Unidirectional dispersal of blow fly larvae following decomposition fluids from a pig carcass

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The decomposition of a body, and the associated gaseous and liquid discharges emanating from it, attract gravid female blow flies which lay their eggs in or on the body. After the eggs have hatched, the emerging larvae start feeding on the body. As decomposition progresses, the blow fly larvae often migrate away, typically in a random manner in search of favourable conditions for pupation. In this paper, we report on a rarely described phenomenon of unidirectional mass migration of blow fly larvae and postulate on the factors which may drive this process. A decomposition trial utilising a 60-kg pig carcass, deployed in the summer months in Table Mountain National Park, Cape Town, South Africa, was conducted in 2022. On the fifth day of the trial, simultaneous unidirectional mass dispersal of blow fly larvae was observed. The larvae moved downhill in a southeasterly direction, following the flow of decomposition fluids oozing out from the pig carcass. The 'larval migration stream' had a length of approximately 1.5 m with a width of 40 cm, tapering to 17 cm at the terminal point. The larval migration stream consisted of the larvae of *Chrysomya albiceps* and *Chrysomya chloropyga*. This study demonstrates the importance of understanding the timing and pattern of dispersal of post-feeding blow fly larvae in each geographical region. This is crucial as the minimum post-mortem interval can be miscalculated if older immature insects dispersing from the corpse are not considered and collected during crime scene investigations.

Significance:

- Understanding the timing and pattern of dispersal of blow fly larvae from decomposing vertebrate remains in each geographical region is important in time-since-death estimations when using entomological evidence.
- In the summer season of the Western Cape Province, *Chrysomya albiceps* and *Chrysomya chloropyga* are among the blow fly species of forensic importance as they deposit their eggs on vertebrate remains.
- When a decomposing body is found within the Table Mountain region, we suggest that crime scene investigators should examine the downhill area of the scene for larval/pupal entomological evidence that can assist in time and season of death estimations.

Introduction

In December 2022, during a summer decomposition and insect successional trial of a 60-kg adult-sized pig carcass within Table Mountain National Park, intense blow fly larval activity and feeding was observed on the fifth day in the head and neck regions (Video 1[1]). A close observation of the carcass revealed substantial loss of soft tissues in these regions (Figure 1a). Massive larval activity and feeding were further observed on and in the upper region of the abdomen and forelimbs (Figure 1a). Unexpectedly, a unidirectional mass dispersal of the blow fly larvae was observed in the area directly behind the head and neck regions (Figures 1b, 2a and 2b). The blow fly larvae moved downhill in a southeasterly direction following the flow of the decomposition fluids oozing out from the carcass (Figures 1b, 2a, 2b and Video 2[2]). The 'larval migration stream' had a length of approximately 1.5 m with a width of 40 cm, tapering to 17 cm at the terminal point (Figure 1b). The predominant wind direction and average wind speed from the previous sampling time (i.e. 12:00) on the fourth day until the time the observation was made on the fifth day were south-southwest and 4.82 m/s, respectively.

Composition of the 'larval migration stream'

The 'larval migration stream' consisted of the larvae of *Chrysomya albiceps* Weidemann 1819 (Diptera: Calliphoridae) and *Chrysomya chloropyga* Weidemann 1818 (Diptera: Calliphoridae). Their identities were established in situ and by the collection of a subsample of 5–10 eggs and larvae on and around the decomposing pig carcass, after which they were taken to the Forensic Entomology Laboratory at the University of Cape Town for further processing. The larvae of *Ch. albiceps* were identified by the presence of fleshy protuberances on their abdominal segments.[3] The eggs/larvae of *Ch. chloropyga* were reared to adulthood on minced pig liver in a climate chamber.[4] After the emergence of the adult flies, the insects were killed by gassing in a killing jar containing paper towels dampened with ethyl acetate.[4] Thereafter, species identity was confirmed using the identification keys in Lutz et al.[5] The immature stages of these two blow flies have been reported on decomposing human cadavers and animal carcasses during the summer in South Africa.[4,6,7]

Discussion

Shortly after death, a vertebrate's body undergoes a series of physicochemical changes known as decomposition.[8] As these changes progress, dipterous insects belonging to the family Calliphoridae become attracted to the body as first colonisers, arriving within minutes, hours, or days.[4,9-12] These insects are attracted to the vertebrate remains by the volatile organic compounds associated with the gases and decomposition fluids emanating from the body. After their arrival, gravid female flies oviposit in or close to natural body openings or skin lesions, between the limbs and/or

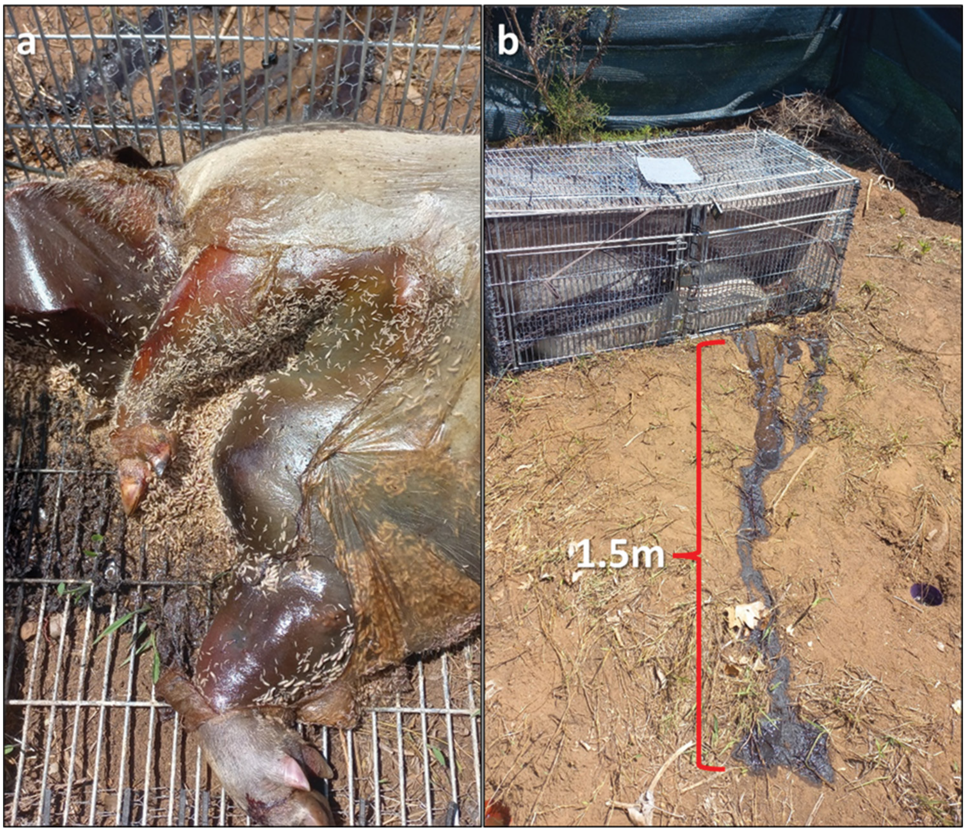

Figure 1: (a) Larval activity and feeding on the soft tissues in the head, neck, forelimbs, and upper abdominal regions of the pig carcass. (b) Downhill dispersal of blow fly larvae together with the decomposition fluids in a southeasterly direction on the fifth day of the experimental trial in summer.

Figure 2: Close-up views of some larvae (a) at the starting point and (b) further down the stream of the decomposition fluids oozing out from the pig carcass.

underneath the vertebrate remains, after which the emerging larvae start feeding on the body.[9,11,13]

Upon reaching the transition from third instar feeding to third instar post-feeding stage, the larvae begin to disperse individually or en masse from the decomposing carcass into the surrounding environment in random and sometimes specific directions.[10,12 14,15] This characteristic movement – termed post-feeding larval dispersal – has been hypothesised to be due to the depletion in food resources by vertebrate and invertebrate scavengers, competition with other larvae, completion of the larval stage, saturation of the surrounding soil by rainfall and decomposition fluids, movement triggered by other larvae, and/or avoidance of predation or parasitism.[10,12,14-16] Consequently, the larvae disperse in search of either another food source in the absence of enough food reserves needed for the next stage called pupariation, or suitable pupariation sites.[14,17]

Other factors such as temperature, humidity, wind, moisture availability, luminosity, photoperiod, and soil compactness play important roles in the dispersal pattern of fly larvae.[10,14] There are at least four published reports on the unidirectional dispersal of significant numbers of blow fly larvae from vertebrate remains under natural conditions.[10,12,15,17] However, we are not aware of any decomposition studies within Africa that have documented the unidirectional dispersal of blow fly larvae from decomposing vertebrate remains. Also, studies documenting the coordinated dispersal of blow fly larvae in the direction of the flow of the decomposition fluids oozing out from vertebrate remains are scarce. Thus, we report here a rarely described phenomenon of unidirectional mass migration of blow fly larvae in the direction of the flow of the decomposition fluids from a pig carcass within the Table Mountain National Park of the Western Cape Province of South Africa.

In this study, the observed synchronised and unidirectional migration of blow fly larvae in the direction of the flow of decomposition fluids was unusual as we had not observed it in all our previous trials on neonate ($n = 12$) and adult pig carcasses ($n = 1$) in different seasons within the same study area.[4] As with Goddard et al.[15], it is important that we highlight the possibility of missing out on the timing of the mass dispersal of blow fly larvae during our previous decomposition trials within the study location by virtue of our sampling time, which was variable and at most ~2 hours for every sampling day.

We attribute the downhill mass migration of blow fly larvae together with the decomposition fluids in a southeasterly direction to the topography of the study site and associated force of gravity.[12,14] While it was not categorically stated, it seems that in Lashley et al.'s[12] study, the millions of blow fly larvae from a location containing a 725-kg carrion biomass, dispersed downhill in a synchronised manner and in a unified direction. Secondly, we speculate that the coordinated dispersal of blow fly larvae in the direction of flow of the decomposition fluids may be one of the mechanisms employed by blow fly larvae to escape the saturated environment, to reduce the rate of desiccation and to enable them to travel easily and further away from the food source during their post-feeding migratory period.[10,14,15]

The downhill mass dispersal of blow fly larvae together with the flow of the decomposition fluids emanating from a carcass, increases the area of the cadaver decomposition island, which in turn can complicate the location of clandestine cadaver deposition sites, especially when human cadaver detection dogs are utilised.[12,18,19] In fact, a follow-up study revealed that the electrical conductivity in the soil within the dispersal trail of the blow fly larvae and decomposition fluids (mean ± standard deviation: 220.4 ± 102.4 µS/cm) was significantly higher than those of the control soils (mean ± standard deviation: 117.6 ± 30.8 µS/cm).[20] While the design of the study from which this observation was made excluded vertebrate scavengers from interacting with the pig carcass, the southeasterly directional flow of the decomposition fluids from the carcass might be misconstrued as scavenger-induced dispersal of the carcass appendages and soft tissues.[21-23] Furthermore, this can potentially be misinterpreted as the dragging trail of a body on or around the scene of death.[21]

In conclusion, understanding the timing and pattern of dispersal of post-feeding fly larvae in each geographical region is important, especially if the oldest immature insects (i.e. larvae or pupae) found on or around a corpse are to be employed in minimum post-mortem interval estimations.[24,25] This is attributed to the fact that different locations, regions and/or countries have different weather conditions (e.g. temperature, rainfall, humidity, and photoperiod), landscape and habitat types (e.g. vegetation, forest types, soil types and conditions), all of which exert a considerable influence on the decomposition rate/pattern of vertebrate remains and vertebrate scavenger assemblage, alongside the development, breeding behaviour, assemblage, and activities of carcass-associated insects.[4,10,14,17,26-31]

Equally important, documenting the dispersal patterns of post-feeding blow fly larvae under natural conditions is crucial as the minimum post-mortem interval can be miscalculated if older immature insects dispersing from the corpse are not considered and collected.[17] The reasons for the unidirectional en masse dispersal of blow fly larvae from the food source are still not well understood in the literature.[10,15] Thus, further studies incorporating a 24-h camera surveillance system, together with an increase in the frequency of sample collection, are needed to improve our understanding of the timing and ecological factors triggering this unique behaviour in blow fly larvae under natural conditions.[15]

Ethical declarations

Ethical approval for the decomposition and carcass entomofauna successional studies in the Table Mountain National Park was granted by the University of Cape Town, Faculty of Health Sciences Animal Ethics Committee (UCT FHS AEC Reference number: 021_021; valid until 30 December 2024). Approval to conduct the decomposition and carcass entomofauna successional studies in the Table Mountain National Park was also obtained from the authorities of the South African National Park/Table Mountain National Park (permit number: CRC/2022-2023/024--2019/V1; valid until 31 December 2023). This work is based on research conducted for a PhD thesis by A.D.A. on 'Insect succession and changes in the soil pH and electrical conductivity associated with decomposing pig carcasses on the Table Mountain National Park of the Western Cape Province of South Africa' at the University of Cape Town. This work was previously presented at the Royal Entomological Society 2023 Student Forum.

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Data availability

All the data supporting the results of this study are included in the article itself. Furthermore, supplementary materials supporting the results of this study have been deposited in a recognised repository (Figshare) and are openly accessible via the links included.

Declaration of AI use

We declare that we did not use any AI or large language models in the conceptualisation of the study and in preparing, editing, and revising the manuscript throughout the entire submission or publication process.

Authors' contributions

A.D.A.: Conceptualisation, data collection, sample analysis, writing – the initial draft, writing – revisions. C.G.M.: Writing – revisions, student supervision, project leadership, project management D.A.F.: Conceptualisation, writing – revisions, student supervision, project leadership, project management. M.H.: Conceptualisation, writing – revisions, student supervision, project leadership, project management, funding acquisition. All authors read and approved the final manuscript.

Competing interests

We have no competing interests to declare.

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