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Effect of height to ground level on the insect attraction to exposed rabbit carcasses

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Abstract

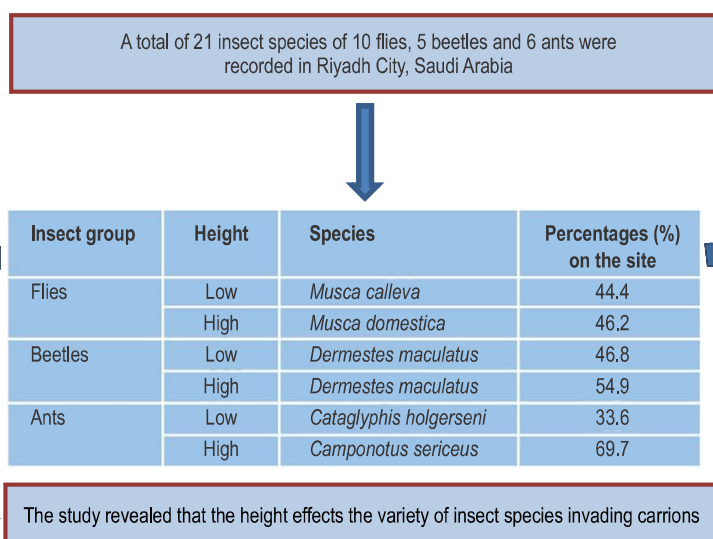
Aim : The present study aimed to determine the effect of height from ground on the colonization of carrion insect species.

Methodology : Rabbit (*Oryctolagus cuniculus* L.) carcasses were positioned at two different heights with respect to ground level in Riyadh, Saudi Arabia to determine populations of carrion insects at different decomposition stages. Steel cages were used to defend the carcasses from flesh eating vertebrates without effecting surrounding environmental condition. Ambient temperatures and the patterns of insect succession were monitored at both heights.

Results : In total, 14 and 18 different carrion-associated taxa were collected at low and high sites, respectively. The primary and dominant necrophagous colonizer was the muscid dipteran *Musca calleva* (Walker) at low site and *M. domestica* (L.) at high site. The dominant beetle species at both sites was *Dermestes maculatus* (De Geer). The dominant ant species at low site were *Cataglyphis holgerseni* (Collingwood & Agosti) and *Ca. savignyi* (Dufour) and *Camponotus sericeus* (Fabricius) at high site.

Interpretation : This research verified that the height of carrion in relation to ground level considerably affected the variety of insect species, particularly flies and beetles.

Key words: Carcasses, Carrion insect, *Oryctolagus cuniculus*



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Introduction

Forensic entomology is the science that studies the taxonomy, life cycle and behavior of arthropods correlated with a decomposing carrion (Cruise *et al.*, 2018). A critical element of forensic entomology studies is documenting the ecological succession of local arthropods fauna on the decomposing carrions. The patterns obtained from forensic entomology research may be used in criminal inquiries and legal proceedings, such as postmortem interval estimation (Merritt and De Jong, 2015). Many animals such as pigs (Rosa *et al.*, 2011), rabbits (Silahuddin *et al.*, 2015), rats (Silva *et al.*, 2014), dogs (Boulkenafet *et al.*, 2015) and animal sections such as liver have been used as a model for studies on forensic entomology, (Ahmad *et al.*, 2018). For many creatures, a corpse is a large food resource.

The corpse progresses over time from flesh to skeletal through a known series of compositional stages (Henssge *et al.*, 1995). Flies, beetles and many other arthropods have been reported to attract dead bodies (Kim *et al.*, 2014). Vasconcelos *et al.* (2015) reported that flies are the most significant group of insects, where flies such as Calliphoridae, Sarcophagidae and Muscidae families are generally the first to colonize a carcass. Beetles occupy an ecologically assorted part of the carrion community, providing a wide range of potential sources of proof in medico-legal inquiries (Bala and Singh, 2015). In addition, ants can affect the general ecology of carrion. Catts and Haskell (1990) indicated that ants could feed on carcasses or prey on other carcass related arthropods.

The composition of faunal communities in an area is affected directly by abiotic factors such as temperature, humidity, rainfall and food source (Campobasso *et al.*, 2001). These variables may affect the insect succession and carrion decomposition (Anderson, 2000). Furthermore, Byrd and Castner (2010) concluded that the habitat, vegetation, soil type and meteorological conditions of the area may affect the insect succession. Studying the effect of height on the attraction of insects as well as the sequence of their presence on the corpses have not receive much attention. In Europe and North America, the presence of some carrion flies has been reported in high-rise buildings (Anderson, 2001). While in Penang, Malaysia three families of flies (Phoridae, Calliphoridae and Sarcophagidae) was recorded on three forensic cases occurring on the 4th and 7th floor of residence buildings (Kumara *et al.*, 2010). Also, in Kuala Lumpur, Malaysia Syamsa *et al.* (2012) reported the occurrence of muscid fly, *Synthesiomyia nudiseta* Wulp on a corpse found at 13th floor of a building. Similarly, Syamsa *et al.* (2015) reported dipterans in high-rise buildings in three forensic cases in Kuala Lumpur, Malaysia.

The post-mortem interval (PMI) could be estimated by recording the pattern of arthropod succession and the decomposition stages of a cadaver. Where the time of death is unknown, the police investigators use this type of analysis (Morris and Dadour, 2015). Accurate estimation of PMI requires

comprehensive studies on the effect of different parameters on the insect succession pattern on a decomposing cadaver. Different countries and biogeographic regions/habitats show variations in insect species and communities (Voss *et al.*, 2011). It is, therefore, important to get primary information in a given region to apply the forensic entomology analyses. Several factors that may affect insect colonization of carcasses, including habitat, the presence or absence of clothing, sun exposure and whether the carcass has been burned (Anderson, 2000; Mashaly, 2016). Taking into account present study was Undertaken to undertake procure basic information in Riyadh, Saudi Arabia by deducing the varieties of insects attracted to rabbit carcasses and their succession at two different heights.

Materials and Methods

The study was carried out at roof of the College of Sciences building, King Saud University and adjacent college building presenting high and low site respectively. Every 30 min, the ambient temperature was recorded throughout the experiment by using a data logger (LASCAR Electronics, UK) at each site, and to obtain average values over the experimental period. The experiment was performed during June 2016. Rabbits (*Oryctolagus cuniculus* L.) were obtained from a local farm. Eighteen rabbits (weighing 1.80–2.10 kg) were used for the study, the experiments were carried out in accordance with the terms of Graduate Studies and Scientific Research Committee, Department of Zoology, College of Sciences, King Saud University. In addition, the instructions indicated in the study of Al-Mesbah *et al.* (2012) on rabbit carcasses in Kuwait were also followed. The experiments were carried out in three replicates.

At each study site, rabbit carcasses were arranged in a regular, symmetrical pattern of one row, spaced 2 m apart and protected by steel cages (55 × 40 × 24 cm³) that allowed access by insects and other arthropods but prevented access by carnivorous vertebrates. For each carcass, two pitfall traps (10 cm in diameter) filled with a solution of water (30 ml), soap (0.5 g), and salts (0.5 g) were used. During the testing period, the carcasses were visited daily between 9.00 a.m. and 2.00 p.m. The insect activity was recorded immediately after setup the experiment. Sampling was continued during the decomposition stages from fresh to dry stage.

Specimens were collected in 70% ethanol in vials labelled with the date and time of collection and then transferred to the entomology laboratory in the Zoology Department for identification. Insects were identified to the lowest possible taxonomic level by using specialized taxonomic; for flies (Greenberg and Kunich, 2002; Setyaningrum and Dhafer, 2014), and for beetles (Catts and Haskell, 1990), and those of ants by Dr. Mostafa Sharaf (College of Food & Agriculture Sciences, King Saud University). Significant differences in diversity (as quantified by the number of insect species) between the two sites were evaluated using the Kruskal-Wallis test. F-tests were used to determine the effects of interaction between different variances.

Results and Discussion

The study imparts the influence of insect species attraction towards carrion with respect to height, thus exploring the species composition. Temperatures ranged from 39 to 43 °C at ground and from 35 to 40 °C on the roof, about 4°C lower. The insect species identified on the rabbit carcasses are presented in Table 1. In total, 21 taxa comprising different order were recorded (19 species and two unidentified beyond genus). Ten species belonged to the order Diptera, five to order Coleoptera, and six to order Hymenoptera. Insect species recorded at both high and low site are presented in Table (1). In total 14 insect species were identified: five fly species (*Lucilia sericata* Meigen, *Musca calleva* Walker, *M. domestica* L., *M. sorbens* Wiedemann and *Wohlfahrtia trina* Wiedemann), three beetle species (*Necrobia rufipes* Fabricius, *Dermestes maculatus* De Geer, and *Saprinus moyses* Marseul), and six ant species (*Camponotus aegyptiacus* Emery, *C. sericeus* Fabricius, *Cataglyphis holgerseni* Collingwood & Agosti, *Ca. lividus* André, *Ca. savignyi* Dufour, and *Monomorium venustum* Smith). At this site, the most abundant species from each order were *M. calleva* from flies, *D. maculatus* from beetles, and *C. sericeus* and *C. aegyptiacus* from ants. At high site, 18 insect species were recorded: eight fly species (*L. sericata*, *L. cuprina* Wiedemann, *Platypalpus* sp. Fabricius, *Atherigona theodori* Hennig, *M. calleva*, *M. domestica*, *Ravinia pernix* Harris and *Physiphora alceae* Preysler), four beetle species (*N.*

rufipes, *D. maculatus*, *Saprinus* sp. Erichson and *S. semipunctatus* Fabricius), and the same six ant species were attracted to the carcasses at low site. At this site, the most abundant species from each order were *M. domestica* from flies, *D. maculatus* from beetles and *Ca. holgerseni* and *Ca. savignyi* from ants beetles (by one species) The results shown in Table 1 also level that *M. sorbens* and *W. trina* flies were recorded only at low site, whereas *L. cuprina*, *Platypalpus* sp., *A. theodori* and *R. pernix* were recorded at high site only. The beetle *S. moyses* was recorded only at low site; *Saprinus* sp. and *S. semipunctatus* were recorded only at high site.

At low site, *W. trina* and *Ca. holgerseni* were the only fly and ant species recorded at the fresh stage of decayed carcasses; no beetles were recorded at this stage at the low site. At the high site, no flies or beetles were recorded on fresh carcasses, but four ant species were found (Table 2). At the bloated stage of decomposition, five fly species and two ant species, but no beetle species, were recorded at the low site. At the high site at this stage, two fly species, three beetle species, and six ant species were recorded. At decaying stage five fly species, two beetle species, and three ant species were recorded at the low site. At site at this stage, most of the insect species identified on carrion were present; the exceptions were *M. sorbens*, *W. trina* and *Ca. holgerseni*. At dry stage of decomposition, few insect species were recorded at either site: at

Table 1: Mean number of recorded insects at two different heights

Order	Family	Species	Number of insects		
			Low	High	
Diptera	Calliphoridae	<i>Lucilia sericata</i>	202.6±6.71	53.5±2.31	
		<i>Lucilia cuprina</i>	0.0±0.0	3.7±1.7	
		Hybotidae	<i>Platypalpus</i> sp.	0.0±0.0	2.3±1.2
	<i>Atherigona theodori</i>		0.0±0.0	76.2±4.67	
	Muscidae	<i>Musca calleva</i>	1014.5±11.37	143.5±5.93	
		<i>Musca domestica</i>	656.9±5.75	253.7±7.29	
		<i>Musca sorbens</i>	339.2±	0.0±0.0	
		Sarcophagidae	<i>Ravinia pernix</i>	0.0±0.0	4.02±1.1
			<i>Wohlfahrtia trina</i>	69.8±3.21	0.0±0.0
	Ulidiidae	<i>Physiphora alceae</i>	0.0±0.0	12.3±2.5	
	Cleridae	<i>Necropia rufipe</i>	17.25±1.45	38.08±3.72	
	Coleoptera	Dermestidae	<i>Dermestes maculatus</i>	29.21±2/31	55.6±3.35
			<i>Saprinus</i> sp.	3.23±0.13	0.0±0.0
		Histeridae	<i>Saprinus semipunctatu</i>	3.51±0.21	0.0±0.0
<i>Saprinus moyses</i>			0.0±0.0	25.1±3.57	
<i>Camponotus aegyptiacus</i>			58.37±4.13	30.5±4.38	
<i>Camponotus sericeus</i>			69.65±4.52	24.2±2.36	
Formicinae		<i>Cataglyphis holgerseni</i>	25.08±2.57	77.6±6.21	
		<i>Cataglyphis lividus</i>	40.43±3.21	16.8±1.4	
Hymenoptera		Myrmicinae	<i>Cataglyphis savignyi</i>	43.12±3.42	75.2±5.31
			<i>Monomorium venustum</i>	11.53±1.11	6.9±0.32

Values are mean of three replicates ±S.E.

Table 2: Insect succession on rabbit carcasses at different stages of decomposition at two different heights

Insect	Species	Decomposition stage							
		Fresh		Bloated		Decay		Dry	
		Low	High	Low	High	Low	High	Low	High
Flies	<i>Lucilia sericata</i>		✓	✓	✓	✓			
	<i>Lucilia cuprina</i>					✓			
	<i>Platypalpus sp.</i>					✓			
	<i>Atherigona theodori</i>						✓		
	<i>Musca calleva</i>		✓		✓	✓	✓		
	<i>Musca domestica</i>			✓		✓	✓	✓	
	<i>Musca sorbens</i>		✓		✓				
	<i>Ravinia pernix</i>					✓			
	<i>Wohlfahrtia trina</i>	✓		✓		✓			
	<i>Physiphora alceae</i>				✓		✓		
	<i>Necropia rufipe</i>					✓			
	Beetles	<i>Dermestes maculatus</i>				✓	✓	✓	✓
<i>Saprinus sp.</i>				✓		✓		✓	
<i>Saprinus semipunctatu</i>					✓		✓		✓
<i>Saprinus moyses</i>						✓	✓		
<i>Camponotus aegyptiacus</i>			✓		✓	✓	✓		
<i>Camponotus sericeus</i>			✓	✓	✓		✓		
<i>Cataglyphis holgerseni</i>		✓	✓	✓	✓	✓			
Ants	<i>Cataglyphis lividus</i>		✓		✓		✓		✓
	<i>Cataglyphis savignyi</i>				✓		✓		✓
	<i>Monomorium venustum</i>				✓	✓	✓		

✓: referred to the presence of insect species

low site, two fly species and one beetle species were recorded; at high site, two beetle species and two ant species were recorded. No insect species were present on the carrion at each stage of decomposition (Table 2).

Table 3 shows that rabbit carcasses at low site attracted a significant number of flies and beetles as compared to the high site. There was no significant difference in the number of ants between the two sites. Generally, the low site attracted more insect than the high site. With regard to the species richness, the high site attracted more fly and beetle species, however, but the two sites attracted the same ant species. Overall, eighteen insect species were attracted to the high site compared to fourteen for the low site. In addition, results have shown that by studying the correlation between the height and the number of insect species attracted to the rabbit carcasses, we found correlations between the numbers of flies and beetles and the height. Kruskal-Wallis test was recorded: $\alpha = 0.05$, $H = 10.23$, $df = 1$, $P = 0.002$ for flies and $\alpha = 0.05$, $H = 1.33$, $df = 1$, $P = 0.045$ for beetles; however, this association was not significant for ant species (Kruskal-Wallis test: $\alpha = 0.05$, $H = 0.05$, $df = 1$, $P = 0.818$). The present of data showed an increase in species richness and decrease in species

Table 3: Mean number of recorded insects at different heights and total richness (total number of scavenger species)

Insects	Number of insects		Species richness	
	Low	High	Low	High
Flies	2283.21±18.1 ^a	549.19±9.7 ^b	5	8
Beetles	118.78±1.3 ^a	53.31±3.3 ^b	3	4
Ants	231.62±8.2 ^a	248.68±8.3 ^a	6	6
Total	2633 ^a	850 ^b	14	18
	3483		21	

Values are mean of replicate ±S.E. Letters (a, b) at the horizontal level indicate significant differences by Mann-Whitney U test ($P < 0.05$)

diversity of flies and beetles with increasing height. These variations may be due to the decrease of habitat area at high rise and low natural resource diversity. There were no significant differences for the number of ant species or total number of ants at the two heights. Abiotic factors acting as limiting factors, also affected the species diversity at higher rises. In Europe and North

America, some carrion flies at high-rise buildings (Anderson, 2001). In Malaysia, the species richness at high-rise buildings was studied by Syamsa *et al.* (2015) was found a similar range of dipteran species viz. *Megaselia scalaris* Loew and *Synthesiomia nudiseta* Van Der Wulp, and larvae of blow fly species *Chrysomya megacephala* Fabricius and *Ch. rufifacies* Macquart.

The arrival and oviposition of sarcophagids and blowflies may be delayed under the effect of buildings, which act as a physical barrier (Reibe and Madea, 2010). In the present study, *D. maculatus* was the dominant beetle species at both the sites. We also found that *L. sericata*, *M. calleva* and *M. domestica* were present at both the heights. The presence of these three fly species in an urban habitat was reported in Riyadh city (Mashaly and Al-Mekhlafi, 2016). *Necrobia rufipes* and *D. maculatus* were also recorded at both the heights. Catts and Goff (1992) indicated that the Dermestid family has been registered in many countries as one of the widespread forensic beetles. In Riyadh, a study recorded the presence of both beetle species in high numbers in an urban habitat (Mashaly, 2017). The appearance of *D. maculatus* on decomposing remains of humans or other animals makes this species a candidate for estimating PMI in cases of suicide, homicide, or unattended death (Richardson and Goff, 2001).

Ants are amongst the most dominant species in different habitats of the world (Stork, 1991). The diversity of ant species depends on several biotic and abiotic factors (Mashaly *et al.*, 2018). In addition, Heo *et al.* (2009) indicated that ants preyed on insect larvae but also fed on corpse skin. In this study, *Ca. holgerseni* and *Ca. savignyi* were the dominant ant species at low site while *C. sericeus* was dominant at high site. *Camponotus* was suggested as the most diverse genus in the subfamily Formicidae (Wilson, 1976). Also, they colonize buildings to utilize their wide array of potential nesting materials (Fowler, 1990). *Cataglyphis* ants do not attempt to escape the heat; rather, they use their heat tolerance to avoid competitors and predators (Boulay *et al.*, 2017). They have adaptations strategies in body size and morphology that improve heat tolerance.

For example, the legs of worker *Cataglyphis* ants are considerably longer than those of similarly sized phylogenetically related species from mesic habitats (Sommer and Wehner, 2012). Longer legs allow the insects to raise their bodies from the ground, reducing heat exposure and enhancing convection cooling (Sommer and Wehner, 2012); this adaptation also enables the ants to run faster (Hurlbert *et al.*, 2008) and improves their foraging efficiency (Anderson and McShea, 2001). The results also indicated differences in insects attracted to the carcasses according to the decomposition stage. Henssge *et al.* (1995) reported that a distinct group of arthropods attract to each stage. Some are directly attracted by the corpse, which used it as a food resource or a medium of oviposition, while other species are attracted by large aggregation of other insects that use as a food resource. Thus from this study it can be concluded that, when carcasses were placed at two different height in Riyadh, Saudi Arabia. it was found that the height at which the carrion was

located is obviously a significant factor affecting the species richness. Knowledge of insect biology at these locations will be of value to forensic investigations.

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