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A STUDY ON CURRENT STATUS OF FORENSIC ENTOMOLOGY IN INDIA

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Abstract : Forensic entomology plays a significant role when a crime or death is being investigated. Arthropods are drawn to the decaying body from the outset and may lay their eggs there. By examining insect populations and developing larval stages, forensic investigators can ascertain the cause of death, the post-mortem index, and any changes in the position of the corpse. Forensic entomology uses entomological evidence, such as arthropods' life cycles, habitat preferences, seasonal emergence, fragments and remains, or the chemical composition of body parts, mostly for legal purposes. The scientists began used their understanding of how insects consume dead bodies and rotting flesh as carrion to estimate the time of death. There is a continued disregard for forensic entomology in crime and death investigations in India. Much of the potentially relevant data is being lost in our country because we lack the necessary knowledge about insects that can be crucial forensic indications. This study's main objective was to present the current condition of forensic entomology in India.

Key words*: Arthropods, forensically relevant insect groups, Post-mortem interval, Stages of decomposition*

I. INTRODUCTION

Economics, anthropology, dentistry, pathology, toxicology, entomology, psychology, accounting, engineering, and computer forensics are just a few of the disciplines that have been associated with the term "forensics". In accordance with the legal requirements of admissible evidence and criminal procedure, forensic science employs information gathered in these fields together with criminal and civil laws during criminal investigations. The bulk of forensically connected cases now fall under the purview of forensic entomology, which has grown over time. A subfield of Zoology called Entomology (Salvador and Cunha; 2020) is the scientific study of insects (Gullan and Crantson; 2014), mainly belonging to the phylum Arthropoda (Moore;2013). Forensic entomology is the systematic investigation of the orientation pattern of insect species, such as crustaceans, millipedes, centipedes, insects, and arachnids, found on decaying corpses. It involves applying and researching the biology of insects and other creatures to legal issues. In solving crimes, it primarily involves arthropods that serves as an evidential clue. One of the earliest subfields of forensic science is forensic entomology. Entomology is used to aid investigate many crimes, including those involving murder, suicide, rape, physical abuse, and drug trafficking. The environment has an impact on both the development of insects and their succession. As a result, the variables aid in determining the location and the time as well as providing insight into the conditions in which the body would have been maintained. In other words, it provides information on the location(s) where the corpse had been lying, being held, or being stored, as well as the time and season of the incident. The details reveal how the incident happened.

HISTORY OF FORENSIC ENTOMOLOGY

Forensic entomology has been defined as the scientific study on the diverse aspects of insects in a court of law (Hall, 2001). The discipline can be classified into three major domains namely urban entomology, stored product entomology and medico-legal entomology (Lord & Stevenson, 1986). The latter, also known as medico-criminal entomology is the greatest influential field of forensic entomology and the employment and prospect of the domain can be termed versatile for its application on varied ways (Hall, 1990).

Although entomology as a science has been utilized for numerous forensic purposes since the nineteenth century, research in this area has been ignored across various parts of the world. The earliest known account of entomology is Sung Tz'u (1235), which was translated in 1981. The countries of northern and southern hemisphere widely approve of the entomological evidence, even though the latter lags the former in this sector. To identify the reason behind the delay comes down to the fact that research has not been formally introduced to the discipline until recently (Williams & Villet, 2006). Fundamentally, the use of arthropod knowledge in criminal investigation is known as forensic entomology. In civil and criminal cases insect related evidence are used as evidentiary clue and it is considered as one of the earliest branches of forensics.

The first Westerner to use "Entomology" to a forensic scenario was Dr. Bergeret d' Arbois. Bergeret identified some arthropods from a child's body in 1850. Early 20th-century literature is scarce on the subject of forensic entomology case studies and research. In the UK, forensic entomology was first applied in a case in 1935. Leclercq and Nuorteva were among the first to routinely use forensic entomological evidence in European courts during the previous century; in this instance, the forensic pathologists heavily relied on maggots to offer an estimate of the period of death.

INSECTS AND ANIMAL DECOMPOSITION

An animal begins to decompose as soon as it dies; different morphological and chemical changes take place at different phases of the decomposition process. Five stages of decomposition were defined by Anderson & Van Laeerhoven (1983): fresh, bloat, active decay, advanced decay, and dry/skeletal stage. They are:

I. Fresh: This stage begins abruptly just after death and lasts until the body completely decomposes. At this point, the body could undergo algor mortis (body cooling), livor mortis (body pooling), or rigour mortis (muscular rigidity).

II. Bloat: Especially in men, the scrotum may enlarge abnormally and their limbs may appear lifted off the ground. The stage is brought on by the proliferating presence of anaerobic bacteria in the stomach of a human, which in turn causes the immune system to break down.

III. Active decay: The stage where the majority of the flesh is swiftly stripped from the body sees the feeding of existing blow larvae take over as the main activity. Bloating is lessened as a result of the gas's progressive release.

IV. Advanced decay: Although blow fly larvae may still be present at this point, the majority of the carcass has likely already experienced substantial deterioration. The cadaverous beetles will eat the body's drying tissues like skin and hair after the majority of the flesh has been removed.

V. Dry/ Skeletal: This is the last stage, which may go on for several weeks, months, or even years. The remaining skin on the stage will become mummified by revealing the bones since it can survive in warm regions.

According to Rodriguez and Bass (1983), The succession of insects and the pace of degradation are directly correlated. Invertebrates that consume animal carcasses fall into one of four ecological categories that Smith (1986) proposed.

- Necrophagous species: The category includes Calliphoridae (blowflies), Siliphidae and Dermestidae (beetles) who all are carrion-feeding insects.
- Predators and Parasites: The second group has Staphylinidae (beetles) and Muscidae (house flies) and some Calliphoridae (eg. Chrysomya) that feed on necrophagous species.
- Omnivorous species: Both cadaver and carcasses eaters are consumed by this class of insects. Hymenoptera (wasps, bees, and ants) and some Coleoptera (beetles) constitute the group.
- Adventive species: They live in carcass as their extended habitat and the examples of the insects classifying the group are Arachnida (spiders) and Collembola (springtails).

IMPORTANCE OF INSECTS IN DECOMPOSITION PROCESS

The event of decomposition of plants and animal is one of the most pivotal ecological activities. Despite their relevance, animal decomposition gains poor consideration because of the enormous amount of carbon release from plants. For the purpose of nutritional cycling, the creation of surface soils, resource endowments within trophic levels, and interactions with lipids, micronutrients, and a variety of environmental functions, the occupancy of matter is essential for animals. There are only a few applications and uses for degradation. One such use is taxidermy, which frequently necessitates the professional use of dermestid beetles in their colonies as well as in museums and for the general public. Moreover, amongst the other diverse scope of application, the most primal and relevant association of arthropod science is with the judicial system. As crucial mediators in this process, arthropods play an enormously dominant function in forensic entomology. According to the general supposition, flies occupy importance as the most typical agents in the deterioration procedure next to bacteria. Beetles can undertake a variety of ecological roles in relation with dead animals of being a predator, fungivore, parasite, and even herbivore. Beetles are not as lively as flies in scavenging the dead tissues.

The decomposition of buried body depending upon how they buried or have recently been thoroughly reviewed (Gaudry, 2010). The decomposition process affects the suite of animals that may be attracted. The role of insects, mammals, birds in decomposition are inevitable. Several insects are attracted to the cadaver, mainly insects like flies (Diptera), beetles (Coleoptera) and their larvae, ants and wasps (Hymenoptera), cockroach (Blattidea), moths (Lepidoptera) respectively, but also mites, isopods, opiliones and nematodes can be found. Depending on their biological preferences and the phases of decomposition, these insects can feed, live, or breed in and on the body. Arthropods can be found in a number of places, including crime scenes, as they are the largest and most significant biological group on Earth. Forensic entomology, the study of insects retrieved from crime scenes and bodies, has a wide range of applications because of insects and their succession (Mark Benckel, 2008).

FORENSICALLY RELEVENT INSECT GROUPS

Coleoptera and Diptera are the two dominant types of arthropods that are drawn to carcass and chief supplier of knowledge in forensic examinations. Dermestidae is a family of beetles thought to be aggressive colonizers in many regions, approaching when just skin and bone are left to be consumed, an affair that can happen even months after death (Easton & Smith, 1970 as cited in Byrd 2001; Fuller, 1934; Payne & King, 1970; Rodriguez & Bass, 1983; Smith, 1986). But adult dermestid beetles are congregated within three to ten days of death (Early & Goff, 1986; Hewadikaram & Goff, 1991). Dermestids are generally cited as carpet, hide, ladder or beacon beetles as they common scavengers that appear on carcass, found in a variety of habitats. Within the category, there are several ecological subtypes that can be found, including free-living Dermestes that feed on animal carcasses, common scavenger inquilines or spider, insect, bird, and rodent nests, and the prestigious group of myrmecophiles in the Thorictini tribe (Kiselyova & Mchugh, 2006).

Dipteran families like Calliphoridae, Sarcophagidae, Stratiomyidae and Muscidae are important pointers in forensic studies. In optimum environmental conditions, flies (dipterans) are known to undergo their usual life-cycle on dead decaying matter and is well-documented. This data can serve useful in understanding the PMI and since they are excellent indicator organisms, also can uncover presence of xenobiotics in the dead organism. Temperature is identified as the key factor influencing the rate of insect succession and their development. A significant warmer weather ensures their proliferation faster and colder condition does opposite (Ames & Turner, 2003). In brief, for a valid estimation of the age of blowflies and PMI, ambient temperature should be managed. Moreover, when the blowfly larvae progress to an advanced phase of the second instar and right to the third instar, they convene to form larger larval masses. The local temperature rises as a result of the increased metabolic activity, which causes the larvae within the mass to develop more quickly than they would if they were developing at room temperature (Goodbord & Goff, 1990). To be conclusive, if the larvae are or were in the later second or beginning of the third instar stage, then the calculation of the PMI should be estimated on the larval mass temperature and not on the ambient temperature. If not, the whole estimation of the age of larvae may turn out inaccurate out of under-estimation larvae (Turner & Howard, 1992) and false PMI out of over-

estimation (Slone & Gruner,2007). However, any rise in larval mass temperature is unaffected of the ambient temperature (Ives, 1991). Larvae on the other hand, have an extreme temperature limit, at which they will perish. As a result, the difference between the temperature of the larval mass and the surrounding air is probably greater when the air is cooler (Doenier, 1940; Joy et al., 2002). Another crucial point to note is that the larval mass's raised temperature has a significant impact on the number of larvae in the mass as well as the location and dimensions of aggression (Turner and Howard, 1992).

The fly larvae leave the body to pupate at the conclusion of the third instar stage once their feeding process is complete. The fly larvae can still be used to calculate the PMI, though. But the assessment of PMI may not be accurate if a prior wave of larvae has already migrated from the corpse and the same is ignored (Greenberg, 1990). Finally, when the pupation ceases, the adult flies appear leaving the remnants of empty pupal cases. The empty pupal case, however, becomes a key aspect if a body is not discovered for an extended period of time because it is the only insect evidence left for examination and PMI detection. Given that the sole certainty is that any flies present on the body have gone through one generation, this may not be of use in many situations. A significant indicator of whether a body has decomposed in a specific location or not can sometimes be found in the presence of a substantial number of pupal cases. Similarly, the empty puparium can offer the investigation with valid seasonal information too. For example, if a corpse is exposed in the seasons of spring or summer, the body can be identified with the presence of a more diverse fauna than in winter since various insects appear at various times of the year (Smith, 1986). However, there isn't much information available that has been gleaned from the ancient sites on how long pupal cases can last until they degrade or dissolve (Gilbert & Bass, 1967; Stafford, 1971; Teskey & Turnbull, 1979; Faulkner, 1986). Other sources being the casework such as Nuorteva (1987) from which reports about empty puparium Phormia terraenovae Robineau-Desvoidy (1830) was discovered from a body after four years of decomposition.

The active movements of ants (Hymenoptera: Formicidae) were primal occurrence in crime inquiries (Singh & Bharati 2000), using a number of processes, their effects on carcasses can overlap with entomology applications in forensic research. Another significant effect of ants eating carrion is their competition with necrophagous flies, which should be mentioned. The ants obstruct their rivalry with frequent oviposition and low larval survival rates. The discovery also has significant ramifications for forensic entomologists since necrophagous Diptera growth patterns and community succession patterns can be used to precisely date the deaths under investigation (Eubanks et al., 2019).

In forensic entomology, ants that consume corpses are categorized as carnivorous species since they also eat the animals that live around the carrion (Smith, 1988; Tabor et al., 2009). As the adept insects are, ants snare the adults and remove the larvae off the flies and beetles from the corpse which would presumably affect the rate of decaying (Heo et al., 2009). Additionally, tiny punctate or scratch-like lesions left by ants eating through carcasses may be misinterpreted for antemortem abrasions or acid burns (Campobasso et al., 2009). Ants mark a constant presence throughout the whole process of decomposition and are far more crucial in tropical than temperate regions for carrion decomposition. Ants survive on carrion from vertebrates and hunt on other arthropods, preventing carcasses from decaying. Though they stand as a pivotal constituent of the whole process forensic pathologists and crime scene investigators rarely cite them as forensic markers (Chen et al., 2014; Heo et al., 2009).

Wasps are found on the initial phases of degradationtion; they can feed on fluids and tissues of the cadaver. Vespidae species are predators of sacrophagid and calliphorid immature and adult flies, that will lead to the decalin of population, they have an important role in decomposition process, by stopping it (Well &Greenberg, 1994). Cadaver may be an essential food material for wasps (Vespidae) and bees (Apidae)in the Neotropical region (Silveria et al., 2005).

The deceased's appearance may change depending on the species of animals or arthropods present in the burial habitat. Cockroaches are common in the residential setting and have helped in uncovering cries in a forensic approach. Here discuss three examples of sudden and unexpected new-born deaths where post-mortem cockroach bites caused first worries of non-accidental harm. The people who were there at the death scene did not realize the true nature of the lesions, and in one instance, neck injuries sparked suspicions of possible strangulation. The lesions were assumed to be variously aged burns. All-consuming scavengers, cockroaches eat keratin. They will eat human flesh from the living and the dead, causing harm. The examination of injuries found during child death investigations has in fact been aided by the identification of cockroach bites (Denic et al., 1997).

Mites are involved in the decomposition of human and animal carcasses at every stage (Braig et al., 2009). Many types of mites are known to feed on corpse and help in their active decomposition. Some mites appear in the early stages (fresh stage) of decomposition, while other mites feed on dry skin in the later phases (skeletal stage) of degradation. If the mites get to the body before any fly eggs can develop into maggots, they devour the eggs first, delaying the development of the maggots. This will lead to incorrect PMI. Certain beetles have mites on their bodies that feed on the eggs of flies. Before any fly eggs can develop into maggots, mites arrive at the corpse and begin feeding the eggs. It halts the growth of maggots. This could result in a false PMI.

Moths are the last visitors to the corpse assisting in its decomposition process. The moth larvae feed on hair. During their larval stages, moths mostly consume mammalian hair, though they will occasionally eat any remaining hair. They are amongst the last arthropods contributing to the decomposition of a cadaver (Sharma, 2020) and can be useful in determining the PMI based on their incidence.

II. AIM AND OBJECTIVE OF CURRENT STUDY

- Forensic entomological study is done to comprehend the role that insects play in forensically significant species that are present on and around the body at different stages of decomposition. Additionally, to verify that different types of insects arrive on the body in a predictable order.
- This study's primary goal was to comprehend the state of forensic entomology in India today and its numerous applications in death investigation.

III. REVIEW OF LITERATURE

In India few studies are carried under this forensic field. This section helps to understand the current state of forensic entomology in our country. The importance of forensic entomology and insects with forensic connections were discussed by D Singh et.al., in (1999), "Forensic Entomology in The Indian perspective." This study mentions various decompositional stages. Another study on insects identified in carcasses was carried out by Manish Sharma and Devinder Singh, Department of Zoology

& Environmental Science, Punjabi University (Forensic Entomology: An Indian prospective, 2016). The primary emphasis of the study was cadaver PMI estimation. In this study, the state of forensic entomology in India was also mentioned.

"Forensic Entomology World: A new study on Chrysomya rufifacies from India" was published in 2013 by K. Verma. The primary goals of this work were to describe entomology's applications from an Indian perspective and to provide information on the lifespan of insects." Knowledge and Awareness about Forensic Entomology in India Among Dental Students" was published in a journal by T Imtiaz and A Arthanari in 2022. Arthropods' role in PMI estimation was described. The study's primary objective was to look into dental students' understanding of forensic entomology. A study was carried out in Uttar Pradesh in 2018 by MR Amin and S K Sinha, and their findings were published in the journal "PROGRESS OF FORENSIC ENTOMOLOGY RESEARCH IN INDIA FROM PAST TO PRESENT." Here, various forensic entomological research facets are highlighted. The "Role of entomology in forensic science" study was carried out in 2000 by R Varatharajan and A Sen. This study explored the function of entomology in forensic science and provided information about forensic entomology in India. In 2004, the study "Forensic entomology-past, present, and future" was carried out by A Gupta and P Setia. The history of entomology is discussed in this work.

RESEARCH GAP

In India, no thorough research has been done in the area of forensic entomology. The study's objective was to understand the current situation of forensic entomology in India. In this study, the key insect groups for forensics are mentioned.

IV. RESULTS AND DISCUSSION

The most recent global directory of forensic entomology indicates that there aren't many researchers globally working in this area. In India, forensic entomology is still in its infancy. There aren't many researchers working in this area right now. As a result, little study in this area is done in India. There are several insects that can be used to identify the time, location, and cause of death, including flies, beetles, wasps, ants, mites, and moths.

There are two active researchers in India, Pankaj Kulshrestha and Devinder singh. Kulshrestha introduced the application of entomology in crime investigations, and he published an article describing the use of insects and their larvae to determine PMI of an individual. Devinder Singh conducted a major project on gathering informations about carrion-feeding fly fauna in Punjab.

The main distinction of Indian geography is the abundance of insects and plants, yet there aren't many records or studies in this area. A cadaver's decomposition is influenced by geographical distribution, animal and plant diversity, environmental conditions, and seasonal shifts. In the broad and varied area of forensic entomology, numerous insects and all of their life phases are collected from and around the corpse when a forensic entomologist conducts an experiment on it. Entomology was primarily used to determine the location, reason for, and duration of death.

V. CONCLUSION

Forensic entomology plays a crucial role in death investigations. The insect evidence collected from the cadaver helps to find the period of death, cause of death and place of death. By using proper tools and techniques in conventional procedures are used for insect collection and preservation methods. Insects and their successional pattern are major source or evidence in PMI estimation. The purity or accuracy of using insects in crime investigation is mainly depends on the knowledge of entomologist in that field. Expertise peoples and their availability are important in investigations. Wrong inferences or reports will result from incorrect interpretation of insects and their life cycles. According to Article 138 of the Indian Evidence Act, Indian courts of justice accept any scientific evidence to support a claim. Due to the lack of skill and understanding of insects, forensic entomology is a field of forensic science that is underdeveloped in Indian scenario. There should be public-private partnerships and government policies to alter this pathetic situation and thus to develop the forensic entomology as a significant branch of forensic science in India.

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