

## **Use of Insect Evidence in Criminal Investigations: Developing a Framework for Strengthening of the Justice System**

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### **Abstract**

Forensic entomology is the utility of arthropods/ insects in legal investigations. Insects are an important component of cadavers feeding on the nutrient rich resource provided to them by nature. In doing so they are performing the important ecological service of decomposition. Blow flies are among the first insects arriving at the body and laying their eggs. The larvae that hatch out of the eggs are necrophagous i.e. they feed on flesh. The flies pupate in soil/dirt beneath the body. The development time of flies is specific for instance 9-10 days for oriental latrine fly. This time period allows the entomologists to calculate the time of death roughly corresponding with the time of egg laying. Besides estimating the time of death, forensic entomology in some cases can also determine child neglect, drug use prior to death and identifying potential assailants. In order to strengthen our justice system training workshops in the discipline should be made mandatory for the law enforcement agencies. A frame work should be developed to gradually incorporate the discipline in the legal system. For this purpose the science should be given its due share in the curricula of institutes of higher education and collaborative efforts must be taken to educate the current and future law enforcement professionals.

**Key Words:** Forensic entomology, blow flies, Pakistan, time of death

### **1. Introduction**

Forensic entomology describes utility of insects and other arthropods in legal matters, especially in a court of law (Catts and Goff 1992). The science can be broadly classified into three types, i.e. urban, stored grain and medico-criminal forensic entomology.

Urban applications relate to criminal litigations in perspective of insect infestations of human habitations (Bryks 2011). Stored products entomology, involves the criminal enquiries regarding insects and insect residues in stored products (Anderson

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2001; Gennard 2012). However the goal of medico-criminal entomology is completely different i.e. to contribute to determination of the time, cause, manner and place of a wrongful death (Campobasso and Introna 2001).

Association of insects with human cadavers is known since prehistoric times. There is contemporary evidence that the Ancient Egyptians were aware of the problems of insect when mummifying human remains (Abdel-Maksoud et al., 2011). The birth of forensic entomology however occurred, several millennia later probably in far off China (Greenberg 1991). The first case in China was of a farmer who was murdered in a rice field by a sharp object. The suspects were asked to gather and to place their sickles on the ground. One sickle attracted many blow flies, apparently because of invisible traces of blood on the blade. The owner of the sickle on seeing this confessed to the killing (McKnight 1983).

Today forensic entomology is a part of justice system in many regions of the world (Benecke 2005). Murder investigations from across the world utilize insect data to determine the time of death. Guidelines and protocols have been developed to collect and analyze insect evidence found at the scene of death (Amendt et al., 2004).

## **2. Estimations of time of death (Post mortem interval, PMI)**

Perhaps most important application of medico-criminal forensic entomology is the estimation of Post mortem interval/ time elapsed since death (Anderson 2004). The estimation of the time of death by entomological data after 24 hrs is more accurate than the medical examiner's estimation which is based on soft tissue examination (Joseph et al., 2011). How insects can represent an accurate measure even in later stages of death when the classical forensic pathological methods fail (Benecke 2005) is due to the specific development of an insect species from egg to adult stage (figure 1) under a particular set of environmental conditions especially temperature (Mohr and Tomberlin 2015). Among insects blow flies are perhaps the most important and have been employed in majority of forensic investigations carried out globally during the past few decades (Kamal 1958, Greenberg 1991, Grassberger and Reiter 2001, Benecke and Lessig 2001, Mohr and Tomberlin 2015, Verma and Paul 2016). These flies belong to family Calliphoridae in

Order Diptera of Class Insecta. The blow flies are the initial colonizers of human bodies and spend the longest time on the cadaver (Goff 2009). The female blow flies lay eggs on carrion and other organic material (figure 1a). Their larvae are necrophagous, feeding on decaying flesh during the course of their time on the body (Rabelo et al., 2011) as shown in figure 1b. After completing the growth the larvae pupate in nearby dirt/ soil (figure 1c). Finally the adult flies emerge from the pupal cocoon completing the life cycle (figure 1d).

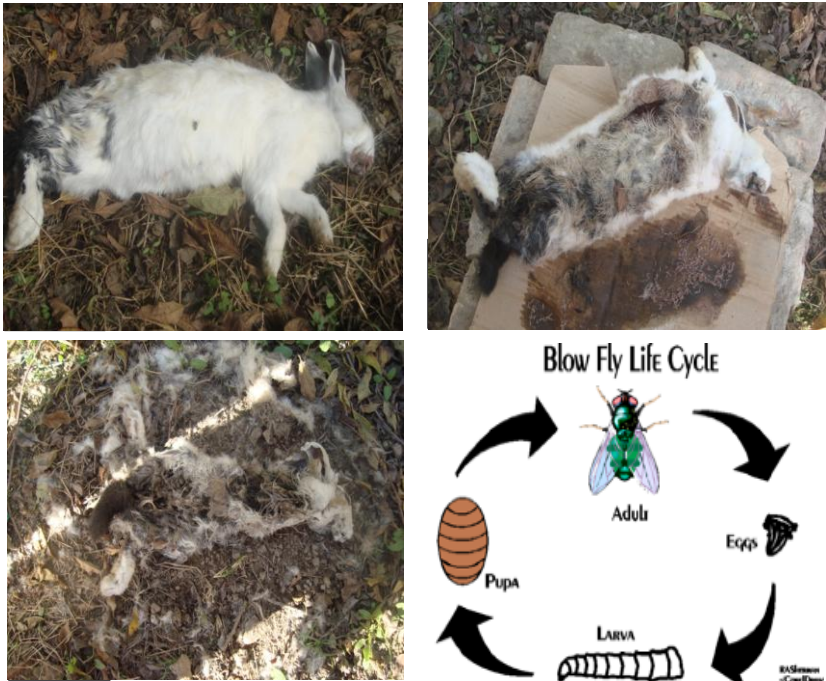


Figure 1: Life cycle of oriental latrine fly *Chrysomya megacephala* on a freshly euthanized rabbit (a) Adult female blow fly *C. megacephala* laying eggs on the fresh carcass (b) Larvae of *C. megacephala* feeding on the same (c) Pupation in surrounding soil; Source: Gul, 2014 (d) Diagrammatic representation of life cycle (Source of diagram: [https://web.stanford.edu/group/parasites/ParaSites2009/AnonymousStudent\\_Myiasis/AnonymousStudent\\_Myiasis.ht](https://web.stanford.edu/group/parasites/ParaSites2009/AnonymousStudent_Myiasis/AnonymousStudent_Myiasis.ht))

It is the predictability of life cycle under a given set of environmental conditions that is used in death time estimations. The life spans of two blow fly species that commonly breed in dead bodies across the world are given in Table 1. The life cycle of

oriental latrine fly (*C. megacephala*) is completed in about 9-10 days at air temperatures of 25-26°C. In contrast the life cycle of common green bottle fly (*Lucilia sericata*) takes 12-15 days to be completed at 22-27 °C as shown in Table 1.

**Table - 1**  
**Comparison of development of two fly species at comparable temperature and humidity conditions**

Species name	Oriental Latrine fly, <i>Chrysomya megacephala</i>				
Year of study	Region	Rearing Medium	Temperatur/ Humidity	Life span (days)	References
2014	China	Pork liver	25.6°C/75.6 %	9.38-10.22	Li et al., 2014
2011	Brazil	Beef	26 °C/75 %	9.62	Rabelo et al., 2011
Species name	Common green bottle fly, <i>Lucilia sericata</i>				
Year of study	Region	Rearing Medium	Temperatur/ Humidity	Life span	References
1958	USA	Beef	22-27.6 °C/ 50 %	12-15	Kamal, 1958
2001	Austria	Beef	25 °C/ not mentioned	12.37	Grassberger and Reiter

Modified from Verma and Paul 2016

This information is useful in determining the time of death in doubtful cases and can be applied to similar set of environmental conditions across the world. Arnaldos et al. (2005) described a case when the body of a woman was discovered in the month of January, from her home with no external wounds. Temperatures were noted and insect evidence was collected and analyzed. The entomological evidence consisted of the blue bottle fly *Calliphora vicina* a species quite common inside the houses and build up areas. Therefore it is commonly encountered in human bodies discovered exclusively from buildings, except when windows are open. In the case described here the absence of other fauna suggested that death had occurred in the house itself since no insects other than *Calliphora vicina* had gained access to the body. The time of death was estimated at 15 days prior to the discovery of body based on (1) the condition of the body: In the absence of external wounds, flies were not invited for an immediate egg laying (2) Egg laying by blue bottle fly must have occurred around the second day of death (3) the physical and environmental conditions (winter temperatures

influencing insect development) (4) and on length of time necessary for the larvae found to have fully developed at the given temperatures which could be put at about 12–13 days.

The judicial enquiry considered the entomological evidence and put the time of death at 16 days prior to discovery of the body. This study demonstrates how the time of development of an insect in a dead body at a given climatic regime can be utilized in measuring the time of death.

### **3. Other applications of medico-criminal forensic entomology**

Today the science of forensic entomology is developing on a rapid pace and there are many avenues being investigated (Midgley 2009) apart from estimating time of death. Some of the novel applications of forensic entomology include:

#### **3.1 Child neglect**

Benecke and Lessig demonstrated a case of child neglect in 2001. The body of a child discovered had maggots of lesser house fly, *Fannia canicularis* under the diaper (anal-genital area) and maggots of blue bottle fly, *Calliphora vomitoria* in the face region. The lesser house flies, *F. canicularis* are attracted to feces and urine and adult females often lay their eggs in fecal material. The blue bottle fly in contrast is a truly necrophagous species and prefers dead bodies for egg laying. Based on the development times of the two fly species it was estimated that the anal-genital area of the child had not been cleaned for about 14 days while death occurred around 6-8 days prior to the discovery of the body. The insect evidence clearly showed that lesser house fly infested the body when the child was still alive and thus establishing child neglect prior to death.

#### **3.2 Entomo-toxicology**

The potential use of insects for detecting drugs and other toxins in decomposing tissues has been widely demonstrated in death investigations (Introna et al., 2011) especially in the absence of tissues and fluids (Goff 1994) also when the bodies are severely burned (Bugelli et al., 2017). The maggots feeding on a body of drug addict would have that drug in their gut contents.

#### **3.3 Identification of human remains/ assailant**

Lourdes et al. (2013) described a case where a badly burned body was discovered with its face and neck regions colonized by maggots. Given the condition of the body identification was not possible. On analyzing gut contents of maggots forensic scientists were able to salvage intact human DNA. DNA profiling was further used to identify the victim.

Gut content analysis of insects can also lead to the identification of potential suspects and/ or assailants. Human blood meal recovered from the gut of a mosquito can be used in identifying the genotype of that particular person. This information could place a suspect at the location of crime where the mosquito was found. Similarly, blood in a louse transferred during a sexual assault could identify the assailant (Wells and Stevens 2008).

#### **4. Developing a framework for strengthening of Justice system**

In Pakistan the field of forensic entomology is as yet nascent and in its initial phase of development. Unfortunately the literature is lagging in this important discipline with only handful of studies on identification of fauna of forensic importance (White et al. 1940, Kurahashi and Afzal 2002, Zaidi et al. 2011, Zaidi and Chen 2011). Pakistan represents a rich fauna of insect species of forensic importance (Zaidi and Chen 2011) with about 48 species of blow flies being identified (Kurahashi and Afzal 2002). Each of these species has a potential utility in criminal forensic investigations of the country.

In fact an adequate death investigation requires efforts and expertise in various disciplines with front line experts being crime scene technicians, crime scene investigators, forensic pathologists, anthropologists, forensic entomologists other medical and non-medical professionals. Unfortunately not all these disciplines are always represented (Campobasso and Introna 2001).

In Pakistan entomological evidence is ignored as maggots on a corpse are considered disgusting and are often discarded. For the delivery of justice, insect specimens, such as maggots and flies must be considered as physical evidence just as blood stains, hairs or any other biological material (Lord and Burger, 1983). In order to develop a framework for our justice system what is needed at this stage is generating awareness among professionals about emerging fields like forensic entomology. To do so, collaboration among

institutes of higher education is required. At university level various departments such as that of life sciences, forensic science and criminology must offer courses that would enhance the knowledge of future professionals in these fields. In addition a continuous input of field work and seminars on advances in, for example forensic entomology, should be compulsory, in the training of current generation of professionals in law enforcement agencies (Figure 2).

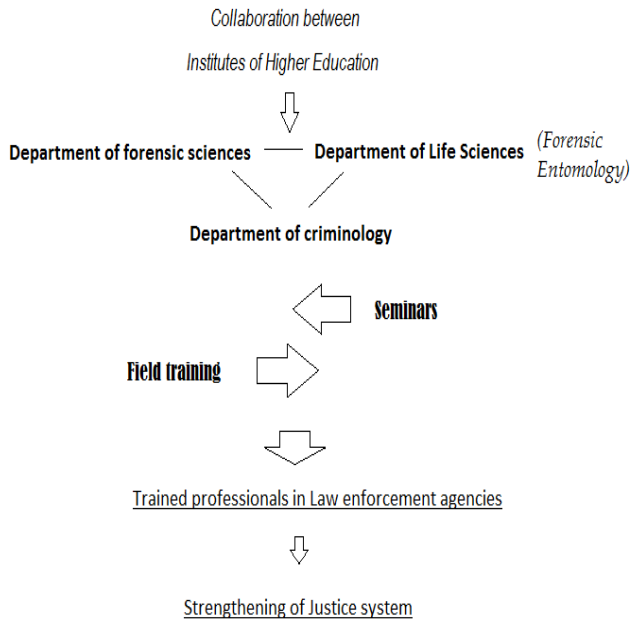


Figure 2:Frame work for strengthening the justice system based on collaboration between Institutes of higher education.

The police officials and technicians should have mandatory training in collecting insect evidence as they are the ones who first arrive at the scene of death and move the body. A protocol sheet for collection of insect evidence that is modified after Amendt et al. (2007) is provided in Table 2.

**Table 2**  
**Protocol Sheets for collection of insect evidence**

<b>Information about victim</b>			
Age:	Sex:	Height:	Weight:
District:	Urban:	Rural:	Coordinates:
<b>Cause of death</b>			
Drug overdose:	Drowning:	Blunt force trauma:	Hanging: Gunshot: Burning: Other:
<b>Stages of Decomposition</b>			
Fresh:	Early decomp:	Advance decomp:	Skeletonization:
<b>Potential scavengers:</b>	Body part affected:	location of wounds:	Number of wounds:
<b>Crime scene specifications</b>			
<i>Outdoor</i>		<i>Indoor</i>	
Land: Forest, Field	Water: Pond, lake	House:---, Room:---	Office building:
		Barn/ stable:	Store house:
If land: sunlight or shadowed	If water: Exposed, submerged	Windows: closed/ open	Doors: closed/ open
<b>Temperatures</b>			
Temperature of maggot mass:	Temperature of body:	Temp between body & Interface	Air temperature
Water temperature:	Soil temperature:		
<b>Environmental conditions</b>			
If outdoor	Humidity:	Vegetation type:	
Windy:	Cloudy:	Sunny:	Rainy:
<b>Insect Evidence</b>			
<b>Sample No.</b>	<b>Approx. No</b>	<b>Type</b> L: P: AF: AB: Ex:	<b>Preserved/ alive</b>
1			<b>Location on body</b>
2			
3			
4			

L, larva/ maggot P, pupa AF, adult fly AB, adult beetle Ex, Exuviae

## Conclusion

Forensic entomology is the science of collecting and analyzing insect evidence associated with human cadavers. Its main application is the determination of time elapsed since death under dubious circumstances. In Pakistan the study is budding at a slow pace. If incorporated into the legal system through training of current and future professionals in law enforcement agencies it can greatly strengthen and support the legal system of the country.

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