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## Activity and behavior of blowflies on pig liver baits in spring

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Blowflies were attracted to baited traps with fresh, 2-days- or 4-days-old pieces of pig liver during nine days of experiments (April to May 1999). Among the 451 specimens collected, seven species of Calliphoridae were identified. Weather, as expressed by rain, temperature and solar radiation has a significant influence on flies activity. With the exception of *Lucilia sericata* and *L. illustris*, most species showed a clear preference for 4-days-old liver. Sex-ratio was always in favor of females varying from 1.7:1 (*L. silvarum*) to 18.8:1 (*L. illustris*).

Des pièges attractifs contenant du foie frais et du foie âgé de 2 et 4 jours ont été utilisés au cours de 9 journées de capture (avril à mai 1999). Parmi les 451 spécimens récoltés, 7 espèces de Calliphoridae ont été identifiées. Les conditions météorologiques, exprimées par la pluie, la température et les radiations solaires, ont une influence significative sur l'activité des mouches. A l'exception de *Lucilia sericata* et *L. illustris*, les autres espèces montrent une nette préférence pour les pièges contenant du foie de 4 jours. Le sex-ratio est toujours en faveur des femelles et varie de 1.7:1 (*L. silvarum*) à 18.8:1 (*L. illustris*).

Keywords: Calliphoridae, blowflies, pig liver, decomposition stage, attraction, sex-ratio, forensic entomology.

### INTRODUCTION

After death, animal tissues are attractive to a number of insects and other invertebrates (Smith 1986). Moreover, insects, primarily blowflies (Diptera, Calliphoridae), are attracted within minutes, to human corpses (Nuorteva 1977; Leclercq 1978; Erzinçlioğlu 1983, 1996). Since blowflies are of great forensic importance in determining postmortem interval (see Faucherre et al. 1999; Anderson 2001; Wells & Lamotte 2001; Wyss et al. 2003) it is essential to determine conditions under which blowflies are active and to understand their biology and behavior.

Blowflies are the first to colonize corpses and can be attracted over great distances (MacLeod & Donnelly 1963). They detect carcasses primarily by odor, but the attractiveness varies with the degree of decomposition (Nuorteva 1977). For example, some species such as *Calliphora vicina* Robineau-Desvoidy, 1830 prefer decomposed remains to fresh when given a choice (Erzinçlioğlu 1996). In England, *Lucilia illustris* (Meigen, 1826) was not attracted to corpses in woodland until 76 hours after death, or to corpses in open grassland until 48 hours after death (Lane 1975). However this seems not to be the case in British Columbia where *L. illustris* was found on pig carrion in open pasture within minutes after death (Anderson & VanLaerhoven 1996).

The aims of our study are to get information on blowflies diversity and abundance in an open area in spring, to evaluate the impact of meteorological conditions on blowflies activity and to compare attractiveness of different stages of tissue decomposition.

## MATERIAL AND METHODS

### *Trapping and baiting*

We used traps based on Upton's model (1991) modified by Faucherre (in Faucherre & Cherix 1998). Flies are collected in traps made of two joined plastic boxes with removable bottom containing the bait. After entering the trap through lateral funnels (with a diameter of 1 cm), flies are directed upwards to the receiving container from which they are unable to escape.

Pieces of pig liver were collected early in the morning at the city abattoir. Fresh liver was separated into portions of approximately 200g each. One fresh portion was used the same day while two other portions were stored at constant temperatures (15°C) for 48 and 96 hours. These portions were used later as 2- and 4-days-old baits.

Nine traps were placed in a meadow of the University campus (University of Lausanne, Switzerland: N. 46°30' E. 6°33') set 50 m apart. For each experiment, three traps contained fresh liver, three 2-days-old liver and three 4-days-old liver. A randomized procedure was used to decide the type of bait in each trap. Nine experiments (9 a.m. to 5 p.m.) were conducted between April and May 1999. We obtained meteorological data (radiation and mean temperature) from the nearest local weather station (Pully) about 5 km away. At the end of each experiment flies were killed with ethyl acetate, identified (Rognes 1991), sexed and mounted for collection. The material is deposited in the entomological collection of the Museum of Zoology in Lausanne.

### *Statistical methods*

The effects of radiation and temperature were tested using a regression test with 5% confidence interval. Liver age is considered as category variable and its influence on each species collected has been tested via an ANOVA with 5% confidence interval.

We used binomial test to determine whether the observed sex-ratio for each species is significantly different from the expected 1:1.

## RESULTS

A total of 451 blowflies belonging to three genera and seven species of Calliphoridae were captured during the nine days of experiments. Captures are summarized in Tab. 1. Because of a single capture of *Calliphora vomitoria* (Linnaeus, 1758) this species was dropped from the analyses. Forty-one flies belonging to the family of Sarcophagidae have also been collected, but were ignored here.

One species is dominant (*Lucilia silvarum* [Meigen, 1826]); three are rather abundant (*C. vicina*, *L. sericata* [Meigen, 1826] and *L. illustris*), the other species are rare or very rare like *C. vomitoria*.

Tab. 1. Number of captured flies of seven different species in traps baited with pieces of pig liver at different decomposition stages (zero, 2 and 4 days after death) in an open field (University campus in Lausanne) in spring 1999. For each trapping day, nine traps are disposed for a period of 8 hours (9 a.m. to 5 p.m.)

Days	28.04.99			30.04.99			05.05.99			07.05.99 sunny + stormy			12.05.99			14.05.99			19.05.99			21.05.99			27.05.99				
Weather	cloudy			cloudy			cloudy			cloudy			cloudy			rainy			cloudy			sunny							
Radiation (J/m <sup>2</sup> )	1558			1697			1717			2162			420			539			1030			962			2561				
Mean temperature (°C)	13.5			13.8			16.9			16.9			17			15.4			14.4			12.8			20.6				
Age of liver (d)	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	N	
<i>Calliphora vicina</i>		2	6	2	2	3	2	8	2	1	13			2								1	2		2	2	9	<b>59</b>	
<i>Calliphora vomitoria</i>		1																										<b>1</b>	
<i>Cynomyia mortuorum</i>			3		1			2			1	4						1								1	2	5	<b>20</b>
<i>Lucilia sericata</i>							2	2	1	1	8	8	1		1									1		28	12	21	<b>86</b>
<i>Lucilia silvarum</i>				1			1	6	3	4	2	32	1	1	4								5	4	38	16	70	<b>188</b>	
<i>Lucilia illustris</i>							9	5	6	2	8	18					1						1		9	5	15	<b>79</b>	
<i>Lucilia caesar</i>							1	1		1	5															2	1	7	<b>18</b>
<b>Total</b>	<b>0</b>	<b>3</b>	<b>9</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>14</b>	<b>24</b>	<b>13</b>	<b>8</b>	<b>20</b>	<b>80</b>	<b>2</b>	<b>1</b>	<b>7</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>9</b>	<b>4</b>	<b>80</b>	<b>38</b>	<b>127</b>	<b>451</b>	

Tab. 1 shows that rain prevents fly activity. Statistical analyses (see Tab. 2) of influence of radiation and temperature showed a clear dependence of flies on both factors with less statistical significance in the second variable (temperature).

With the exception of *L. sericata* and *L. illustris* which did not show any age preference, all other species captured are influenced by bait categories (0-, 2- or 4-days-old).

Sex-ratio (Tab. 3) is either extremely variable running from 1.7:1 (*L. silvarum*) to 18.8:1 (*L. illustris*). With the exception of *Cynomyia mortuorum* (Linnaeus, 1761) probably due to the low number of specimens, all species show a biased sex-ratio towards females.

Tab. 2. Results of the regression testing meteorological conditions and of the multivariate analysis testing the effects of the decomposition stage of the liver on the number of flies captured for each species.

Variable:	radiation	temperature	age of liver
Satistical test:	regression (5%)	regression (5%)	ANOVA (5%)
<i>Calliphora vicina</i>	<b>p &lt; 0.001</b>	<b>p = 0.049</b>	<b>p = 0.009</b>
<i>Cynomyia mortuorum</i>	<b>p &lt; 0.001</b>	<b>p = 0.005</b>	<b>p = 0.040</b>
<i>Lucilia sericata</i>	<b>p &lt; 0.001</b>	<b>p &lt; 0.001</b>	NS
<i>Lucilia silvarum</i>	<b>p &lt; 0.001</b>	<b>p &lt; 0.001</b>	<b>p = 0.013</b>
<i>Lucilia illustris</i>	<b>p &lt; 0.001</b>	<b>p &lt; 0.001</b>	NS
<i>Lucilia caesar</i>	<b>p &lt; 0.001</b>	<b>p &lt; 0.001</b>	<b>p = 0.016</b>

## DISCUSSION

All captured species belong to the Swiss fauna (see Merz et al. 1998). They are all heliophilous species typical of open fields. Comparing this diversity with

Tab. 3. Sex ratio and relative frequency of the different captured species of blowflies.

	# f	# m	sex ratio	binom. test	rel. freq
<i>Calliphora vicina</i>	50	9	5.6 : 1	<b>p &lt; 0.001</b>	13.1%
<i>Calliphora vomitoria</i>	0	1	-	-	0.2%
<i>Cynomyia mortuorum</i>	14	6	2.3 : 1	NS	4.4%
<i>Lucilia sericata</i>	62	24	2.6 : 1	<b>p &lt; 0.001</b>	19.1%
<i>Lucilia silvarum</i>	118	70	1.7 : 1	<b>p &lt; 0.001</b>	14.7%
<i>Lucilia illustris</i>	75	4	18.8 : 1	<b>p &lt; 0.001</b>	17.5%
<i>Lucilia caesar</i>	15	3	5 : 1	<b>p &lt; 0.001</b>	4.0%

other studies (Faucherre & Cherix 1998; Wyss & Cherix in prep.) in a nearby area (10 km away at an altitude of 800 meters for the study of Faucherre & Cherix) reveals no big differences except for two species which were not observed here (*Calliphora loewi* Enderlein, 1903 and *Lucilia ampullacea* Villeneuve, 1922). These two species are rather rare in open field and *C. loewi* probably occurs only later in the season. Nevertheless in our study all species occur approximately one month earlier. This is due to altitude that is 450 m lower and to the proximity of Lake Geneva that temperates local climate.

Local weather conditions are responsible for the activity of blowflies. Flight activity for all collected species is highly correlated with temperature and solar radiation. Influence of temperature seems to be less important for *C. vicina* and *C. mortuorum*. This could be explained by the fact that they are both bigger than the other captured species. Moreover, Meyer & Schaub (1973) demonstrated that *Calliphora* species have a higher metabolic rate for identical temperatures compared to the genus *Lucilia*.

The influence of weather conditions as studied by Nuorteva (1959b) in Finland may be easily generalized in our case, except for the lower limiting activity temperature of 16°C on cloudy days in Finland, which is rather different in our case (10°C for *C. vicina*, 12°C for *L. caesar* [Linnaeus, 1758], C. Wyss, pers. com.).

More than half of the captured flies were caught in baits with 4-days-old liver. This is confirmed by the ANOVA statistical test except for *L. sericata* and *L. illustris* which show no preference. In our experiment 4-days-old liver was more attractive than fresh liver even if individuals of each species were found on fresh liver a couple of hours after trapping started.

Our experiment is somewhat unique because of our trapping system and the limited size of the bait. Nuorteva (1959b) showed that carcass size has an influence on the number of attracted flies. *C. vomitoria* is less attracted by small carrion (Nuorteva 1959b; Davis 1990). Experiments on pig carrion (C. Wyss, unpublished) showed that *Calliphora* species (*C. vicina* and *C. vomitoria*) are among the first to colonize.

Concerning sex-ratio, females are clearly more numerous on carrion and in traps than males. Numerous hypotheses have been cited to explain this biased sex ratio documented by MacLeod & Donnelly (1957) and Nuorteva (1959a, 1959b). This could be partly due to the fact that females are looking for suitable places to lay eggs (Smith 1986). But adult females may also be interested in having a protein meal for the maturation of their eggs. The fact that males are also present in significant number (26%) on the substrate may indicate that the bait could be used either as a mating place or a food source. But compared to the study of Faucherre (1997), we collected a rather high proportion of males except for *L. illustris*. This could be explained by the fact that in spring males, which are short-living, are still abundant and looking for females. Later in the season as shown by Faucherre, most of the females collected are gravid. This is also the tendency found by MacLeod & Donnelly (1957) for the same species, males having slightly different habitat preferences. There is one interesting fact concerning *C. mortuorum*. According to Faucherre (1997), males are always more abundant in traps than females which are not gravid. In our experiment, due to small sample, this is the only species with no statistical difference between males and females caught.

These results are not to be generalized to any piece of large remains or carrion. The size of the substrate is a factor that influences the entomofauna found on a decomposing corpse (Mégnin 1894). On the other hand, baits and trapping sys-

tem used in this experiment do not allow competition between species and/or individuals as shown by Smith & Wall (1997). Under natural conditions the smaller flies like *Lucilia* species are probably ousted by large flies like *Calliphora vicina* or *Sarcophaga* species (C. Wyss, unpublished). Nevertheless this study showed the clear influence of weather conditions and the diversity of Calliphoridae of forensic importance.

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