **[5,8]**. The determination of time span after death and potential causes of death relies on the predictable patterns of succession waves, which are influenced by factors such as bio-geolocation, seasonality, and habitats, as well as the developmental stages of larvae **[9]**. A forensic entomologist, acting as an expert witness, can provide invaluable information to investigating agencies, aiding in the clarification of civil and criminal cases. In fact, the use of insects as reliable indicators in forensic inquiries had been reported by Sung in his book which recounts the earliest known instance of employing insects as tools in a criminal investigation. This historical account describes a murder case in China in 1235, where the presence of numerous blow flies (calliphoridae) landing on a specific sickle played a crucial role in leading the killer to confess to using the same sickle to murder a fellow Chinese farm worker. During his investigation, Dr. Bergeret, a renowned medico-legal forensic entomologist often recognized as the pioneer of forensic entomology, made a significant discovery. He encountered the mummified remains of an infant concealed within a chimney. Upon conducting an autopsy on the cadaver, Dr. Bergeret observed the presence of various moth species and larvae, including Sarcophagidae (Flesh Fly) larvae, specifically Sarcophaga carnaria. Through meticulous examination of the entomofauna, Dr. Bergeret deduced that the newborn body had been sealed within the chimney in 1848, and later in 1849 the moths had approached to it.

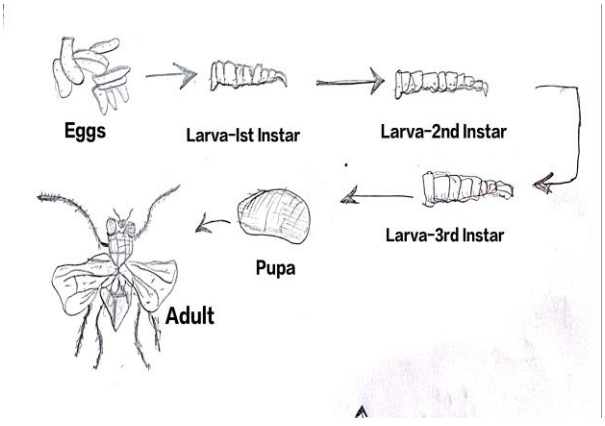

Figure 1: The life cycle of blowfly - insects speaking for crime victims.

TYPES OF FORENSIC ENTOMOLOGY

Lord and Stevenson established a classification system for forensic entomology, which encompasses three distinct categories:

Stored products entomology

Insect infestations in stored are the subject of legal proceedings.

Urban entomology

Insect and related creature studies that have an impact on human surroundings, particularly components of the built environment.

Medico-legal entomology

Forensic entomology is a specialized field that specifically deals with cases involving violent or severe crimes. Its primary objective is to ascertain crucial information such as the postmortem interval (time since death), the location of death (both primary and secondary crime scenes), and the mode of death **[1].**

Decomposition of human corpse and entomofauna association

Following the death of an organism, a series of decay processes commence, causing the cells, tissues, and organs to undergo deterioration. Autolysis, a cyclical process, involves the internal consumption of cells by biocatalysts, leading to the progressive decomposition of the corpse. Bacteria play a crucial role in initiating the breakdown of soft tissues along the gastrointestinal pathway, resulting in the liquefaction of internal organs and the release of gases such as ammonia, hydrogen sulfide, carbon dioxide, hydrogen, and methane [**10**]. These volatile chemical compounds are emitted by the decaying corpse and serve as attractants for insects of forensic significance.

REPUTATION OF ENTOMOLOGY IN THE COURT OF LAW

The judicial significance of evidence collected through forensic entomology can impact the course of a criminal investigation and legal prosecutions in different. In the context of scientific expert testimony, the analysis of forensic insect evidence falls within the purview of Session courts, High courts, and the Supreme Court. This entails that a qualified expert with expertise in entomology must assess the entomological data and provide an opinion on its relevance to the facts of the specific case. Different state and federal rules of evidence, recognized by national authorities, govern the admissibility and presentation of this type of expert testimony **[16].**

ADVANCES IN THE FIELD OF ENTOMOLOGY

Entomo-toxicology refers to the study of detecting poisons, toxins, or medications during different stages of insect development. It utilizes

entomological evidence collected from crime scenes to determine if poisoning was the cause of death. J.C. Beyer's work in 1980 highlighted the potential of using arthropods found on corpses or at crime scenes to detect the presence of toxins at the time of death. This led to the emergence of Forensic Entomo-toxicology as a sub-branch of forensic entomology. Extensive scientific research conducted in Western countries, including France, has demonstrated the valuable role that insects play in identifying poisons. In some cases, medications were undetectable in body tissues examined two months after death, but the liquid chromatography approach developed by Kintz enabled the detection of triazolam in maggots. Interestingly, research suggests that maggot tissues may be more suitable for toxin detection compared to muscular tissues. In certain situations, poisons can even be identified from an insect's diapause stage. Experimental studies have revealed the detection of a wide range of toxic substances (abuse drugs) in the developmental stages of insects that feed on corpses. Furthermore, toxins can also be present in the shed casings and feces of insects. Advanced techniques are employed to determine and analyze the presence of these toxins **[12,13].**

WILD LIFE ENTOMOLOGY

Forensic entomology holds equal significance in the investigation of wildlife crime cases, including illegal hunting, poaching, and trade, which are regulated by The Wildlife Protection Act of 1972. Similar to human death investigations, forensic entomology provides valuable information in wildlife cases, such as the time since death, cause of death, and the geographical location of the crime scene. By studying the life cycles of insects and considering various factors like season, temperature, rainfall, and relative humidity, it becomes possible to estimate the postmortem intervals in both human and wildlife cases **[14].**

IDENTIFICATION OF INSECT SPECIES

Traditional morphological identification methods have become outdated and challenging for certain species, particularly in immature life stages. To overcome these limitations, scientists have developed a molecular technique known as Polymerase Chain Reaction-Restriction fragment length polymorphism (PCR-RFLP) of mt-DNA. Molecular markers like mitochondrial COI and COII genes, which exhibit high genetic diversity, are used for accurate and efficient species identification. DNA barcoding and PCR-RFLP techniques are preferred over phenotypic identification due to their reliability and speed. Molecular biology techniques are employed to differentiate insect species and aid in estimating the postmortem interval. PCR-RFLP analysis is also utilized for identifying closely related species across different life stages, offering a convenient, rapid, and cost-effective approach for routine diagnostics **[15,16]**.

HUMAN DNA IDENTIFICATION FROM LARVAL GUT PORTION

Recent advancements have led to the development of molecular techniques that enhance the efficacy of identifying insect species and detecting human DNA within the guts of insects feeding on human corpses. Utilizing DNA extracted from maggot crops, both insects and their gastrointestinal contents can be accurately identified. In cases where collecting samples directly from the deceased is not feasible, maggots feeding on decomposing tissues can provide a source of human STR profiles, particularly when skeletal remains are not available. These advancements contribute to the improvement of forensic entomology as a field **[17,18].**

INSECT COLLECTION AND IDENTIFICATION

Insect collection and identification can be a fascinating hobby or a valuable scientific endeavor. To start, you'll need some basic supplies like a net, forceps, and a killing jar. When collecting insects, remember to be respectful of their environment and follow ethical guidelines. For identification, a good field guide or online resources can help you identify the insects you've collected. You may also want to consider joining local insect enthusiast groups or reaching out to entomologists for assistance in identifying more challenging species.

Remember to record the date, location, and other relevant details when collecting insects, as this information can be crucial for research purposes or personal records. Enjoy your insect collecting journey **[11].**

Table 1: Stages of decay and ecological succession information of certain fly species

	Fresh	Bloated	Decay	Post Decay
Day After Death	1-4	3-6	5-20	19+
Appearance on body	Natural	Bloated	Deflated Odiferous	Mummified or Skeletal
Calliphora Vomitoria larva	Yes	Yes	Yes	No
Sarcophaga Carnaria Larvae	Yes	Yes	Yes	No
Musca Domestica Larvae	No	Yes	Yes	No
Piophila Nigriceps Larvae	No	No	Yes	No
Location of Larvae	Orifices Wound	Orifices Wound	Throughout body	None
Pupae are present	No	No	Yes	Possible

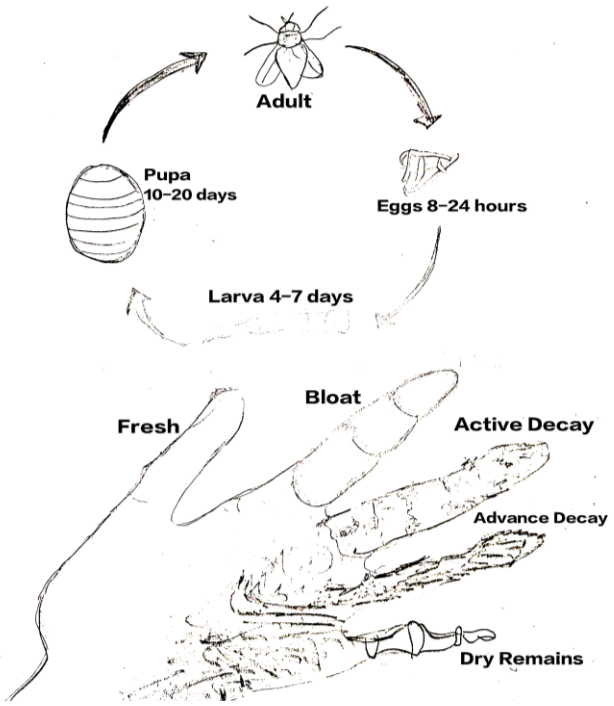

Figure 2: The life cycle of flies and the stages of decomposition of human hand.

FUTURE PERSPECTIVES

Forensic entomology holds equal significance in the investigation of wildlife crime cases, including illegal hunting, poaching, and trade. Similar to human death investigations, forensic entomology provides valuable information in wildlife cases, such as the cause and duration since death and the geographical location of the crime scene. By studying the life cycles of insects and considering various factors like season, temperature, rainfall, and relative humidity, it becomes possible to estimate the postmortem intervals in both human and wildlife cases **[14].**

CONCLUSION

Throughout the course of a criminal investigation, the significance of entomofauna's silent testimony becomes increasingly evident to medico-legal experts, police investigators, and forensic investigators. Previously disregarded as a mere nuisance, the presence of entomofauna at crime scenes or on bodies is now recognized for its remarkable contributions.

The study and analysis of forensic insect infestation and behavior are emerging as valuable scientific tools due to advancements in research and technology. Forensic medico-legal entomologists are now being recognized as expert witnesses and are employed by law enforcement agencies, including the FBI (USA). In order to effectively solve crime cases, comprehensive knowledge about insect life cycles, habits, habitats, developmental phases, biogeographical locations, biodiversity, taxonomy, and species identification is essential. The improved utilization of medico-legal entomology by investigators and forensic entomologists has the potential to significantly impact crime scene investigations.

REFERENCES

1. Anderson GS. The use of insects to determine time of decapitation: a case-study from British Columbia. J. Forensic Sci. 1997; 42: 947-950.
2. Amendt J, R Krettek, R. Zehner. Forensic Entomology. Naturwissenschaften 2004; 91: 51-65.
3. Campobasso CP, JG Linville, JD Wells, F Introna. Forensic genetic analysis of insect gut contents. Am. J. Forensic Med.Pathol. 2005; 26: 161-165
4. Gomes L, WA Godoy, CJ Von Zuben. A review of postfeeding larval dispersal in blowflies: implications for forensic entomology. Naturwissenschaften 2006; 93: 207-215.
5. Amendt J, CP Campobasso, E Gaudry, C Reiter, HN LeBlanc, M J Hall. European Association for Forensic Entomology. Best practice in forensic entomology--standards and guidelines. Int. J. Legal Med. 2007; 121: 90-104.
6. Erzinçlioglu Z. Forensic entomology. Clin. Med. 2003; 3: 74-76.
7. Benecke M, JD Wells. DNA techniques for forensic entomology. Forensic entomology: Utility of arthropods in legal investigations. CRC Press, Boca Raton 2001, 341-

352.
8. Campobasso CP, F Introna. The forensic entomologist in the context of the forensic pathologist's role. Forensic Sci. Int. 2001; 120: 132-139.
9. Otranto D, JR Stevens. Molecular approaches to the study of myiasis-causing larvae. Int. J. Parasitol. 2002; 32: 1345-1360.
10. Joseph I, Mathew DG, Sathyan P, Vargheese G. The use of insects in forensic investigations: An overview on the scope of forensic entomology. J Forensic Dent Sci. 2011; 3(2):89-91.
11. LeBlanc HN, Logan JG. Exploiting Insect Olfaction in Forensic Entomology. In: Amendt J, Goff ML, Campobasso CP, Grassberger M (eds). Current Concepts in Forensic Entomology. Springer, Netherlands. 2010; 205-221.
12. Chen WY, Hung TH, Shiao SF. Molecular identification of forensically important blow fly species (Diptera: Calliphoridae) in Taiwan. J Med Entomol. 2004; 41:47-57.
13. Chophi R, Sharma S, Sharma S, Singh R. Forensic entomotoxicology: current concepts, trends and challenges. Journal of forensic and legal medicine. 2019; 67, 28-36.
14. Singh R, Sharma P, Mehta RK. Wildlife forensic entomology: A study on national level highlighted cases of tigers death in Ranthambour and Sariska national parks (Rajasthan) J. Appl. Biosci. 2012; 38(2): 127-131
15. Thyssen PJ, AC Lessinger, AM Azeredo-Espin, AX Linhares. The value of PCR-RFLP molecular markers for the differentiation of immature stages of two necrophagous flies (Diptera: Calliphoridae) of potential forensic importance. Neotropical Entomology 2005; 34(5): 777-783.
16. Jangir S, Sharma JD. Molecular identification of carrion insects and their role in justice delivery system 2019.
17. Campobasso CP, FA Sperling, F Introna, G Di Vella, J Hayes, JD Wells. Human and insect mitochondrial DNA analysis from maggots. Journal of Forensic Science 2001; 46(3): 685-687.
18. Wells JD, T Pape, FA Sperling. DNA-based identification and molecular systematics of forensically important Sarcophagidae (Diptera). Journal of Forensic Science 2001; 46(5): 1098-1102