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The nocturnal oviposition behaviour of blowflies (Diptera: Calliphoridae) in Central Europe and its forensic implications

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Abstract

Numerous factors may cause delayed colonisation of a corpse by blowflies, leading to a discrepancy between the entomologically determined post-mortem interval (PMI) and the time of death. Blowflies, for example, are considered to be inactive at night, however, published observations are contradictory. In the present study, several field experiments and one type of indoor experiment were conducted in summer of 2004 and 2005 in order to investigate the nocturnal ovipositional behaviour of blowflies. In the field, two types of bait, dead hedgehogs and fresh beef liver, were placed at night in different urban and rural locations in Frankfurt and in Munich, Germany. For the indoor-experiments beef liver was placed in small plastic boxes containing caged *Lucilia sericata* females in the evening and left overnight. At night, no ovipositon was observed in the field ($n = 51$, $T = 10$–24 °C). Nocturnal oviposition in complete darkness occurred in the plastic boxes in two of six cases ($T = 25$ °C). Considering the behavioural and physiological characteristics of flies we suggest that nocturnal oviposition of blowflies appears to be unlikely under natural conditions in Central Europe but may occur under certain circumstances, such as unusual high nightly temperatures and the presence of gravid flies with an appropriate arousal threshold.

Keywords: Forensic entomology; Blowflies; *Lucilia sericata*; Nocturnal ovipositon; Post-mortem interval; Central Europe

1. Introduction

The main application of forensic entomology is the estimation of the post-mortem interval (PMI) by identifying the necrophagous species present and calculating the age of the oldest immature insect stages feeding on a corpse [1–3]. An essential question is whether the dead body has been colonised by flies shortly after death or whether oviposition was delayed. Several factors may cause a delay in colonisation of a body by insects such as rain, low temperatures or hampered accessibility. The knowledge of these factors may improve the interpretation of entomological findings [4,5].

The diurnal activity pattern and the oviposition behaviour of blowflies at night are two other important aspects that are presently under discussion. Generally, calliphorid flies are considered to be inactive at night [6,7]. As a result, a victim killed during the night would not be colonised before the following morning. This may lead to a considerable discrepancy between the calculated PMI and the actual time of death of up to 12 h.

Few studies exist on the nocturnal activity and oviposition in blowflies, however, these report contradictory results. While Nuorteva [6], Haskell et al. [8], Tessmer et al. [9] and Spencer [10] did not observe any oviposition at night, Greenberg [11] as well as Singh and Bharti [12] found clear evidence for a nocturnal egg-deposition. Baldridge et al. [13] report limited nocturnal oviposition on a bloated pig at a lighted rural site. However, this was the case in only one out of numerous experiments. Recently, Wooldridge et al. [14] demonstrated a decrease in flight activity of two blowfly species in the laboratory, linked with reduced light intensity.

In the present study, experiments were conducted to investigate the nocturnal oviposition behaviour of blowflies in Central Europe.

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2. Materials and methods

Field experiments were carried out in Frankfurt am Main (50°07′18N, 8°52′50E) and in Munich (48°07′23N, 11°38′26E), Germany. All times given in this study are Central European Time (CET). In August 2004 (Table 1), five frozen hedgehogs (obtained from a station, where they died during hibernation) were thawed and placed at different urban and rural locations in Frankfurt at 10:30 p.m. (sunset between 08:25 and 08:56 p.m.). Before sunrise (at 04:30 a.m.) the baits were inspected for nocturnal oviposition. In the evening of the following day, shortly before sunset, the bait was inspected again to check for ovipositon during daytime. In addition in 2005 (May till September), samples of raw fresh beef liver (approximately 250 g) were placed out of each of 28 and 23 single nights, respectively (Table 1) at two urban locations in Frankfurt and/or Munich. The bait was placed out at 10:30 p.m. (sunset between 08:07 and 08:46 p.m.) on the ground of a site located in a garden near a hornbeam hedge (Munich), protected by a rodent cage (size: 46 cm × 29 cm × 23 cm) and on a window sill 2.5 m above ground, belonging to a terraced house with a small garden and mixed vegetation (Frankfurt), respectively. The next morning at 04:30 a.m., the liver was inspected for eggs. Each bait sample was left at the same place and inspected again before sunset.

For indoor experiments in the laboratory, a strain of *Lucilia sericata* was collected from a corpse at the Institute of Legal Medicine in Frankfurt in 2004 and was reared in a stock culture for 1 year. The colony was subject to an artificial diurnal rhythm of 14h light and 10h darkness at a constant temperature of 25 ± 1 °C. Bait was offered to 10–15 females (8–10 days old), which were caged in a clear plastic box (size: 19 cm × 11 cm × 14.5 cm), from 09:00 p.m. to 07:00 a.m. The box was ventilated by air holes. A wet sponge provided moisture and some sugar cubes provided food. During the placement of the bait the light was switched on for a period of about 1 min. The next morning, the liver was inspected for eggs. The gravid status of the flies used was confirmed at the end of the day by inspecting the bait for eggs again (Table 2). This experiment was performed six times.

3. Results and discussion

In 57 field and indoor experiments, oviposition was recorded on only two occasions at night in darkness, both times when caged females of *L. sericata* oviposited in the small plastic boxes in the laboratory at 25 °C, i.e. under unnatural conditions.

Table 1
Nocturnal oviposition (field experiments) on two types of carrion bait (in 2004: hedgehogs, ∼ 500 g; in 2005: beef liver ∼ 250 g) in Munich (Mu) and Frankfurt (Fr) "+": oviposition; "−": no oviposition; n.d.: not determined; ◑ = 22:30; ☼ = 04:30; night = 22:30–04:30; day = 04:30 following day–sunset; lighting conditions: source www.wunderground.com

Date	Oviposition				Temperature (°C)		Lighting conditions and comments
	Night		Day		◑/☼	◑/☼	
	Mu	Fr	Mu	Fr	Mu	Fr	
09/10 August 2004	n.d	−	n.d.	+	n.d.	24/18	Clear; waning moon
16/17 August 2004	n.d	−	n.d.	−	n.d.	19/18	Cloudy (rain on 17.08); waxing moon,
19/20 August 2004	n.d.	−	n.d.	+	n.d.	21/19	Clear; waxing moon
23/24 August 2004	n.d.	−	n.d.	+	n.d.	18/15	Slightly cloudy; waxing moon
24/25 August 2004	n.d.	−	n.d.	+	n.d.	18/15	Clear; first quarter of the moon
02/03 May 2005	−	−	n.d.	n.d.	∼18/∼15	20/15	Slightly cloudy; last quarter of the moon illuminated
13/14 May 2005	−	−	n.d.	n.d.	>10/<10	15/10	Clear; waxing moon
20/21 May 2005	−	−	n.d.	+	15/10	20/14	Cloudy; in the morning rain; waxing moon
03/04 June 2005	−	−	n.d.	n.d.	21/17	18/16	Cloudy; beginning rain at the morning; waning moon
08/09 June 2005	n.d.	−	n.d.	n.d.	n.d.	13/10	Clear; new moon
11/12 June 2005	n.d.	−	n.d.	n.d.	n.d.	13/10	Clear; waxing moon
13/14 June 2005	−	−	n.d.	n.d.	15/13	17/12	Clear; waxing moon
16/17 June 2005	−	−	+	n.d.	17/17	21/18	Cloudy (Mu)–clear (Fr); waxing moon
17/18 June 2005	−	−	+	+	19/18	22/20	Cloudy; waxing moon
20/21 June 2005	−	−	+	+	18/15	24/18	Clear; waxing moon
21/22 June 2005	−	−	+	+	20/18	24/20	Slightly cloudy; waxing moon; egg deposal at 6.00 a.m. (*L. sericata*)
22/23 June 2005	−	−	+	n.d.	19/15	23/16	Slightly cloudy; full moon
24/25 June 2005	−	−	+	n.d.	22/22	24/22	Clear; partly windy; waning moon; temperature. at 24:00:24 °C
26/27 June 2005	−	−	+	+	20/19	22/16	Clear; waning moon
27/28 June 2005	−	−	+	+	22/21	24/20	Clear; waning moon
28/29 June 2005	−	−	+	n.d.	21/19	24/21	Slightly cloudy; waning moon
03/04 July 2005	−	−	+	+	20/14	23/17	Slightly cloudy; waning moon
14/15 July 2005	−	−	+	+	18/15	23/18	Clear; waxing moon
15/16 July 2007	−	−	+	+	22/17	23/18	Slightly cloudy; first quarter of the moon
17/18 July 2005	−	−	+	n.d.	21/16	22/16	Slightly cloudy; waxing moon
18/19 July 2005	n.d.	−	n.d.	+	n.d.	24/20	Cloudy; waxing moon
19/20 July 2005	n.d.	−	n.d.	+	n.d.	19/17	clear; waxing moon
23/24 July 2005	n.d.	−	n.d.	n.d.	n.d.	19/12	clear; waning moon
26/27 July 2005	−	−	+	n.d.	18/15	20/18	Clear (Mu)–cloudy (Fr); waning moon
27/28 July 2005	−	−	+	n.d.	21/17	24/21	Clear (Mu)–stormy (Fr); waning moon,
28/29 July 2005	−	−	+	n.d.	24/20	24/20	Clear; waning moon
31 August 2005/01 September 2005	−	n.d.	+	n.d.	21/16	n.d.	Clear; waning moon
01/02 September 2005	−	n.d.	+	n.d.	20/18	n.d.	Cloudy; waning moon