Saudi Journal of Biological Sciences 30 (2023) 103822

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Saudi Journal of Biological Sciences

journal homepage: www.sciencedirect.com

Original article

Decomposition and dipteran succession on buried rabbits carcasses

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ARTICLE INFO

Article history:
Received 10 August 2023
Revised 16 September 2023
Accepted 29 September 2023
Available online 5 October 2023

Keywords:
Buried carrion
Forensic entomology
Dolichotachina marginella Megaselia scalaris Sarcophaga dux

ABSTRACT

The rabbit carcasses used in this study were buried at depths of 20 and 40 cm, were examined to construct a fly succession database on buried carrion in Riyadh, Saudi Arabia. Twenty-four rabbits were buried, 12 at 20 cm and 12 at 40 cm. One carcass at each depth was exhumed at 10-day intervals up to 120 days. The degradation rate varied among the carcasses. Differences in species and their colonization were also found in the superficial and exhumed carcasses. Eleven species of flies were recorded on carcasses interred at a depth of 20 cm and seven species at 40 cm, while 13 species were recorded on the carcasses over the top of the soil. Species *Rhyncomya* sp (Diptera: Calliphoridae), *Sarcophaga dux* Thomson, and *Dolichotachina marginella* (Wiedemann) (Diptera: Sarcophagidae) were dominant at both depths, while *Chrysomya albiceps* (Wiedeman), *Chrysomya rufifaces* (Macquart) (Diptera: Calliphoridae), *Musca domestica* Linnaeus, and *Musca sorbens* Wiedemann (Diptera: Muscidae) were dominant in surface carcasses. *Megaselia scalaris* (Loew) ((Diptera: Phoridae) is a common and typical forensic indicator that was found in the decay/advanced decay and dry stages at a depth of 20 cm. These findings are possibly useful in forensic investigations involving buried bodies in Riyadh, Saudi Arabia.

1. Introduction

Insects invade carcasses soon after death (Catts and Goff, 1992) albeit internal and external variables can influence their presence and behavior on the remains (George et al., 2013). The rate of decay and diversity of species is influenced by temperature, humidity, and the surrounding environment (Gilbert and Bass, 1967; Shean et al., 1993). Bodies are often disposed of by burial. According to previous research, buried carcasses disintegrate more slowly than those exposed to air (Moses, 2012; Payne et al., 1968). Graves are seldom deep as digging takes time and energy. The longer a perpetrator remains in touch with the body, the further probable he is to be detained or leave evidence linking them to the murder. As a result, attackers typically dig shallow graves for their victims.

Previous studies on buried carcasses and pieces of meat found numerous necrophagous species, the majority of which belonged to groups of Diptera, including Muscidae, Phoridae, and Sarcophagidae (Bourel et al., 2004; Huchet, 2014; Huchet and Greenberg, 2010; VanLaerhoven and Anderson, 1999), Leptoceridae, Sphaeroceridae, Psychodidae, Calliphoridae, and Leiodidae (George et al., 2013; Gilbert and Bass, 1967).

In the case of buried carcasses, forensic entomology practitioners may struggle to appropriately quantify PMI due to a lack of reference data and the influence of local variables. These obstacles might be overcome by effectively combining fieldwork and laboratory research, as well as using animal models for experimental studies in circumstances pertinent to forensic entomology. These experiments may offer valuable information for forensic investigations in the future. Except for a study on rat carcasses done by (Al-Mekhlafi, 2021), we are aware of no studies in the Kingdom of Saudi Arabia that attempted to catalog the different kinds of flies found on buried bodies. To identify species and succession of flies and provide information about the decomposition rate on buried remains, we carried out this study in the city of Riyadh, Saudi Arabia. We used rabbit carcasses as an animal model for this investigation.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sjbs.2023.103822
1319-562X/

2. Methods

The examination was conducted from 28 January to 30 May 2021 in an area of ksu campus. The area was roughly 175 m by 250 m. Except for a limited acacia trees and about common wild herbs, the area is virtually barren of vegetation. Experimental animals were purchased from the local market in Riyadh. The Research Ethics Committee approved the use of rabbits for the project at IMSIU, under project No (35–2021). All rabbits were killed on the morning of burial using chloroform. The day before burial, 24 holes (60 × 30 cm) were dug at depths of 20 and 40 cm using a short-handled spade. To avoid interfering with the succession fauna, the pits were separated from one another on all sides by at least 10 m. Carcasses were packed into yard trash bags in order to inhibit colonization and transported by a covered pickup truck. A total of 24 mature rabbits *Oryctolagus cuniculus* L. (Leporida: Lagomorpha) were buried. Each Carcass was weighed before and after burial to determine the Weight loss. Rabbits were placed on a 30 × 60 piece of chicken wire the holes of which were 25 mm, for make removal simpler and to stop animal scavenging. The interval between the moment of death and the burial of the carcasses was 25 min. Data loggers (EM50G data logger, Ecotone, Gdynia, Poland) capable of measuring soil humidity and temperature were buried alongside the rabbits' bodies. this logger were positioned across the midsection of the rabbits and programmed to record temperature and humidity readings every hour. Rabbits in pits were buried immediately after being placed in the hole (Pastula and Merritt, 2013).

Exposed bodies were positioned inside robust steel 2-cm mesh boxes with a layer of wire screening, each measuring 60 × 50 × 30 cm^3 to prevent animal scavenging. using a Lascar EL-USB-2 data recorder. The site's ambient temperature and relative humidity were recorded hourly for the duration of the experiment (Al-Mekhlafi et al., 2020).

2.1. Sampling of insects and decay of carcasses

A carcass was extracted from each depth (20 and 40) every 10 days for 120 days. Before excavation, the soil covering the buried carcasses underwent inspection for the presence of insects. The soil was regularly hand-sorted for insects while being removed with a shovel. The chicken wire was used to help raise the carcasses directly from the pit and was meticulously examined for about 15 min. Insects were collected from the uncovered soil at the bottommost of the hole and the layers of soil cover in addition to the body of the rabbit. Forceps were used to delicately remove larval specimens. The remaining 50 % of the collected larvae were then allowed to mature into adult flies to aid in their identification, with the remaining 50 % being kept in 70 % ethanol for future reference. The construction of rearing containers followed the guidelines provided by Byrd and Tomberlin, (2010). Before transporting the live fly larvae to the laboratory, they were placed directly on chicken liver. The larvae were then reared in a growth chamber maintained at a constant temperature of 27 °C, with 50 % humidity and constant illumination. The adults of the newly emerging Diptera were kept in 70 % ethanol. Adult and larval species were identified, whenever feasible, using (Smith, 1986), (Marshall et al., 2011), (Courtney, 2000) and (Setyaningrum and Al Dhafer, 2014), or referred to experts in the Insect Museum, Faculty of Food and Agricultural Sciences - ksu. The database recorded only insects that were significant for forensic purposes; hence, soil-associated insects were excluded.

Additionally, insects were gathered daily from the surface of control carcasses. A trap that was filled with a solution of water, soap, and salts was used to catch adult insects according to the method provided by (Mashaly and Al-Mekhlafi, 2016). The larvae were collected using the same methods as before. Each carcass's rate of decomposition as well as the duration of each decomposition stage were observed and recorded.

2.2. Data analysis

To determine the statistical differences in the abundance of Dipteran groups between the different depths in carcasses buried. One-way ANOVA, then Tukey's test, was performed and $P < 0.05$ was considered statistically significant. by IBM SPSS Statistics 28.0.0.0.

3. Results

3.1. Soil analysis

The soil's grain size, analyzed by the Laboratory of Soil Department, College of Food and Agriculture Sciences, King Saud University, revealed a composition of 76.52 %, 67.02 % sand, 10 %, 18.5 % silt, 13.48 %, and 14.48 % clay before and after burial, respectively (Table 1). Therefore, the soil was described as "sandy loam", according to the categorization by the US Department of Agriculture.

3.2. Temperature and humidity

During the course of the experiment, the daily average air temperature displayed fluctuations between 18 and 38 degrees Celsius. Likewise, the daily average soil temperature at a depth of 40 cm ranged from 21.4 to 39.2 °C, while at a depth of 20 cm, it fluctuated between 21.5 and 36.5 °C. Notably, both ambient air humidity and the humidity of the soil surrounding the grave exhibited variations at different depths. However, it was observed that the soil humidity at both depths demonstrated lower variability compared to the surrounding air humidity, as depicted in Fig. 1.

3.3. Decay rate

The above-ground carcasses underwent decomposition over a period of 30 days, whereas the buried carcasses at depths of 20 and 40 cm took 120 days to decompose. Both sets of carcasses exhibited distinct stages of decomposition. The exposed carcasses went through four stages: fresh, bloated, decay, and dry. On the other hand, the buried carcasses showed the following stages: fresh, bloated, decay/advanced decay, and dry. Notably, the dry stage was observed in the buried carcasses after 60 days, while the control carcass reached this stage within 14 days, as illustrated in Fig. 2. The of weight loss of the buried bodies differed in both depths 20 and 40 cm, as it reached 10 and 20 % in the first ten days, while it was 87.55 %, and 76.59 % at 120 day, respectively (Fig. 3).

3.4. Fly succession

A total of 1604 flies were collected, 270 at a depth of 20, 202 at a depth of 40, and 1132 on surface carcasses. The dominant species at depths of 20 and 40 cm were *D. marginella* (26 and 34 %), *Rhyncomya sp* (27 and 32 %), and *S. dux* (24 and 22 %), respectively, while they differed in surface carcasses where *Ch. albiceps* (33 %), *M. domestica* (30 %), *Ch. rufifaces* (18 %), and *M. sorbens* (7 %) were the dominant species (Table 2). The results of the statistical analysis showed significant differences between the numbers of flies on the surface and buried bodies ($p \leq 0.05F = 1.73$) while there were no differences between both depths.

Table 1
Results of soil tests as determined by the King Saud University's College of Food and Agriculture Sciences' Laboratory of Soil Department.

Specimen	Clay %	Silt %	Sand %	Calcium Carbonate CaCO3 %	PH	Electrical Conductivity (EC) ds/m	Organic Matter %
Before burial	13.48	10	76.52	15.455	8.24	2.06	0.91
After burial	14.48	18.5	67.02	18.69	8.29	2.70	1.21

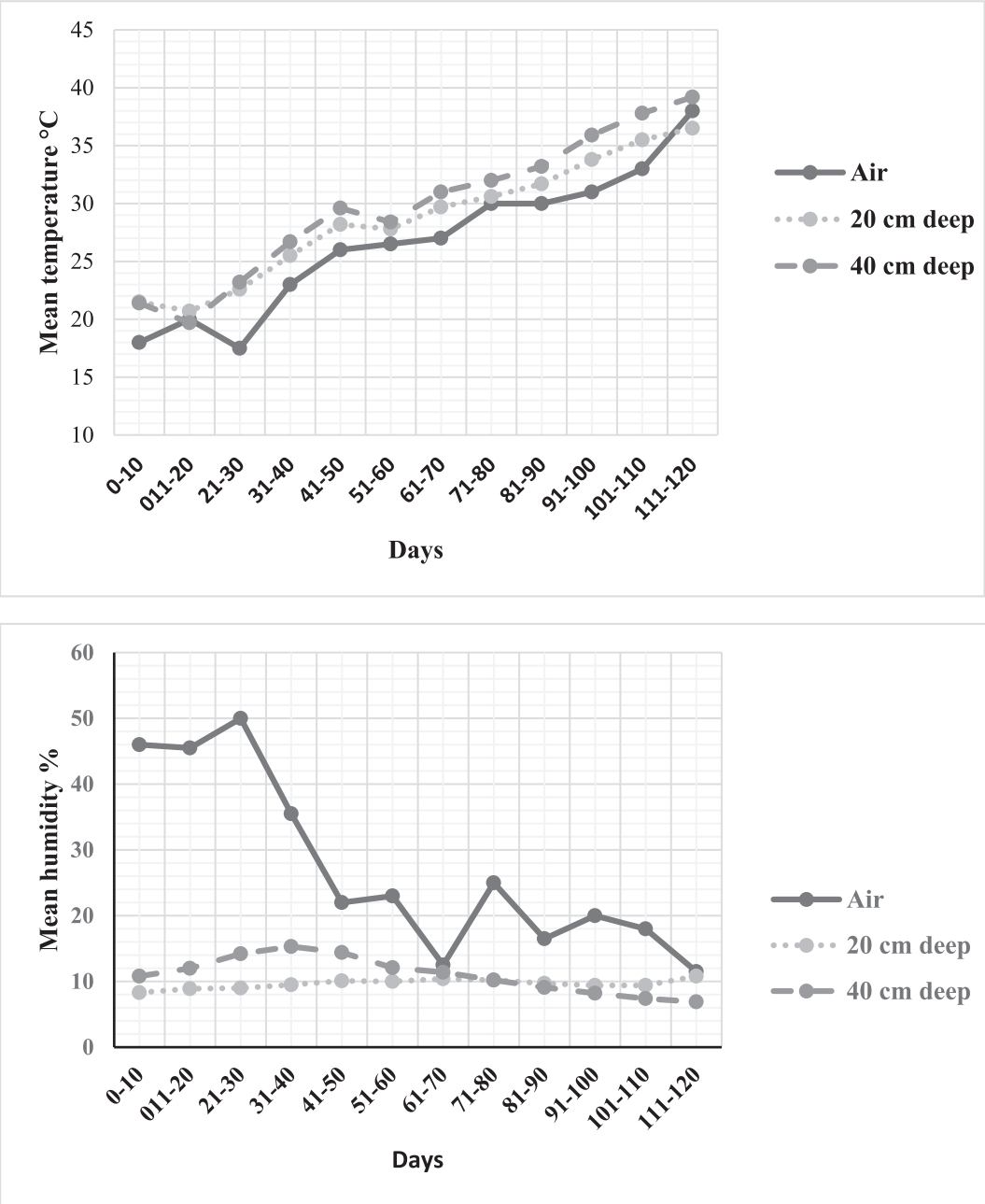

Fig. 1. Mean daily temperature and humidity of ambient air and soil at 20, 40 cm for 120 days.

Sixteen species of flies belonging to six families were identified, 11 and seven species of it on carcasses buried at depths of 20 and 40 cm, respectively, and 13 species on surface carcasses, where five species of flies *Hemipyrellia pulchra*, *Rhyncomya sp*, *Wohlfahrtia nuba*, *Dolichotachina marginella*, *Musca domestica*, and *Physiphora alceae* were identified on carcasses buried at both depths and surface carcasses. Species *Chrysomya megacephala* and *Megaselia scalaris* were recorded at a depth of 20 only, and types *Bengalia sp*, *Calliphora vicina*, *Sarcophaga sp*, *Musca sorbens*, and *Eremotrichoma perspiciendum* on surface carcasses only. While species *Sarcophaga dux* were found at both depths only, species *Ch. albiceps* and *Ch. rufifaces* were found at depth 20 and on surface carcasses (Table 3).

The fly larvae began to appear in the buried carcasses after 30 days, and no type of fly was recorded in the buried rabbit carcasses on days 10 and 20, and the carcasses were in the stage of decay/advanced decay. The carcasses continued at this stage until

Fig. 2. Stages of decomposition of buried rabbits carcass at 20 cm (A), at 40 cm (B) and carcass above the surface of the soil (C).

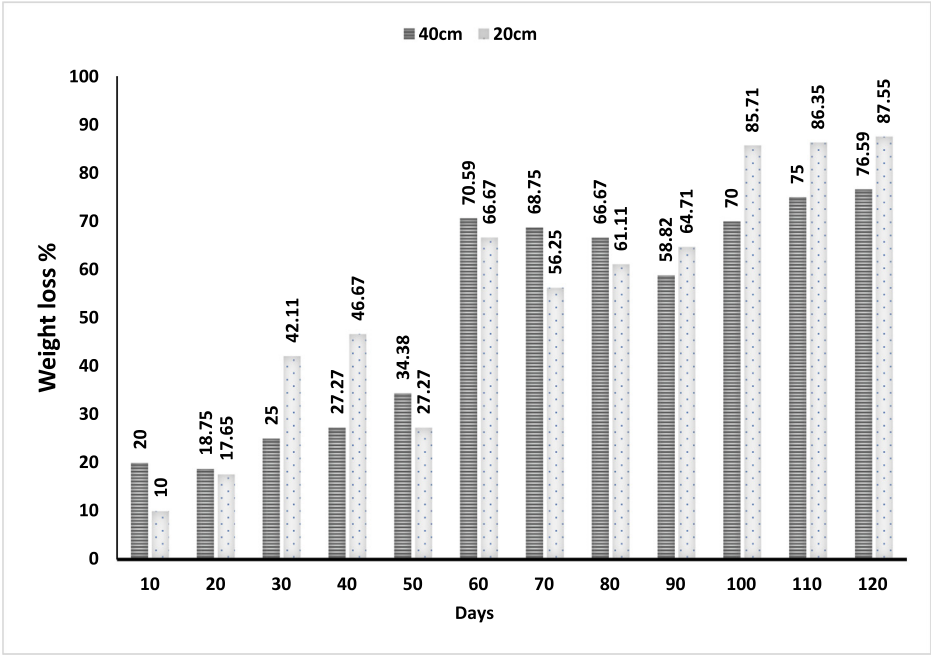

Fig. 3. Weight loss of bodies buried at both depths (20,40 cm).

day 50. All classified species in our study were recorded at this stage. Some of continued throughout the dry stage. The first appearance of species *Rhyncomya sp* (L20) and types *W. nuba* (L6) and *D. marginella* (L3) were recorded on day 30 at a depth of 20 only. In addition to the previous species, the emergence of eight species was recorded on day 40. Species *H. pulchra*, *M. domestica,* and *S. dux* were recorded at the two depths, while the five species were recorded at depth 20 only (Table 4).

The dry stage began on day 60 and continued until day 120. Six species continued to appear, namely *Rhyncomya sp*, *S. dux*, *W. nuba*, *D. marginella*, *M. domestica,* and *Me. scalaris*. While five species were not recorded in this stage of decomposition, which is *Ch. albiceps, Ch. megacephala*, *Ch. rufifaces*, *H. pulchra,* and *P. alceae*. Where its presence was limited to the decay/advanced decay stage only. The results of the statistical decomposition showed significant differences ($p \leq 0.05$, $F = 4.91$) between the decay and dry stages of decomposition and, also, between both depths in terms of the abundance of fly species (Table 4). In terms of decomposition time, fly populations, and the species observed, there is a definite difference between buried and surface carcasses (Table 5).

Table 2
Percentage of presence of the different species of flies in buried and superficial carcasses.

family	Genus and species	buried		Soil surface
		20 cm	40 cm	
Calliphoridae	*Chrysomya albiceps*	8 (3 %)	0 (0 %)	378 (33 %)
	Chrysomya rufifaces	4 (1 %)	0 (0 %)	200 (18 %)
	Chrysomya megacephala	4 (1 %)	0 (0 %)	0 (0 %)
	Hemipyrellia pulchra	4(1 %)	2 (1 %)	6 (1 %)
	Rhyncomya sp.	54 (20 %)	64 (32 %)	26 (2 %)
	Bengalia sp.	0 (0 %)	0 (0 %)	16 (1 %)
	Calliphora vicina	0 (0 %)	0 (0 %)	2 (0 %)
Sarcophagidae	*Sarcophaga* sp.	0 (0 %)	0 (0 %)	32 (3 %)
	Sarcophaga dux	64 (24 %)	44 (22 %)	0 (0 %)
	Wohlfahrtia nuba	20 (7 %)	10 (5 %)	18 (2 %)
	Dolichotachina marginella	70 (26 %)	68 (34 %)	30 (3 %)
Muscidae	*Musca domestica*	30 (11 %)	9 (3 %)	334 (30 %)
	Musca sorbens	0 (0 %)	0 (0 %)	76 (7 %)
Phoridae	*Megaselia scalaris*	6 (2 %)	0 (0 %)	0 (0 %)
Ulidiidae	*Physiphora alceae*	6(2 %)	8 (4 %)	8 (1 %)
Ephydridae	*Eremotrichoma perspiciendum*	0 (0 %)	0 (0 %)	6 (1 %)
Total		**270**	**202**	**1132**
Mean		**8.70 ± 1.07b**	**6.52 ± 1.30b**	**45.28 ± 6.50 a**
***F*-value**		**1.73**		

Table 3
Species of flies collected from buried carcasses at a depth of 20 and 40 cm compared to surface carcasses.

family	Genus and species	soil surface	buried	
			20 cm	40 cm
Calliphoridae	*Chrysomya albiceps*	√	√	–
	Chrysomya rufifaces	√	√	–
	Chrysomya megacephala	–	√	–
	Hemipyrellia pulchra	√	√	√
	Rhyncomya sp.	√	√	√
	Bengalia sp.	√	–	–
	Calliphora vicina	√	–	–
Sarcophagidae	*Sarcophaga* sp.	√	–	–
	Sarcophaga dux	–	√	√
	Wohlfahrtia nuba	√	√	√
	Dolichotachina marginella	√	√	√
Muscidae	*Musca domestica*	√	√	√
	Musca sorbens	√	–	–
Phoridae	*Megaselia scalaris*	–	√	–
Ulidiidae	*Physiphora alceae*	√	√	√
Ephydridae	*Eremotrichoma perspiciendum*	√	–	–

Flies species presence (√) or absence (–).

4. Discussion

Criminals frequently bury bodies to conceal them, but soil hardness and burial depth act as physical barriers that have a substantial impact on temperature and insect succession (Payne et al., 1968). In our investigation, rabbit carcasses were buried at a depth of 20 and 40 cm, and these depths were adequate to reduce the pace of decay. These findings agree with those made on pig carcasses by Bonacci et al. in Italy in 2021 (Bonacci et al., 2021). During the study period, there was a difference in the rate of decomposition between buried and surface corpses. In comparison to the buried corpses, the control carcass decomposed more quickly. Carcasses placed on the surface of the ground are in direct touch with some abiotic elements, such as temperatures, wind, and rainfall, which makes succession and arthropod colonization by specific arthropod species easier to happen. The rate of a cadaver's decomposition is known to be significantly influenced by abiotic variables (Byrd and Tomberlin, 2019; George et al., 2013). Buried cadavers are exposed to different sets of abiotic factors and biotic elements driving decomposition processes, such as increased bacterial activity, fungal growth, and various sets of arthropod colonization, in contrast to above-ground scenarios, where they are exposed to ambient temperatures, wind, and rain (Haglund and Sorg, 1997; Tibbett and Carter, 2008). In excessively dry soils, microbial and soil organism activity is reduced, according to (Janaway, 2013). The cold weather and dry soils prevented enhanced activity of soil organisms and microbes, which resulted in comparatively slow decomposition and, consequently, buried carcasses losing biomass at a slow rate.

The first signs of below-ground colonization were observed 30 days after burial, indicating that dipteran succession occurred on the buried carcasses at a significantly slower rate than on the control carcasses. Although they were placed in their placements simultaneously, the uncovered carcasses had a distinct insect successional pattern compared to buried ones. Species such as *Rhyncomya sp*, *W. nuba,* and *D. marginella* first arrived on buried carcasses on deep 20 cm. In contrast to what happened in the surface carcasses, the first appearance of the following species *Ch. albiceps*, *H. pulchra*, *Sarcophaga sp*, *M. domestica,* and *M. sorbens* was recorded. Species *Rhyncomya sp* was not recorded in any study in Saudi Arabia on surface carcasses, while it was recorded in South Africa (Tembe and Mukaratirwa, 2020) and Nigeria (Izuma Joshua 2019). It was also found to be attracted to termite nests (Zumpt, 1958; Zumpt and Tsacas, 1978). This was also observed

Table 4
Timing and succession of fly species collected from rabbit carcasses buried at depths of 20 and 40 cm.

Days	family	Genus and species	D. stage	20 cm	40 cm
10	–	–	Bloated	–	–
20	–	–	Decay and advanced decay	–	–
30	Calliphoridae	*Rhyncomya* sp.		L(40)	–
	Sarcophagidae	*Wohlfahrtia nuba*		L(12)	–
		Dolichotachina marginella		L(6)	–
40	Calliphoridae	*Chrysomya albiceps*		L(8)	–
		Chrysomya megacephala		L(4)	–
		Chrysomya rufifaces		L(4)	–
		Hemipyrellia pulchra		L(4)	L(2)
		Rhyncomya sp.		L(12)	–
	Sarcophagidae	*Sarcophaga dux*		L(8)	–
		Wohlfahrtia nuba		L(8)	–
		Dolichotachina marginella		L(30)	–
	Muscidae	*Musca domestica*		L(28)	L(6)
	Phoridae	*Megaselia scalaris*		L(2)	–
	Ulidiidae	*Physiphora alceae*		L(6)	–
50	Sarcophagidae	*Sarcophaga dux*		L(34)	L(6)
		Dolichotachina marginella		L(32)	–
	Ulidiidae	*Physiphora alceae*		–	L(8)
Total decay				**238**	**22**
Mean				**14.00 ± 1.59 a**	**1.30 ± 0.32c**
60	Calliphoridae	*Rhyncomya* sp.		–	L(52)
	Sarcophagidae	*Sarcophaga dux*	Dry	L(22)	L(38)
		Wohlfahrtia nuba		–	L(8)
		Dolichotachina marginella		L(2)	L(56)
	Muscidae	*Musca domestica*		L(2)	–
70	Calliphoridae	*Rhyncomya* sp.		L(2)	–
80	–	–		–	–
90	Calliphoridae	*Rhyncomya* sp.		–	L(4)
	Sarcophagidae	*Dolichotachina marginella*		–	L(6)
		Wohlfahrtia nuba		–	L(2)
100	Calliphoridae	*Rhyncomya* sp.		–	L(8)
	Sarcophagidae	*Dolichotachina marginella*		–	L(6)
110	–	–		–	–
120	Phoridae	*Megaselia scalaris*		L(4)	–
Total dry				**32**	**180**
Mean				**2.28 ± 0.78 bc**	**12.86 ± 2.67 ab**
***F*-value**			**4.91**		

L = larvae, A = adult. Number of insects collected in parenthesis.

Table 5
Timing and succession of fly species collected from control rabbit carcasses placed on the soil surface.

Days	family	Genus and species	D. stage	Numbers
1–2	–	–	Fresh	–
3–7	Calliphoridae	*Chrysomya albiceps*	Bloated	A(156)
		Hemipyrellia pulchra		A(4)
	Sarcophagidae	*Sarcophaga* sp.		A(20)
	Muscidae	*Musca domestica*		A(188)
		Musca sorbens		A(32)
	Ephydridae	*Eremotrichoma perspiciendum*		A(4)
8–12	Calliphoridae	*Chrysomya albiceps*	Decay	A(104)+L(50)
		Chrysomya rufifaces		L(200)
		Hemipyrellia pulchra		A(2)
	Sarcophagidae	*Sarcophaga* sp.		A(6)
		Wohlfahrtia nuba		L(16)
	Muscidae	*Musca domestica*		A(14)
		Musca sorbens		A(36)
	Ephydridae	*Eremotrichoma perspiciendum*		A(2)
	Ulidiidae	*Physiphora alceae*		A(6)
13–30	Calliphoridae	*Chrysomya albiceps*	Dry	A(68)
		Bengalia sp.		A(16)
		Calliphora vicina		A(2)
		Rhyncomya sp.		A(26)
	Sarcophagidae	*Wohlfahrtia nuba*		A(2)
		Sarcophaga sp.		A(6)
		Dolichotachina marginella		A(30)
	Muscidae	*Musca domestica*		A(6)
		Musca sorbens		A(8)
	Ulidiidae	*Physiphora alceae*		A(2)

L = larvae, A = adult. Number of insects collected in parenthesis.

in our study. Also, type *W. nuba* was not recorded except on surface carcasses only (Al-Qahtni et al., 2020; Haddadi et al., 2019). As for type *D. marginella,* it was not recorded in the Saudi fauna but was documented in the Middle East in the United Arab Emirates and Egypt (Verves and Khrokalo, 2018). It was recorded on buried carcasses in Sudan (Yassin and Mohamed, 2015). The appearance of these types on buried corpses is very curious and requires further verification in Saudi Arabia.

Flesh fly *S. dux* were present in abundance, at both 20 and 40 cm depths, and this might be a result of the sandy soil, which facilitates the larvae's ability to dig and access the carcasses for feeding. (Rodriguez and Bass, 1985) saw a similar event when they observed different species of flesh flies larvipositing close to soil fissures and the immatures burrowed down to the carcass. Therefore, it appears that the sandy soil plays a role in easing the tunneling process and enabling access to carcasses. At a depth of 60 cm, other species of the genus *Sarcophaga* that are unknown were found (Botham 2016). The presence of *S. africa* and *S. bullata* were previously reported in buried remains at 20–40 cm depth (Albushabaa, 2016) (Pastula and Merritt, 2013). *Ch. albiceps*, *Ch. Rufifaces,* and *Ch. megacephala* were collected from carcasses buried at a depth of 20 cm and have been reported in different previous studies (Albushabaa, 2016; Leşinin and Bölgesinden, 2018; Sharif and Qamar, 2021). *Ch. rufifacies* larvae can burrow several inches into the soil to colonize buried remains (Byrd and Tomberlin, 2019). In addition, *P. alceae* was also found at both depths in our study and was not previously recorded on buried carcasses to our knowledge, but was only reported in surface carcasses (Al-Mekhlafi et al., 2020; Al-Qahtni et al., 2020; Haddadi et al., 2019). The presence of P. alceae at both depths suggests that this species may exhibit a more diverse foraging behavior than previously thought, and it highlights the importance of considering various ecological factors and adaptations that can influence the behavior and distribution of carrion-feeding insects. Further research may be needed to understand the specific factors driving this behavior in *P. alceae*.

Two fly species, *H. pulchra* and *M. domestica*, were collected 40 days after burial at a depth of 40 cm, indicating that insects would take longer to colonize carcasses buried at 40 cm compared to 20 cm. *H. pulchra* was not recorded on carcasses, but (Nandi, 2002) stated that it was attracted to dead animals. It was attracted to the bait consisting of 250 g of beef offal (Klong-Klaew et al., 2018), while *M. domestica* was recorded on buried carcasses (Bala and Kaur, 2015; Kekillioğlu and Başar, 2021).

Species *M. scalaris* is a common and typical forensic indicator reported in buried remains (Botham, 2016; Bourel et al., 2004; Byrd and Tomberlin, 2019; Pastula and Merritt, 2013; Sharif and Qamar, 2021; Turner and Wiltshire, 1999). It was found in the decay/advanced decay and dry stages at a depth of 20 cm in very low numbers. This may be attributed to soil texture or other factors. This is also consistent with the study of (Bonacci et al., 2021). According to reports, the only species inhabiting a human corpse buried in a wooden coffin at a depth of 30 to 40 cm in Italy are coffin flies, *M. scalaris*. Campobasso et al 2004 also found these species in pig carcasses that were buried 60 cm deep (Pastula and Merritt, 2013). *M. scalaris* has been found colonizing remnants at depths of up to 1.8 m (Merritt et al., 2007), so it is not unexpected that it can colonize a cadaver at a depth of 20 cm. (Al-Qahtni et al., 2019) recorded *M. scalaris* in Riyadh, Saudi Arabia, on human corpses inside the building and did not record it on corpses outside the building. It was also found on human corpses inside a car (Al-Khalifa et al., 2020). The Phoridae family prefers enclosed environments as rooms with closed doors and windows or sealed plastic bags (Reibe and Madea, 2010). Overall, these findings may be useful in forensic investigations concerning buried bodies in Riyadh, Saudi Arabia.

5. Conclusion

Our findings constitute an experimental investigation of the impacts of burial on diptera colonization of carcasses, which should be expanded to various habitats, including suburban, urban, and forest ones, as well as various seasons, to support future forensic investigations. Other factors besides depth and time may also play a role in insect community separation, such as the kind of soil and the presence of microbes. It is necessary to conduct more research on the influences of soil type and microbial activity on insect arrival and succession. In addition to studying the succession of various necrophagous insects, such as Coleoptera, Lepidoptera, and Hymenoptera, it would be valuable to conduct a comprehensive investigation encompassing these insect groups. This expanded research approach will provide a more holistic understanding of the ecological dynamics surrounding carcass decomposition and its relevance to forensic applications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors express their sincere appreciation to the Researchers Supporting Project number (RSP2023R112), King Saud University, Riyadh, Saudi Arabia.

Funding

This project was funded by Researchers Supporting Project number (RSP2023R112), King Saud University, Riyadh, Saudi Arabia.

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