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CASE REPORT

Maggots reveal a case of antemortal insect infestation

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Introduction

Insects on corpses can give a wide range of information in forensic investigations. The most common application is calculating when insects oviposited on a dead person to give an estimation of the postmortem interval [1]. Since the infestation of a dead body may be delayed by certain circumstances such as indoor locations [2] or wrapping [3], it is more accurate to talk about the colonization time. Insects, being restricted to a certain area, can give further hints to the investigators such as if a body has been moved to a different location after death; also, body parts of insects can link a suspect to a crime scene [4]. Another application is the detection of toxic substances in insects feeding from dead persons' tissues [5]. There have been several studies done according to the biology of these animals' living associated with corpses as well as their application in legal investigations in the last years [6–12].

Many necrophagous flies are attracted by the odor of decomposition [13], but for some, other odors such as those from urine, feces, and the associated bacterial fauna are quite attractive and stimulate oviposition [14, 15]. The infestation of the living by dipterous fly larvae is known as myiasis. Wounds or anogenital regions are often found being fed by maggots in cases of neglect in humans or animals [16–19]. In certain cases, the chronologically nonmatching infestation of the anogenital area and favorable sites for oviposition of flies being attracted by the dead, such as the face, can give both the information of how long somebody has been neglected as well as how long a person has been dead [14, 15, 20].

Flies of the genus *Lucilia* belong to one of the first and most abundant summer species on corpses in Europe [21] and play an important role as facultative parasite causing myiasis [22].

It has to be emphasized that blowfly maggots will mostly feed from necrotic tissues [23] and will seldom eat the fresh and healthy skin or organs in humans or animals which has been reported for other fly species such as those from the family Oestridae under mostly tropical circumstances [24]. This unique property of fly maggots is commonly used in the maggot debridement therapy for treating nonhealing wounds [25]. Sterile fly larvae are applied to such resulting in a cleaning, disinfection, and increased healing-rate of the damaged tissue. The green bottle fly *Lucilia sericata* is the usual species used in this form of wound management [26].

The following case of an elderly dead woman reports the possibility to distinguish between maggot infestation before and after death, helping to reconstruct the formerly unknown circumstances.

Case report

An 80-year-old woman was reported missing since September 1 in 2008. She suffered from dementia but was physically fit and had a history of running away once in a while. On September 9, 2008, her body was found dead in a recreational area in North Rhine-Westphalia, Western Germany. This area was where she was usually found after running away.

Her body was found about 10 m away from the regular footpath, lying in a supine position in a southwest-facing gulley, directly exposed to the sun. Her handbag and shoes

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were found approximately 5 m beyond her head. It seemed as if she had slid down into the gulley. Her tights were slipped down with one foot completely off one leg of the tights, and her skirt was slipped up (Fig. 1). Her other clothes, cardigan, blouse, and underwear were undisturbed.

An accumulation of soil beneath her feet could be observed as well as scratch marks about 2 m above her head at the side of a small slope framing the gulley on one side. A strong stench of urine was coming up from the woman's underpants and her skirt.

In contrast to the time interval of the woman's missing where the weather was predominantly rainy at night and in the early morning hours with temperatures around 17°C, it was a sunny day when the corpse was recovered, and temperatures reached up to 26°C.

The corpse hardly showed any beginning signs of decomposition. Only parts of the face revealed some superficial reddish mummified colorations, primarily on the forehead. Flies were visiting her face, laying egg batches in the eyes, the mouth, and in her hair. Her head and throat were covered with fly spots. There was a considerable area of macerated tissue where maggot masses were feeding around the genitals (Fig. 2). The woman's body was moved to the Institute of Legal Medicine in Cologne where the autopsy was performed on the next day. During the night the body was kept at 5°C. When the corpse was prepared for autopsy the next morning, the face of the elderly woman was completely covered with tiny fly maggots being reminiscent of sawdust (Fig. 3).

Material and methods

During the autopsy, which was performed 19 h after the body has been found, the largest fly larvae were collected from the facial and genital region in order to calculate each time when the first eggs were laid. Fifty percent of all larvae taken from each area were transferred into hot but no longer boiling water for 30 s and subsequently preserved in 96% ethanol to record their length and estimate their age.

The other half was grown separately on commercial dog food in a HERAEUS incubator at 23°C until adult flies had hatched to determine their species.

The identification of the flies' species was done under a ZEISS operation microscope using morphological features [27].

Due to the fact that temperature is the main influencing factor in insect development, it was crucial to obtain temperature data of the time interval when the woman was still missing. Therefore, temperature data in the gulley were hourly measured with an EBRO data logger (EBI 20-IF) for 3 days after the body has been found. Additionally, temperature data for the missing time interval were obtained from a privately run weather station, situated only 2.5 km away from the finding place. The weather station gathered data every 15 min using a wireless meteorological basis station WS 2500 and S 2001 A-1 wireless-combo-sensors. By generating a regression equation (IBM SPSS Statistics, Version 19), predicted temperature data for the finding place were given with $R=0.953$ and $R^2=0.908$.

Fig. 1 Site where the dead woman was found in a recreational area in North Rhine-Westphalia, Western Germany. *Inset* overview of the dead woman with her tights slipped down, showing superficial reddish mummified coloration of the forehead

Fig. 2 The genital area of the woman showing the area of macerated tissue being consumed by fly larvae

Results

At autopsy the woman was fully dressed. Since the woman weighed 48 kg and measured 154 cm, her body was in a reduced nutritional status with a body mass index of 20.2.

Rigor mortis was already relaxed when the autopsy started. The body of the elderly woman showed superficial abrasions on both knees and lower legs as well as haemorrhages reaching the subcutaneous fat tissue on the back and buttocks. The woman was seen to have moderate general arteriosclerosis which was high graded in the descending branch of the left coronary artery. No other pathological changes of the inner organs and no other injuries could have been observed during the autopsy. The toxicological analyses were negative; histology showed discrete autolytical changes as well as a general arteriosclerosis and arteriolosclerosis.

Fig. 3 The face of the woman at autopsy 1 day after Fig. 1. Many tiny larvae cover the face like sawdust

The autopsy did not reveal a clear cause of death. No signs of violence were found.

Larvae from both the facial and genital region were determined as those from the green bottle fly *L. sericata*.

The length of 42 larvae taken from the facial region was measured with a mean length of 2.68 mm. They were too small to surely identify their developmental stage by looking at the posterior spiracles. The mean length of the 27 postfeeding maggots taken from the genital region averaged 12.36 mm. Much smaller maggots were also found in the genital area but not collected since we were looking for the oldest maggots in order to calculate always the first oviposition of the infested body regions.

Established growth data [21] were used to calculate the age for the largest maggots from each body region.

Investigations concerning when the first ovipositions had occurred on the body of the woman revealed that the earliest eggs were laid on the facial region in the evening of September 7 before rain set in, whereas those from the genital region were deposited earliest in the evening of September 2.

The evaluation of the climatological data showed mean temperatures of the missing time interval from September 1 to 8 of about 17.8°C. Figure 4 shows temperature data from the very nearby weather station as well as those calculated for the finding place. Rain data for the same time period can be seen in detail in Table 1.

On September 1 when the woman was reported missing, temperatures reached up to over 22°C. The next day showed similar temperature conditions. Until the early morning of September 3, day temperatures were about 20°C, those at night around 15°C. On September 3 and 4, mean temperatures were between 14°C and 15°C. The following days, until the body was found, temperatures rose and ranged between 17°C and 19°C.

No rain was measured on September 1. On September 2 much rain fell in the late evening with 3.9 l/m^2. The rain got moderate on September 3, paused 1 day, and started again in the afternoon on September 5. The following next 2 days showed only little rainfall of 0.3 l/m^2. Furthermore, no rainfall was quantified until the body was found.

Discussion

Myiasis is defined as the infestation of the livings by insects, especially by fly larvae. Numerous cases of myiasis have been reported, mostly concerning the infestation of sheeps or other pet animals [16, 18, 19, 28]. If an animal's wound is left untreated and neglect results in the accumulation of urine and feces, blowflies are highly attracted by the developing odor [29]. The involvement of fly maggots

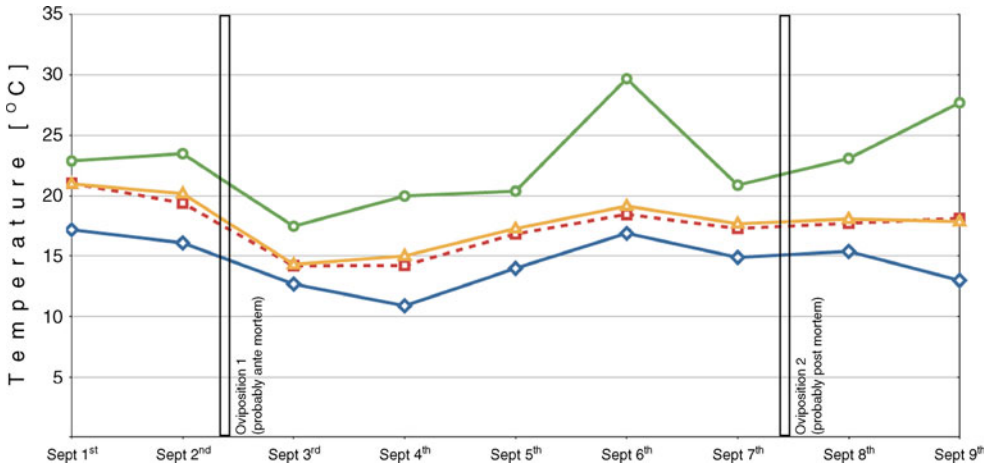

Fig. 4 Temperature data of the weather station (*white circle* maximum temperatures, *white triangle* mean temperatures, *white diamond* minimum temperatures) and of the finding place for the period when the woman was reported missing until she was found dead. Temperatures of the finding place (*white square*) are shown as *dashed line*. Times of ovipositions marked with a *frame*

in the infestation of living people is not that rare as suggested. Flies are attracted by wounds and especially by a soiled anogenital region which serves as a potential target for flies for oviposition. Often, myiasis in humans is a result of the neglect in the very old or very young as well as in those unable to care for themselves properly and living under insufficient hygiene conditions [14, 15, 20, 22].

It is still unknown why fly larvae may also feed on living tissues surrounding wounds. If feeding at overcrowded sites, larvae may need to sidestep from the rotten to the living tissue. Another reason could be seen in the facilitated access to the living tissue due to the fact that the wound is surrounded by healthy tissue and larvae do not need to break through the upper skin layer.

Table 1 Rain data taken from the weather station in detail

Date	Time	Rain (l/m^2)
September 2	10.15–10.30 p.m.	0.3
	10.30–10.45 p.m.	1.2
	10.45–11.00 p.m.	2.1
	11.00–11.15 p.m.	0.3
September 3	00.00–00.15 a.m.	0.6
	01.00–01.15 a.m.	0.3
September 5	03.15–03.30 p.m.	0.3
	03.30–03.45 p.m.	0.3
	04.00–04.15 p.m.	0.3
	07.30–07.45 p.m.	0.3
	09.30–09.45 p.m.	0.6
	09.45–10.00 p.m.	0.6
	10.00–10.15 p.m.	0.6
	10.15–10.30 p.m.	0.3
	10.30–10.45 p.m.	0.6
	10.45–11.00 p.m.	0.3
	11.00–11.15 p.m.	0.3

L. sericata is a common and ubiquitous blow fly species that is frequently reported to be involved in forensic homicide cases [30]. Concluding from the fact that this fly is also called the sheep blow fly [13], *L. sericata* is the main agent in cases of myiasis [31].

Because of the findings of the oldest maggots of *L. sericata* in each the genital and facial body region, the reported case shows the function of this fly species being involved in cases of myiasis as well as being one of the first settlers on corpses in Europe [13]. Weather and temperatures are thought to be the major factors affecting the oviposition of flies. It is reported that no oviposition takes place when it rains all day long [32], but in this special case, the skirt of the woman might have provided protection for the flies. We made the observation that flies do hide under the clothing of dead piglets under rainy conditions. Clothing may also restrict the loss of heat during unfavorable climatic conditions [3]. In this particular case, it was warm and also dry enough for flies to oviposit until the evening of September 2 before the rain set in.

We focused on the calculation of the first oviposition in each body region. By this and the fact that the egg laying behaviour of flies with forensic entomological importance is not fully understood yet, we, of course, cannot exclude that further ovipositions took place between the two calculated dates. Temperature and rain conditions were acceptable for the flies on September 4 and 6 during the day to lay some eggs in between the calculated times of oviposition.

Since maggots collected from the genital region were about 1 cm larger than the smaller larvae of this region without having transitional sizes, we calculated the age of the biggest maggots.

The body of the elderly woman showed no signs of relevant decomposition eliminating September 1 as the day of death. An assumed collapse of the woman, proved by the abrasions and bleedings, and a possibly unconscious state

could have resulted in the gathering of flies under the skirt providing direct access to the genital area for oviposition. The colonization of unconscious or even sleeping persons by blowflies has been reported by Khayat [33] and Goff [20]. Payne [34] stated that the decomposition odors became more noticeable after the rain. It should be considered that this could be also true for the odor of urine. Blowflies are mainly attracted by the early decomposition odor [13], whereas other flies are known to be attracted by the odor of both urine and feces and are less attracted to corpses themselves, as it is true for the lesser house fly, *Fannia canicularis* [14, 15]. The stench of urine coming up from the underpants and skirt of the elderly woman therefore could have served as an important factor in the infestation of the living woman since *L. sericata* is known for being attracted to excrement [29].

On September 6 and 7, when the temperatures rose and the rain became less, weather conditions became favorable for the flies to become active. After the rain has stopped on September 7, the flies might have laid eggs in the natural openings of the face. The face provides an easily accessible body region contributing soft tissues for the maggots to feed from. Since this body region does not provide any kind of protection for the files, an earlier oviposition of the face might have been prevented by the rain.

We suggest that when the body was found, some maggots already had hatched from eggs which have been laid in the face. Maggots do avoid light and might have been hidden in the natural orifices of the head. But inside the body bag during the transport to the institute as well as in the cooling chamber, it was dark. It is possible that this had let some of the maggots to come out from the inside of the head. Although we could observe this behaviour of larvae in pigs, we finally do not know why maggots started covering body parts instead of feeding inside the body under protected and moist conditions at all. In all probability, we can exclude that the maggots did further develop in the cooling chamber of the institute under 5°C. Due to the data of Grassberger and Reiter [21], no larval development takes place under this temperature [35].

Together with the forensic entomological results, it seems to be the most obvious scenario that the woman fell down, got unconscious, and died of lacking nutrition, water supply, as well as of a hypothermic state of some level [36]. Of course, other considerations might be also true such as that she has fallen after trying to urinate in the area of the gulley also explaining the position of the clothings of her lower body.

A sexual assault also had been considered but besides the position of the clothing, nothing was pointing to that theory.

Since forensic entomology is still not fully established in processing forensic cases, this case gives insights in the importance and the amount of different kinds of information the insects can give to the involved disciplines. In this case, the different locations of developing larvae helped to distinguish between the circumstances before and after death, giving an idea of its importance in cases of real neglect when fly larvae from a soiled genital region could give an idea of when the neglect has started and those, for example, from the facial region when death might have set in. In such cases statements of care attendants or caring relatives can be proofed.

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