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CASE REPORT

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Caddisflies Assist with Homicide Case: Determining a Postmortem Submersion Interval Using Aquatic Insects*

ABSTRACT: Although few indicators of time since death for corpses found in aquatic ecosystems are comparable in precision to the insect indicators used in terrestrial cases, there are observations that can be useful in suggesting or ruling out an approximate PMSI (postmortem submersion interval). For example, the time intervals required for certain growth phases of aquatic insects, such as caddisflies, that may attach themselves to the submerged remains can be used to estimate a minimum PMSI. Approximately 8 of the 13 orders of insects containing species with aquatic or semi-aquatic stages are likely to be associated with carrion or corpses in aquatic habitats. We present a case study in which portions of a body from an adult male were discovered in a south central Michigan stream. The body was dismembered and portions were recovered from two bags floating and submerged in the stream. Insect specimens collected from mesh and plastic bags consisted of one fly larva belonging to the family Muscidae, and caddisfly larvae belonging to two families: the Limnephilidae. (case-makers) and the Hydropsychidae, (net spinners). We used unique case-building behaviors of the limnephilid caddisflies found on the remains to elucidate a PMSI range consistent with the disappearance of the victim. It is important for forensic investigators to understand that although some precision is lost in estimating a PMSI with aquatic insects, these organisms should not be ignored in gathering evidence from aquatic crime scenes, and in fact, they can provide valuable details in estimating a PMSI.

KEYWORDS: forensic science, caddisflies, postmortem submersion interval, life history

There are few truly sarcophagous aquatic insects (e.g., some caddisflies and midges) that have evolved functionally to feed on carrion (1–3). In contrast, there are major groups of common terrestrial indicator species such as blow flies and flesh flies useful in the estimation of a range or portion of the postmortem interval or earliest oviposition interval (4). Not surprisingly, published literature reflects an 80–20% difference between studies focusing on terrestrial versus aquatic systems, respectively (2). This dichotomy can be explained because terrestrial insects have evolved to feed on carrion while aquatic insects have not. Consequently, aquatic insect evidence is often ignored from crime scenes that otherwise would be very useful in estimating a Postmortem Submersion Interval (PMSI). The PMSI in aqueous environments refers to the time period from when the body enters the water to the point of discovery, noting that the body may be totally submerged for all or part of the time period. Understanding the growth phases of aquatic plants and animals that attach themselves to submerged remains is particularly valuable information and can be used to estimate a minimum PMSI (5).

The evolution of a vast array of physiological and behavioral adaptations in aquatic insects, such as caddisflies (Order: Trichoptera), enables these organisms to inhabit virtually all water bodies. Because corpses are often dumped into and recovered from aquatic environments such as freshwater and marine systems (6–8), it is important that forensic scientists and crime scene investigators have an increased knowledge of the aquatic organisms that could potentially colonize human remains (6,9). The purpose of this report is to identify a specific insect model and relevant life history information useful in estimating a PMSI.

Case Description

On Monday, June 13, 2005, an officer from a local sheriff's office responded to a dispatch call to a bridge over a river in lower Michigan. A sanitary engineer for the local county health department was at the location and noticed a suspicious plastic bag in the river that contained bones. At that time it was not known whether the bones were human or from an animal. The engineer first saw a duck decoy bag in the river and inside the bag was a dark colored plastic garbage bag (Fig. 1). When he pulled the bags to shore and opened them, he observed bones and human flesh and then proceeded to phone the police. From the odor emanating from the bag, it was clear that the body and bones were in a state of decay. Apparently, part of the decoy bag containing the body parts was at the surface and not entirely submerged. There also appeared to be rocks inside the second bag along with a portion of a chest containing a bone, rib bones, hair, and other fragments.

The remains contained within two bags were examined at the morgue at Sparrow Hospital in Lansing, Michigan to determine if there were any insects present on any parts of the body or within the bags that could assist in estimating a PMSI. Insect specimens collected from the decoy and plastic bags containing body parts were preserved in ethanol and transported to the laboratory for identification. The macroinvertebrates identified consisted of three aquatic taxa and a terrestrial species (Table 1).

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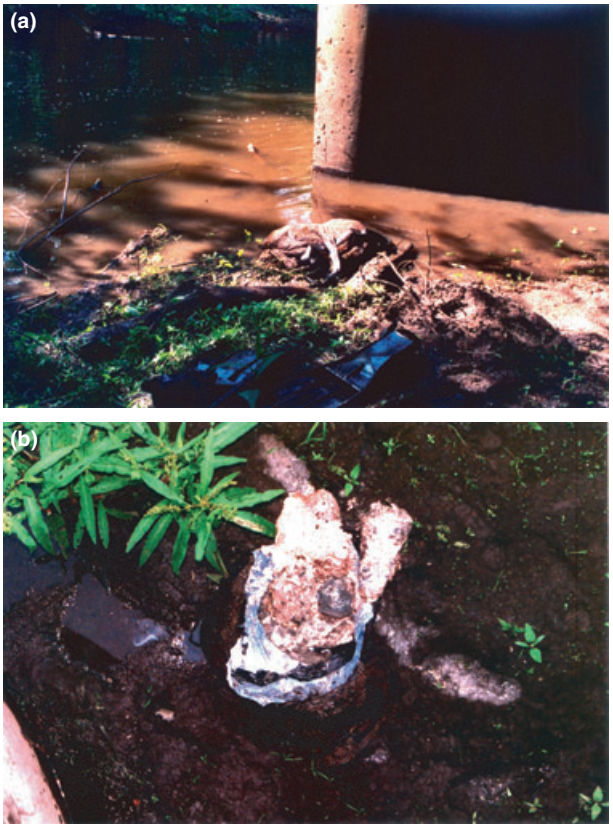

FIG. 1

The larva of the muscid fly found on the body parts was of little help in this specific case because there are significant limitations on an accurate PMSI estimation due to the body having been placed in the water initially, most likely sinking then floating to the surface at a later date. Muscid fly colonization would have occurred while the remains were floating and exposed at the surface, therefore at a later date. Because of their complex life histories and other taxonomic factors, the hydropsychid caddisflies did not provide us an immediate time frame for the estimation of the PMSI. However, many species of limnephilid caddisflies construct portable cases made of sticks, leaf pieces, small stones, sand grains, and other inorganic and organic objects. Because of case material type, the size of mineral pieces used in case construction, and the size of the stream from where they were collected, we were able to differentiate between two different species of larval limnephilid caddisflies from the remains, *Pycnopsyche lepida* (stone case) and *Pycnopsyche guttifer* (primarily stick case) (Fig. 2).

TABLE 1—*Taxonomic list of the macroinvertebrates collected from the two bags containing the remains of the victim.*

Taxon	Number & Develpmental Stage Collected
Filth fly (Muscidae)	1 larva
Net-spinning Caddisfly (Hydropsychidae)	4 larvae
Case-building Caddisfly (Limnelphilidae:*Pycnopsyche guttifer*)	19 larvae
Case-building Caddisfly (Limnelphilidae:*Pycnopsyche lepida*)	2 larvae
Snail (Gastropoda)	1 individual

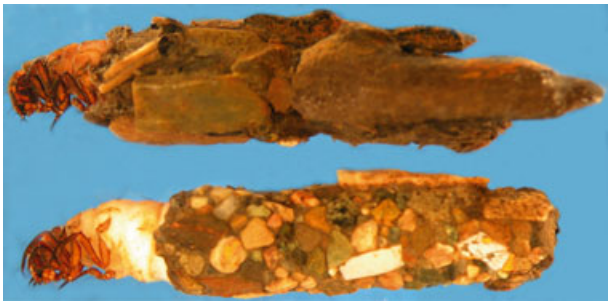

FIG. 2

In evaluating these specimens, we reached the conclusion that these species could be found in this river at that time of year based on their geographic distributions (10–12). The phenologies or timing of each life stage for *P. lepida* and *P. guttifer* with the larval stages denoted by roman numerals I–V (first–fifth) are shown in Table 2 (13). Since *P. lepida* larvae were not found attached to the substrate with a silken strand prior to pupation, and none of the *P. guttifer* larvae were observed to be attached upon collection, we determined that larvae of both aquatic insect species had not entered the pupal stage of development. However, it was observed that a few larval cases had silken mesh across the anterior end indicating that these larvae had initiated a dormant period prior to pupation. This was further supported by the observation that no larvae were physiologically metamorphosing from larvae to pupae at the time they were removed from their cases. Therefore, we estimated that for these larvae to be found on the remains at this time of year, the body had to be submersed prior to the initiation of the dormant period, while the larvae were still active. Thus, the PMSI range we provided investigators was between late April to late May. It is possible that the remains entered the water prior to this time interval, but the period most likely to be defined as a colonization period by these larvae would have fallen within this time frame. Understanding the timing of specific life history events in these two limnephilid caddisfly species was crucial to providing a range for the PMSI.

TABLE 2—*Life cycles of Pyncopsyche lepida and P. guttifer as established by Howard (1975) on Gull Creek, Kalamazoo, Michigan.*

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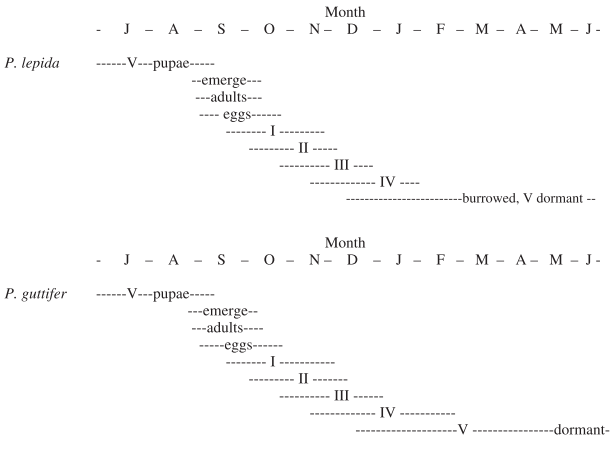

Discussion

The use of terrestrial insects to estimate a portion of the postmortem interval (PMI) has been facilitated by decades of research on the life cycle, development rates and other life history aspects as well as understanding the basic ecology of terrestrial insects (14). This template can be applied to the use of aquatic insect evidence for PMSI estimation through increased knowledge of the basic life histories of those aquatic insects typically found on decomposing remains. Historically, preliminary work has examined how midge larvae (Chironomidae) have been used as indicators of a PMSI using pig carcasses in a woodland stream (15), and case reports helped associate the presence of this dipteran family on a decedent with a nearby stream (16). The remains in this case were in such an advanced state of decomposition that the colonization by caddisfly larvae (either directly on the remains or the attached clothing or material) provided evidence that was useful in more accurately estimating the time period during which the remains had been submersed. Perhaps, life history information including an understanding of benthic macroinvertebrate feeding habits (2), the role and timing of aquatic insect drift (17), oviposition periods, and overwintering stages of aquatic insects (14) could offer additional valuable evidentiary information than that utilized by past investigators. The use of aquatic insects in this case suggests a new avenue of basic research that forensic investigators can apply to cases involving submersed and/or floating human remains.

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