

Forensic Entomology: Insect Evidence in Criminal Investigations

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Abstract: -

Forensic entomology is a specialized branch of forensic science that uses insects and other arthropods as evidence in legal investigations. The study of insects associated with decomposing remains helps estimate the post-mortem interval (PMI), which is the time elapsed since death. Insects, particularly blow flies and beetles, colonize dead bodies in a predictable sequence, making them valuable indicators in criminal investigations. Their life cycles, developmental stages and succession patterns provide important information regarding the time and circumstances of death. Apart from PMI estimation, forensic entomology assists in identifying body relocation, detecting wounds or trauma and understanding environmental factors affecting decomposition. Accurate identification of insect species is essential because different species exhibit distinct developmental rates and ecological preferences. Recent advances in molecular techniques and DNA-based identification methods have further improved the reliability of insect evidence. Although environmental conditions may influence insect activity and limit accuracy in some cases, forensic entomology has become an important tool in modern criminal investigations. This article highlights the principles, significance, major insect groups and applications of forensic entomology in medicolegal investigations.

Keywords: Forensic entomology, post-mortem interval, blow flies, insect succession, forensic insects, criminal investigation etc.

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Introduction:

Forensic entomology is a specialized branch of forensic science that deals with the application of insects and other arthropods to legal investigations. It primarily focuses on the study of insect colonization on decomposing human and animal remains to estimate the post-mortem interval (PMI), which refers to the time elapsed since death. Because insects are among the earliest organisms to colonize a dead body, their predictable patterns of development, succession and distribution provide valuable evidence for criminal investigations.

The discipline utilizes the biology, ecology and developmental stages of insects associated with decomposing remains to assist in determining the time, place and circumstances of death. In addition to estimating the post-mortem interval, forensic entomology can provide information regarding the movement of a corpse, presence of wounds or trauma, environmental conditions surrounding death and the possible association of suspects with a crime scene.

Forensic entomology is generally classified into three major branches: urban forensic entomology, stored-product forensic entomology and medicolegal forensic entomology. Urban forensic entomology deals with insects affecting humans and their immediate surroundings, including household

infestations and structural pests. Stored-product forensic entomology involves insects associated with commercially produced food products and stored commodities. Medicolegal forensic entomology, the most widely studied branch, focuses on insects associated with human remains and their applications in criminal investigations.

Among the various applications of forensic entomology, estimation of the post-mortem interval is considered the most important. Insects undergo distinct developmental stages, including egg, larva, pupa and adult, at predictable rates influenced primarily by environmental factors such as temperature and humidity. Furthermore, different insect species colonize decomposing remains in a relatively predictable sequence, known as insect succession. Early colonizers such as blow flies typically arrive within minutes or hours after death, whereas beetles and other scavenging insects appear during later stages of decomposition (Kotze *et al.*, 2021). Knowledge of these developmental patterns and successional changes enables forensic entomologists to estimate the time since death with considerable accuracy.

Accurate identification of insect species is essential in forensic investigations because developmental rates and ecological preferences vary considerably among species. Incorrect species identification may lead to

inaccurate estimations of the post-mortem interval and erroneous forensic conclusions. Therefore, proper taxonomic identification, supported by morphological and molecular techniques, is fundamental to the reliability of forensic entomological evidence.

Recent advances in molecular biology, DNA-based identification methods and ecological studies have significantly improved the accuracy and applicability of forensic entomology. Consequently, insects have become valuable biological indicators that contribute substantially to criminal investigations and judicial proceedings. The present article highlights the importance of forensic entomology and provides an overview of major insect species of forensic significance and their role in medicolegal investigations.

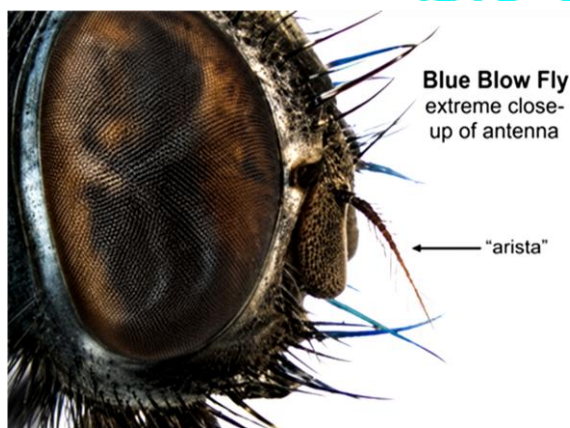


Fig.: 1 Blow fly

Blow Flies (Family: Calliphoridae)

Blow flies (Family: Calliphoridae) are among the earliest and most important insect colonizers of decomposing remains and play a critical role in forensic investigations.

Numerous experimental and field studies have demonstrated that calliphorid flies can locate and colonize exposed carcasses within minutes after death, making them valuable indicators for estimating the post-mortem interval (PMI).

Female blow flies possess a telescopic ovipositor formed by the terminal abdominal segments, which enables them to deposit eggs in suitable sites on the body. Eggs are commonly laid in natural body openings such as the nose, mouth, ears and eyes, where moisture and protection favor larval development. In addition, exposed wounds, abrasions and areas of trauma often serve as preferred oviposition sites.

Following egg hatch, large aggregations of larvae or maggot masses develop, generating considerable metabolic heat that accelerates tissue decomposition. The presence, distribution and abundance of these maggot masses can provide valuable information regarding the timing of colonization and the progression of decomposition. Furthermore, localized larval activity and uneven tissue removal may indicate the presence of ante-mortem or peri-mortem injuries that existed before insect colonization.

Therefore, careful examination of insect-infested areas by forensic pathologists, anthropologists and forensic entomologists is essential, as insect evidence associated with

wounds and body openings may contribute significantly to the reconstruction of events surrounding death and improve the accuracy of forensic investigations.

Significance of forensic entomology in legal cases:

Forensic entomology has emerged as an indispensable tool in criminal investigations



Fig.:2 Species of Blow flies

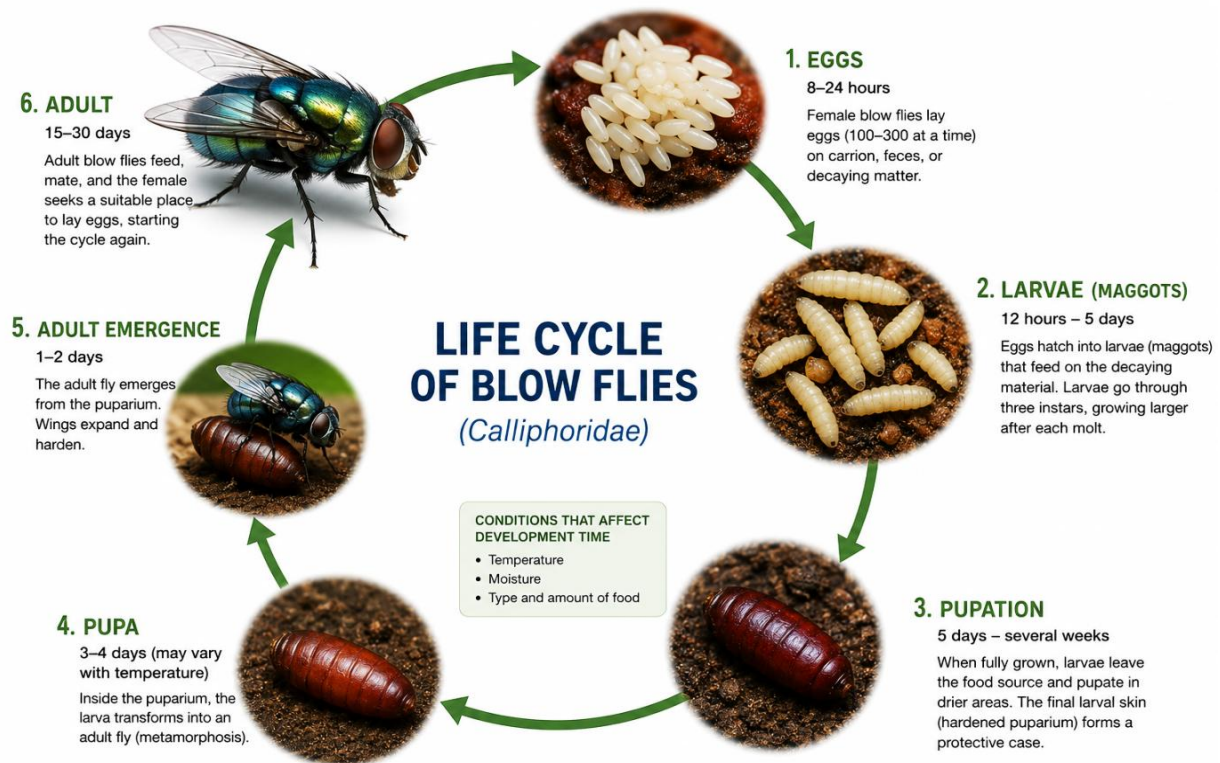


Fig.: 3 Life cycle of Calliphoridae

by providing valuable biological evidence that assists in the reconstruction of events surrounding death. The application of insect evidence has significantly improved the accuracy of forensic investigations, particularly in cases involving decomposed, burned, buried, or concealed bodies. The major contributions of forensic entomology in legal investigations are described below.

1. Estimation of post-mortem interval

(PMI): One of the primary applications of forensic entomology is the estimation of the post-mortem interval. The developmental stages of insects, particularly flies and beetles, together with their succession patterns on decomposing remains, provide reliable information regarding the time elapsed since death.

2. Identification of insect evidence:

Forensic entomologists identify insects collected from crime scenes at different life stages, including eggs, larvae, pupae and adults. Accurate species identification is essential because developmental rates vary among species and directly influence PMI estimations.

3. Collection and preservation of evidence:

Proper collection, preservation and documentation of insect specimens constitute an important aspect of forensic investigations. Insect evidence collected from the body and surrounding environment

serves as valuable biological material for subsequent laboratory analysis.

4. Determination of cause and circumstances

of death: Certain patterns of insect colonization may indicate the presence of wounds, trauma, neglect, or environmental conditions associated with death. Insect activity around injuries can provide clues regarding ante-mortem or peri-mortem trauma.

5. Assessment of environmental factors:

Temperature, humidity, rainfall, habitat conditions and seasonal variations influence insect development and decomposition processes. Understanding these environmental factors enhances the precision of forensic estimations.

6. Molecular identification of insects:

Modern molecular techniques, including DNA-based methods and DNA barcoding, facilitate the identification of morphologically similar species, thereby increasing the accuracy and reliability of forensic evidence.

7. Courtroom testimony and judicial

support: Forensic entomologists frequently serve as expert witnesses, presenting scientific evidence and explaining insect-related findings during legal proceedings. Their testimony assists courts in interpreting biological evidence and strengthens judicial decision-making.

Table:1 List of Important Major and Minor insect involve in Forensic Entomology

S.N.	Common Name	Scientific Name	Family	Order
	Flies			
1.	Blue Bottle fly	<i>Calliphora vicina</i>	Calliphoridae	Diptera
2.	Blue Blow fly	<i>Calliphora vomitoria</i>	"	"
3.	Oriental Latrine Fly	<i>Chrysomya megacephala</i>	"	"
4.	Maggot Blow Fly	<i>Chrysomya rufifacies</i>	"	"
5.	Screwworm Fly	<i>Cochliomyia macellaria</i>	"	"
6.	Shiny Blue Bottle Fly	<i>Cynomyopsis cadaverina</i>	"	"
7.	Green Bottle Fly	<i>Lucilia illustris</i>	"	"
8.	Green Bottle Fly	<i>Phaenicia cluvia</i>	"	"
9.	Green Bottle Fly	<i>Phaenicia coeruleiviridis</i>	"	"
10.	Bronze Bottle Fly	<i>Phaenicia cuprina</i>	"	"
11.	Green Bottle Fly	<i>Phaenicia eximia</i>	"	"
12.	Sheep Blow Fly	<i>Phaenicia sericata</i>	"	"
13.	Black Blow Fly	<i>Phormia regina</i>	"	"
14.	Holarctic Blow Fly	<i>Protophormia terraenovae</i>	"	"
15.	Red-Tailed Flesh Fly	<i>Sarcophaga haemorrhoidalis</i>	Sarcophagidae	Diptera
16.	Lesser House Fly	<i>Fannia canicularis</i>	Muscidae	Diptera
17.	Latrine Fly	<i>Fannia scalaris</i>	"	"
18.	Bronze Dump Fly	<i>Hydrotaea aenescens</i>	"	"
19.	Black Dump Fly	<i>Hydrotaea leucostoma</i>	"	"
20.	House Fly	<i>Musca domestica</i>	"	"
21.	Cheese Skipper	<i>Piophilidae casei</i>	Piophilidae	Diptera
22.	Common Dung Fly	<i>Scatophaga stercoraria</i>	Scatophagidae	Diptera
23.	Black Scavenger Flies	<i>Sepsis sp.</i>	Sepsidae	Diptera
24.	Small Dung Fly	<i>Poecilosome angulata</i>	Sphaeroceridae	Diptera
25.	Black Soldier Fly	<i>Hermetia illucens</i>	Stratiomyidae	Diptera
26.	Humpbacked Fly	<i>Megaselia scalaris</i>	Phoridae	Diptera
27.	Coffin Fly	<i>Conicera tibialis</i>	"	"
28.	Moth Fly, Drain Fly, Sewage Fly, Trickling Filter Fly	<i>Psychoda alternata</i>	Psychodidae	Diptera
	Beetles		"	"
1.	Garden Carrion Beetle	<i>Heterosilpha ramosa</i>	Silphidae	Coleoptera
2.	Carrion Beetle	<i>Necrodes surinamensis</i> <i>Oiceoptoma inaequale</i> <i>Oiceoptoma noveboracense</i> <i>Oiceoptoma rugulosum</i>	"	"
3.	American Carrion Beetle	<i>Necrophilia americana</i>	"	"
4.	American Burying Beetle	<i>Nicrophorus americanus</i>	"	"
5.	Burying Beetle	<i>Nicrophorus carolinus</i> <i>Nicrophorus investigator</i>	"	"
6.	Margined Burying Beetle	<i>Nicrophorus marginatus</i>	"	"
7.	Sexton Beetle	<i>Nicrophorus orbicollis</i>	"	"
8.	Gold-Necked Carrion Beetle	<i>Nicrophorus tomentosus</i>	"	"
9.	Lapland Carrion Beetle	<i>Thanatophilus lapponicus</i>	"	"
10.	Incinerator Beetle	<i>Dermestes ater</i> <i>Dermestes caninus</i> <i>Dermestes maculatus</i> <i>Dermestid Frass</i>	Dermestidae	Coleoptera

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S.N.	Common Name Flies	Scientific Name	Family	Order
11.	Hairy Rove Beetle	<i>Creophilus maxillosus</i>	Staphylinidae	Coleoptera
12.	Brown Rove Beetle	<i>Platydracus comes</i>	''	''
13.	Spotted Rove Beetle	<i>Platydracus fossator</i>	''	''
14.	Clown Beetle	<i>Saprinus pennsylvanicus</i>	Histeridae	Coleoptera
15.	Red-Legged Ham Beetle	<i>Necrobia rufipes</i>	Cleridae	Coleoptera
16.	Hide Beetle	<i>Trox suberosus</i>	Trogidae	Coleoptera
17.	Tumblebug	<i>Deltochilum gibbosum</i> <i>gibbosum</i>	Scarabaeidae	Coleoptera
18.	Dung Beetle	<i>Phanaeus vindex</i>	''	''

Thus, forensic entomology provides scientifically validated evidence that contributes significantly to criminal investigations, supports legal proceedings and enhances the overall reliability of forensic conclusions.

Limitation of Forensic Entomology

1. Time of death estimates depend on accurate temperature information, but local weather patterns can be variable and data may come from stations quite distant from the crime scene.
2. Forensic entomology relies on insect abundance. In winter, there are fewer insects and entomology's use is limited.
3. Since it takes time to rear insects, forensic entomology cannot produce immediate results.
4. Treatments (like freezing, burial or wrapping) that exclude insects can affect estimates.

References

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