African Invertebrates 58(1): 1–8 (2017)
doi: 10.3897/AfrInvertebr.58.9537
http://africaninvertebrates.pensoft.net

RESEARCH ARTICLE

African Invertebrates

The temporal occurrence of flesh flies (Diptera, Sarcophagidae) at carrion-baited traps in Grahamstown, South Africa

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Academic editor: *B. Muller* | Received 13 June 2016 | Accepted 5 January 2017 | Published 18 January 2017

http://zoobank.org/61C10542-0AB9-4A14-B597-A4E051A585AC

Citation: Villet MH, Clitheroe C, Williams KA (2017) The temporal occurrence of flesh flies (Diptera, Sarcophagidae) at carrion-baited traps in Grahamstown, South Africa. African Invertebrates 58(1): 1–8. doi: 10.3897/AfrInvertebr.58.9537

Abstract

Eleven species of flesh fly were identified in a sample of 737 specimens captured during fortnightly trapping at three sites in Grahamstown, South Africa, over a year. *Sarcophaga africa* Wiedemann, 1824, *S. inaequalis* Austen, 1909, *S. exuberans* Pandellé, 1896 and *S. tibialis* Macquart, 1851 showed well-defined peaks between early October 2001 and late April 2002, and only *S. africa* was trapped at other times of year. These peaks occurred when average minimum and maximum ambient air temperatures were above 12°C and 22°C, respectively, and showed no obvious relationship to rainfall. There were indications of population cycles in all of these species. *Sarcophaga hera* Zumpt, 1972, *S. arno* Curran, 1934, *S. inzi* Curran, 1934, *S. langi* Curran, 1934, *S. freyi* Zumpt, 1953, *S. nodosa* Engel, 1925 and *S. samia* Curran, 1934 were too scarce to assess their patterns of occurrence rigorously. Insects attending a corpse are reputed to assist forensic entomologists in estimating the time of year when the body died. Some flesh flies provide more precise estimates than others, so several species should be used for cross-validation. Insect activity at a corpse depends on the weather, so that presence of a species indicates particular environmental conditions and not simply calendar dates (particularly if climate changes). Absence of a species is not necessarily evidence of specific conditions because species may not be present at all sites simultaneously, populations cycle even when their members are active, and low population densities may hamper detection of a species.

Keywords
Sarcophagidae, seasonality, weather, population dynamics, forensic entomology

Introduction

Texts about forensic entomology claim that the presence of certain insects on a corpse may provide information about the time of year when the corpse died (Smith 1986, Byrd and Castner 2010, Fremdt and Amendt 2014). A text-book example is the presence of winter gnats (Trichoceridae) that implies that an associated body died in winter (Smith 1986). Louis Bergeret used the presence of (*inter alia*) eclosed puparia of the flesh fly *Sarcophaga carnaria* (Linnaeus, 1758) on an infant's corpse to infer that the child had died two summers previously (Bergeret 1855), and *S. carnaria* has been deemed a particularly useful species in this context (Szpila et al. 2015). Flesh flies also have acknowledged medical, veterinary and forensic importance (e.g. Sukontason et al. 2007, Cherix et al. 2012, Fremdt and Amendt 2014), but little is known about their biology in southern Africa (Zumpt 1965, 1972, Aspoas 1991, Villet et al. 2006), so that such forensic evidence requires validation before it can be deployed in practice.

A year-long carrion fly monitoring programme in Grahamstown provided an opportunity to explore whether southern African flesh flies might be relevant in this context. Assuming that the flies that are attracted to the carrion used to bait the monitoring traps are representative of the flies likely to colonise a corpse, these data can be used to test the assumption that particular species of flesh fly are attracted to corpses during only specific times of year. It can also be hypothesised that flesh flies are active only at these times of year because that is when environmental conditions such as temperature lie between physiological thresholds for activity (cf. Richards et al. 2009a).

Materials and methods

Three sites were monitored (Table 1), corresponding to Sites 5, 6 and 8 of the study by Williams (2003). At each site a Redtop fly trap (Miller Methods, Ltd.), modified as described by Richards et al. (2009b), was suspended from a 0.2 m-long horizontal arm at the top of a 1.2 m long metal pole planted into the ground to standardise the height of the traps. The traps were placed in open areas exposed to direct sunlight for most of the day. About 125 g of chicken liver was placed in each trap, which was left in the field for four days at fortnightly intervals from May 2001 to June 2002. At the end of each four-day period, the catch was chilled to 4°C, removed from the trap and preserved in 95% ethanol. The flies were then identified using the key and illustrations published by Zumpt (1972). Rainfall and temperature data for Grahamstown (station Grahamstown 0056917 8; 33°17'26"S 26°30'8"E) during the trapping period were provided by the South African Weather Service.

Table 1. Locations and characteristics of monitoring sites.

Site	Location	Specimens	Characteristics
5	33°18'24"S, 26°31'30"E	291	Suburban middle-income residential; sparsely vegetated; 4 dogs, 1 cat; neighbouring properties similar
6	33°18'56"S, 26°31'46"E	340	Suburban middle-income residential; well vegetated; 1 dog, ~20 geese; neighbouring properties similar but lacking geese
8	33°16'29"S, 26°34'59"E	106	Quasi-rural low-income residential; sparsely vegetated; dogs, cats donkeys, cattle, goats and chickens common in area

Results

The traps yielded 737 specimens, mainly from Sites 5 and 6 (Table 1), but catches were more consistent at Site 5. There was a sharp increase in captures (to about 80 flies/month) in October 2001, and a similar decrease in April 2002 (Fig. 1B), with fewer than 15 captures/month in other months. The weather during the trapping period was warm in summer, cool in winter and had bimodal rainfall (Fig. 1A). The peak of fly captures corresponded to a period when the average minimum and maximum ambient air temperatures were above 12°C and 22°C, respectively (Fig. 1). No finer correspondence between trapping success and either rainfall or ambient temperature was obvious (Fig. 1A), and concurrent catches were weakly correlated between sites (Figs 1 and 2). There was a very sharp, transient and inexplicable crash in trapping success in early March 2002 (Fig. 1B).

Females (481 specimens) dominated the sample but generally could not be identified because the taxonomy of flesh flies relies heavily on the form of the male genitalia (Zumpt 1972). Because of their numerical dominance, the temporal pattern of occurrence of females (Fig. 1D) was similar to that of the total sample. The occurrence of males (Fig. 1C) was similar to that of females in terms of the general period of activity and cycling, although the peaks in their cycle did not match those of the females exactly.

Males of 11 species of *Sarcophaga* were caught, six of them quite commonly (Fig. 2) and five in very low numbers that were insufficient for meaningful quantitative analysis (Table 2). A particular species was sometimes present at one site and simultaneously absent at another, e.g. *S. africa* in mid-November (Fig. 2A). There were generally very few flesh flies at Site 8 at any time, even when they were more common elsewhere (Figs 1 and 2).

About 85% of the sample was made up of four species: *S.* (*Bercaea*) *africa* Wiedemann, 1824 (103 males, 40%; Fig. 2A), *S.* (*Bercaea*) *inaequalis* Austen, 1909 (52 males, 20%; Fig. 2B), *S.* (*Thrysocnema*) *exuberans* Pandellé, 1896 (36 males, 14%; Fig 2C) and *S.* (*Curranea*) *tibialis* Macquart, 1851 (29 males, 11%; Fig. 2D). *Sarcophaga africa* was present year-round, although in small numbers outside the October to April season. Occurrences of *S. inaequalis*, *S. exuberans* and *S. tibialis* were restricted to the October to April window of activity, and the same might be true of *S.* (*Liopygia*) *hera* Zumpt, 1972 (Fig. 2E) but the sample is too small (15 males) to be certain. There is an

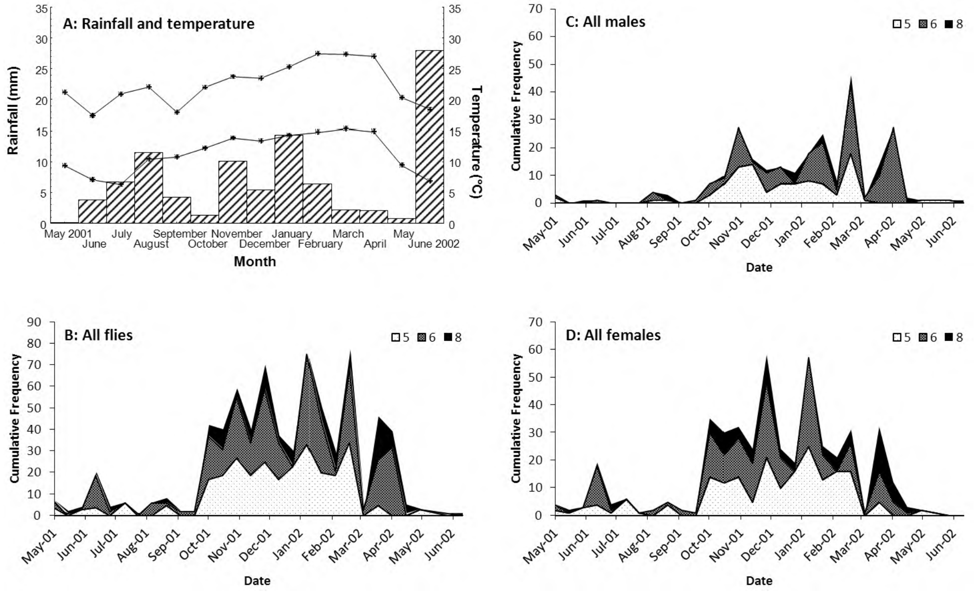

Figure 1. A Average rainfall histogram and mean minimum and maximum temperatures during the study period **B–D**: Captures of **B** all specimens **C** all male specimens and **D** all females of all species of flesh fly at carrion-baited traps in Grahamstown. The frequencies at each date are composed of subtotals from the three sites (Sites 5, 6, and 8) described in Table 1.

Table 2. Occurrence of males of flesh fly rarely collected at carrion-baited traps in Grahamstown. The three capture sites are described in Table 1.

	Species				
Date	***S. freyi***	***S. inzi***	***S. langi***	***S. nodosa***	***S. samia***
04 May 2001	-	-	-	1	-
19 October 2001	-	1	-	-	-
11 January 2002	-	1	-	-	-
25 January 2002	-	-	-	-	1
22 February 2002	1	-	-	1	-
05 April 2002	-	1	3	-	-
Capture site	Site 6	Site 6	Site 6	Site 5	Site 8

indication that *S.* (*Bercaea*) *arno* Curran, 1934 might be most active in the dryer warm months (Fig. 2F), but again the sample (11 males) is too small to judge. The remaining species, *S.* (*Thrysocnema*) *inzi* Curran, 1934 (3 males), *S.* (*Prionophalla*) *langi* Curran, 1934 (3 males), *S.* (*Prionophalla*) *freyi* Zumpt, 1953 (2 males), *S.* (*Thrysocnema*) *nodosa* Engel, 1925 (2 males) and *S.* (*Scotathyrsia*) *samia* Curran, 1934 (1 male) were possibly only incidental captures, and their presence could not be interpreted in terms of the forensic hypothesis examined here (Table 2).

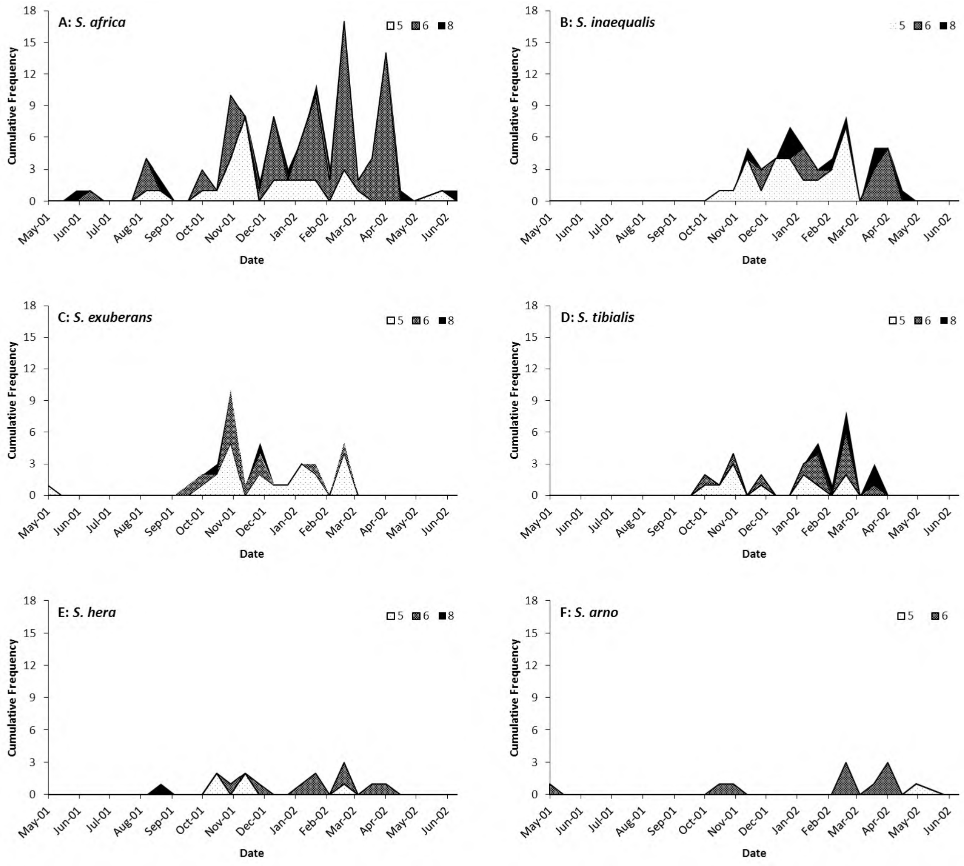

Figure 2. Occurrence of males of six species of flesh fly collected commonly at carrion-baited traps. **A** *S. africa* **B** *S. inaequalis* **C** *S. exuberans* **D** *S. tibialis* **E** *S. hera* **F** *S. arno*. The frequencies at each date are composed of subtotals from the three sites (Sites 5, 6, and 8) described in Table 1.

Discussion

The results suggest that adults (and more particularly larvae and pupae) of at least five species of flesh fly that occur in the Grahamstown area of South Africa can provide evidence of the time of year when a corpse died. Assumptions underlying this are that the identity of males reflects that of the morphologically unidentifiable females, and that the species attracted to decaying chicken liver are also attracted to corpses. Neither of these assumptions is unreasonable, but both require validation by data from corpses. Female-biased sex ratios were also observed in Japanese, Spanish and some Polish species of sarcophagids (Tachibana and Numata 2006, Martín-Vega and Baz 2013, Szpila et al. 2015), while other Polish species were male-biased (Szpila et al. 2015), which might reflect a difference in the food preferences or mate-seeking strategy of the sexes (Martín-Vega and Baz 2013, Szpila et al. 2015). Forensic inferences based on larvae and pupae need to take females' activity periods into account.

The data also indicate that the period of activity of the flies is defined by at least a lower threshold temperature for activity, and that this threshold is similar between species. A similar result was found in the sarcophagid community in Osaka, Japan (Tachibana and Numata 2006). Experiments with blow flies (Nicholson 1934, Norris 1966, Richards et al. 2009a, , Matuszewski et al. 2014) and other insects (Christian and Morton 1992, Sanborn and Phillips 1996, Williams 2003, Sanborn et al. 2003) showed that physical activity is not possible below a threshold temperature, and the promptness with which insects arrive at a carcass can be related to ambient temperatures above a characteristic threshold (Michaud and Moreau 2009, 2011, Matuszewski and Szafalowicz 2013, Matuszewski et al. 2014). Similarities in such thresholds of different species may arise from close phylogenetic relationships (Richards et al. 2009a) or biogeographical adaptation.

The lack of finer correlation between trapping rates and ambient temperatures can be ascribed to population cycles and to thermoregulation by the flies. The 4-6 week fluctuations in trapping success reported here correspond to the length of development of flesh flies (Villet et al. 2006), and may reflect population cycles that are coordinated by the onset of suitable weather conditions for activity and breeding of the flies. Flesh flies thermoregulate by basking and taking refuge in protected microhabitats, which offers them some independence from ambient temperatures once they are warm enough to be active.

From a forensic perspective, these results have several implications. First, the idea that the time of year when a death occurred can be estimated from the insects present is apparently validated, but the evidence of physiological threshold for activity (e.g. Nicholson 1934, Norris 1966, Richards et al. 2009a, Matuszewski et al. 2014) imply that the period when a species may be expected to occur at a corpse is more probably contingent on the weather, for which ambient temperature is a biologically logical proxy, and time of year is only an indirect correlate of weather if the climate is stable. The presence of a species should therefore be interpreted as indicating particular environmental conditions and not simply a calendar date.

Second, some species are better indicators of particular environmental conditions than others, and data from different species should be used to cross-validate one another.

Finally, the absence of a particular species is not necessarily robust forensic evidence for at least three reasons: a species may simultaneously be present at one site and absent at another, populations may cycle even when a species is active, and low population densities may lead to a failure to detect a species (Fig. 2).

Acknowledgements

We thank Thomas Pape for his generous assistance to CLC in identifying the specimens. Krzysztof Szpila and our reviewers for their constructive feedback; the South African Weather Service for providing data; and the National Research Foundation (NRF) of South Africa for research funding. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Research Foundation.

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