

**Review (Derleme)****Application of entomology in forensic sciences**

Adli bilimlerde entomolojinin uygulanması

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Forensic entomology is the use of the insects in legal purposes is becoming increasingly more valuable in criminal investigations. Insects are attracted to the body immediately after death and lay eggs in it. Forensic entomologist use knowledge of insect to solve crimes and insect evidences may shed light on different aspects of the crimes. This science emerged as a major discipline in the developed countries and its role in criminal investigations became more widespread. Nowadays, forensic entomologists are called upon more frequently to refer their knowledge and expertise and to collaborate in criminal investigations and to become important part of forensic investigation teams. Unfortunately, it has not received much attention in Turkey as an important investigative tool. In spite of this major potential, however, the field of forensic entomology uncertain in our country, largely. There are lack of knowledge of the benefits, application and hesitation on practically in our country. This study aims to describe the principles and concept of forensic entomology, to determine the usefulness and applicability of insect evidence, to develop awareness of insect and to attract attention of forensic medicine professionals to the issue.

**Key words:** Forensic entomology, decomposition, postmortem interval, arthropods

**Özet**

Böceklerin adli amaç için kullanımı olan adli entomoloji olay yeri incelemelerinde oldukça artan bir öneme sahiptir. Böcekler ölümden sonra cesede hemen ulaşırlar ve yumurtlarlar. Adli entomolog suçları çözmek için böcek bilgisini kullanır ve böcek delilleri suçun farklı yönlerine ışık tutabilirler. Bu bilim dalı gelişmiş ülkelerde önemli disiplin olarak ortaya çıkmış ve yasal soruşturmalardaki rolü yaygınlaşmıştır. Günümüzde adli entomologlar uzmanlıklarından yararlanmak, işbirliklerine başvurmak üzere adli araştırmalara çağrılmakta ve adli araştırma ekibinin önemli bir kısmını oluşturmaktadırlar. Ne yazık ki Türkiye' de adli entomolojinin suç araştırmalarda önemli bir araç olarak kullanımı yeterince dikkat çekmemiştir. Ülkemizde adli entomolojinin uygulaması hakkında bilgi eksikliği ve tereddütlerin olmasından kaynaklanan belirsizlikler vardır. Bu çalışma adli entomoloji ilkelerini ve içeriğini tanımlamak, böcek delillerinin uygulama alanlarını, faydalarını belirlemek, böceklerin farkındalığını arttırmak ve adli tıp profesyonellerin ilgisini bu alana çekmeyi amaçlamıştır.

**Anahtar sözcükler:** Adli entomoloji, çürüme, ölüm sonrası geçen zaman, böcekler

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## Introduction

Lord & Stevenson (1986) divided forensic entomology into three different branches: urban, stored products and medicolegal. Medicolegal entomology is a branch of forensic entomology that use of the knowledge of arthropod in investigations of crimes and legal matters (Haskell et al., 2008).

As soon as death occurs, the body starts decomposing, insects are attracted to dead bodies by volatile chemicals that released from carrion and play an active role in the decomposing process (Anderson & Cervenka, 2001). Forensic entomology evaluate with the use of insects associated with a corpse in legal investigation to provide data not present by using the normal methods of classic pathology (Wolff et al., 2001).

Evidence that extracted from the study of arthropods can be employed in a forensic investigation in a variety of ways (Ames et al., 2006). The most important additive of forensic entomology is the estimation of the postmortem interval (PMI), event reconstructions and solving cases (Greenberg, 1991; Catts & Goff, 1992; Anderson & VanLaerhoven, 1996; Amendt et al., 2006). Insects also provide valuable clues in cases of deaths determining the death location or post-mortem transfer (Sumodan, 2002), recognize of wound sites, cause and manner of death, chemical and drug intoxication, abuse and neglect of child and other aspects of a forensic investigation (Smith, 1986; Goff & Flynn, 1991; Catts & Golf, 1992; Introna et al., 1998). Criminal investigation needs the collaboration of experts from different fields. The present article aims to define the emphasis entomology in crime investigations, to review various sights of forensic entomology and to ensure for an organised approach of different professionals.

## Insects

Insects belong to a large group of animals known as arthropods. There are about one million insects species described worldwide. They are found in almost every ecosystem worldwide. Vertebrate corpses consist on excellent food sources for a more or less specialized insect community (Anderson & Cervenka, 2001) and about 400 insect species have been found on a pig cadaver during its various stages of decomposition (Payne, 1965).

During the crime scene, specimens of insect are used as physical evidence such as blood-stains, hair, fingerprints (Sharma et al., 2013). After death, insects are attracted to the body in a predictable sequence (Payne, 1965; Tullis & Goff, 1987; Catts & Goff, 1992) and insect are often laid on the body within minutes of death (Anderson & Hobischak, 2004). Each group of insects attract to the different stage of decomposition. Knowledge of the distribution, biology, life cycles and habits of arthropod can ensure clues in criminal investigations (Hall, 2008).

According to Smith (1986), insects can be classified into four different ecological categories comprising: parasites and predators of necrophagous species; omnivores, and incidentals (Smith, 1986; Catts & Goff, 1992).

1. Necrophagous species; feeding on the carcass. Necrophagous (carrion) insects may play important roles in carcass decomposition (Payne, 1965; Carvalho & Linhares, 2001)
2. Predators and parasites of necrophagous species, feeding on other arthropods; saprophagous species feeding on dead organisms
3. Omnivorous species; feeding dead organisms and its colonizers (Amendt et al., 2004)
4. Other species, which use the corpse as an incidentally

Diptera and Coleoptera represent the main groups of insects associated in decomposition processes (Greenberg, 1991; Carvalho & Linhares, 2001). Diptera are the primary decomposers to arrive at a dead body, the most common being species belonging to the families Calliphoridae (blow flies), Sarcophagidae (flesh flies) and Muscidae (house flies). However, Coleoptera generally encountered during the later stages of decomposition (Kökdener, 2012).

Correct species identification is very important and the first step. Different species differ in their growth rates and maturation. Identification of insect species has been traditionally carried out using morphological characteristics. Insect larvae and adults are often difficult to recognize by morphology but DNA analysis method is more certain method for identification of species. Maggot, empty puparial and other fragments are obtained on human remains could potential be to identified forensically important species used for molecular techniques (Amendt et al., 2011).

### **Postmortem interval (PMI)**

Correct estimation of the PMI is extremely important for death scene investigations (Anderson & Hobischak, 2004) when a death is not witnessed. PMI means the time between the death and corpse discovery (Sukontason et al., 2007). There are many scientific methods used for the time elapsed since death, however, approaches based on entomological data are supposed the most valuable and accurate ones (Hall, 2001) when medical parameters are no longer of value (Anderson & VanLaerhoven, 1996). Insect evidences are used to determine of postmortem interval or estimate period of insect activity. Insect activity (PIA) period is described as the time from insect colonization until discovery of the corpses following death (Tomberlin et al., 2011). This period depend upon environmental condition (rain, low temperatures, wrapping the corpse) (Amendt et al., 2006).

There are two approaches to estimate the PMI using entomological evidence (Schoenly & Reid, 1987; Anderson, 2015). First, knowledge of insect succession on corpses in a special area can also be used to estimate the PMI (Amendt et al., 2004; Schoenly & Reid, 1987). Insect succession data are more applicable to estimate both minimum and maximum post mortem intervals (Sharma et al., 2013). This method is more helped PMI when the corpses have been death between a month up to a year. Knowledge of regional insect succession is needed for this method to be accomplished (Amendt et al., 2010).

Second, the calculation of the growth rates of the insects feeding on the corpse can be represent as an estimate of the minimum time of death (Catts & Goff, 1992). This method is used when death appeared less than a month (Amendt et al., 2010). Arthropods often lay eggs within minutes after death (Catts & Goff, 1992), thus providing a developmental reference. When larvae invade a corpse, the determination of insect species and their stage of development can be helped to determine of post-mortem interval (Amendt et al., 2011). Aging the oldest larvae on the corpse gives the time when the insects first arrive and laid eggs on a body (Amendt et al., 2006). Recently, analyses of cuticular hydrocarbons are a reliable indicator for age estimation when the fly puparia are obtained from the death scene (Sharma et al., 2013).

Insects are 'cold blooded', so their development is immensely temperature dependent. Meantime, temperature is a critical factor influencing the dynamics of insects. Temperature sets the limits of biological activity and metabolic rate in arthropods. Higher temperature increases rate of metabolic and development of insect and vice versa (Haskell et al., 2008).

Decomposition of the carrion, insect succession patterns and insect development rates can be affected by temperature, heavy rain, humidity (Smith, 1986; George et al., 2009) region of the body, and density of larval (George et al., 2009; Payne, 1965) and geographic location, habitat (Payne, 1965), size of carcass, vertebrate scavengers, the biology and geographical distribution of the insects (Payne, 1965; Tullis & Goff, 1987). Thus, these changes can influence the estimates of PMI.

A new approach in the estimation of PMI based on microbial succession. Microbes play a major role in the decomposition process and changing microbial communities present during decomposition of body have the potential to be used to establish a "postmortem microbial clock. Recent studies suggest that microbial analysis can provide a reliable estimation for PMI, or time since death (Metcalf et al., 2013)

### **Postmortem transfer**

Determination of the movement of the body is a crucial and fundamental step in homicide investigation. Information of insect species distributions and preferred regions are helpful in investigating postmortem transfer between geographic areas (Sumadon, 2002; Hall, 2001). Besides many species of fly prefer to specific

geographic region and different environments. One species general in city center may not be obtained in rural areas and vice versa. If city species identified from the death body obtained in rural may also show that the body has been moved to a rural site after death (Sumadon, 2002).

## **Abuse and neglect**

Insects evidence may be use to determine the circumstances of death. Sometimes entomological evidence may involve living victims. The diverse applications of forensic entomology include the detection of abuse in children and neglect of the elderly. Insect evidence represents how long a person was abused/neglected. Elderly people of wounds are potential target for the insects. However, wounds and circumstance of bad hygiene in elderly and very young person are attracted certain species of flies. Blowflies are valuable as forensic indicators in cases of abuse, rape and neglect. Sometimes victims that are bounded, helpless and drugged have associated urine soaked clothes. Such material is potential targets for flies (Anderson & Huitson, 2004). When sexual assault has occurred prior to death, blowflies will more likely to attract and oviposit in these regions (anus and penis or vagina), and investigators can start to suspect a sexual crime. Insect evidence can yield many clues to both antemortem and post-mortem circumstances of the crime (Khimani, 2015).

## **Entomotoxicology**

Entomotoxicology is the analysis of drugs and toxins on the development rate of carrion-feeding insects (Dayananda & Kiran, 2013; Introna et al., 2001). Insect tissue or remnants are collected from decomposing bodies and in their surroundings can be used as alternate specimens for toxicological analyses, when the blood, urine or internal organs used are not available. In such badly decomposed bodies, fly larvae and their remnants can also be used as a credible substrate for toxicological analysis when poisoning is suspected (Nolte et al., 1992).

Drug related deaths are increased in the world. They are discovered after a period of time and it is not extraordinary that the body could be highly decomposed (Dayananda & Kiran, 2013) toxicological analyses of insect evidence are able to provide a more reliable and sensitive result in legal cases (Magni et al., 2014; Golf & Lord, 2001)

Many of the chemical substances associated drug-related deaths are obtained through analyses of maggots: opiates such as morphine and codeine (Introna et al., 1990; Goff & Flynn, 1991), cocaine and benzoylecognine (Goff et al., 1989; Nolte et al., 1992), amphetamines (Goff et al., 1992), tricyclic antidepressants (Miller et al., 1994), benzodiazepines (Carvalho et al., 2001). Toxin substance and drugs in the feeding substrate may be influenced larval growth rate (El Samad et al., 2011; O'Brien & Turner, 2004, Goff et al., 1989), can be altered PMI estimates and leading to important errors. Presence of malathion in the body elongated the period of pupation in *Chrysomya megacephala* (Fabricius) (Mahat et al., 2009), the presence of morphine in tissues delays maggot growth (Goff et al., 1989). Some drugs can delay the colonization of insects, (Gunatilake & Goff, 1989)

## **Other applications**

Insects feeding on the dead body help in determining the cause of death or detection of an antemortem trauma. Observation of heavy fly colonization in the parts of a body is evidence that a trauma or mutilation of the body may have occurred. In some cases, wasps and bees employed as murder tools. Usually, bees' stings do not cause a serious reaction. The severity of an insect sting reaction varies from person to person, sometimes bees' sting can induce a severe allergic person, the person can die. Second important way of wasps and bees are their effect on drivers. Many car accidents caused by uninvited insects because of the open window (Khimani, 2015)

Lately, human DNA isolated from the gastrointestinal tract of maggots might be used to identify a victim in a criminal case. This kind of analysis is suggested if the food source of the larvae sampled at the scene is in

doubt and no corpse is present but larvae are found. But this kind of studies is rare. The detection of human DNA from maggot can definite that decomposition corpse was exist at crime scene (Amendt et al., 2011)

## Conclusions

Despite 150 years of use, forensic entomology is an emerging field in forensic sciences and still a new discipline. Forensic entomology has become an important tool in investigations of homicide, suicide, and other violent crimes. Insect evidence collected from the body of a victim, when properly collected and analysed by trained forensic investigators, can provide valuable information. One problem in application of entomological evidence is the insect fauna which changes from one region to another region. Insects' databases are still needed for many parts of the world. Therefore study of succession should be doing many part of world and regional data should be created. The another problem is the lack of standardized reference protocols about the development stages of arthropods (Tomberlin et al., 2012).

In this study, we aimed to draw attention of the importance of forensic research, and to contribute to the building of awareness among law personnel. A death investigation usually supposes the effort of multidisciplinary coordination. The number of trained staff should be increased. Only by cooperation between such professionals can be understandable of importance of insect evidence obtained at crime scene. Forensic entomologists have been involved in criminal investigations, as part of the forensic team.

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