ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

Entomological Abundance and Difference in Insect Activity in Various Crime Scene Conditions

Akhilesh[1]; Anirudhvaibhav Gupta[2]; Aastha Sharma[3]; Midhuna E[4]; Vishnupriya_KK[5]
Department of Anthropology University of Delhi-110007

Abstract:- Forensic entomological research encompasses the study of role of insects in context of death and in the different environmental conditions .Bugs and Beetles play important role in estimating the time of death and also has a role in post mortem index determination . Apart from these major types of insects, other kind of insects such as Dermastids, mites, and even ants play an important role in determination of postmortem interval. Differences in the conditions of the scenes in which the body or cadaver is found also determines the insect activity or types of entomological abundance found . Various conditions such as dry , moist , cold , burial deaths , and drowning conditions also have different effects on the insect abundance found in the area , which would effect the decomposition difference in that particular surrounding . Depending upon what stage of decomposition the body is found, the abundance and kind of insects associated with it will vary, giving insights into the time elapsed since death. This paper also provides insights into the latest emerging field in forensic entomology, namely, Entomotoxicology. This emerging field provides insights into the effects different toxins and chemicals, originally found in the cadavers, have on the insect population feeding on them. This could possibly link us towards the possible cause of death, if by poisoning, and to determine the kind of poison. Forensic entomological research possess various limitations in the current scenario and have a great scope for future studies and further researches.

Keywords:- *Forensic Entomology, Decomposition, Larvae, Metamorphosis, Postmortem Interval.*

I. INTRODUCTION

"In forensics , seeking truth have the utmost importance and sometimes , the tiniest creations of the nature – the bugs and beetles helps in unveiling this truth ." Insects are one of the most common visitors to a dead body and its surrounding regions. They can sometimes help in discovering many important findings about the concerned dead body , it's surroundings and the conditions of it's death. Ever since the evolution of insects , they have lived along the humans , feeding on the organic bodily fluids and organic wastes such as meat and vegetables (Magni, 2022) .

Entomology is the branch of zoology which deals with insects . It encompasses their biology and control , ecology and impact of it on animal , plant and human health (entomology, n.d.) . Forensic entomology is the study of insects and other arthropods as evidence in investigations of suspicious death crimes (Pigoli, et al., 2023). Just like other important trace evidences like blood , fingerprints , soil , insects also holds a probative value as evidence in criminal investigation of death . Apart from aiding in decomposition process by breaking down the carcasses by feeding on them , they also lay their eggs which develop into larvae which in turn helps in ascertaining the important conditions and time of death (Joseph, 2011) . There are different insects that help in the process of criminal investigations . the type of these insects would depend upon the conditions of the death , the crime scene , cadaver conditions , atmospheric conditions , etc. . Insects like blow flies , flesh flies , cheese skippers , hide and seek beetles , rove beetles , clove beetles are some of the most common varieties of insects that are of forensic importance and relevance . Some of these insects could only feed in their respective juvenile phases while some only feed in their adult phases . these are the necrophagous insects. But some other insects feed on these primary necrophagous insects that firstly infest the cadavers for feeding (Gennard, 2007) . Apart from the very important role in estimating the since death , it also helps in determining if the cadaver has been moved or not , has been disturbed either by the animals or the killers who may have visited the crime scene after the crime to get rid of the existential evidences from the scene (Anderson, n.d.) . Studies also show that in cases suspected of drug abuse , sexual assault , neglect deaths , movement of the carcasses , concealment etc. , various entomological evidences can help through providing valuable information regarding the actual scenario of death , the identification of cause , antemortem postmortem trauma and more (Introna, Cattaneo, Mazerelli, De Micco, & Campobasso, 2021) .

However , one of the challenges faced by the field of entomology in forensic science is its admissibility by the court of law as a valid evidence . This issue can be resolved by the involvement of various accreditation standards as per the instructions of the EAFE – European Association of Forensic Entomology (with regards to the sampling and collection standards of the insect evidence from the crime scenes) , ABFE – American Board of Forensic Entomologists (for certification of the forensic entomology experts and even accreditation of laboratories , among other boards such as OSAC (Organisation of Scientific Area Committees for Forensic Science) , Crime Scene Investigation Subcommittee, Forensic Entomology Task Group etc. (Kotzé, et al., 2021) .

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

Entomotoxicology is the application or use of these entomological richness in the carcasses for toxicological purposes . it would help in detecting drugs or other toxicological substances in the cadaver or on the surroundings of the scene of crime (Lord & Goff, 1994).

The following study tries to understand some of the important questions arising while applying the field of entomology in the crime investigation cases :

- To understand the basic science behind the application of entomological sciences with the crime investigation
- To comprehend the various major species involved in the process , their respective life cycles , succession and the PMI (Post mortem Interval) estimation .
- To analyse the effects of different environmental conditions of the death – like , different weather conditions (dry , moist , cold) , drowning deaths , different burial heights , different drug effects .
- To understand the limitations , challenges , future aids , and scope for further studies .
- To aid the practitioners in the field by providing an universal standard and comprehensive understanding of the above mentioned problems and topics.

This study would be able to answer the questions of differential effects on the entomological populations in the dead bodies , which would help in the standardisation of these differences in these respective conditions of death . This would provide the entomologists to provide a clearer and much accurate analysis and estimation of the variables of death such as time since death , conditions , etc in accordance with their differential effects .

This paper reviews the various secondary sources such as already published studies and researches .The paper tries to incorporate various findings about various environmental conditions and their effect on the entomological species by various experts in the past. The paper offers a comprehensive review about all the previous studies that has been carried out on the topic regarding the same . Various research papers have been studied and referred from various science websites such as pubmed , science scholar , ncbi , among various other renowned scientific webpages . It is a comprehensive and encompassing review about the different studies on different entomological population in different conditions of death . Scanty of researches has been performed with understanding these differential conditions. However, some of the papers , from the entomology and forensic journals have been referred for the same providing a detailed account of the topic under study .

II. ENTOMOLOGICAL ABUNDANCE IN DECOMPOSITION REMAINS

Forensic entomology is the use of arthropod-related knowledge in the administration of justice. Arthropods vary greatly in terms of temperature, humidity, season, and available food. Forensic entomology has been subdivided into four classes they are medico-legal, general, urban, stored food-stuff forensic entomology. The medico legal forensic entomology mainly focuses on the post-mortem interval (PMI). The basis of general forensic entomology is the fact that arthropods have distinct habitat characteristics that help to establish a connection between the criminal and the crime, the victim, the scene, the weapon of offence. The study of urban forensic entomology focuses on the fauna, which is posing a severe threat due to increased urbanization. Food-storage forensic entomology concentrate on the effect of insect infected foods on human after the consumption. Most of the forensic entomology evidence is corroborative (Sharmma). To ascertain the time and location of death, forensic entomology typically entails identifying insects and other arthropods connected to human remains (Mullen & Durden, 2002) .

➢ *Common Species Encountered in Forensic Entomology*

The most important aspect of forensic entomology is the accurate identification of insect and arthropod species. It is species identification that permits appropriate developmental data and distribution ranges to be applied to an investigation. Species determinations ought to be constantly conducted by a skilled forensic entomologist (Byrd & Castener, 2010). Sung Tzu's 1235 AD commentary in a book titled The Washing Away of Wrongs is the trace of insects used to solve the crime. In it, he described a homicide investigation in which files falling on a sickle suggested the murder weapon and culminated in the murderer's confession (Catts & Goff, 1992) . In forensic entomology, the most prevalent insects are Files (Diptera) and beetles (coleoptera). Files gravitate to moist tissue and hence arrive early to remains. The larvae of files are responsible for substantial degradation in soft tissue. Beetles generally arrive later in the arthropod succession cycle, drawn by more dried tissue. Other arthropods may also visit to feed on the insects (D.H.Ubelakar, 2013) . Diptera or true flies, are the insects that are primarily used in forensic investigations. The calliphoridae (blow flies), sacrophagidae (flesh flies), and muscidae (house flies) are the most common species in this group. Calliphoridae and sacrophagidae might shoe just minutes after death. Muscidae do not begin colonizing a body until the final stages of decomposition (Joseph I. M., 2011) . The following are important beetle families that are significant for forensics: Sliphidae, Staphylinidae, Histeridae, Dermestidae, and Nitidulidae (Bala & Singh, 2015) . Sliphidae, also known as carrion beetles or burying beetles, are a family of coleoptera found around remains. These large insects, typically opportunistic predators, feed on Diptera eggs or larvae. Histeridae are also frequently discovered near carcasses. Nitidulidae or sap beetles are discovered at a decomposing scene (Gemmellaro, 2017) . Staphylinidae includes species of the greatest forensic importance. They function as indicators of the time of death or corpse relocation can be examined (Madra, Konwerski, & Matuswezki, 2014) . The flesh-eating Dermestidae beetles accelerate the process of decomposition, leaving only ligamentous connections and skeletal remnants. By thoroughly cleaning the bones, these beetles reduce biohazard waste and harm from fleas or carrion-eating animals (Lowdermilk & Henson, 2020) . Carrion contains members of the Histeridae family, who have been shown to be significant in several forensic analyses. The many insects on

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

the body, especially Diptera, will be the primary food source for the rapacious Hister beetles (Saprinus planiusculus (MotsFakoorziba, et al., 2017) .

➢ *Life Cycle (Metamorphosis) of Fly*

Fly's go through four life stages: the egg, larva, pupa and adult.

- **Eggs** fly life begins as an egg, just like that of the majority of insects. Often, eggs are placed in a variety of protective areas close to food or decomposing materials. After reproduction, female flies may lay up to 100 eggs, and during their lifetime, they can reproduce in up to 5 or 6 batches. After being laid, the eggs hatch in a day.
- **Larvae (maggots)** these larvae develop into white, legless insects that spend three to five days feeding at the location of their development. During this phase, their focus is on consuming food to store energy for the subsequent stage of their life cycle. During this stage, they molt multiple times before finding a dark area to pupate. The larvae will dig deeply into the food source they have been eating on when they are ready to pupate.
- **Pupae** the white larvae grows darker outer shells during the pupae stage. Females can begin reproducing a few hours after they emerge from the pupa case. They have hard shells and stay dormant for the next 3 to 6 days while their pupae grow legs and wings. Since files lack teeth, they must tear through the pupae shell which deflates after they emerge using a fluid filled pouch on their heads.
- **Adult** houseflies have a life expectancy of 15- 30 days, influenced by location, temperature, and living conditions. Warmer area like buildings develop faster and live longer (Life cycle of the fly : How to eliminate each stage, n.d.).
- **Faunal succession** is the sequence in which various insects or their byproducts appear on a corpse. A thorough examination of insects and their byproducts can help forensic entomologists identify the five stages of decomposition, which helps in determining the PMI. The stages are; initial fresh stage, bloated stage initial active decomposition stage, desiccated corpse remnants. The rough indicators of succession is the presence of eggs, maggots, larval stage, pupae (Sharmma).
- **Post-mortem interval** forensic entomology is a well-studied means of determining postmortem interval. In forensic entomology, the arthropod evidence linked with the corpse is most commonly employed to estimate the time since death (Vermma & M.P, 2013). By examining the life cycle of insects and the faunal succession it aids to estimate the elapsed time of death (Sharmma) .

III. DECOMPOSITION STAGES AND THE FLIES ASSOCIATED WITH EACH STAGE

➢ *Stage 1 Fresh/Initial (0-3 Days)*

- **Initial Appearance:** The body might still look very similar to how it appeared in life. There might not be immediate noticeable changes right after death.
- **Presence of Blow Flies:** Within minutes, blow flies are attracted to the body. They're among the first insects to arrive, drawn by the odours that the body emits, although these odours might not be strong or unpleasant to human noses yet.
- **Internal Changes:** Inside the body, a process called autolysis begins. This is when cells start breaking down. Meanwhile, the blood inside the body begins to pool (livor mortis), the muscles stiffen (rigor mortis), and the body's temperature starts to decrease (algor mortis).
- **Odor Detection:** Even if humans don't detect strong smells, flies can sense and are attracted to the initial odours the body starts emitting (Rivers & Geimann, 2014).

➢ *Stage 2 Bloated (3-6 Days)*

- **Bodily Changes:** The body might start swelling or bulging because gases are produced by bacteria inside. This makes the body look bigger than before. The skin might also get a mottled or marbled look, changing color in patches.
- **Strong Smell:** Now, the body starts to smell bad. It emits a very unpleasant odor that humans can notice. This smell comes from the breakdown of the body.
- **Lots of Flies and Maggots:** There are many flies around the body, and you'll see a lot of maggots too. Flies lay eggs on the body, and these turn into maggots, which eat the body.
- **Different Insects:** Besides flies and maggots, other bugs might show up. Some eat the body, like certain beetles, while others might drink bodily fluids, like butterflies

➢ *Stage 3 Active Decay (5-11 Days)*

- **Body Deflates:** The body starts to shrink and get smaller. Gases that smell bad are released from it, which insects really like.
- **Active Maggots:** There are still a lot of maggots moving around the body. Some are big, some are small because they're at different stages of growth. The first ones that hatched might start leaving the body to turn into pupae.
- **Different Insects:** Besides maggots, you might see ants and beetles around. Some insects are there to eat other insects or the body itself.

At this stage, the body keeps changing, getting smaller and emitting smells that attract insects. Maggots are still busy eating, and some might start leaving to become adults. Other insects like ants and beetles join in to feed on the body or the insects already there.

➢ *Stage 4 Post Decay (10-24 Days)*

- **Most Flesh Gone:** At this point, most of the body's flesh is gone. What's left are mostly bones and some skin.
- **Fewer Flies and Maggots:** You won't see as many flies and maggots now. They've mostly left or finished their job of eating.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

- **Different Insects:** There might still be ants and beetles around. Some eat other insects or what's left of the body. Other bugs, like crickets, might show up too.

At this stage, the body has mostly turned into bones with only a bit of skin remaining. Flies and maggots are mostly gone, but other insects like ants, beetles, and crickets might still be hanging around, eating whatever's left. **Stage 5 Skeletal (24+ days).**

By now, the remains are just bones. Some dermestid beetles may still be present, but otherwise, the body is decomposed, and other insects would be incidental. Insects visit the corpse in a successional way, depending upon the stage of decomposition.. Please note that this is a general timeline, there can be an overlap of species in some stages. Also be aware that these decomposition stages are for corpses found on land that experience normal weather and climatic patterns. In other environments, such as aquatic systems or the extremely dry conditions that lead to mummification, these stages may vary (Byrd & Castener, 2010) (Byrd & Tomberlin, 2020).

A. Decomposition Rate Differences and Insect Activity in Different Weather Conditions

➢ *Cold Conditions:*

- **Slowed Decomposition:** Low temperatures slow down the decomposition process significantly. Enzymes responsible for decomposition work slower in cold conditions.
- **Limited Insect Activity:** Insects, which play a crucial role in breaking down tissues, are less active or even dormant in cold weather. This can delay the arrival and activity of insects involved in decomposition.
- **Preservation of Tissues:** The cold can act as a preservative, slowing bacterial growth and preserving tissues for longer periods.
- **Moist Conditions:**
- **Accelerated Decomposition:** Moisture accelerates decomposition by facilitating the activity of bacteria and fungi responsible for breaking down tissues.
- **Increased Insect Activity:** Moist conditions attract a wider variety of insects like blowflies and flesh flies, which lay eggs in the moist tissues. This leads to faster larval development and quicker breakdown of the body.
- **Faster Odor Production:** Moisture allows for rapid bacterial growth, resulting in the quicker production of strong odors associated with decomposition.

➢ *Dry Conditions:*

- **Slowed Decomposition:** Lack of moisture slows down the activity of bacteria and insects involved in decomposition.
- **Limited Bacterial Action:** Dry conditions restrict bacterial growth, slowing down the breakdown of tissues and preservation of the body.
- **Delayed Insect Activity:** Insects might still be attracted to the body, but their activity is reduced due to the lack of moisture, which can delay the decomposition process.

➢ *Weather Impact:*

- **Hot and Humid:** High temperatures and humidity accelerate decomposition by fostering bacterial and insect activity. This leads to faster tissue breakdown and the rapid progression of decomposition stages.
- **Cold and Dry:** Low temperatures and dry conditions slow down decomposition, preserving the body for longer periods and delaying the stages of decay.

The rate and stages of decomposition are influenced by a combination of temperature, humidity, access to oxygen, presence of insects and scavengers, and the initial condition of the body. Forensic investigators use these variations in decomposition to estimate the postmortem interval (PMI), considering the specific environmental conditions where the body is found (Goff, 2000).

B. Succession in Differential Conditions

➢ *Cold Conditions:*

- **Blowflies (Calliphoridae):** Common blowfly species like *Calliphora vicina* and *Lucilia sericata* are often among the first insects to arrive on a body. They have some tolerance for colder temperatures but are less active in very cold conditions .
- **Beetles (Staphylinidae and Histeridae):** Rove beetles (Staphylinidae) and clown beetles (Histeridae) are seen in colder climates. These beetles are more adapted to lower temperatures and may dominate the decomposition process in such conditions.

➢ *Moist Conditions:*

- **Blowflies and Flesh Flies:** Common species like *Lucilia sericata* (green bottle fly) and *Sarcophaga spp.* (flesh flies) are predominant in moist environments due to the availability of moisture necessary for their larvae.
- **Dermestid Beetles:** Some species of dermestid beetles, like *Dermestes maculatus* and *Dermestes lardarius* (hide beetles), are attracted to moisture and are often found in later stages of decomposition in these conditions.

➢ *Dry Conditions:*

- **Blowflies (limited activity):** In dry conditions, blowflies might still be attracted to the body initially, but their activity could be reduced due to the lack of moisture.
- **Dermestid Beetles:** Species like *Dermestes maculatus* and *Attagenus unicolor* (black carpet beetle) are commonly associated with dry environments. They feed on dry tissues and hair, and their presence might increase in drier conditions.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

➢ *Weather-Specific Species:*

- **Hot and Humid:** In tropical or hot climates, a wider variety of insects, including various species of flies, beetles (like carrion beetles), ants, and mites, are attracted due to the accelerated decomposition caused by high temperatures and humidity.
- **Cold and Dry:** Certain beetles like rove beetles (Staphylinidae) and clown beetles (Histeridae) are more prevalent in colder conditions. These insects can survive in low temperatures and might dominate the decomposition process in cold environments.

These are some of the common insects associated with decomposition in different weather conditions. However, the specific species present can vary based on geographic location, local fauna, and the unique environmental factors surrounding the body. Forensic entomologists analyze these species' presence and life cycles to estimate the time since death (postmortem interval) and gather evidence in criminal investigations (Marchenko, 2001) .

C. Drowning Death

➢ *Early Stages:*

- **Sinking Phase:** At first, the body sinks and stays in an "N" shape, head down, bum up, knees down, and feet up. Gases start forming inside, making it buoyant.
- **Floating Phase:** Depending on the water's temperature, the body might start floating. If it's cold, the body might stay submerged, but in warmer water, it could pop up.

➢ *Advanced Stages:*

- **Bloated Phase:** Gases build up more, and the body gets really swollen and bloated.
- **Floating or Sinking:** Depending on the water temperature, the body might float or sink. Cold water might make it sink again.

➢ *Other Changes:*

- **Physical Changes:** The body might show signs like wrinkled skin (maceration), lost nails, stiffness (rigor mortis), dark patches where blood settled (livor mortis), and slowing decay (if the water is cold) (Bauer, Barksdale, Sidel, & LaViolette, 2022).

Insects you'd usually find on land won't be there unless the body stays above water for a long time. The time the body spends in water before it's found is called the PMSI (postmortem submergence interval). This timeline helps understand how long the body was in the water before it was discovered (Gennard D. , 2012) .

D. Burial Environment and Importance of Mites

Mites (Acari assemblages) are seen as the burial indicators under different burial conditions . species of soil mites can help in such situations along with other members of coleoptera , diptera and other mammalian scavengers ((Perroti & Bordas , 2014) . Studies demonstrated that the continuous physicochemical change in the soil associated with decomposition results in change in abundance / diversity of mite species in surrounding area and their succession studies could prove beneficial . Jean Pierre in 19th century was the first to recognise the importance of mites in buried and exposed cadavers (Megnin, 1984) . The pH of soil underneath the cadaver varies throughout the decay process and can become moderately alkaline to strongly alkaline . this directly affects the mite population. The pH of soil underneath the cadaver varies throughout the decay process and can become moderately alkaline to strongly alkaline . this directly affects the mite population.

Mesostigmata mites are the most abundant in alkaline conditions while orbadita is the most abundant in acidic conditions . Orbadita mites are the secondary decomposers in soil associated with nutrient cycling . The succession pattern of mite species in the burial environment will be as follows :

- Orbitada (in fresh cadaver dump) – reappear in dry decay stage when soil begins to normalize
- Mesostigmata (predominant and most abundant group in entire decay process) – are phoretic mites , i.e., accompanied as a parasite with Diptera an Coleoptera sp.
- Prostagmatids
- Astigmatids (generally associated with dry stages of cadaver decay – skeletonization and mummification) ((Rai, Pickles, & Perotti, 2021)

The Orbitada species were the most abundant in control (and dry) soil samples while Mesostigmata _ most abundant during Bloated , Active and Advanced stages of decomposition . Studies show that the overall richness , evenness and diversity varied over the course of cadaver decomposition . Biodiversity increased started during the bloating stage , Coincidentally with abundance of VOCs (Volatile Organic Compounds) released into atmosphere , which attracted the insects and the mites accompanies them. In crime scene , access to specific body parts by insects carrying mites , and thus occurrence of species specific phoretic mites , can add information on localization of wounds , help to describe the circumstances of the death (Rai, Pickles, & Perotti, 2021) .

E. Effect of Drugs on Insect Development

Analysing the various developmental stages of insects present on deceased bodies help in precise estimation of post-mortem interval. Drugs metabolized by an individual before death affects the rate of insect development when feeding on the corpse (soni, et al., 2020). Exoskeletons of insects are made of chitin analogous to the hair protein called keratin. Like keratin in hair, chitin in exoskeleton of insects store traces of drugs (Magni, 2022) . A study was conducted to analyse the effects of cocaine and heroin on an insect (*Calliphora vomitoria*). Results were very much varying than the control group. Larvae which grew on cocaine feed became short in size and weighed less than control group while larvae which grew on heroin feed developed larger in size towards pupa stage. Larvae grew on combination feed

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

showed same growth as those larvae that grew on cocaine feed (Wood, Pyper, & Causal, 2022) . Studies conducted at Forensic Entomology Laboratory, University of Hawaii at Manoa, determined the effects of crystal methamphetamine on the development of a species called sarcophagid fly (*Parasarcophaga ruficornis*) indicated an increase in developmental stages of maggots when fed on tissues containing crystal methamphetamine.In addition to this earlier pupariation is also noted (Lord & Goff, 1994) . Insects are also considered as specimens for toxicological evidences when body tissue and fluids are not available (when cadaver is completely skeletonized) as insect specimens can give more precise quantitative results (soni, et al., 2020) . Effect of diazepam on development of necrophagous flies showed that control sample of larvae developed slower than the larvae exposed to the drug. The early development of insect *Lucilia sericata* was delayed that fed on tissue treated with doses of ketamine was also observed in a study (soni, et al., 2020).

IV. LIMITATIONS OF FORENSIC ENTOMOLOGY IN INVESTIGATIONS

Medicolegal forensic entomology is the study of the insects associated with a human corpse. It is primarily used to estimate time since death or postmortem interval (PMI), although other inferences may be made (Catts and Goff, 1992).However there are some drawbacks to the application of forensic entomology in criminal investigation (Joseph, Mathew, Sathyan, & Vargheese, 2011).

➢ *These are Enlisted as follows:*

- The life cycle of some insect species may end before proper forensic analysis leading to unavailability of certain species for analysis (Volckaert, 2020) .
- Due to the condition of decomposition of deceased body, collection of insect colonies may be difficult. In addition to this requirement of proper equipment for collection and transportation of insects are not met in some cases as properly collected evidences are to be presented in court (Volckaert, 2020) .
- Improper handling of corpses can disturb the colonized insects making them fly away.
- Environmental conditions such as temperature and humidity affects the optimal growth of insects to colonize on dead and decomposing bodies. When these requirements fail to showcase in the surrounding environment, the survival of insects also fails (Volckaert, 2020) .
- Forensic entomology is a new discipline of forensic science doubting their application to criminal investigation and requires academic certification (Volckaert, 2020).
- Problems are faced during identification of species as most of the insect species show similar characteristics at various stages of development (Amendt, Krettek, & Zehner, 2004).
- Presence of drugs and toxins in the deceased might be ingested by insects reflecting retarded growth to some degree making insects imprecise to estimate postmortem interval (Amendt, Krettek, & Zehner, 2004).

V. SCOPE AND FUTURE AIDS IN FORENSIC ENTOMOLOGY

Forensic entomology isn't just about figuring out when insects show up on a body. Now, scientists use modern techniques like PCR to identify insects better. It's hard to tell different insects apart just by looking at them, especially when they're at different stages like larvae. So, PCR helps a lot with that.

These little bug larvae that eat the body sometimes release toxins. This whole new area is called forensic entomotoxicology. If these toxins are in the body, they can tell investigators a lot. They might show how someone was harmed or even killed. So, it's a big help in solving crimes by giving hints about what might have happened to a person (Joseph I. M., 2011).

The major area of research and application of entomology in forensic science is the use of species identification, known growth rates, and insect succession data to determine both the location and approximate time of the victim's death (Kaur, 2020) . Due to the relatively recent widespread acceptance of entomology within forensic science, many police agencies, medical examiners, coroners, and federal agencies throughout the United States request assistance from entomologists knowledgeable in the behaviour and biology of carrion insects to help answer critical questions pertaining to human death investigations (Gennard, 2007).

Other forensic uses of entomology include identifying deaths resulting from anaphylactic shock due to insect bites or stings, resolving traffic accidents resulting from panic due to stinging insects in an automobile, and to be used in consultation in criminal cases involving the misuse of insects that are induced to bite or feed upon the victim .

VI. CASE STUDY

In a study conducted at the UNL Forensic study grounds from July 2 to August 2, 2019. They studied how pigs decompose in different situations simulating real crime scenes (Bauer, Barksdale, Sidel, & LaViolette, 2022) . Eight small piglets (each weighing less than 10 lbs) were placed in scenarios as follows :

- Control ; set in mowed open area
- Clothed; dressed in a child’s lavender hooded sweatshirt
- Hanging; back feet hung by string on a tree branch in a shady area
- Trunk; placed inside an enclosed car truck , which was warped and had gaps .
- Buried in a shallow grave

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

- Cistern; put in bottom of old child's swimming pool , filled with soil and trash; damper environment
- Trash bag ; wrapped in plastic and put in a weedy area.
- Trauma; hit postmortem with a baseball bat , primarily on the head and some near the rib cage, and then placed in an enclosure made of used car tires.

Over a month, the piglets were observed for insect activity during decomposition stages. Surprisingly, the control and cistern piglets decomposed first, contrary to the hypothesis that the car trunk, traumatized pig, and hanging pig would decompose more quickly. Blowflies and flesh flies were the first to appear during this process (Bauer, Barksdale, Sidel, & LaViolette, 2022)

➢ *Forensic Significance*

- PMI – Forensic entomology is primarily used to estimate the minimum postmortem interval (PMI), which is the time since the first insect colonization on human remains. This is achieved by analyzing the age of insect stages developing on the remains and studying the successive pattern of insect activity, including pre-appearance, arrival, residency, and departure from the carcass (Lutz, Zehner, Verhoff, Bratzke, & Amendt, 2021)
- PMSI – the term for estimating the time since submersion of a body in water is referred to as PMSI (Postmortem Submersion Interval). It helps determine the duration between when the body was immersed in water and when it was discovered (Bauer, Barksdale, Sidel, & LaViolette, 2022)
- Toxicological analysis – In the absence of tissues and fluids, insects are often more reliable than hair for detecting drug use shortly before death (Magni, 2022)
- DNA – Forensic entomology extends beyond the deceased and can be applied to cases of neglect or abuse involving the living, especially children, the elderly, or animals. Additionally, lice found at crime scenes can be examined to compare their most recent blood meal and DNA contents with the collected DNA of suspects or victims (Volckaert, 2020)
- Location – the presence of non-native insects or pollen on cadavers can be significant in forensic investigations. Comparing them to the closest geographical location with similar insects or pollen can help determine if the body was potentially moved from that area. This analysis contributes valuable information to understand the circumstances surrounding the death and aids in establishing the possible location history of the deceased (Volckaert, 2020)

VII. CONCLUSION

Insects serve multiple roles in the environment, contributing to the equilibrium of ecosystems (Prasad & Meena, 2022). Beyond their ecological functions, insects are pivotal in medico-legal forensic entomology (Prasad & Meena, 2022). Forensically important insects, such as blowfly larvae, play a crucial role in investigations related to homicide, untimely death, and violent crimes (Lord & Rodriguez, 1989). Blowfly larvae are particularly valuable as indicator species, arriving shortly after death and progressing through distinct larval stages during different decomposition phases (Bauer, Barksdale, Sidel, & LaViolette, 2022). Forensic pathologists must carefully consider various factors before providing statements about the postmortem interval (PMI) (Franceschetti, et al., 2021) . Insects play a crucial role in forensic investigations by providing valuable clues about the circumstances of a person's death. They can offer insights into wounds, toxicology, the location of death, and even aid in suspect identification (Bauer, Barksdale, Sidel, & LaViolette, 2022) .

REFERENCES

[1]. Amendt, J., Krettek, R., & Zehner, R. (2004). Forensic Entomology. *Naturwissenschaften*, 51-65.

[2]. Anderson, G. S. (n.d.). *Forensic entomology : the use of insects in the death investigations*. Retrieved from sfu.ac.in : https://www.sfu.ca/~ganderso/forensicentomology.htm

[3]. Bala, M., & Singh, N. (2015). Beetles and Forensic entomology : A comprehensive review. *Journal of Entomological Research*.

[4]. Bauer, E., Barksdale, L., Sidel, E., & LaViolette, J. (2022). *Death scene insect succession in Nebraska : A Guidebook.* Nebraska: Faculty Publications : Department of Anthropology.

[5]. Byrd, J., & Castener, J. (2010). *Forensic Entomology : The utility of Arthropods in legal investigation.* CRC Press.

[6]. Byrd, J., & Tomberlin, J. (2020). *Forensic Entomology : The utility of arthropods in legal investigations* . CRC Press.

[7]. Catts, E., & Goff, M. (1992). Forensic Entomology in criminal investigations. *Annual review of Entomology*.

[8]. D.H.Ubelakar. (2013). Postmortem interval. In J. A. Seigel, P. J. Saukko, & M. M. Houck, *Encyclopedia of Forensic Sciences* (pp. 24-27). Academic Press.

[9]. *entomology*. (n.d.). Retrieved from nature: https://www.nature.com/subjects/entomology#:~:text=Entomology%20is%20a%20branch%20of,animal%2C%20plant%20and%20human%20health.

[10]. Franceschetti, L., Pradelli, J., Tuccia, F., Giordani, G., Cattaneo, C., & Vanin, S. (2021). Comparison of Accumulated Degree Days and Entomological Approaches in Post Mortem Interval Estimation. *insects*.

[11]. Gemmellaro, D. (2017, october 3). *Flies and beetles that turn death into dinner*. Retrieved from Entomology today : https://entomologytoday.org/2017/10/03/the-flies-and-beetles-that-turn-death-into-dinner/#

[12]. Gennard, d. (2007). *Forensic entomology : an introduction.* london: wiley publisher.

[13]. Gennard, D. (2012). *Investigation in an aquatic environment* . London: Wiley- Blackwell.

[14]. Goff, M. (2000). *A fly for prosecution : How insect evidence helps solve crimes* . Harvard College.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24AUG351

[15]. Intronna, F., Cattaneo, C., Mazerelli, D., De Micco, F., & Campobasso, C. (2021). Unusual Application of Insect-Related Evidence in Two European Unsolved Murders. *Insects*.

[16]. Joseph, I. M. (2011). The use of insects in forensic investigations: An overview on the scope of forensic entomology. *journal of forensic dental sciences*, 89-91.

[17]. Joseph, I., Mathew, D., Sathyan, P., & Vargheese, G. (2011). Use of insects in forensic investigations : an overview on the scope of Forensic Entomology. *Journal of Forensic Dental sciences* .

[18]. Kaur, R. (2020). Scope of Forensic Entomology. *International journal of pure and applied zoology*.

[19]. Kotzé, Z., Aimar, S., Amendt, J., Anderson, G. S., Bourguignon, L., Hall, M. J., & Tomberlin, J. K. (2021). The Forensic Entomology Case Report—A Global Perspective. *insects*.

[20]. *Life cycle of the fly : How to eliminate each stage*. (n.d.). Retrieved from Terro: https://www.terro.com/articles/life-cycle-of-the-fly

[21]. Lord, W. D., & Goff, M. L. (1994). Entomotoxicology: a new area for forensic investigations. *American Journal of Forensic Medicine and Toxicology*, 51-57.

[22]. Lord, W. D., & Rodriguez, W. C. (1989). Forensic Entomology : The use of insects in the investigation of Homicide and Ultimately Death. *The Prosecutor*, pp. 41-48.

[23]. Lowdermilk, K. M., & Henson, K. (2020). Using Dermastid beetles to enhance Forensic science Curriculum.

[24]. Lutz, L., Zehner, R., Verhoff, M. A., Bratzke, H., & Amendt, J. (2021). It is all about thye insects : a retrospective on 20 years of forensic entomology highlights the importance of insects in legal investigations. *International Journal of Legal Medicine*, 2637-2651.

[25]. Madra, A., Konwerski, S., & Matuswezki, S. (2014). Necrophilous Staphylininae (Coleoptera: Staphylinidae) as indicators of season of death and corpse relocation. *Forensic science Internationale*.

[26]. Magni, P. A. (2022, february 28). *flies , maggots and methamphatamine : how insects can reveal drugs and poisons at a crime scene.* Retrieved from the conversation : https://theconversation.com/flies-maggots-and-methamphetamine-how-insects-can-reveal-drugs-and-poisons-at-crime-scene-176981

[27]. Marchenko, M. (2001). Medicolegal relevance of cadaver entomofauna for the determination of the time of death. *Forensic science Internationale*, 89-109.

[28]. Megnin, J. (1984). *The fauna of corpses. Application of entomology to forensic medicine.* Paris : G. Masson and Gauthier-Villars et Fils.

[29]. Mullen, G., & Durden, L. (2002). Medical and Veterinary entomology.

[30]. Perroti, M. A., & Bordas , S. (2014). First contribution of mites (Acari) to the forensic analysis of hanged corpses: a case study from Spain. *Forensic Science Internationale*.

[31]. Pigoli, D., Ferraty, F., Aston, J. A., Mazumder, A., Richards, C., & Hall, M. J. (2023). Estimation of temperature-dependent growth profiles for the assessment of time of hatching in forensic entomology. *Journal of the Royal Statistical Society Series C: Applied Statistics*, 231-253.

[32]. Prasad, A., & Meena, S. (2022, March 18). *Succession of Forensically important Coleopterans from Southern Rajasthan : A preliminary study and their forensic relevance.* Retrieved from Research square: https://doi.org/10.21203/rs.3-rs1355209/v1

[33]. Rai, J. K., Pickles, B. J., & Perotti, M. A. (2021). Assemblages of Acari in shallow burials: mites as markers of the burial environment, of the stage of decay and of body-cadaver regions. *Experimental and Applied Acarology*, 247–276.

[34]. Rivers, D., & Geimann, T. (2014). *The science of Forensic Entomology*. London: Wiley-Blackwell.

[35]. Saprinus planiusculus (MotsFakoorziba, M., Assareh, M., A, K., Soltani, A., Moemenbella-Ford, M., & Zaraenezhad, M. (2017). Saprinus planiusculus (Motschulsky, 1849) (Coleoptera: Histeridae), a beetle species of forensic importance in Khuzetan Province, Iran. *Egyptian journal of forensic sciences*.

[36]. Sharmma, B. (n.d.). *Forensic Science in criminal investigations and trials.* Haryana: Lexis Nexis Publishers.

[37]. soni, muskan and saini, subham and singh, jaskaran and harish, Dasari and Sharma, & Neeta. (2020). Drugs and their effect on Developmental rate of decomposers : An Entomotoxicological approach. *Journal of Punjab Academy of Forensic Medicine and Toxicology*.

[38]. Vermma, K., & M.P, P. (2013). Assessment of Post Mortem Interval, (PMI) from Forensic Entomotoxicological Studies of Larvae and Flies. *Entomol , Ornithol and Hepetol*.

[39]. Volckaert, H. (2020). Current Applications and limitations of Forensic Entomology. *Research Journal of Justice Studies and Forensic Science*.

[40]. Wood, T., Pyper, K., & Causal, F. (2022). Effects of Cocaine and Heroin , and their combination , on the development rate of Calliphora vomitaoria (Diptera : Calliphoridae). *Scientific Justice*, 471-475.