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Decomposition process for buried rat (*Rattus norvegicus*, Berkenhout 1769) carcasses in Riyadh city, Saudi Arabia: A preliminary study

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ABSTRACT

The present report outlines the initial observations from an ongoing study examining the decomposition rate of buried rat (*Rattus norvegicus*, Berkenhout 1769) carcasses in Riyadh city, Saudi Arabia. Eight rat carcasses were buried in separate holes at depths of 20 and 40 cm (four holes per depth) to allow natural decomposition and examined at 10-day intervals up to 40 days. During the study period, environmental factors such as humidity, soil temperature, and air temperature were monitored at each depth on a daily basis. At the end of each burial period, one carcass from each depth was exhumed and the degree of decay and presence of insect activity were examined. The results showed that burial depth and temperature were major factors affecting the decomposition rate, whereas no insect activity was observed. The findings of this study can be used to more accurately estimate the time since burial of carcasses.

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1. Introduction

After committing homicide, most offenders conceal the victim's body by interment in a shallow grave owing to the difficulties of handling the large-sized human cadaver in the short time available (Kamaluddin et al., 2018). Consequently, numerous environmental factors will influence the decomposition rate and postmortem interval (PMI) estimation of the victim's cadaver, including both abiotic factors, such as soil type, temperature, moisture, and pH, and biotic factors, such as access of carrion insects (Junkins and Carter, 2017). In particular, the population dynamics of insects are of paramount importance in estimating the PMIs of inhumed cadavers.

Numerous studies have used pig (*Sus scrofa* L., 1758) and rat (*Rattus* spp.) carcasses and occasionally human cadavers to investigate the decomposition of buried remains under temperate conditions, including in Argentina (Mariani et al., 2014), Canada (VanLaerhoven and Anderson, 1999; Lowe et al., 2013), the United

States of America (Rysavy and Goff, 2015), Britain (Gunn and Bird, 2011; Gunn, 2016), Poland (Szpila et al., 2010), Germany (Bernhardt et al., 2016), South Africa (Marais-Werner et al., 2017), Australia (Carter et al., 2010), and Romania (Iancu et al., 2018). These reports have considered the in-soil decomposition process from a range of perspectives, such as primary observations (Carter et al., 2010), necrophagous insect species, and colonization patterns (VanLaerhoven and Anderson, 1999; Gaudry, 2010; Gunn and Bird, 2011), for forensic applications.

A wide range of extrinsic taphonomic factors affect the decomposition rate of buried carcasses, including the soil characteristics, temperature, season, insect species, and access of scavengers (Haglund and Sorg, 2017). Among these, temperature and climatic variations play critical roles in the decomposition process by affecting insect activity and colonization of the inhumed carcasses, while the oxygen content also affects insect colonization and the decay rate (Carter et al., 2010). In addition, the inhumation depth, meteorological conditions at the site, and soil chemistry also contribute to carcass decomposition (Gunn and Bird, 2011).

Most previous studies on carcass decomposition in Saudi Arabia have only considered the insects that are associated with surface remains (Al-Mekhlafi, 2020; Al-Mekhlafi et al., 2020). Therefore, the aim of this study was to investigate the decay process for rat (*R. norvegicus*, Berkenhout 1769) carcasses buried in Riyadh city, Saudi Arabia, as a model for human cadavers. This work provides an insight into the effects of the depth and duration of inhumation on the decomposition rate of carcasses, as well as the potential

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environmental factors that influence this process and the importance of carrion insect activity.

2. Materials and methods

2.1. Study location

This work was carried out in the botanical garden within the King Saud University campus in Riyadh, Saudi Arabia (24°43'19.2 0"N, 46°37'37.20"E). The garden soil type was determined by the Soil Laboratory on College of Food and Agricultural Sciences, King Saud University, and classified as sandy on the both site (Table 1) and is dominated by palm trees and shrubs. The allocated area for this work measured approximately 10 × 30 m, and the carcasses were separated by approximately 10 m in all directions to prevent any overlap of olfactory cues. Each carcass was buried in a 50 × 50 cm hole that was dug to a depth of 20 or 40 cm using a short-handled spade.

2.2. Animal model and design

Rats were selected as the animal model for the current study as they are considered analogs to humans in biological research and decomposition investigations (Carter et al., 2008; Goutianos et al., 2015.). Eight adult rat (*R. norvegicus*) carcasses each weighing approximately 150 g were obtained from the animal house at the College of Sciences at King Saud University, and their decomposition was examined from Oct 21 to Dec 1, 2020. The rats were euthanized by cervical dislocation and immediately weighed using a hand-held scale. Each carcass was then buried under normal environmental conditions without any physical barriers except a

Table 1
Soil test results as determined by Soil Laboratory.

Sample depth (cm)	Sand%	Silt%	Clay%	Soil Type
0–20	94.31	5.69	0.0	Sand
20–40	93.71	6.29	0.0	Sand

40 × 30 cm piece of poultry netting (gap diameter, 25 mm) that was placed around the carcass to protect it from animal scavengers and facilitate its later removal during exhumation. Each carcass was placed in its assigned hole and immediately buried with an EM50G data logger (Ecotone, Gdynia, Poland) to monitor the temperature and relative humidity of the soil. One rat from each depth was then exhumed after 10 (Oct 31), 20 (Nov 10), 30 (Nov 21), and 40 (Dec 1) days.

Prior to exhumation, the surface soil was examined for insects. Gentle digging was then performed with a shovel, during which the exposed soil was continuously scrutinized for insects. Once the carcass was exposed, it was lifted by the surrounding wire and weighed with a hand-held scale to determine the removed biomass. The carcass was then carefully examined from the head to the rear for approximately 15 min for insects.

2.3. Statistical analysis

Differences in decomposition rates between the treatment groups were evaluated using analysis of variance. This analysis was carried out in the SPSS 26 software (SPSS Inc., Chicago, IL) using a significance level of $p < 0.001$.

3. Results

3.1. Environmental conditions

3.1.1. Temperature

The temperatures of the soil at each depth and the ambient area at the surface were monitored throughout the study period. There was no significant difference in-soil temperature between the two depths ($p > 0.001$), but the ambient air temperature was significantly lower than the soil temperature at each depth for all burial periods ($p < 0.001$) (Fig. 1).

3.1.2. Relative humidity

The average relative humidities of the ambient air and the soil holes at depths of 20 and 40 cm were 18.09%, 21.65%, and 27.03%, respectively, after 10 days; 28.58%, 20.16%, and 26.42%,

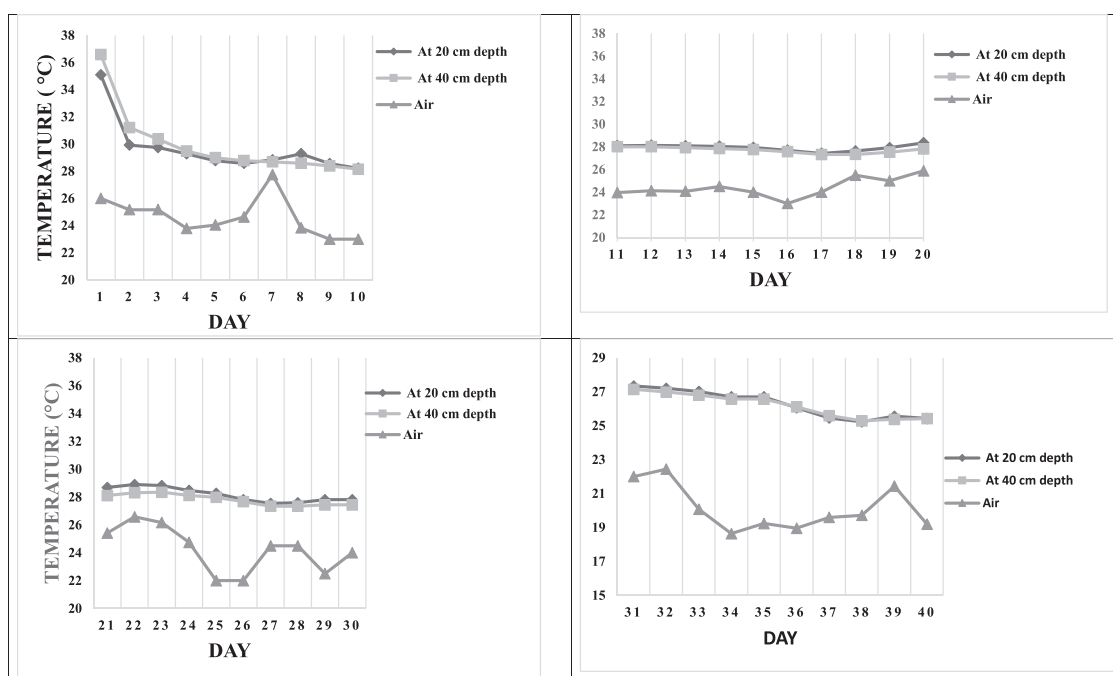


Fig. 1. Ambient air and soil temperatures recorded during the study period.

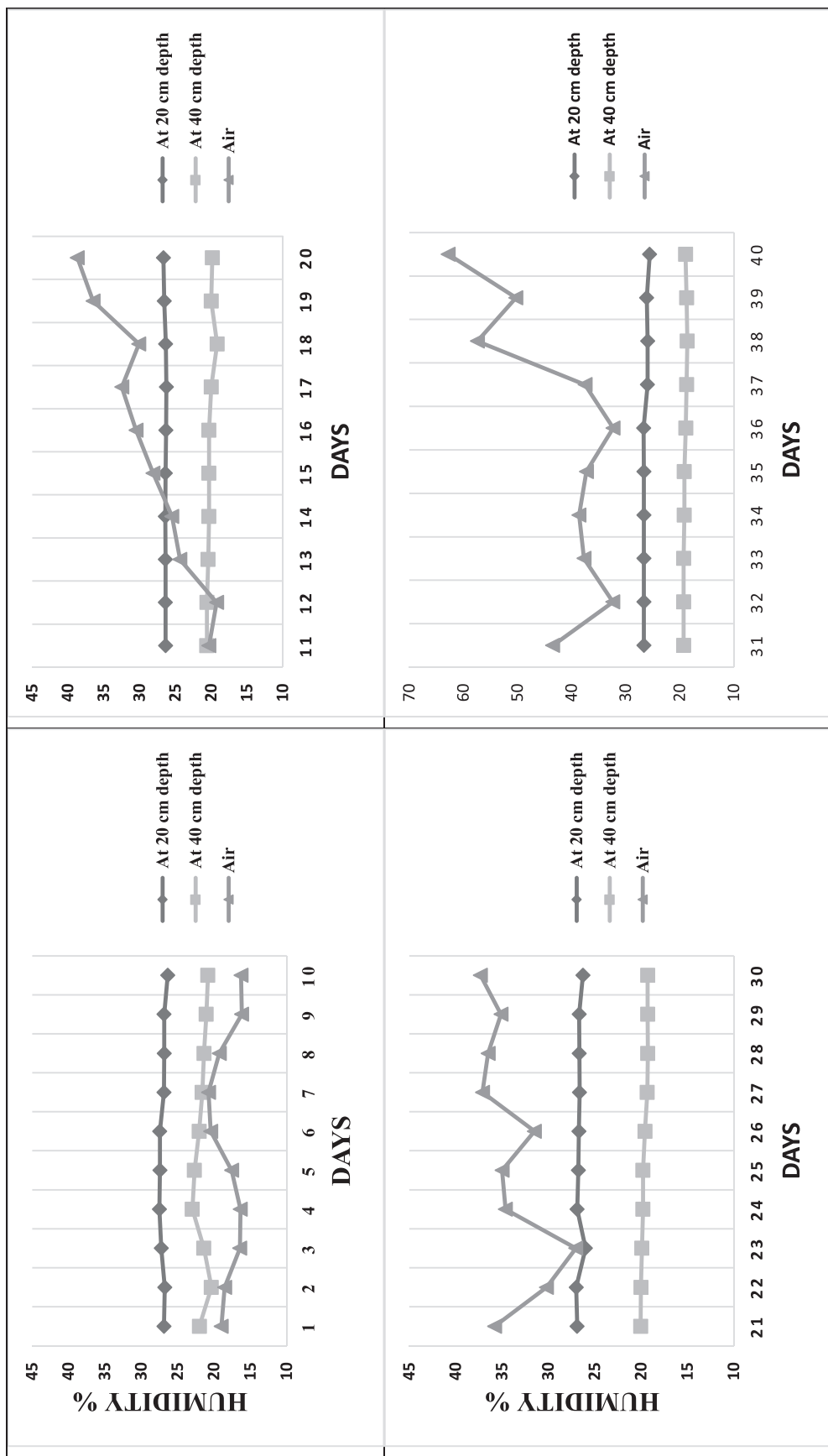


Fig. 2. Ambient air and soil humidities recorded during the study period.

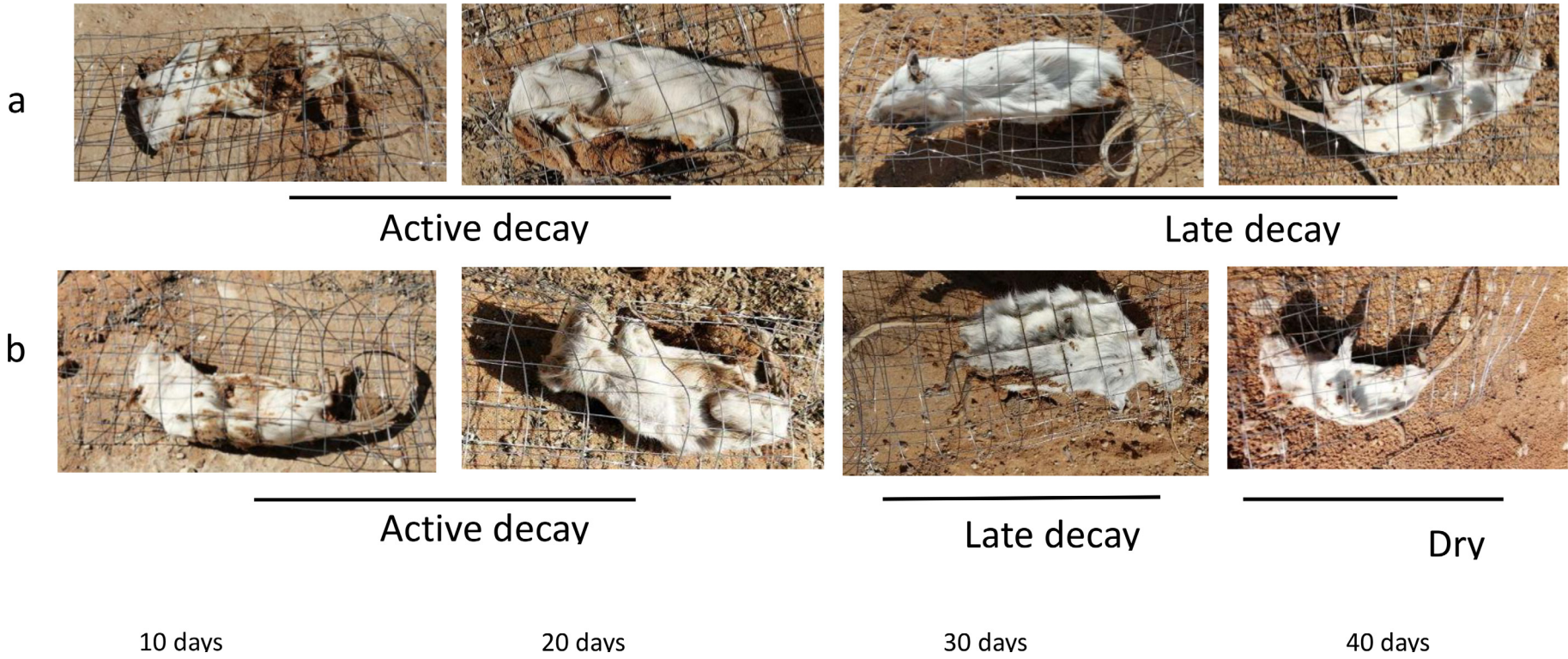


Fig. 3. Decomposition stages of the buried rat (*Rattus norvegicus*) carcasses at depths of (A) 20 cm and (B) 40 cm.

respectively, after 20 days; 34.02%, 19.64%, and 26.66%, respectively, after 30 days; and 42.98%, 19.01%, and 26.34%, respectively, after 40 days of inhumation (Fig. 2). There were significant differences in humidity within and between all burial periods ($p < 0.001$).

3.2. Decomposition stages and biomass loss

The decay of carcasses can be separated into five stages based solely on the physical characteristics of the exhumed carcass and the associated arthropods (Payne, 1965; Iancu et al., 2018). The stages of decomposition observed in the present study are shown in Fig. 3, while the biomass losses at different depths during the study period are depicted graphically in Fig. 4.

3.2.1. After 10 days

At the time of exhumation, the rat carcasses were found to be at the beginning of the active decomposition stage. The carcasses had deflated soft tissues but the flesh was still present. Decay fluids had started to leak out and appeared as dark discolorations in a few areas of the soil surrounding the carcasses. Biomass losses of 34% and 33% were observed at depths of 20 and 40 cm, respectively.

3.2.2. After 20 days

Upon exhumation, the carcass buried at 20 cm had very wet tissues and a strong odor, and had experienced a 50% loss of biomass, indicating the active decay stage of decomposition. By contrast, the carcass buried at 40 cm had minimal soft tissue remaining, a strong odor, and deflation of the abdominal cavity, and had experienced a 53% loss of biomass, indicating the latter period of the active decay stage.

3.2.3. After 30 days

The carcass buried at a depth of 20 cm was still in the late decay stage, while that buried at 40 cm had entered the dry stage, with skin adhering to the bones, a stiffening and alteration of the color in the limbs, tail, and head, and a biomass loss of 62%.

3.2.4. After 40 days

After 40 days of burial, the rat carcass buried at a depth of 20 cm was still in the late decay stage, while the carcass buried at 40 cm had entered the final stage of decomposition, with a completely dry body and apparent discoloration in the abdominal area but no decomposition of the hair and skin, which were still stiff. This latter carcass had experienced a biomass loss of 68%.

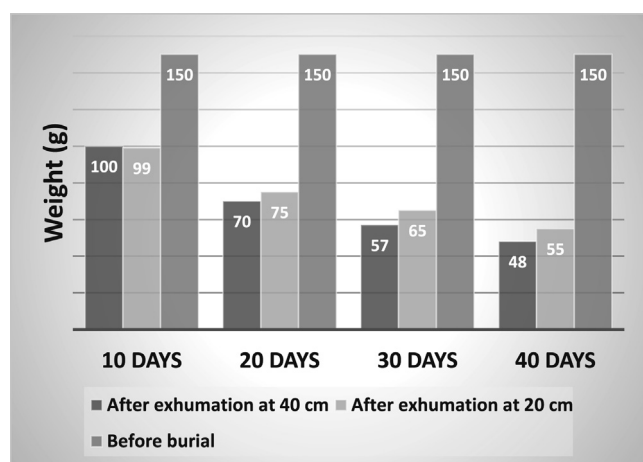


Fig. 4. Biomass losses experienced by the buried rat (*Rattus norvegicus*) carcasses at each depth during the study period.

4. Discussion

Various climate factors and soil characters collectively influence the decay process of buried carcasses (Forbes et al 2017). Further, the amount of oxygen and the soil type can influence the decomposition rate (Stuart and Ueland, 2017). For instance, if carcasses were buried in lower temperatures and environmental conditions from contact with the soil, differentiating buried and exposed taphonomic studies becomes important (Gaudry, 2010). The decomposition rate is particularly affected by temperature, with optimal soft tissue decay occurring between 20 °C and 40 °C, but is also affected by the soil type and amount of available oxygen in the soil (Stuart and Ueland, 2017).

In the present study, there were no significant differences in soil temperature between depths (20 and 40 cm), but the soil temperatures were significantly higher than the ambient air temperature, supporting the findings of Pastula and Merritt (2013). These temperatures may have reduced the decay rate—indeed, it has been shown that a decrease in temperature below the minimum threshold prevents carcass decomposition (Rodriguez, 1997). However, other factors besides temperature will also play important roles in PMI estimation (VanLaerhoven and Anderson, 1999). While meteorological data can easily be retrieved from weather stations for surface decomposition studies, data regarding underground conditions are difficult to obtain for burial studies. Consequently, in forensic studies, investigators may substitute soil temperature measurements with air temperature records to estimate the PMI when the former are absent. However, the results should be interpreted with caution as soil type and climate are also contributing factors.

The decomposition rate of buried carcasses will be slower than that of surface carcasses. In the present study, biomass losses of only 63% and 68% occurred at depths of 20 and 40 cm, respectively, after 40 days of burial. Furthermore, the exhumed carcasses from these depths appeared to be at different points within the same stage of active decay. By contrast, surface-exposed carcasses of the same species of rat at the same location were recently found to span 4 days and be completed in approximately 24 days (Al-Mekhlafi et al., 2020). This significant variation in the decomposition rate can mostly be attributed to the absence of carrion activity in the burial environment due to the soil not only physically covering the carcasses but also preventing the escape of odors that attract insects to the burial site (Gaudry, 2010).

No insects were recorded in any of the carcasses during this study. This observation is in good agreement with Iancu et al. (2018), who reported an absence of insect activity during March owing to the low temperature but recorded dipteran adult activity during the active stage in June when the temperature increased. In their study, Iancu et al. (2018) documented three species of Muscidae: *Muscina prolapsa* (Harris, 1780), *M. levida* (Harris, 1780), and *Hydrotaea ignava* (Harris, 1780). Similarly, Pastula and Merritt (2013) found *Sarcophaga bullata* (Parker) (Diptera: Sarcophagidae), *Megaselia scalaris* (Loew) (Diptera: Phoridae), and *Hydrotaea* sp. (Diptera: Muscidae) on inhumed pig carcasses, while other studies have documented *Philonthus* sp. (Coleoptera: Staphylinidae) as a dominant species in buried carcasses (VanLaerhoven and Anderson, 1999; Gaudry et al., 2006; Rysavy and Goff, 2015). This diversity of insects is mostly attributed to differences in the environmental conditions, burial depth, and soil type (Carter et al., 2007), as well as body size (Al-Mekhlafi et al., 2020).

5. Conclusion

The effects of shallow inhumation on the decomposition rate and insect community dynamics of carcasses have previously been

investigated in a range of climates and locales, but none of these have been similar to Riyadh. Therefore, this preliminary work provides a framework for larger investigations in Riyadh and other tropical regions. Different burial depths and seasons can be used to investigate the decomposition rate of carcasses under various environmental conditions. In addition, studies on the physical and chemical properties of the soils surrounding the carcasses, as well as the associated microfauna, are highly recommended.

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.

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