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***Research Article***

# A Brief Review of Forensic Entomological Process and Terminology

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***Abstract –*** Forensic entomology is the branch of science in which insect and Arthropoda taxa are used in criminal and legal cases. Today, it is a new discipline that used in forensic and crime scene investigations for especially corroborating witnesses used in cases where classical methods cannot be used. The most basic reason for using ınsects in criminal investigations is that they are one of the living species that detect and find the body in the shortest time, and that they exist in every stage of decomposition as some insect species are specific to certain environments and living spaces. In crime scene investigations, information on the distribution, biology and behavior of insects is used to find out when, how and where death occurred. Insects that feed on the body are considered part of the evidence of the crime as physical evidence, such as blood, hair, fingerprints and other biological materials As a result, the main purpose and content of this study is to examine and evaluate the terminological concepts and processes of the discipline of forensic entomology, which is considered new in our country, in short frames.

*Keywords – Entomology, Ecology, Forensıc Sciences, Terminology, PMI.*

## I. INTRODUCTION

Today, "Forensic entomology" is a new discipline that used in forensic and crime scene investigations for especially corroborating witnesses used in cases where classical methods cannot be used. Within the scope of forensic entomology; examining insects that come to the body shortly after death provides important data on issues such as the person's time of death, place of death and cause of death [1]-[6]. The most basic reason for using ınsects in criminal investigations is that they are one of the living species that detect and find the body in the shortest time, and that they exist in every stage of decomposition.

Postmortem interval (PMI), that is, the time elapsed after death; is tried to be estimated based on the physical and biochemical changes that occur in the body after death, such as body temperature, rigor mortis, mortis, and decay [1], [7], [8]. In estimating PMI, it has been found that entomological methods are statistically more reliable, mostly for 72 hours and more, when compared to postmortem changes in tissues and commonly used forensic medical procedures [1], [4], [9].

Forensic entomological studies, in addition to PMI estimation; It can be done for purposes such as determining the geographical and/or ecological conditions where death occurred, the manner of death, the trauma area, whether the corpse/corpse remains were transported, the duration of stay in water, the

analysis of drugs and toxins, and DNA samples obtained from insects[2]-[4], [6], [10]-[16]. While blood, bile, urine, intraocular fluid, stomach content, liver and kidney tissue samples are commonly taken for forensic toxicological analyses; [17]-[22] in decomposed corpses, it is important to take samples such as brain, hair, bone, and entomological samples (larva, prepupa, pupa, adult) in addition to liver, kidney and muscle samples [19], [21], [23]. The analysis of entomological samples found on or around the corpse allows the toxicological evaluation of the cause of death [24]-[29]. As a result, the main purpose and content of this study is to examine and evaluate the terminological concepts and processes of the discipline of forensic entomology, which is considered new in our country, in short frames.

## II. FORENSIC ENTOMOLOGY HISTORY -TERMINOLOGY – PROCESS –TAXA (FAMILIES)

### *A. Brief History*

The first known document on forensic entomology dates back to the 13th century (1235). Here, Calliphoridae larvae were found on a sickle that was thought to have invisible traces of blood, and the perpetrator of the incident was identified [5], [30], [31].

The importance of insects in the decomposition of the human body began to be documented in the early 19th century. Mégnin is considered to be the first person to conduct real scientific research on forensic entomology. In his book published in 1894 (Fig. 1.), he touched on the order in which insects came to corpses and put forward the theory of succession, thus pioneering subsequent forensic entomological studies [2], [11], [12],[31]-[33].

Since the second half of the 20th century, interest in forensic entomology has increased and developed, and the subject has been revisited by many researchers. Forensic entomology, as a scientific discipline, is constantly advancing day by day, and the research carried out provides a deeper understanding of insects.


Fig. 1 Book of Mégnin (1894)

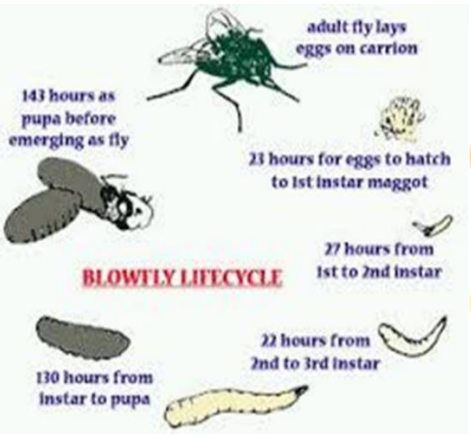


Fig. 2 Life cycle of Calliforidae

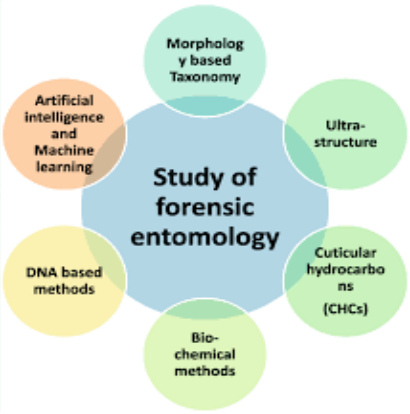


Fig. 3 Forensic entomological studies

### *B. Decay Process - PMI - Succession – Bioecology*

A wide variety of criteria and methods are used in forensic science applications in terms of determining the time of death. In forensic entomology, PMI estimation methods focus on calculating the minimum and maximum time after death [1], [2], [4], [31], [34], [37]-[40].

After the initial period of decomposition, insects are the most important factor in the decomposition of corpses left open. Among insects, Diptera, especially Calliphoridae and Sarcophagidae, usually come first. Female flies lay their eggs especially around natural openings (nose, eye, ear, anus, vagina) on the body, if there is a wound on the body. Changes that occur at each stage of the decomposition process can be determined and this data can be used to estimate PMI [2], [4], [6], [10], [34], [41], [42].

In many studies, the time of death was estimated based on the developmental stages of larvae, pupae, and adults of the Diptera (Calliphoridae, Sarcophagidae) and Dermestidae families, along with the crime scene (temperature, humidity, environment, etc.) and autopsy data (decomposition stages, etc.), and the estimates coincided with the information revealed after the investigation [36], [43], [44].

In the late 1970s, entomotoxicology was seen as a new branch of forensic entomology. In addition to the use of insects in postmortem estimation, insects can be an alternative material for toxicological analysis in the absence of biological sources such as tissue, blood or urine in corpses or skeletons in advanced stages of decomposition [45]-[77]. In addition, toxicological analysis of insects that come to corpses and determination of time of death by evaluating the development of insects in deaths due to drugs and toxins are within the scope of entomotoxicology [25], [28], [48]-[55].

Studies on the factors affecting the development of insects and especially the order Diptera in PMI estimation focus on factors such as temperature, humidity, habitat, the environment where the corpse is located, differences in the tissue fed, various chemical substances, and surface size [1], [2], [56]-[63].

Decay has 5 stages: initiation, swelling, active decay, advanced decay, and drying. In this process, Calliphoridae, Sarcophagidae, Muscidae, mostly belonging to Diptera and Coleoptera, play an important role[11], [30], [41], [64]-[69]. In addition, insects that feed on corpses are hierarchically defined in 4 ecological categories: necrophagous, predator-parasitic, omnivorous, and accidental. [3], [4], [6], [8].

Insects that are effective in decay consist of four different stages (70). These stages are; egg, larva, pupa and adult.

Eggs develop very quickly after being laid. Depending on the environmental conditions, eggs can hatch after approximately 8 hours. When environmental conditions are not suitable, it may take 1-2 days for eggs to hatch [1], [30], [57]. Different larval stages are experienced from egg hatching to pupa formation. (Fig.2) The growth rate of the larva changes linearly with the temperature rate between certain temperature limits [1], [8], [30], [57], [67]. The larva that has completed its feeding period leaves its food environment in order to enter the prepupa stage. Larvae can migrate up to 10-15 m. away from the area where they feed.

In order to reach the correct result in determining the time of death, a careful search should be made in the soil area around the corpse and the pupae under the soil should be collected and examined. The presence of empty pupae around the corpse indicates that the adult individuals on the corpse are the 2nd generation [1], [30], [57].

### *C. Factors and Stages of Decay*

The basic element in forensic entomological studies is the decomposition process and its factors. Many factors can change the speed of decomposition [71]-[75]. Therefore, factors such as the temperature and climate conditions of the environment where the body is located, the ways insects reach the body, the amount of rain, the manner of death, whether the body is clothed or wrapped, the presence of pesticides in the environment, the size of the body, the presence of narcotics in the body, which side of the body touches the soil, and the pH of the soil should be taken into consideration when determining the stages of decomposition [1], [3], [30], [36].

There are five basic stages accepted for the stages of decomposition today [1], [31], [33], [42], [75]-[78]:

The first stage of the decomposition process, the autolysis stage, is the first few days after death. The first flies belonging to the Sarcophagidae and Calliphoridae families, which belong to the order Diptera, come to the body. In the second stage, the gases released as a result of the metabolic activities of anaerobic bacteria cause the abdominal area to swell. The young larvae spread throughout the body, breaking down the tissues with digestive enzymes. In this stage of decomposition, the majority of insect activity comes from members of the Calliphoridae family. Eggs, first, second and third stage larvae of these family members are seen in the body. In the third stage, the active decay stage begins when the swelling of the body ends. This is the stage when the most fly species come to the body. Towards the end

of the stage, pupae of different fly species are present, species of the Staphylinidae and Historidae families eat the diptera larvae and beetles begin to come to the body. This stage ends when the bones become visible. The fourth stage begins when the Diptera larvae leave the body. Most of the body has been consumed. The dominance of Diptera disappears, and from the Coleoptera, Dermestidae, Cleridae, Histeridae, Scarabaeidae and Nitidulidae species are predominantly seen. In the fifth stage, the corpse is completely dried and remains of the corpse are bones, hair, dried skin, etc. Dermestidae, Cleridae species are seen.

### *D. Analysis Materials and Analysis Methods*

However, in forensic toxicological studies, an attempt is made to establish a definitive relationship between death and drugs and toxic substances that cause death [18], [20], [22] [79]-[84] (Fig3). Samples used for toxicological examination are; Blood [21], [23], [85], urine [86], [87], intraocular fluid [22], [86], [88], bile [84], [86], [88], gastrointestinal content [86], [88], pericardial, synovial, spleural, cerebrospinal fluid and ascitic fluid. In addition; organ and tissue samples such as liver (19,21,87,89,90), kidney [83], [86], [90], lung [83], [86], [88], spleen [87]-[88], adipose tissue [83], [87], muscle [83], [87], [88], skin [19], [83], [88], hair [87]-[89], bone/bone marrow [20], [84], [89], nail [20], [84], [89] are also effectively used in forensic toxicological research and examinations. In addition, entomological samples are evaluated as alternative samples that can be used for drug identification [25], [27], [28].

Flies (Diptera) and members of the Dermestidae family of beetles are most commonly used for toxicological analysis. As entomotoxicological material, larvae, prepupae, pupae, adult flies, empty pupa shells, skins and fecal materials of beetles, adults and larvae of beetles can be used in different stages: [95]-[131].

For inorganic substances, flameless atomic absorption spectrophotometry (FAAS), atomic emission spectroscopy (AES), optical ICP (inductively coupled plasma) or ICP/MS, for organic substances, tests such as radioimmunoassay (RIA) and fluorescence polarization immunoassay (FPIA) and specific and sensitive tests such as GC, GC/MS, HPLC, LC-MS, LC-MS-MS are used as analysis methods that provide definitive identification of toxic substances and metabolites [24], [25], [29], [106], [107].

In cases of gunshot wounds that have undergone advanced decomposition, gunshot residues such as lead (Pb), barium (Ba), and antimony (Sb) can be detected in larvae by Inductively coupled plasma-mass spectrometry (ICP-MS) [25], [48]. Similarly, pesticides such as malathion and parathion from organophosphates have been detected in the larval, pupal, and adult stages of Diptera and Coleoptera species by GC-MS and LC-DAD methods [101]. Studies on phenobarbital, opiates, morphine, heroin, cocaine, amitriptyline, nortriptyline, benzodiazepines, antidepressants, amphetamine derivatives, acetylsalicylic acid, and paracetamol found on corpses, pupae, empty pupa remains, and fecal materials of beetles can be conducted and significant results can be obtained [25], [73], [102], [119], [121], [122].

## III. RESULTS & CONCLUSION

Although the importance of entomological examination in determining the time of death in advanced stages of decomposition in corpses is known, sufficient research has not been conducted on these issues in our country, which has a very rich ecosystem. The number of studies conducted on Calliphoridae species, which are the most valuable species in terms of estimating the time of death in our country, is increasing day by day, and no study has been found to determine the developmental stages of Calliphoridae species belonging to the Turkish fauna [5], [6], [30], [34], [37], [131], [132]. Information on the larval developmental stages of these species, which are of great forensic importance, and the time they spend in these stages is quite insufficient. Thesis and article studies in the field of forensic entomology are also increasing day by day in our country. However, no research articles have been found in the field of entomotoxicology, except for a few compilations [5], [6], [11], [12], [30], [32], [37]. Detailed and

comprehensive research is needed for entomology, forensic entomology and also entomotoxicology to take an important place among forensic sciences.

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