M. Lee Goff

A *fly* for the PROSECUTION

How Insect Evidence Helps Solve Crimes

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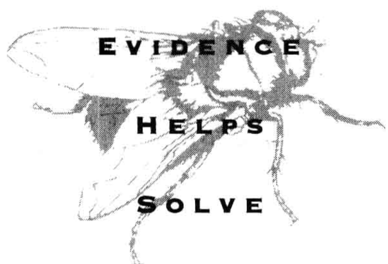

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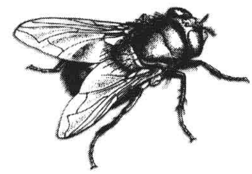


Prologue: Honolulu, 1984

It was a perfect morning for shoreline fishing and throwing nets for crabs. The sun was shining brightly and the air was perfumed with the scent of plumeria when the three fishermen set off for Pearl Harbor, only a few miles from home. At the abandoned Primo Brewery grounds, they parked and started on the short walk to the beach. As they went along the path, they noticed an unpleasant odor stronger than the smell of their bucket of bait. Peering over the fence in the direction of the stench, one spotted a dead body lying on its back.

When the homicide investigators arrived at the scene, they could see that the body was stretched across a shallow, brush-filled drainage ditch, with the head facing the ocean and the legs pointed inland toward Honolulu. The fingernails and toenails were painted bright red. The left arm was raised over the skull with a slight bend at the elbow, as if trying to defend against a blow. The left hand was missing, but the right hand was intact, although desiccated. The lower jaw had been separated from the skull and lay in the mud about 16 inches away. The left leg was crossed over the right. Three toes were missing from the left foot, but the legs were otherwise undisturbed. Many beetles and other insects were crawling both on and inside the body.

The body appeared to match the description of a woman who had been reported missing on September 9, 1984, some 19 days before the discovery of the corpse. When last seen alive, the woman, accompanied by a tall white male, was leaving a restaurant in Pearl City of which she was part owner. Her car was later found over 30 miles away, in the Waianae area. There was blood inside it.

The identity of the woman was established beyond reasonable doubt by dental x-rays. When reported missing, she had been wearing a black leotard with a white stripe along the side and a floral print skirt. By the time the body got to the morgue, all of the clothing had turned dark brown or black. Her head was almost completely stripped of flesh, and the exposed skull had been polished by the scraping mandibles of beetle larvae as they fed on the dried tissues. The rib cage was exposed, with some shreds of dried skin still clinging to it, and patches of parchment-like skin adhered to the neck and legs. The internal organs were missing. The only evidence of trauma the medical examiner could find was a fractured hyoid bone in the neck, consistent with manual strangulation. Now the police had an identification and a cause of death—homicide. But when did the victim die? Fortunately there were witnesses: the insects that were infesting the body. The only problem was how to get them to reveal their evidence to the investigators.

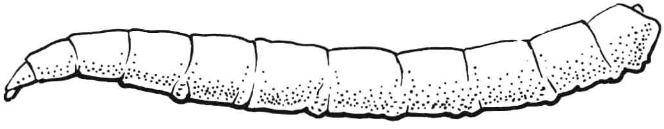
Having been called by the medical examiner, I arrived at the Honolulu morgue as the autopsy was being completed. Given the condition of the body, the procedure had not taken long. At the time, I had been actively involved in forensic entomology for only a little over a year, and the Honolulu Police Department and medical examiners were still getting used to the idea of an entomologist showing up at the morgue on a motorcycle with an insect net and a bag of vials. But my estimates of time of death had been helpful in resolving a couple of earlier cases, and on this occasion, I had been told I could bring along a graduate student, Marianne Early. She was in the final stages of her master's degree program in entomology and had been conducting decomposition studies on pig and cat carcasses on various parts of the island of Oahu. Up to this point, the medical examiner had regarded me as an isolated anomaly; now there were two of us.

What the body lacked in tissues, it made up for in insects. Marianne and I collected specimens of all the species of insects and of each stage of development of every species we could find and took them back to the laboratory at the University of Hawaii at Manoa in Honolulu for identification and analysis. The most obvious and numerous were the hide beetles and the maggots, the larvae of flies. There were three species of maggots on the body, in different locations and in different stages of development. I sorted each type into two sublots. I measured the length of each of the maggots in one of the lots, and used the average of these lengths to give me some idea of their stage of development. Then I preserved them in ethyl alcohol. I put the other sublot of maggots into a rearing chamber to complete their development to the adult stage.

Since most maggots look a lot alike, it is often difficult to identify them to the species level until they have metamorphosed into adults, which do look quite different from one another. Marianne and I had collected some relatively large maggots from the flesh remaining on the back of the body. From the shape of their mouthparts and the breathing openings, or spiracles, at the end of each maggot's body, I was able to tell that these were flesh flies, in the family Sarcophagidae, but could not identify the species until the maggots had completed their development into adult flies. There was also another type of maggot, somewhat smaller, on the back of the body. Over the next 2 weeks, we reared these maggots to adulthood, at which point we could tell they were a species of blow fly, *Phaenicia cuprina,* in the family Calliphoridae. The third type of maggot was a smaller fly in the family Piophilidae. These flies are commonly known as cheese skippers because they prefer to eat stored foods, especially cheese. The maggots of cheese skippers have a unique way of moving away from their food source—usually a corpse—before entering the pupal stage, where they will be transformed into adults. The maggot arches backward and grasps its anal papillae, the fleshy lobes protruding from the body near the anus, with its mouth hooks. Then the maggot flexes its muscles and releases its grasp, flinging itself into the air, a process called popping. Once safely away from the corpse or other food source, the maggot enters the pupal stage.

In addition to the maggots, we collected evidence of yet another species of fly that had fed on the body: empty pupal cases of another blow fly, *Chrysomya rufifacies,* were attached to the exposed ribs and caught in the folds of the skirt. We also found two types of beetles on the body. Hide beetles, in the family Dermestidae, were present both as adults and as larvae. These beetles normally feed on the dried skin of dead animals but may also feed on other dried, stored products that have a high protein content. The second kind of beetle was a species of checkered beetle, *Necrobia rufipes,* in the family Cleridae. Only a few adults of this species were present on the body.

By the time of this investigation, 1984, I had begun experimenting with computers to estimate the postmortem interval—the time elapsed between the death of a person and the discovery of the corpse—and had developed a computer program using data from the decomposition studies one of my graduate students and I had conducted. This was the first time I used the program in an actual criminal case. After entering all



Larva of the cheese skipper *Piophila casei*

the data, I watched with distinct displeasure as my computer produced a completely illogical analysis. It seemed either that no such body existed, or that I had entered the data for two different bodies. Although this result was disconcerting, the test was a success of sorts. The program did detect a problem with the data; it just lacked the ability to solve it. I had simply made a few modifications to some off-the-shelf business software, and had allowed for only an either/or option. The resulting program was not capable of resolving the problem with the insects found on this particular body: sarcophagid (flesh fly) maggots should not have been on the body at the same time as empty pupal cases of the blow fly *Chrysomya rufifacies.* Normally both insects are present as larvae early in the decomposition process or both as pupae later in the process. The combination of sarcophagid larvae and empty puparial cases of *Chrysomya rufifacies* was not in any database available to the software program I was using. Another visit to the scene of the crime was in order. Late afternoon found me in a squad car with a detective and the medical examiner on our way to the drainage ditch in the Primo Brewery grounds.

At the site, we found that friends of the victim had already erected a wooden cross to commemorate her. By looking at the photographs of the scene, I pinpointed exactly where the body had lain across the shallow drainage ditch. Removing the brush from the surface of the ditch, I found water approximately 5 inches deep with a number of sarcophagid maggots moving across the surface. Here was the answer that had eluded the computer. Maggots can feed only on soft, moist flesh. As tissues lose moisture, they become more and more difficult for maggots to eat, until finally the maggots can no longer use the body as a food source. Since the victim's back had been partially submerged, these sarcophagid maggots had been able to continue feeding on the body far longer than they could have under dry conditions. Carefully examining the soil around the spot where the body had lain, I discovered some pupal cases of blow flies—the same kind of cases that would soon be formed by the blow fly maggots collected during the autopsy. I also collected some ants and a number of predatory beetles in the families Staphylinidae and Histeridae.

Blow fly adults of the species *Chrysomya rufifacies* can locate exposed human remains in a remarkably short period of time. In Hawaii, I have found them at test carrion less than 10 minutes after exposure of the carcass. Typically, the adults of this species of blow fly arrive at the body and feed briefly on blood and other secretions from the natural body openings or from wounds. The females then lay their eggs in dark areas either in body openings or underneath the body. Egg laying starts the biological clock that forensic entomologists use to estimate the postmortem interval. For *Chrysomya rufifacies*, egg laying can begin quite soon after the adult females reach the body and will continue, under Hawaiian conditions, for approximately the first 6 days following death. In the late summer to early fall in lowland areas on the island of Oahu, completion of development from egg to maggot to pupa and finally to adult usually requires 11 days. Since the only evidence of this species on the body was the empty pupal cases, discarded when the flies reach adulthood, I was confident that all *Chrysomya* maggots maturing on the body had completed development before it was discovered. Therefore, the minimum time since death was 17 days: 6 days of egg laying, followed by 11 days of development.

The cheese skipper maggots were still in the early stages of development, but in Hawaii, I have found, this fly typically does not invade remains until several days after death. The specimens I collected from the body were at the same stage of development as those I had collected from test animal carcasses set out for study after 19 days of decomposition.

The hide beetles also provided valuable clues for estimating the time of death. These beetles, which I identified as *Dermestes maculatus*, do not feed on moist tissues and arrive only when the remains have begun to dry. In lowland habitats on Oahu, they begin to arrive between 8 and 11 days after the onset of decomposition, and during decomposition studies I have gathered lar-

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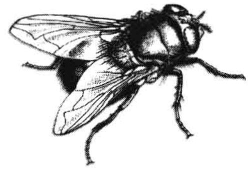
vae comparable in size to those collected from this case beginning on day 19. The remaining species I collected, including the Histeridae and Staphylinidae found in the soil, were consistent with a postmortem interval of 19 to 20 days but did not yield more precise information.

Considering all the data, and having satisfied myself of the reason for the presence of the sarcophagid maggots, I determined that the most likely minimum postmortem interval was 19 days. This was the official estimate I gave to the medical examiner, Charles Odom.

In time a suspect was identified: the man in whose company the victim was last seen alive. I testified about the insect evidence first during a grand jury proceeding in April 1985. In late September 1985, I testified as to the probable time of death during a murder trial in the First Circuit Court in Honolulu.

The suspect was convicted of second degree murder and the major witnesses were flies. From that time on, I became a routine participant in investigations of decomposed human remains in Honolulu.



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BEGINNINGS

Anyone involved in death investigations quickly becomes aware of the connection between dead bodies and maggots. Insects are major players in nature's recycling effort, and in nature a corpse is simply organic matter to be recycled. Left to its own devices, nature quickly populates a corpse with a diverse community of organisms, all dedicated to reducing the body to its basic components. Very quickly, "worms" appear, crawling out of the various orifices. Until quite recently, most death investigators regarded these insects as merely a sign of decay, to be washed away or otherwise disposed of as quickly as possible, rather than potentially significant evidence. Thus while other forensic sciences, such as toxicology, forensic pathology, blood-spatter analysis, and ballistics, developed into accepted forensic tools, beginning in the late 1800s, forensic entomology was seldom practiced.

Yet the application of insect evidence to criminal investigations is not a new idea. A form of forensic entomology was practiced at least as early as the thirteenth century. In 1235 a Chinese "death investigator" named Sung Ts'u wrote a book entitled *The Washing Away of Wrongs,* which was translated into English by B. E. McKnight in 1981. Sung tells of a murder in a Chinese village in which the victim was repeatedly slashed. The local magistrate thought the wounds might have been inflicted by a sickle. Repeated questioning of witnesses and other avenues of investigation proved fruitless. Finally, the magistrate ordered all the village men to assemble, each with his own sickle. In the hot summer sun, flies were attracted to one sickle, because of the residue of blood and small tissue fragments still clinging to the blade and handle. Confronted with this evidence, the owner of the sickle confessed to the crime. The magistrate's action demonstrates considerable knowledge of the activity patterns of the flies, which were certainly blow flies. Indeed, in other parts of the book, Sung talks about the blow flies' activities in natural body openings and wounds, including an explanation of the relationship between maggots and adult flies, and discusses the timing of their invasion of a corpse.

Not until several centuries later, in 1668, was the link between fly eggs and maggots discovered in the West. Before then, people did not realize that maggots hatched from the eggs flies laid on exposed meat or decomposing bodies. Francesco Redi's studies of meat that was exposed to flies and meat that was protected from flies resulted in a major discovery. His observations of fly infestations on the exposed meat demonstrated the link between the flies' egg laying and the maggots, and disproved the concept of spontaneous generation. Before Redi, maggots were believed to arise spontaneously from rotten meat, not emerge from fly eggs. If my telephone log at the University of Hawaii at Manoa is any indication, quite a few people still think that maggots are worms with no connection to flies; one man even told me that maggots normally live "inside people" and only come out after we die.

Unfortunately, Redi's discovery did not lead immediately to the use of entomological evidence in death investigations. The first record of the use of insects in a forensic investigation in the West dates from 1855. During a remodeling of a house outside Paris, the mummified body of an infant was discovered behind a mantelpiece. Suspicion soon centered on the young couple then occupying the house. An autopsy was performed on the infant by Dr. Bergeret d'Arbois of nearby Jura, Switzerland, who concluded that the child had died in 1848. He noted evidence that a flesh fly, *Sarcophaga canaria,* had exploited the body during the first year (1848) and that mites had laid their eggs on the dried corpse the following year (1849). Bergeret's analysis of the insect evidence demonstrated to the satisfaction of the police that the death had occurred much earlier than 1855 and that the logical suspects were the occupants of the house in 1848, and they were subsequently arrested and convicted of the murder. The methods employed by Bergeret d'Arbois in his analysis are essentially the same as those forensic entomologists use today in estimating the time since death. He recognized and drew conclusions from the predictable pattern of succession of different insect species onto a corpse, and saw the significance of the duration of the life cycles of different carrion-frequenting insects. But although the assumptions underlying his analysis were correct, he appears to have misinterpreted some of the life cycles of the insects involved, and his conclusions would probably not have passed muster in a modern courtroom.

FORENSIC ENTOMOLOGY SHOULD logically have continued to develop steadily, with new discoveries arising from the findings of previous research. But progress was uneven and sporadic. Research was usually conducted in response to a murder and often ceased once the case was solved. There were some exceptions, particularly the work of J. P. Megnin in France. During the late 1800s, he published a series of papers on medicocriminal entomology that alerted both doctors and lawyers to the usefulness of entomological evidence. Possibly the most significant of these papers was *La faune des cadavres: Application l'entomologie a la medicine legale,* which was published in 1894. The central thrust of Megnin's work was that the postmortem interval can be determined by analyzing the various species of arthropods—invertebrates with a segmented body and paired, jointed legs, such as the insects, the mites, and the spiders—that are present on a decomposing body, without regard to their age. Today's forensic entomologists recognize this principle, but usually also take into account the age of each species in determining the postmortem interval.

In the mid-1930s entomological evidence came to the fore in a particularly brutal murder case, recently chronicled in *New Scientist* by Zak Erzinçlioglu. On September 29, 1935, a woman spotted a severed human arm while looking over a bridge spanning a small stream in Scotland. Ultimately, over 70 pieces of two badly decomposed corpses were recovered from the area, since known as the Devil's Beef Tub. The reassembled parts were eventually identified as the remains of Isabella Ruxton, the wife of a local physician named Buck Ruxton, and her personal maid, Mary Rogerson. Mrs. Ruxton had last been seen alive on September 14. Among the varied pieces of evidence collected at the scene was a group of maggots feeding on the decomposing body parts. These maggots were sent to a laboratory at the University of Edinburgh, where A. G. Mearns identified them as maggots of a blow fly, *Calliphora vicina,* and estimated that they were between 12 and 14 days old when they were collected. Since these maggots had developed from eggs laid on the body parts by adult flies in the vicinity, the bodies could not have lain near the stream for less than 12 to 14 days. This was the minimum time between the deaths and the discovery of the dismembered bodies. Suspicion fell on Buck Ruxton for a number of reasons, and

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