CASE REPORT

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Estimation of Postmortem Interval Based on Colony Development Time for *Anoplolepsis longipes* (Hymenoptera: Formicidae)*

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ABSTRACT: The postmortem interval for a set of human remains discovered inside a metal tool box was estimated using the development time required for a stratiomyid fly (Diptera: Stratiomyidae), *Hermetia illucens,* in combination with the time required to establish a colony of the ant *Anoplolepsis longipes* (Hymenoptera: Formicidae) capable of producing alate (winged) reproductives. This analysis resulted in a postmortem interval estimate of 14 + months, with a period of 14–18 months being the most probable time interval. The victim had been missing for approximately 18 months.

KEYWORDS: forensic science, forensic pathology, insects, ants, soldier flies, colony formation, forensic entomology, postmortem interval

Use of insects and other arthropods in estimations of postmortem intervals has been well documented by various authors (1–6). Techniques for deriving these estimations were presented by Smith (5) and Catts (7) and reviewed by Goff (8) and Schoenly et al. (9) have discussed statistical approaches for consideration in the derivations of estimates dealing with succession. There have generally been two approaches taken in use of entomological evidence. The estimate is based on either the period of time required for a given species to reach a stage of development collected from decomposing remains or the estimate is based on an analysis of patterns of succession of a number of different species of arthropods onto the decomposing remains. In both approaches, various environmental factors, such as temperature and rainfall, must be considered along with the possible effects of drugs and/or toxins which may be present in the remains (2,10). The estimates resulting from these approaches are estimates of arthropod activity periods, rather than necessarily reflecting actual time since death. As arthropod invasion of decomposing remains generally occurs rapidly following death, these estimates generally do, for practical purposes, reflect a minimum period of time since death (8).

Arthropods involved in published case studies, to date, have generally been solitary insect species rather than the social insects. One notable exception to this was documented by Lord (2) where a death investigation involved a wasp nest (*Polestes sp.*) inside a skull which was found in eastern Tennessee. The social insects include the termites, ants, bees, and some wasps. These insects form eusocial colonies which may be characterized by having cooperative efforts in raising immatures, an overlap of generations and presence of one or more non-reproductive castes which are often sterile. One characteristic of these social insects is polymorphism among members. Some members are involved only in reproduction, while others function for maintenance or defense of the colony. There are distinct morphological differences among the colony members which are directly related to these differences in function. New colonies are initiated by social insects in two ways: by swarming or by reproductives leaving the existing colony, mating and initiating a new colony. In a new colony, the female, termed a queen, initiates a colony and raises the first generation by herself. Subsequently, the Queen's function is almost entirely egg production while other members of the colony take over the tasks of maintaining the colony, food gathering, rearing of immatures and colony defense. The structure of a colony with respect to numbers of different castes present will vary over time thus allowing for some estimate of colony age (11).

Due to the somewhat ephemeral nature of a decomposing body, social insects are not generally encountered as complete colonies in forensic investigations, although individual wasps and ants are routinely encountered as predators. Adult wasps and ants have frequently been observed to prey on adult flies and maggots during the earlier stages of decomposition and can serve to retard the decomposition process by decreasing the maggot population (12,13). In addition to their predatory activities, many species of Hymenoptera are parasitoids of larvae and pupae of Diptera, Coleoptera and other insects on the remains (14). The case presented here is unusual in that a major factor in the estimated minimum postmortem interval was the period required for establishing a colony by social insects.

Case History

The skeletal remains of a male were discovered inside a metal tool box off a road in the vicinity of Mt. Olomana on the island

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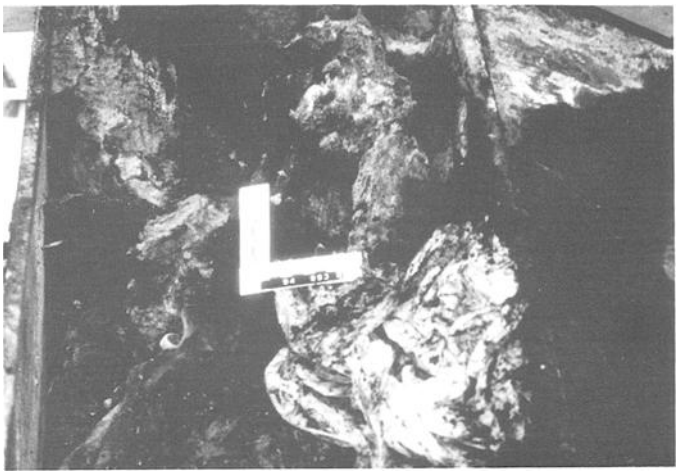

FIG. 1—*Tool box containing body.*

of Oahu, Hawaii on the evening of 24 Oct. 1994. The metal box (108 × 42 × 38 cm) was opened on the morning of 25 Oct. 1994 at 8:53 A.M. and contained skeletal remains, white plastic trash bags, cement fragments, dirt and insect material (Fig. 1). Bunches of hair were stuck to the inside of the box near the lid. A short-sleeved, one-size fits-all, T-shirt was present. Remains were clad in a faded, pink, short sleeved aloha shirt, briefs and short jeans. Feet were clad in socks and steel toed construction boots. Exposed parts of the socks were in shreds. A digital pager, watch and belt buckle also accompanied the body. The remains were completely devoid of soft tissue, but were consistent with that of an adult Caucasian male.

Entomological Collections

The remains, clothing and tool box were examined in the City and County Morgue on the morning of 25 Oct. 1994. At that time the remains had been refrigerated for approximately 15 h. Empty puparial cases of the flies *Hermetia illucens* (L.) (family Stratiomyidae) (Fig. 2) and *Chrysomya megacephala* (Fabricius) (family Calliphoridae) were recovered from the skeletal material and associated clothing. The ant species *Anoplolepis longipes* (Jerdon) (Hymenoptera: Formicidae) was represented by adults (Fig. 3), larvae (Fig. 4), and pupae. The pupae were attached to the bones and present inside the skull. Adult ants were present moving over the surface of the remains. On the clothing and inside the tool box

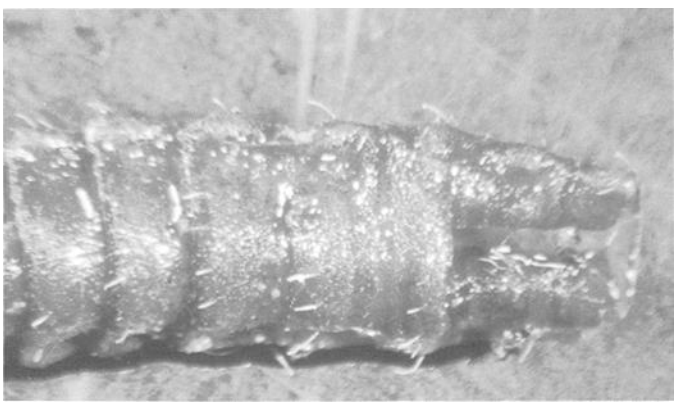

FIG. 2—*Empty puparial case of* Hermetia illucens *(Diptera: Stratiomyidae)—anterior portion.*

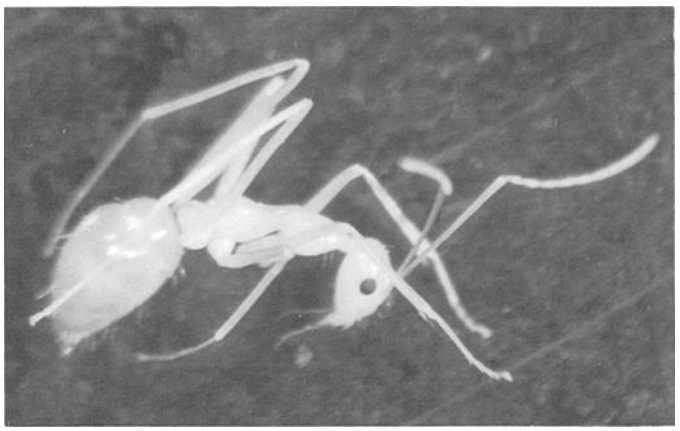

FIG. 3—*Adult worker of* Anoplolepis longipes *(Hymenoptera: Formicidae).*

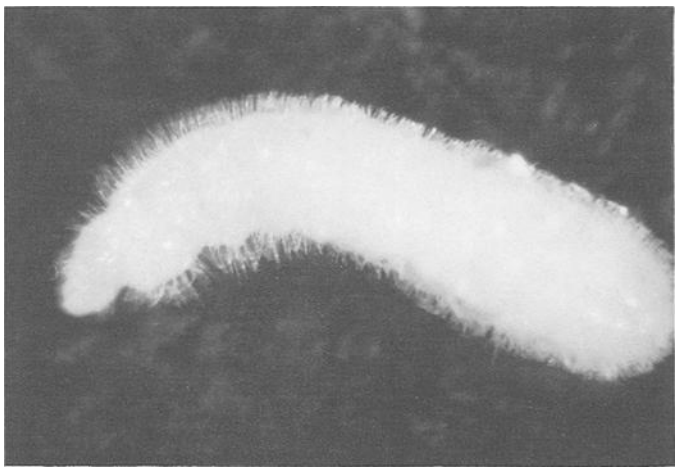

FIG. 4—*Larva of* Anoplolepis longipes *(Hymenoptera: Formicidae).*

were empty egg cases (ootheca) of a species of cockroach (family Blattidae), but no nymphs or adult cockroaches were found. The Coleoptera or beetles were represented by adults of a species of Scarabaeidae, *Onthophagus incensus* Say. Nymphs and adults of the earwig *Euborellia annulipes* (Lucas) (Dermaptera: Labiidae) were present in the soil on the bottom of the tool box. Additional empty puparia of *H. illucens* were present, along with 5th and 6th instar larvae, measuring 17–20 mm total length (Fig. 5). Adults, pupae and larvae of *A. longipes* were also collected. The pupal cases of *A. longipes* were of two distinct size classes. Dissection of the cases revealed that there were pupae developing into both workers (Fig. 6) and alate or winged forms (Fig. 7).

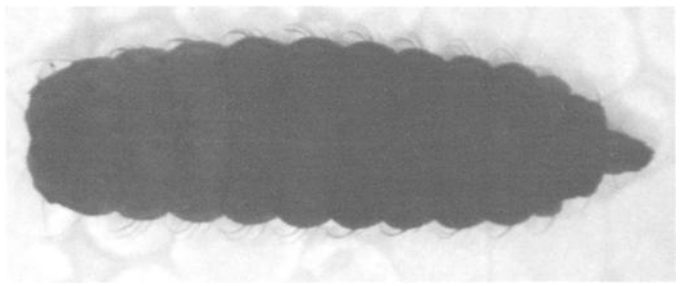

FIG. 5—*Larva of* Hermetia illucens *(Diptera: Stratiomyidae).*

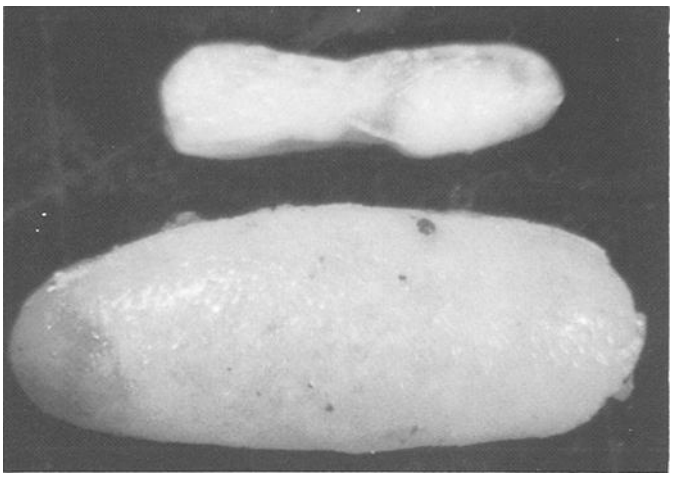

FIG. 6—*Cocoon and pupa of worker caste of* Anoplolepis longipes *(Hymenoptera: Formicidae).*

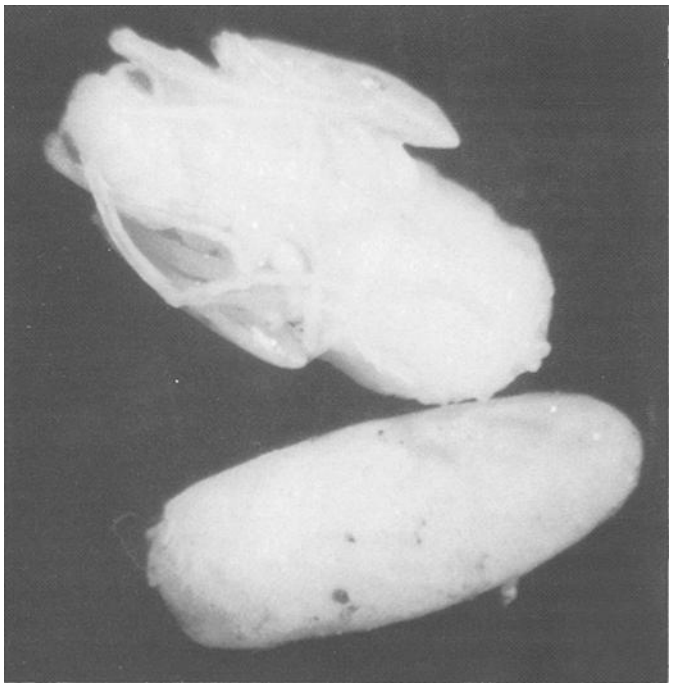

FIG. 7—*Cocoon and pupa of alate form of* Anoplopepis longipes *(Hymenoptera: Formicidae).*

Insect Activity Estimate

Fourteen Months + Prior to Discovery of Remains

This estimate was based on the time required for development of the colony of *Anoplolepis longipes* associated with the skeletal material and the soil inside the tool box, combined with developmental data for *Hermetia illucens.* In the location for these remains temperatures are relatively stable, generally ranging between 20°C and 28°C year round. Ironically, while a tool box containing a body was able to remain untouched at this site for some 18 months, climatic recording equipment was vandalized routinely, thus preventing accurate extrapolation of temperature data from weather stations nearby. For this reason, generalized developmental times derived from Lord et al. (15) and Furman & Catts (16) along with results from previous cases in Hawaii involving *H. illucens* were used in the analysis. Exposed remains become attractive to *H. illucens* for oviposition some 20–30 days following death (15) and the life cycle from egg to adult requires from 44 days to up to 5 months (15,16). As there were no intact puparia for this species present with the remains, all of the first oviposition appeared to have completed development to the adult stage. The larvae present represent a second, later oviposition. Using the minimum periods of 20 days prior to oviposition and 44 days for development from egg to adult, there would have been a period of approximately two months required for development of the first oviposition by *H. illucens* to adults. By contrast, the maximum periods for invasion of remains and development from egg to adult given by Furman et al. (16) for the remains to become attractive for oviposition and the first generation to complete development to the adult stage, would require a period of approximately six months.

The ants, *Anoplolepis longipes,* tend to seek drier places in which to establish their colony, frequently in disturbed areas (17). Colonization thus would not have begun until the remains had begun to dry, consistent with the period of several months indicated by *H. illucens* development. According to Holldobler & Wilson (11), alate reproductives are not produced for a period of 12 months following establishment of an ant colony. As the pupae sampled from the metal tool box contained pupae of both worker and alate reproductive forms, a minimum period of colony development of 12 months is indicated. At present, interactions between *H. illucens* and *A. longipes* are largely unknown, although *A. longipes* is an aggressive predator. Presence of numerous empty puparia of *H. illucens* indicates an absence of predation on the egg, larval or puparial stages of *H. illucens* of the degree which would have been associated with an active ant colony in near proximity. Assuming that the first oviposition by *H. illucens* would have completed development in a period of approximately 2–6 months (20–30 days before colonization and 45 days to 5 months for development of adults from first oviposition) and prior to colonization of the remains by *A. longipes,* a period of approximately 14 months to 18 months is the most probable estimate of the postmortem interval. As all puparia from the first oviposition had completed development, the upper end of this time frame appears to be more probable.

In this case, dental records were not available and the victim was identified through odontological/anthropological superimposition work done at the United States Army Central Identification Laboratory, Hawaii, primarily by George A. Gould, D.D.S., and Peter S. Miller, Ph.D. The victim had been reported missing for a period of approximately 18 months prior to discovery of the remains. The suspect in this case confessed to the murder and was convicted of homicide during a trial held in Honolulu during June 1996. This case illustrates the use of colony formation by social insects as a tool for establishing a postmortem interval estimate.

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