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Review

Determination of post-burial interval using entomology: A review

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ABSTRACT

Insects and other arthropods are used in different matters pertinent to the criminal justice system as they play very important role in the decomposition of cadavers. They are used as evidence in a criminal investigation to determine post mortem interval (PMI). Various researches and review articles are available on forensic entomology to determine PMI in the terrestrial environment but very less work has been reported in context to buried bodies. Burring the carcass, is one of the methods used by criminals to conceal the crime. So, to drive the attention of researchers toward this growing field and to help various investigating agencies, the present paper reviews the studies done on determination of post-burial interval (PBI), its importance and future prospective.

1. Introduction

Forensic science is a multifaceted branch, and Forensic Entomology is one of the important branches of forensic science, which primarily used for the estimation of the time since death or PMI by studying stages of decomposition, pattern of arthropod succession or estimating the age of the immature stages of the arthropods present at the scene. The data of forensically important arthropods for terrestrial habitat is very well established and also utilized worldwide for helping the investigating agencies one way or other. But, there are still some aspects of forensic entomology which are untouched or on which very little work has been reported, and post-burial interval determination is one of such aspect of forensic entomology. Thus, it is the need of time to make an effort and develop more expertise in this particular field.[1]

As bodies of the victims are sometimes left where they are killed but, there is usually an attempt to conceal or dispose of the evidence. These attempts range from hiding the body behind the nearest hedge to placing it in water stream or acid bath. A relatively common method of concealment is burial, it is a religious act of placing a dead person or animal, into the ground. A pit or trench was dug and the deceased was placed in it, and covered. Burial is one of the methods used for religious practices in old time. There are some religious reasons of burial, but along with these reasons, there may be a criminal intent to burial. Thus, we have to look into both pros and cons of the burial. But, depending upon the weight and size of the body an effort is required to dig to any depth. Thus, in most of the criminal cases victims are buried in shallow clandestine graves and in fact, after 72 h, forensic entomology is usually the most accurate and often the only method for determining PMI.[2] There are several studies on the colonization of dead bodies by insects but many of these relate to bodies placed on the surface of the ground rather than underneath it. Thus, it is important to understand the factors that affect insect colonization because by studying those one can predict when, and sometimes where a person died.[3]

When an organism dies, there is a sequential colonization by arthropods (mainly Diptera and Coleoptera), that originates a predictable ecological succession directly related to the various stages of decomposition. Using these arthropods we can; determine time since death,[4–9] medico-legal questions regarding the surroundings and hygiene of the scene,[6–8] physical abuse or neglect if any,[7,8] determination of poisons or drugs,[7,9] food contamination[6,8] etc. There are many factors that alter the pattern such as, environmental changes, physical barriers (water, plastic bags etc.), or cultural intervention related to funerary practices.[10] The burial environment can also alter the rate of decomposition, and subsequently impact the estimation of time since death. Bodies buried in soil demonstrate a slower rate of decomposition than bodies placed over a soil surface in the same environment. The environment in which a body is buried is generally defined by the chemical, biological and geological conditions of the location. Factors such as, the depth of the burial, the presence or absence of a coffin, the physical composition of the body, clothing type and the physical conditions

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of the soil, such as texture, pH, moisture, temperature and oxygen content can affect decomposition within a burial site.[11]

2. Post-burial interval

Various researchers have contributed to the field of forensic entomology, by keeping in view various aspects and factors that affect the forensic entomology. The first study on buried cadavers was reported in 1985. This study utilized six un-embalmed human cadavers, buried separately in unlined trenches of various depths and allowed to decompose naturally. It took about a year to complete this study, and during this period of burial, sampling was done daily from the air and soil, and cadaver temperature at each burial site was also recorded. After each specified burial period the cadavers were dug out and examined for degree of decomposition along with the changes in the pH of the soil, surface vegetation, and carrion insect activity. From this study it was found, that the decomposition rate of buried cadavers is highly dependent on the depth of burial and environmental temperatures, depth at which the cadaver was buried also directly affected the degree of soil and vegetation changes as well as access to carrion insects[12]. As this was the first study conducted on burial cadaver and some of the important factors such as depth of the burial, pH of soil, temperature etc. which affects the carrion decomposition and insect succession were studied. So, moving further in the forward directions, to determine post-burial interval, in 1999 Vanlaerhoven and Anderson, conducted an experiment using pig carcass to establish a database of insect succession on buried carrion in two bio-geoclimatic zones of British Columbia. The pig carcasses were buried shortly after death in the Coastal Western Hemlock and Sub-boreal Spruce bio-geoclimatic zones of British Columbia. Buried pigs exhibited a distinct pattern of succession from that which occurred on above ground carrion and the species composition and time of colonization differed between the two zones. Thus, it is concluded that, ideally a database of insect succession on buried carrion should be established for each major bio-geoclimatic zone and soil temperature should be used to determine developmental rates of insects for determination of the postmortem interval.[13] Based on literature following table is formed in which post burial insect fauna of forensically importance is listed.

Forensically significant post-burial insect fauna.

Species	Family	Reference
Calliphora vicina	Calliphoridae	Gunn and Bird (2011)
Muscina stabulans	Muscidae	
Lucilia sericata	Calliphoridae	
Muscina prolapsa	Muscidae	
Muscina levida	Muscidae	
Calliphora vomitoria	Calliphoridae	
Muscina stabulans	Muscidae	Introna et al. (2011)
Calliphora vicina	Calliphoridae	
Tinea pellionella	Tineidae	
Tinea bisseliella	Tineidae	
Fannia scalaris	Fanniidae	
Monopis obviella	Tineidae	
Muscina stabulans	Muscidae	Mariani et al. (2014)
Ophyra aenescens	Muscidae	
Fannia canicularis	Fanniidae	
Megaselia scalaris	Phoridae	
Tineola bisselliella	Tineidae	
Eumacronychia persolla	Sarcophagidae	Szpila et al. (2010)
Phylloteles pictipennis	Sarcophagidae	
Calliphora vomitoria	Calliphoridae	Bhadra et al. (2014)
Calliphora vicina	Calliphoridae	
Synthesiomyia nudiseta	Muscidae	Lord et al. (1992)
Calliphora vicina	Calliphoridae	
Conicera tibialis	Phoridae	Martin-Vega et al. (2011)

2.1. Importance of blowflies in cases of burial

Blowflies are the first visitors on the carcass above ground as reported in the literature. Some researchers consider that even a thin covering of soil will prevent a body being colonized by blowflies because the female flies require physical contact with a suitable larval food source before they will lay their eggs. Despite this, there are several reports of adult blowflies being attracted to the site of a buried body by the smell emanating from the ground. For example, Rodriguez and Bass (1985) observed that, the adult blowflies laying eggs in the soil above remains buried at 30 cm deep and also attempting to reach them by crawling through cracks and crevices in the soil.[12] Similarly, VanLaerhoven and Anderson (1999) observed *Calliphora vicina* laying eggs in the soil above remains buried at a depth of 30 cm; although that does not necessarily mean that the larvae subsequently reached the corpse.[13] Thus, there is some uncertainty about the ability of blowflies to exploit buried remains and furthermore it is not known how burial of already flyblown (fly infested) remains affects the hatching of blowfly eggs and the subsequent development of the larvae. This is an important consideration because it could help determine how long the body had been buried.[3]

Keeping this aspect in view, a research on the ability of the blowflies such as *Calliphora vomitoria*, *C. vicina* and *Lucilia sericata* to colonize pig liver baits buried in loose soil was conducted. The experiment included following parameters;

i. **Ability of flies to exploit buried remains**: It has been found that, blowfly *C. vicina* dominated the above ground bait fauna and was also found in large numbers on the buried liver samples but not on buried liver when supplemented by blood. Muscid flies were present on all the buried liver samples and *M. stabulans* and *M. prolapsa* were especially abundant when the liver was supplemented with blood.
ii. **Ability of fly larvae to develop on buried remains**: In both species *C. vomitoria* and *L. sericata*, the eggs were able to hatch underground and the larvae developed through to adult. The rate of development was same as that on surface bait. In *M. stabulans* and *M. prolapsa*, the adult flies laid their eggs on the soil surface and then the larvae crawled down to the bait. When the bait was on the surface of the soil, the flies laid their eggs in the soil around the bait, rather than on the bait.
iii. **The influence of burial on pupariation behaviour**: In *C. vomitoria* and *L. sericata*, the post-feeding 3rd instar larvae placed on the surface rapidly burrowed into the soil and some of them reached to the base (soil depth 25 cm) within 15 min. The majority of *L. sericata* formed puparia in the top (2 cm of soil) and *C. vomitoria*, developed into puparia over a wider range of depths, most were found at the top (8 cm). *L. sericata* puparia were often found embedded within clumps of hard soil or in fragments of vegetation. On the soil surface neither of the species larvae develops into puparia. In *M. stabulans* and *M. prolapsa*, the majority of larvae developing on surface bait formed puparia at the top (4 cm) of the soil. However, the overall distribution of *M. stabulans* puparia was significantly broader than that of *M. prolapsa*. There was no difference between the pupariation depths distributions of the two species when the larvae were developing on baits buried at 20 cm.
iv. **Burrowing capabilities of adult flies**: All the species of *C. vomitoria* and *L. sericata*, emerged from buried puparia that reached the surface regardless of the depth at which they were buried and those, did not reach the surface did not emerge from their puparium.

From experiment, it has been found that, the *C. vomitoria* colonized the baits buried at 5 cm but not deeper, while *C. vicina* and *L.*