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Insect Succession on Dog Carcasses in Isolated Graveyard vs. Agricultural Environments in Al-Diwaniyah, Southern Iraq, under 42°C Thermal Conditions: A Comparative Study

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ABSTRACT

This study analyzed the five decomposition stages of buried dog carcasses (30-40 kg) in Al-Diwaniyah Governorate. The results showed that the level of burial was the strongest influencing factor ($F > 984$, $p < 0.001$), followed by burial environment and their interaction. 10 insect species belonging to 7 families were recorded. Each decomposition stage was associated with a distinct insect community: Calliphoridae flies (Chrysomya albiceps, Calliphora vicina) dominated the early stages (fresh and bloat), while Dermestidae beetles (Dermestes maculatus, D. peruvianus, D. frischii) dominated the late stages (dry decay and skeletal). Insect communities also differed according to burial level, with Dermestidae beetles being more abundant in deep burial (50 cm) compared to shallow burial. This study recommends using these results as a local baseline for post-mortem interval (PMI) estimation in forensic cases.

Results: ANOVA revealed a highly significant effect ($p < 0.001$) of burial on all decomposition stages. The effect of habitat was significant ($p < 0.01$) for most stages except bloated ($p = 0.900$) and advanced decay ($p = 0.183$) for dogs. Surface carcasses in the agricultural environment decomposed fastest (11.33 days to dry remains), while buried carcasses in the graveyard were slowest (45.67 days to dry remains). All differences between treatments were statistically significant at the 5% level as indicated by LSD values. *Chrysomya albiceps* and *Calliphora vicinia* are the dominant species on all surface carcasses, while buried carcasses showed delayed insect arrival (>20 hours) and were colonized almost exclusively by *Chrysomya megacephala* and *Dermestes maculatus*.

Conclusion: Burial has a stronger effect than habitat type on extending decomposition duration under 42°C. Surface carcasses in agricultural environments decompose significantly faster than those in graveyards. The research was conducted under extreme thermal conditions, with temperatures averaging 42°C, to evaluate the impact of heat stress on insect diversity and degradation rates. The results revealed a distinct temporal succession of insect taxa; Dipteran species predominated during the initial decomposition stages, followed by Coleopterans as the carcasses progressed toward desiccation. High temperatures significantly accelerated the insect life cycles and shortened the duration of decomposition stages compared to temperate conditions. This study provides crucial baseline data for forensic entomology in Iraq, aiding in the estimation of the post-mortem interval (PMI) in arid regions and isolated sites, thereby enhancing the accuracy of criminal investigations under extreme climatic conditions. These findings provide the first baseline forensic entomology data for Al-Diwaniyah, Southern Iraq.

Keywords: Insect succession, forensic entomology, dog carcass, cemetery environment, agricultural environment, burial, decomposition stages, 42°C, Al-Diwaniyah, Iraq.

ARTICLE HISTORY

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1. INTRODUCTION

Forensic entomology is a vital branch of forensic science that relies on the study of insects associated with cadavers to estimate the post-mortem interval (PMI), especially when traditional methods based on early decomposition stages are no longer applicable. The accuracy of PMI estimation depends on understanding insect succession patterns and the influence of environmental factors, particularly temperature, on their life cycles [1].

Forensic entomology relies on the predictable succession of insects on decomposing remains to estimate the postmortem interval (PMI). However, insect succession patterns are significantly influenced by local environmental conditions, including habitat type, temperature, and burial status (7). Southern Iraq experiences extreme summer temperatures exceeding 42°C (8).

Dogs (Canis familiaris) are frequently used as human analogues in forensic entomology research due to their similar decomposition patterns and insect attraction (9). Therefore, this study used dog carcasses to provide baseline data for forensic casework in southern Iraq.

The orders Diptera and Coleoptera are the most significant in forensic investigations. Flies (particularly families Calliphoridae, Sarcophagidae, and Muscidae) arrive at the corpse during the early stages of decomposition and lay eggs that develop into larvae feeding on soft tissues [6]. In contrast, beetles (particularly families Dermestidae, Cleridae, and Histeridae) appear during the later stages of decomposition to feed on dry tissues and bones [2]. This predictable chronological succession, influenced by environmental factors, makes insects precise biological indicators for estimating the time of death [1,3].

Temperature significantly affects decomposition rates and insect development. At high temperatures, decomposition processes accelerate and insect life cycles shorten considerably [4,5,6].

This study aimed to:

1. Document insect succession on dog carcasses in two contrasting habitats (isolated cemetery vs. agricultural environment) under 42°C.
2. Compare surface vs. buried (50 cm depth) treatments within each habitat.
3. Record the duration of each decomposition stage (fresh, bloated, active decay, dry decay, skeletal (remains).

Provide the first baseline forensic entomology reference for Al-Diwaniyah, Southern Iraq.

2. MATERIALS AND METHODS

The city of Diwaniyah is located in southern Iraq, within the Middle Euphrates region, on the banks of the Diwaniyah River. It is approximately 180 to 181 kilometers south of the capital, Baghdad, and is characterized by being a fertile agricultural area and a vital link between Baghdad and the southern provinces.

Description of the study areas: The study was conducted in two different environmental locations on the outskirts of the city and consisted of:

1. **The agricultural area:** The agricultural area was chosen and is located in the Al-Daghara district, Marmad village, south of the city center of Al-Diwaniyah (Figure 1). It is characterized by the presence of dense vegetation cover in terms of the presence of fruit trees and vegetables, and the presence of animals such as sheep, cows, and dogs.
2. **The cemetery area:** It is located in the Al-Daghara district, it is about 3000 meters away from the Al-Hajja Umm Jamal Mosque. This cemetery contains human graves and is a sandy environment that incubates insects that play a key role in the decomposition of corpses (Figure 2)

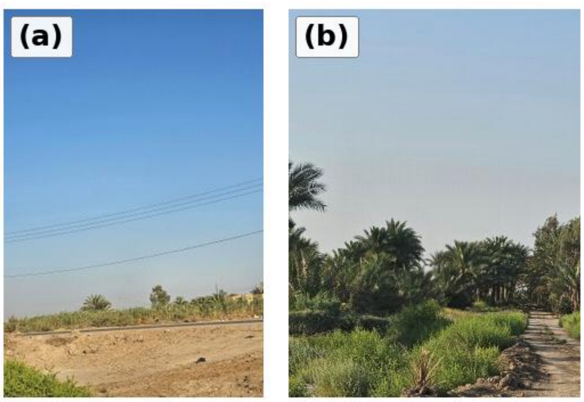

Figure 1. Agricultural study environment in Al-Daghara, Al-Diwaniyah, southern Iraq. (a) cultivated field bordered by an unpaved access road and overhead power lines; (b) date-palm and dense vegetation cover at the study site.

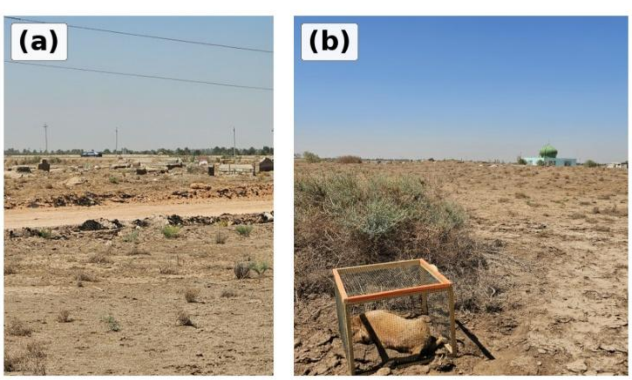

Figure 2. Cemetery study environment and experimental field setup in Al-Daghara, Al-Diwaniyah, southern Iraq. (a) the open, arid cemetery landscape; (b) wire-mesh enclosure used to secure a ground-level dog carcass at the site.

Twelve dogs were used in this study and the carcasses were then divided among two different locations (agricultural area, and cemetery area). In each area, the carcasses were divided into two treatments. In the first treatment, the animals were placed in graves (buried) 50 CM deep, while in the second treatment, the carcasses were left uncovered, with three replicates for each animal type. The animals placed in the graves were covered with wooden pieces, and backfilled with 10 cm of soil. For the treatments at ground level, the carcasses were placed in wire mesh cages measuring 150 cm x 100 cm.

The experimental sites were monitored every 24 hours, sequentially, for all replicates, starting from the time of death until the end of the experiment. The study was structured according to the method of Service (1980) (10) and Chin et al. (2007) (11). All attracted insect species were collected and recorded using a standard insect sweeping net and fly rolls for collecting flying and ground insects (Al-Mesbah, 2010) (12). Larvae and adult beetles were collected using small brushes, spoons, and tweezers of varying sizes. At each visit, all information for each carcass was recorded on a separate sheet, including the location and date of collection, the type of carcass from which it was collected, and all relevant details about the sample. The samples were then transferred to the Entomology laboratory for preservation and storage.

The larvae were collected and washed with distilled water to remove impurities, then killed with hot water (70-80°C). Washing them immediately before preservation with alcohol helps prevent shrinkage or disintegration, which would lead to spoilage (Service, 1980). They were then preserved in glass bottles containing 70% ethyl alcohol for identification using several taxonomic keys (المصادر), and subsequently sent to the Natural History Research Center and Museum for confirmation of the diagnosis. for counting and photographing the insects using a Dino-Lite Digital Microscope (Figure 3). During the field experiment, the average temperature and humidity at the study site were recorded using a Thermo-meter.

Figure 3. Dino-Lite digital microscope used for examination, documentation, and photography of the collected insects during the study.

3. RESULTS

Decomposition stages:

Practical conclusions of the fresh stage

1. The burial level is the strongest factor (F=3721), deep burial yields 3 times higher values than surface (1.517 vs 0.500).
2. The cemetery environment provides higher values than agricultural (1.267 vs 0.750).
3. The interaction is D, which means that the impact of the environment depends on the depth:
- On the surface: No difference between a cemetery and agronomic (0,500 in both).
- In burial: The cemetery is higher than the agricultural (2.033 vs 1.000).
4. Highest value recorded: Cemetery + Deep (2.033).

Lowest value recorded: Surface in both environments (0.500).

Fresh stage			
Environment	Level of burial		Enveronment
	Burial	Surface	
1.267	2.033	0.500	Cemetery
0.750	1.000	0.500	Agriculture
0.038**	0.054**		lsd5%
	1.517	0.500	Average burial level
	0.038**		lsd5%

Practical conclusions of the bloat stage

1. The burial environment alone is not influential (p=0.900) because the values are very similar (3.467 vs. 3.450).
2. The burial level is the strongest factor (F=984), deep burial yields 4 times higher values than surface burial (5.483 vs 1.433).
3. D Reaction (p=0.004):
- In deep burial: agricultural higher than cemetery (5.733 vs 5.233).
- In surface burial: the cemetery is higher than the agricultural (1,700 vs 1.167).
4. Highest value recorded: Agricultural + Deep (5.733).
5. Lowest value recorded: Agricultural + Surface (1.167)

Bloat stage			
Environment	Level of burial		Enveronment
	Burial	Surface	
3.467	5.233	1.700	Cemetery
3.450	5.733	1.167	Agiculture
0.298**	0.421**		lsd5%
	5.483	1.434	Average burial level
	0.298**		lsd5%

Practical conclusions of the wet stage

1. The burial environment is influential: the cemetery is higher than the agricultural one (15.17 vs 12.85).
2. The burial level is the most powerful factor (F=1992), deep burial yields 4 times higher values than surface burial (22.27 vs 5.75).
3. Interaction D:
- In depth: The cemetery is higher than the agricultural (24.33 vs 20.20).
- On the roof: The cemetery is also higher (6.00 vs 5.50).
4. Highest value recorded: Cemetery + Deep (24.33).

Lowest value recorded: Agricultural + Surface (5.50).

Wet decay stage			
Environment	Level of burial		Enveronment
	Burial	surface	
15.165	24.330	6.000	Cemetery
12.850	20.200	5.500	Agriculture
0.853**	1.207**		lsd5%
	22.265	5.750	Average burial level
	0.853**		lsd5%

Practical conclusions of the dry decomposition phase

1. The burial environment alone is ineffective (p=0.183) because the values are convergent (23.33 vs 23.88).
2. The burial level is the most powerful factor of all stages (F=4081), deep burial yields 3 times higher values than surface burial (35.67 vs 11.55).
3. Interaction D:
   - In burial: Agricultural higher than cemetery (37.00 vs 34.33).
   - On the surface: the cemetery is higher than the agricultural (12.33 vs 10.77).
4. Highest value recorded: Agricultural + Deep (37.00).
5. Lowest value recorded: Agricultural + Surface (10.77).

Dry decay stage			
Environment	Burial level		Enveronment
	Burial	surface	
23.330	34.330	12.330	Cemetery
23.885	37.000	10.770	Agriculture
0.870ns	1.231**		lsd5%
	35.665	11.550	Average burial level
	0.870**		lsd5%

Practical conclusions of the skeletal stage

1. The burial environment is influential: the cemetery is higher than the agricultural (31.67 vs 28.17).
2. The burial level is the strongest factor (F=1426), deep burial yields 3 times higher values than surface burial (45.33 vs 14.50).
3. Interaction D:
   - On the surface: the cemetery is higher than the agricultural (17.67 vs 11.33).
   - In burial: The cemetery is slightly higher than the agricultural (45.67 vs 45.00).
4. Highest value recorded: Cemetery + Deep (45.67).
5. Lowest value recorded: Agricultural + Surface (11.33).

Skeletal stage			
Environment	Burial level		Enveronment
	Burial	surface	
31.670	45.670	17.670	Cemetery
28.165	45.000	11.330	Agriculture
1.883**	2.663**		lsd5%
	45.335	14.500	Average burial level
	1.883**		lsd5%

4. DISCUSSION

The results of this study showed that the decomposition of the dog carcass (30-40 kg) in Diwaniyah governorate follows a multi-stage pattern (fresh, bloating, wet decomposition, dry decomposition, structural) (Figure 4), and that the level of burial is the most influential factor in the decomposition rate across all stages. These findings are consistent with the findings of Haidar Naim Al-Ashbel's study (2020-2023) in Karbala governorate, where he also used dog carcasses to monitor the succession of criminal insects across the four seasons, and stressed that the wet and dry decomposition phase witnesses the highest insect diversity, especially in spring and autumn.

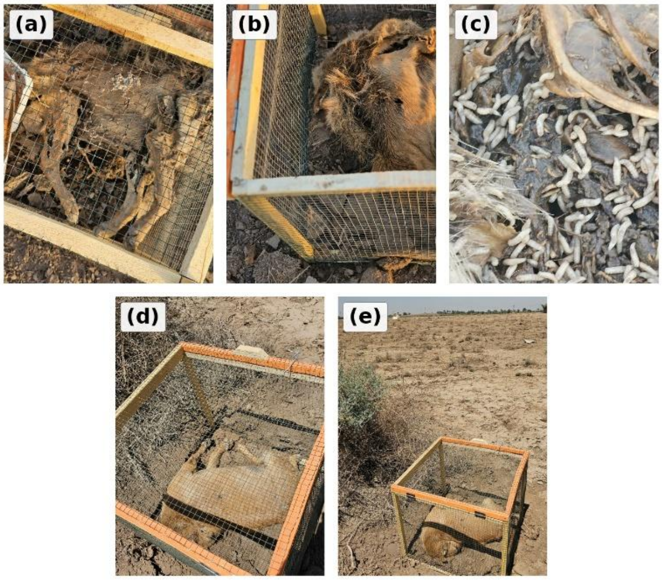

Figure 4. Representative field photographs from the experimental observations, showing dog carcasses within wire-mesh enclosures, visible insect activity, and progressive decomposition. Panels (a–e) correspond to separate field records.

Regarding the impact of the burial environment on the dog carcass, the effect was not fixed across the stages. In fresh, wet and structural stages, the cemetery environment yielded higher values than the agricultural environment, while this difference disappeared in the bloating and dry decomposition phases. This nonlinear pattern explains that the internal processes of decomposition may temporarily overwhelm the influence of the external environment.

The strong inhibitory effect of burial depth on decomposition rate and insect colonization observed in the present study is consistent with several international investigations. Shah (2013) [16], working with dog carcasses in the arid subtropical climate of Mardan, Pakistan, reported that Chrysomya rufifacies was the first blowfly to colonize exposed carcasses and dominated the earliest decomposition stages, mirroring the rapid Calliphoridae-driven colonization recorded on surface carcasses in the current study. Kökdenera and Polat (2014) [17], studying dog carcass succession in Samsun Province, Turkey, likewise documented a shift from dipteran to coleopteran dominance as decomposition advanced, supporting the temporal succession pattern identified here.

Regarding burial depth specifically, a comparative study of buried rabbit carcasses in Riyadh, Saudi Arabia (18) found that depth and season jointly governed both the rate of decomposition and the diversity of colonizing Diptera, paralleling the pronounced depth effect (F > 984) recorded in the present study. Similarly, a recent trial on pig carcasses buried at 40 cm versus 80 cm depths reported markedly slower decay at the greater depth (19), reinforcing the conclusion that burial depth, more than burial environment alone, is the principal driver of decomposition rate. A seasonal study of buried carcasses in the semi-arid Rohtak region of India (20) also confirmed that colonization of buried remains is delayed and restricted relative to surface carcasses, consistent with the >20-hour delay in insect arrival and the near-exclusive dominance of Dermestes maculatus on buried carcasses observed in Al-Diwaniyah. On the surface, *Chrysomya albiceps* remained the dominant colonizing species across treatments, consistent with reports on its biological activity and susceptibility to botanical extracts such as *Solanum nigrum* [21]. Collectively, these comparative findings from arid and semi-arid regions worldwide support the generalizability of burial depth as the dominant factor controlling both decomposition rate and insect community composition, even under the extreme thermal conditions (42°C) characteristic of southern Iraq.

Recommendations:

For Forensic Practitioners

- Measure burial depth first, as it is the strongest factor affecting decomposition rate.
- Record burial environment (cemetery / agricultural), as it affects insect species.
- Collect insects from the carcass and surrounding soil.

For Future Researchers

- Add intermediate depths (30 cm, 40 cm, 60 cm) to determine the precise pattern of effect.
- Study different seasons (winter, spring, autumn), as insects vary with season.
- Analyze soil chemically (pH, moisture, salinity) and link it to decomposition rate.

5. CONCLUSION

This study demonstrates that burial depth is the dominant factor governing dog carcass decomposition and insect succession under the extreme thermal conditions (42°C) of southern Iraq, exerting a stronger influence than burial environment (cemetery versus agricultural land) across nearly all decomposition stages. Surface carcasses decomposed markedly faster than buried carcasses and were colonized almost immediately by Calliphoridae flies, whereas buried carcasses experienced a delayed insect arrival (>20 hours) and were dominated by Dermestidae beetles, particularly in deep burial. These findings provide the first baseline forensic entomology data for Al-Diwaniyah, southern Iraq, and offer a practical local reference for estimating the post-mortem interval (PMI) in forensic casework involving both surface-exposed and buried remains under high-temperature arid conditions.

6. DECLARATION

Funding

This study was self-funded by the authors, and no external financial support was received.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no competing financial or non-financial interests.

Ethical approval

Ethical approval for this study was granted by the Research Ethics Review Committee, College of Science, University of Al-Qadisiyah, Iraq (Approval No. 2442, Project No. 007), in accordance with the Ethical Principles for Research Involving Animal Participants.

Animal ethics statement

This study did not involve any live experimental procedures on animals. Dog carcasses used in this study were obtained post-mortem and handled in accordance with the institutional ethical and animal welfare guidelines approved under the certificate cited above.

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