CASE REPORT

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Wildlife Forensic Entomology: Determining Time of Death in Two Illegally Killed Black Bear Cubs*

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ABSTRACT: Forensic entomology is now commonly used to determine time of death in human death investigations. However, it can be equally applicable to wildlife crimes. This paper describes the use of entomology to determine time of death in the illegal killing of two young bear cubs in Manitoba, Canada. Two cubs were found shot, disemboweled, with their gall bladders removed. Natural Resource officers (Conservation Officers) and a Royal Canadian Mounted Police (R.C.M.P.) officer examined the remains, and the R.C.M.P. officer collected insect evidence. The only insects on the remains were adult blow flies coming to lay eggs and the blow fly eggs themselves (Diptera: Calliphoridae). The time of hatch was recorded and the insects were reared to adulthood. Time of hatch, together with species identification, macro and micro climate and lab developmental data were used to determine the time of death. The time was consistent with the time that the defendants were seen at the scene and was used in their conviction. This case illustrates that insect evidence can be equally as valuable in poaching cases as in homicide cases. However, in most cases Conservation Officers are unaware of this science. It is therefore, extremely important for more Conservation Officers to be educated about this field.

KEYWORDS: forensic science, forensic entomology, bear poaching, blow fly egg development, Canada

Forensic, or medico-legal entomology is the study of insects associated with a dead body and has been used and accepted in courts around the world (1–15). It is primarily used to determine time of death, although it can also be used to determine other factors at a crime scene (16,17). Determining time of death is extremely important in a death investigation as it focuses the investigation into the correct time frame. This can support or refute a suspect's alibi and improves the efficiency of the criminal investigation.

Traditionally, time of death determinations are made for human homicide victims. However, forensic entomology can be equally applicable when the victim is not human, but an illegally killed wild animal.

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The illegal killing, or poaching, of wild animal species in North America is becoming a more and more serious concern, with animals being taken for fur, meat, as trophies, and more recently for organs which have an extremely high black-market value in certain cultures. Wildlife represent a major resource in North America and provide an abundance and variety of recreational opportunities, so have a major economic impact. As well, many wildlife species are threatened with extirpation or extinction.

Determining time of death in a poaching investigation is equally as valuable as it is in a homicide investigation, as it focuses the investigation into the correct time frame, increases the efficiency of the investigation and can support or refute a suspect's alibi in exactly the same way it would in a homicide investigation. This paper presents a case history in which forensic entomology was used in a bear poaching case to determine time of death.

Case History

Between 12–15 July three dead black bears (*Ursus horribilis* (L.)) were found in or near a garbage dump 100 km north of Winnipeg, Manitoba. All had been found covered with garbage, shot in the neck or head, disemboweled, and the gall bladders removed, so all had been killed for profit. The bear gall bladder is valuable in Traditional Chinese Medicine (18). Adult females in an advanced state of decay were found on 12 and 13 July and their orphaned cubs, twins and triplets, were seen in the dump rummaging for food. Attempts to capture the cubs were unsuccessful. On 13 July at approximately 2110 h, Conservation Officers responded to a report of two shots fired at the dump, and with the assistance of the Royal Canadian Mounted Police (R.C.M.P.) and their tracking dog and handler, apprehended two suspects later that night and made a number of seizures. Neither suspect was in possession of bear gall bladders.

The following day, the twin cubs were found dead. They had been shot in the head, disemboweled, and their gall bladders removed (Fig. 1). The cubs were too young for the galls to have any commercial or medicinal value. The two cubs were found at approximately 1600 h on 14 July 10 m SW of the main dump clearing. Both Conservation Officers and an R.C.M.P. officer were called to the scene. The R.C.M.P. officer was aware of the value of forensic entomology from previous human death investigations that I had worked on, and so collected the evidence.

The only insects on the remains were Calliphoridae or blow fly eggs and adult blow flies. The eggs were laid in masses close to the abdominal wound (Fig. 2). Eggs had not yet been laid at the natural orifices.

FIG. 1—*Two dead bear cubs found disemboweled, with galls removed, near a garbage dump in Manitoba. (Photograph courtesy of W. Campbell, R.C.M.P. Winnipeg Manitoba, FIS).*

FIG. 2—*Close-up of cub showing extensive egg masses close to wound site. (Photograph courtesy of W. Campbell, R.C.M.P. Winnipeg Manitoba, FIS).*

On 15 July a two-year-old male bear was found in similar condition to the adult females. As suspects had been apprehended and released, the twin cubs became the main focus of the Conservation Officer's investigation.

Insect Evidence

The police officer collected a sample of the eggs at 1645 h and preserved half of the eggs at the scene at 1712 h. These were preserved for later examination by the entomologist, and by the court, if desired. The rest he placed alive on bear liver and observed over the subsequent hours. The living insects are required in order to determine time of hatching and to identify the insect species. Table 1 indicates the police officers observations. The eggs first began to hatch after 2100 h 14 July and before 0745 h 15 July.

The insects were couriered to me at Simon Fraser University, British Columbia. The preserved specimens were examined and confirmed to be Calliphoridae egg masses, with no sign of eclosion. If some eclosion had taken place, examination of the egg mass would have revealed the chorion or 'egg shell' remaining from eclosed maggots. No signs of this were observed. The live exhibit consisted of 2nd instar Calliphoridae by the time they were received. It was kept in a secure room at Simon Fraser University at room temperature with a photoperiod of 12 h dark and 12 h light. Observations and notes were made on the development of the insects from 17 July until all had emerged or died. After adult emergence, the adult flies were killed, pinned and identified. The eggs of three species of Calliphoridae had been laid on the remains, *Phormia regina* (Meigen), *Phaenicia sericata* (Meigen) and *Lucilia illustris* (Meigen). Three adult flies were also collected from the cubs and identified as *Protophormia terraenovae* (Robineau-Desvoidy), and *Phaenicia sericata.*

TABLE 1—*Time line of insect evidence collection and blow fly egg eclosion.*

Time and Date	Procedure	Insect Stage
1600 h 14 July	cubs discovered	eggs
1645 h 14 July	evidence seized	eggs
1712 h 14 July	50% of evidence placed in alcohol for preservation	eggs
	50% placed in separate vial with bear liver	eggs
2100 h 14 July	observed	eggs
0745 h 15 July	observed	30% hatched into 1st instar
1645 h 15 July	observed	90% hatched into 1st instar

Insects of a given species develop at a predictable rate, within a particular range of temperatures and, because the normal metabolic rate is increased with increased temperature, the duration of development decreases with increased temperature (19). Therefore, the time since oviposition or egg laying can be determined by careful examination of meteorological data, together with the identification of the species and stage of development of the insects associated with the remains.

Meteorological records from the closest Environment Canada weather station indicated a mean temperature of 21.5–23.3°C over the previous two days, with no precipitation. Therefore, the conditions had been ideal for insect oviposition and development.

Studies conducted in my lab indicate that, at a mean of 23.1°C, *Phormia regina* takes between 21.5 and 22.5 h to eclose. This is similar to other, previously published data; approximately 1 day at 20–25°C (20), 20 h at 22°C (21) and 24 h at 20.6°C (22). *Phaenicia sericata* takes 20.9–23.5 h to eclose at 21.4°C (unpublished studies), which is again corroborated by other workers. Greenberg (21) found that *Phaenicia sericata* takes 23 h to eclose at 22°C and Melvin (22) reported 20.9 h at 20.6°C. Very little published data are available for *Lucilia illustris* but studies conducted in my lab indicate that, at 21.2°C, this species takes a minimum of 19.3 h to eclose, with eclosion taking as long as 44 h in rare cases.

Determination of Time Since Death

The insects indicate not the actual time of death, but the minimum elapsed time since death by determining when the eggs were laid on the bodies, which in turn indicates when the carcasses were available for egg laying.

At the ambient temperature of the scene, 21.5–23.3°C, the eggs of *Phormia regina* would have taken 21.5–22.5 h to eclose. Eclo-

sion began after 2100 h 14 July and before 07:45 h 15 July. This indicates that the eggs of this species must have been laid on the carcasses sometime between midnight and 0900 h 14 July.

The eggs of *Phaenicia sericata* would have taken 21–23.5 h to eclose at these temperatures, so would also have been laid between midnight and 0900 h 14 July.

The eggs of *Lucilia illustris* would have taken 19.3 or more hours to eclose, so were probably laid on the carcasses later than *Phormia regina* and *Phaenicia sericata.*

Insects colonize remains very rapidly after death. This has been observed repeatedly in British Columbia on pig carcasses (23,24) and has also been observed on wildlife carcasses, including black bear and cougar (23,25,26). *Phormia regina* sometimes arrives slightly later, although it may arrive immediately after death (24). However, as the carcasses were associated with a garbage dump, it is probable that all carrion species were present in large numbers and would have been attracted to the remains shortly after death. Most blow flies do not oviposit at night as they are usually inactive. Therefore, the first eggs must have been laid on the remains between midnight and 0900 h 14 July, most probably at first light on 14 July. The cubs must, therefore, have been dead before the early morning of the 14 July. They could have died the previous night, in the evening of the 13 July, because the flies would probably not have laid eggs until the following morning. But they could not have died the previous day, the 13 July, had they done so, they would have already developed to maggots by the time they were collected. Also, they could not have died later on in the day of the 14 July as the insects would have hatched much later.

Case Resolution

The insect evidence indicated a time of death that successfully linked the two suspects to the scene at that time. They had been known to be shooting in the area the evening of 13 July, around 9–10 p.m. DNA evidence was used to link the poachers to one of the cubs (27). Both defendants were each found guilty of two counts of poaching under the Provincial Wildlife Act. They were sentenced to three months in jail per count. This was the first time in Manitoba where a jail term was secured for the actual poachers of the animals in question. In his summation, the judge stated that he considered the entomological evidence to be the "most compelling."

Discussion

In many cases when poached remains are discovered it is difficult or impossible to determine the time of death. Without this evidence, it is extremely difficult to pursue a case, so at the present time, many poaching cases are not followed through, with the result that the poacher remains at large, and more animals are killed.

The case presented here is a simple determination of time since death based on blow fly egg development. What makes it unusual is that the 'victims' were bears not humans. However, the principles are the same. Insects are attracted to a dead animal in the same way that they are attracted to a dead human. Recent work in British Columbia has also shown that they will colonize a bear carcass in the same way, and at the same time as they would a pig carcass, the usual model for human decomposition (23,25,26).

In human cases, forensic entomology is usually of most value during the first few months after death. Years after death, it may be possible to determine season of death, based on species and numbers of insect remains present. In some respects, such evidence may be of more value in poaching cases than in human cases, as season alone may not be enough in an old homicide case. However, in animal cases, many species have a legal hunting season, meaning that animals killed outside this time are poached. In such cases, if time of death was known, it would conclusively indicate whether an animal was killed legally in season, or illegally out of season. This would mean that many more cases could be investigated than currently are pursued. The time of death also points the investigation into the correct time frame, which helps to focus the investigation and can be extremely important in the apprehension of a suspect. Once charged, a successful prosecution is dependent on strong physical evidence. Insects provide strong, defensible physical evidence which has been successfully used in court.

It is interesting to note that this case was only brought to the attention of an entomologist because an R.C.M.P. officer was called to the scene. This indicates that it is extremely important for Conservation Officers to be informed of the value of forensic entomology so that it can be applied to more cases.

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