

Insects In Tracing Post-Mortem Interval: A Crucial Tool In Forensic Investigations

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Abstract:

Forensic entomology is a branch of forensic science and is associated with study of insects that are involved in the crime scene and the decomposition process of the carcasses. Insect evidence is more frequently used and are considered important in legal proceedings. Though insects do not commit crime, they act as vectors in carrying the ingested human remains. Varied species of insects rely on human dead for nutrition and to lay eggs in the context of multiplication. The larvae are highly dependent on human remains for nutrition under certain environmental conditions. This gives an overview in estimation of Post-mortem interval. The insects provide immense information such as: whether the corpse has been moved to a different location, information regarding the seasonal changes, prescribed medicines that the dead had consumed, identification of the individual using DNA profiling and gunshot or residues of explosives. This information sometimes can not be traced in human samples but in larval tissues. The insects help us trace evidence, but on the contrary, they are not always helpful, as they erase the evidence by decomposition. In fatal stabbing, the injuries can be modified by these insects, even the clothes of the victim. In cases where the victim is found beyond a period of time, all the evidence is erased by the natural process of decomposition, hampering the reconstruction of crime. It also helps to identify the cause and manner of death. The presenting study is a literature review on various insects that contribute to the investigations of the death. It also establishes a cordial relationship between the insects and Forensic experts in solving a crime. This review considers the approaches towards estimating the minimum time lapsed since death i.e., the minimum post-mortem interval with insects as main source of concern. It also highlights the retrieval of data in a standardized manner.

Keywords: Autopsy, Forensic entomology, Forensic microbiology, Forensic science.

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Introduction

The mysteries surrounding death have captivated scientists, investigators, and the general public for millennia. Death is a universal and inescapable part of existence. A crucial and difficult issue in forensic science is estimating the post-mortem interval (PMI), or the amount of time that has passed since death, among the numerous questions that come up following a person's passing (Matuszewski *et al.*, 2017). In criminal investigations, incidents involving missing persons, and disaster management, an accurate calculation of PMI is essential. Even if there are many ways to determine PMI, the world of insects is one of the most trustworthy and fascinating places to go for information (Wells *et al.*, 2021).

In the immediate aftermath of death, insects, the simple organisms that frequently go unnoticed in our daily lives, play a surprising function. They are the unsung heroes of forensic entomology, an area of forensic science that specializes in the relationship between insects and deceased. (Madea, 2015; Wang *et al.*, 2021). This field has acquired great prominence over the years, owing to its precision in determining the time of death and its potential to offer vital insights into crime scene investigations and natural death situations.

Early observations of flies, beetles, and other creepy-crawlies swarming around decomposing waste sparked an interest in insects' potential role in PMI calculation (Wang *et al.*, 2021). But it wasn't until the late 19th century that researchers started to thoroughly examine these insects and how they behaved around dead bodies. The basis for the advancement of forensic entomology as it is known today was built by the pioneering work of researchers like Jean-Pierre Ménégnin and Amédée Fournier (Acosta *et al.*, 2022).

A variety of insect species with predictable and sequential patterns of colonization on a corpse are used by forensic entomologists. Necrophagous insects, which feed directly on decomposing tissue, can be broadly divided into two groups: detritivorous insects, which eat the organic matter surrounding the corpse as it decomposes (Liangliang *et al.*, 2023; Chopi *et al.*, 2019). The smell of decay attracts flies, especially blow flies (Calliphoridae), who frequently arrive first at a corpse. Beetles that follow the flies include dermestids (Dermestidae) and rove beetles (Staphylinidae), each of which has unique ecological preferences and colonization patterns (Wells *et al.*, 2021).

Due to their consistent life cycles and growth rates, insects play a crucial role in PMI calculation. Forensic entomologists can compute the PMI with a high degree of accuracy thanks to the temperature-dependent growth of insect larvae known as maggot masses (Ceciliason *et al.*, 2018). Experts can estimate the time of death for these insects by evaluating their developmental stage, taking into account variables like temperature, humidity, and geographic location.

Forensic entomology has a lot of uses, but it also has certain difficulties. The assessment of PMI can be made more difficult by variations in ambient factors and insect species' behaviors (Acosta *et al.*, 2022; Wells *et al.*, 2021). The accuracy of estimates may also be hampered by the absence of comprehensive datasets and established processes for various regions. However, continual study and improvements in entomological methods, including the use of cutting-edge technology like environmental DNA (eDNA) and DNA analysis of insect gut contents, are continuously enhancing the accuracy of PMI estimates (Liangliang *et al.*, 2023).

The use of insects in tracking the post-mortem period extends beyond just criminal investigations. (9) They have shown to be extremely useful in archaeology, providing insight into early burial customs and the preservation of human remains. Their importance also extends to ecological research, where they act as markers of habitat alterations and environmental health (Wells *et al.*, 2021).

We will explore the intriguing field of forensic entomology in depth as we examine the role of insects in determining the post-mortem period (Xie *et al.*, 2013). We'll look at the complex connections between insects and death, the methods used to estimate PMI, the difficulties faced by forensic entomologists, and the constantly expanding technology advancements that promise to improve our comprehension of this important topic. We shall learn via this voyage that these common insects, frequently thought of as merely annoyances, actually possess the key to some of the most deep secrets surrounding death, making them the true silent witnesses that convey so much in the field of forensic research (Ceciliason *et al.*, 2018).

Methodology

We had performed an extensive search on Pubmed, Google scholar and Scopus. Researchers, academics, and students all across the world depend on databases like PubMed, Google Scholar, and Scopus because they provide unique benefits and resources for obtaining scholarly knowledge.

The National Center for Biotechnology Information (NCBI) is in charge of PubMed, which is focused on the biomedical and life sciences. Its extensive collection of peer-reviewed articles from recognized journals makes it a crucial tool for scientists and medical practitioners. For individuals in the healthcare and life sciences fields, PubMed's powerful search features, MeSH indexing, and access to clinical studies offer a comprehensive platform.

By indexing scholarly information from many disciplines, Google Scholar, a service provided by Google, adopts a more comprehensive approach. It is a flexible tool for researchers in a variety of subjects because it includes articles, books, theses, conference papers, and patents. Google Scholar is a well-liked option for quick searches and interdisciplinary inquiry because of its approachable interface and accessibility.

The wide coverage of scholarly literature provided by Scopus, which is run by Elsevier, is well known. It spans a wide range of fields, including science, technology, social sciences, and the arts. Researchers may measure the impact of their work and find key pieces of research in their field using Scopus' superior citation analysis and bibliometrics. Both scholars and institutions can benefit from using it because of its extensive database and powerful search capabilities.

Results and Discussion

In criminal investigations and the judicial system, forensic entomology—the science of employing insects to calculate the post-mortem interval (PMI)—is essential (Wang *et al.*, 2018). This field makes use of the fascinating connection between insects and decomposition to offer vital information about when people die. Even though the outcomes of using entomological evidence in PMI estimates are frequently helpful in solving crimes, they also have certain inherent difficulties and restrictions (Wells *et al.*, 2019).

Although forensic entomology is a useful technique for calculating PMI, there are a number of variables that can alter its accuracy (Amendt *et al.*, 2010). The development of insects and the process of decomposition both depend heavily on temperature. In areas with changing climates, it might be difficult to estimate precise PMI because temperature differences can affect how quickly insects develop (Ren *et al.*, 2021). Different bug species have different preferences for settling new areas and evolve at various rates. Therefore, it can be difficult to estimate PMI when a corpse contains a variety of insect species. To produce precise estimations, forensic

entomologists must recognize and research every species present. Insect activity and development can be influenced by the environment surrounding the corpse, including moisture levels, access to the body, and refuge (Amendt *et al.*, 2010; Iancu *et al.*, 2016). Insect colonization patterns on a corpse left outside in a wooded location may differ from those on corpses left in cities. The estimation of PMI can be impacted by insect behavior. For instance, certain blowflies have been observed to be drawn to open wounds rather than the body itself, possibly laying their eggs before the person dies (Iancu *et al.*, 2016). The amount of decomposition and insect colonization depends on the size and state of the body. Insects may be attracted to a little, well-preserved body differently than to a huge, highly decomposed one. Insect activity can be strongly impacted by seasonal changes. In winter, insect activity may be reduced in colder areas, making it more difficult to estimate PMI (Al-Qahtni *et al.*, 2019).

The following are the limitations in tracing the PMI:

- **PMI Estimation Accuracy:** The main benefit of using insects to trace PMI is the potential for extremely accurate estimates. Insects, especially blowflies, have predictable temperature-dependent developmental patterns, which enables forensic entomologists to precisely calculate the time since death. Experts can give law enforcement a small window of when the person most likely passed away by examining the life stages of insects found on or nearby a corpse (Wang *et al.*, 2021).
- **Corroborating evidence:** Evidence that supports or contradicts other aspects of a crime scene investigation can be provided by insects. Insects' presence and stages of development on a victim's body might act as an objective timeline to prove or disprove a suspect's alibi when it is put into question. This corroborative function raises the forensic entomology's credibility in court (Wang *et al.*, 2021).
- **Case Resolution:** Case resolution frequently results from the effective use of insect evidence in PMI tracing. The importance of entomological evidence in identifying and prosecuting offenders has been demonstrated by famous criminal cases like the "Green River Killer" and "Bitter Blood" instances. Law enforcement can concentrate their investigations and bring justice to victims and their families by reducing the time period of a crime (Wang *et al.*, 2021).

- **Environmental Factors:** The capacity to infer details about the surroundings at the crime scene is another useful outcome of utilizing insects in PMI estimate. The existence and developmental stages of insects can provide clues about the local weather, the season, and probable temperature changes in the time after death because insect growth is temperature-dependent. Researchers may be able to gain new insights from this environmental background (Wang *et al.*, 2021).
- **Education and Research:** Forensic entomology advances our knowledge of the ecology and behavior of insects. The ongoing study in this area increases our understanding of how insects function in ecosystems and aids criminal investigations. This two-fold advantage highlights the interdisciplinary character of forensic entomology, where information from criminal investigations informs scientific study and vice versa (Wang *et al.*, 2021).

Conclusion

In conclusion, there is no denying the importance of insects in tracing the post-mortem interval (PMI) in the field of forensic research (Li *et al.*, 2021). As we consider our last observations on this intriguing topic, it becomes clear that the cooperation between human investigators and nature's decomposers has opened vital insights into the mysteries of death, improving our capacity to solve crimes and provide closure to families (Wells *et al.*, 2019).

Using insects to estimate PMI has as its main benefit the availability of precise and timely information regarding the timing of death. Blowflies in particular, which have life cycles that are tightly coordinated with temperature and decomposition processes, are nature's timekeepers (Wells *et al.*, 2019). Insect presence and developmental stages on or around a corpse are meticulously examined by forensic entomologists to provide accurate PMI estimates, frequently resolving the time of death to a small window (Wells *et al.*, 2021). This precision is a priceless asset in criminal investigations since it not only supports or refutes alibis but also directs law enforcement efforts to solve challenging cases.

Furthermore, the importance of insect evidence as corroboration cannot be emphasized. Criminal investigations gain a level of objectivity and credibility when insect-derived timings coincide with or clash with other pieces of evidence (Li *et al.*, 2021). Because of its consistency, forensic entomology is

seen as more credible in court and has the potential to influence the outcome of cases.

The crucial role played by insects in solving crimes has been highlighted by famous instances like the "Green River Killer" and the "Bitter Blood" case, highlighting their ability to locate and punish offenders (Wells *et al.*, 2019). The relevance of forensic entomology in the sphere of law enforcement and its profound impact on the lives of those impacted by crime are demonstrated by these practical applications.

The study of insects in PMI calculation has further advantages besides helping with criminal investigations. It offers information about the weather at crime scenes, giving hints about the local climatic conditions, the time of year, and temperature changes during the post-mortem period (Ren *et al.*, 2021). The contextual comprehension of forensic cases is improved by this information, which could result in more thorough and well-informed investigative methods.

Another interdisciplinary subject that advances our knowledge of insect behavior and ecology is forensic entomology (Wang *et al.*, 2021). The constant advancement of forensic science practice as well as our understanding of the natural world are both benefits of this field's continual research and development. The interdependence of entomological science and forensic entomology emphasizes the value of a collaborative approach, wherein information from criminal investigations can affect scientific study and vice versa.

But it's important to recognize the difficulties and restrictions that come with using insects to estimate PMI (Ren *et al.*, 2021). Forensic entomologists must take all of these variables into careful consideration and apply their knowledge of complicated insect behavior, environmental variability, secondary colonization, and the potential for incomplete data (Yang *et al.*, 2017).

A remarkable union of nature and science is revealed by the voyage into the world of insects in tracing the post-mortem interval, where the tiniest organisms play a crucial role in explaining the mysteries of death (Wang *et al.*, 2021). Despite these difficulties, the partnership between forensic scientists and insects has developed into a potent instrument that keeps up with advances in science and forensic techniques.

We may anticipate even higher precision and dependability in determining PMI in the future as our knowledge of entomology and forensic science

advances (**Haase et al., 2020**). Insects continue to play a crucial part in protecting justice and providing consolation to those impacted by crime with each case resolved and mystery solved, demonstrating that the smallest creatures may make the biggest contributions to the annals of forensic history (**Hayman et al., 2020**).



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