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ORIGINAL ARTICLE

Carrion beetles succession in three different habitats in Riyadh, Saudi Arabia



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Abstract A main objective of the study is the establishment of a forensic entomological database for Riyadh, Saudi Arabia. Decomposition processes and beetle succession were analysed on rabbit carcasses in three different habitats (agricultural, desert and urban) in the period from May to July 2014. Due to the effects of the high temperature at the study sites, carrion reached the dry stage within 12 days in the agricultural habitat, and 6 days in the desert and urban habitats. A total of 125 beetles belonging to eight species and five families were collected during the decaying process, with their abundances increasing from the fresh to decay stages. The prevailing species belonged to the families of Dermestidae and Histeridae. It was not possible to confirm any definitive relationship between the occurrence of a single species and a particular stage of decomposition. The beetle communities were also not distinctively different between desert and urban habitats, but a distinct community was evident in the agriculture habitat. In addition, there were distinct beetle communities between the decay stage and the other stages. The dry stage recorded the lowest number of beetles. This study indicated that, the habitat type had an effect on the decay process and the abundance rate of the beetles.

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1. Introduction

Insects occurring on corpses can be analysed to help determine the post-mortem interval (PMI) specific to a defined biogeographical region (Watson and Carlton, 2003; Grassberger and Frank, 2004; Matuszewski et al., 2010b). The rate of decomposition, insect succession, seasonal availability and composition of carrion communities are influenced not only by the biogeoclimatic zone, but also by temperature and humidity (Mann et al., 1990), by the type and the physical state of the carcass remains (Anderson, 2010), as well as by habitat loss and fragmentation (Anderson, 2010; Caballero et al., 2012).

Coleoptera is the largest order, containing about a third of all known insects (Byrd and Castner, 2010). Beetles occupy an ecologically assorted piece of the carrion community, thus providing a wide range of sources of potential evidence in

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medico-legal investigations (Schoenly et al., 2007). Necrophilous beetles, which cannot be replaced by flies, play a pivotal role not only in estimating minimum postmortem interval time (m-PMI) of dry skeletal remains in the later stages of decomposition, but also to determine the destruction and posture changes of carcasses (Kulshrestha and Satpathy, 2001). Beetle communities with criminological significance differ according to the region, but the most common beetle species, included in the following families were; Cleridae, Dermestidae, Histeridae, Scarabaeidae, Silphidae and Staphylinidae (Hart and Whitaker, 2005). Guo et al. (2012) reported that, most of the developmental studies of carrion related insects have been focused on flies, but beetle development have been largely neglected.

The work reported here sought to test (i) whether different habitats (agriculture, desert and urban) have an effect on beetle diversity, community structure and succession patterns and (ii) whether each habitat and each stage of decaying shows a degree of taxonomic differences. Ultimately, we provide detailed information on carrion beetle communities and succession patterns that can be used as an entomological reference in Riyadh, Saudi Arabia.

2. Material and methods

The study was conducted in three different ecological habitats. The first site was an agricultural area (24°44'36.54" N, 46°33'45.12" E), where the nearest human dwelling was approximate 1 km from the study site, and which contained many palm trees and grasses. The second site was a desert area (24°47'41.61" N, 46°32'38.47" E), where the nearest human dwelling was approximate 4.5 km from the study site. At this site, the soil, which was composed mostly of rocks, was extremely hard-packed and dry. The third site was an urban area (24°43'16.51" N, 46°37'2.45" E), beside the building of the College of Science at King Saud University. Human dwellings were located close to this site. The study was repeated three times, where it was conducted from 9 to 21 May, 15 to 28 June and 11 to 23 July 2014.

Nine live mature rabbits (*Oryctolagus cuniculus* Linnaeus) were used because, it is not allowed to use pigs in experiments in Saudi Arabia. AbouZied (2014) has shown that rabbits can

be used successfully to study decomposition succession in KSA. Rabbits were procured at the sites, euthanized with chloroform, weighed (mean = 1.57 ± 0.44 kg) and divided into groups of three. Three rabbits were located in each of the agriculture, urban and desert habitats. Sampling occurred daily after the carcasses were set down. This pattern was decided upon so as to include decomposition stages up until the dry stage had nearly been reached. In order to exclude scavengers, the rabbits were placed in steel cages (55 cm × 40 cm × 24 cm), which were designed specifically to allow insect access, but prevent them escaping, instead trapping them in a chamber at the top of each cage. For these purposes, each cage was made of a frame composed of a layer of wire screening from a rigid steel 2 cm mesh to keep out scavengers but allow insect access.

For each carcass, four pitfall traps (10 cm in diameter) were used. The four traps were placed around each rabbit carcass. On each sampling day, each trap was filled up with a solution of water, soap and salts. Only adults were included in the counting of collected insects during this field study. Collections were made daily during the sampling period. By using specialized taxonomic keys, the collected beetles were classified into family and species levels (Borror et al., 1989; Catts and Haskell, 1990; Arnett et al., 2002; Navarrete-Heredia et al., 2002) and confirmed by Prof. Ali Maghrabi, King Saud University (see Acknowledgments). Daily temperatures for each habitat were recorded using a Lascar EL-USB-2 data logger (Fig. 1).

In order to compare the mean durations of the decomposition stages between the three different habitats, ANOVA was applied followed by Bonferroni correction. SPSS software (Version 15, SPSS, Chicago, IL) was used for the statistical analyses. A significance level at $P \leq 0.05$ was used in all tests.

3. Results

The rate of decomposition was 12 days in the agricultural habitat and six days in the desert and urban habitats. The fresh stage lasted two days in the agriculture habitat but only one day in desert and urban habitats. The bloat stage was completed by day 3 in the agricultural habitat and by the early hours of day 2 in the desert and urban habitats. The duration of the decay stage also varied between habitats. This stage

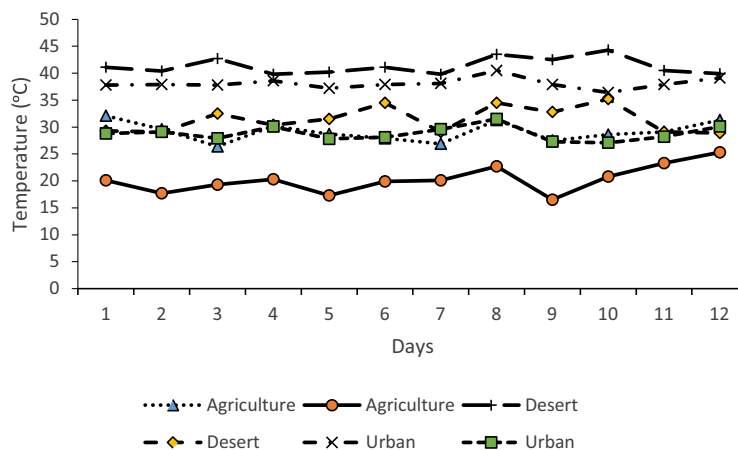


Figure 1 Temperature data for the study period in different habitats.

lasted seven days in the agricultural and three days in the desert and urban habitats. In the agricultural habitats, carcasses reached the dry stage after 12 days, at which point the rabbits' bodies were reduced to skin, cartilage and bone, but in the desert and urban environments the carcasses reached the dry stage after just six days. Also the present study, recorded no difference in the decaying rate between open, clothed and shaded carcasses.

A total of 125 beetles were recorded and, whereas the agricultural habitat had the lowest species abundance values (32 individuals), the desert and urban habitats had very similar values (54 and 39 individuals, respectively). In the desert habitat, carcasses had the highest values, compared to other carcasses in the fresh stage in other habitats. In the bloat stage of decomposition, carcasses in the desert habitat had the highest abundance values (Fig. 2). In the decay stage, carcasses in

the urban habitat had the highest value compared to the carcasses in other habitats. In the desert habitat, the decay stage was the only stage that did not contain beetles. While in the dry stage, the carcass in the agricultural and desert habitats had the highest values. In the urban habitat, carcasses in the dry stage did not have any beetles present. The dry stage, meanwhile, had the lowest number of beetles in all stages of decomposition in the three different habitats while the decay stage had the highest number (Fig. 2).

Five species of beetles belonging to three different families were collected from carcasses placed in the urban and desert habitats, namely *Necrobia rufipes* Fabricius (Cleridae), *Dermestes maculatus* De Geer (Dermestidae), *Saprinus* sp., *Saprinus semipunctatus* Fabricius and *Saprinus moyses* Marseul (Histeridae). On the other hand, in the agricultural habitat six species belonging to three families were found on the carcasses. These were: *D. maculatus*, *Saprinus* sp., *S. semipunctatus* and *S. moyses*, and *Onthophagus nitidulus* Klug, *Maladera insanabilis* Brenske (Scarabaeidae). Family Scarabaeidae were restricted to the agricultural habitat. Beetles were found at all decomposition stages in the three different habitats. In the agricultural and urban habitats only one species was represented during the fresh, *D. maculatus*; and *N. rufipes* was also the only species represented in the dry stage in the desert habitat. No beetles were represented in the bloat and dry stages in the urban habitat and in the decay stage in the desert habitat (Table 1).

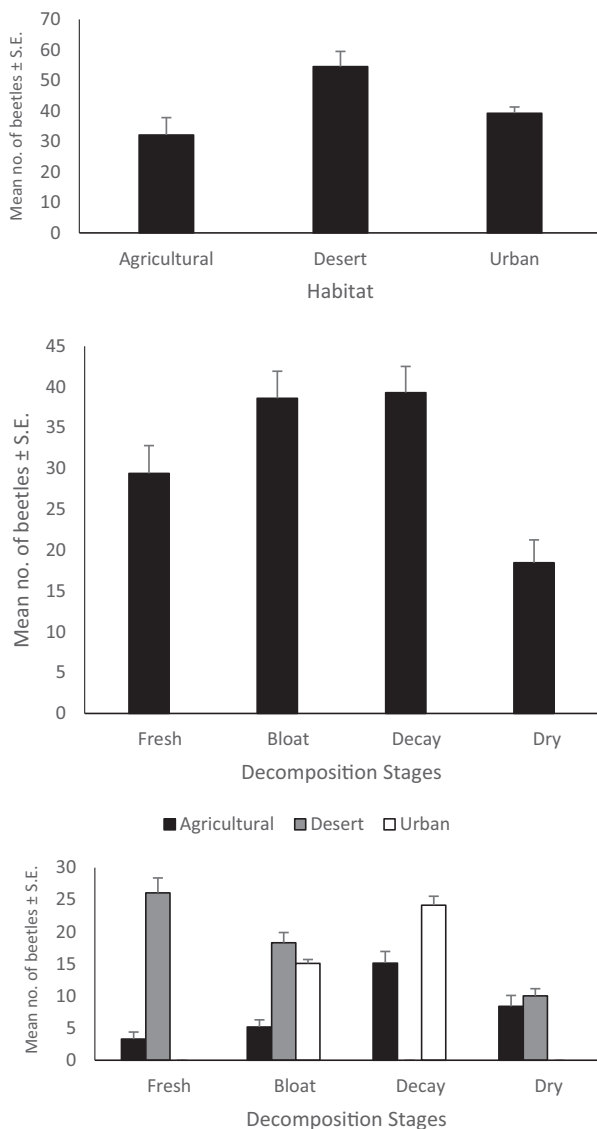


Figure 2 A: abundance of beetles in the three different habitats; B: abundance of beetles in each decomposition stage; C: abundance of beetles in each decomposition stage in three different habitats.

Table 1 Presence of beetles at different stages of decomposition on rabbit carcasses in three different habitats.

Family	Species	Urban habitat			
		Fresh	Bloat	Decay	Dry
Cleridae	<i>Necrobia rufipes</i>			✓	
Dermestidae	<i>Dermestes maculatus</i>	✓		✓	
Histeridae	<i>Saprinus</i> sp.			✓	
	<i>Saprinus semipunctatus</i>			✓	
	<i>Saprinus moyses</i>			✓	
				✓	
<i>Agricultural habitat</i>					
Dermestidae	<i>Dermestes maculatus</i>	✓	✓	✓	✓
Histeridae	<i>Saprinus</i> sp.		✓	✓	✓
	<i>Saprinus semipunctatus</i>		✓	✓	✓
	<i>Saprinus moyses</i>		✓	✓	✓
			✓	✓	✓
Scarabaeidae	<i>Onthophagus nitidulus</i>		✓		
	<i>Maladera insanabilis</i>		✓		
<i>Desert habitat</i>					
Cleridae	<i>Necrobia rufipes</i>	✓			✓
Dermestidae	<i>Dermestes maculatus</i>	✓	✓		
Histeridae	<i>Saprinus</i> sp.	✓			
	<i>Saprinus semipunctatus</i>	✓			
	<i>Saprinus moyses</i>	✓			
		✓	✓		

✓: presence of beetles.

Overall, beetles belonging to seven species and four families were recorded. Histeridae, was the most diverse of the represented families, with three species and 68 individuals (about half of the collected beetles), the three other families (Cleridae, Dermestidae and Scarabaeidae) accounted for 57 individuals about 46% of the total number of individuals (Fig. 3). *Dermestes maculatus* and *S. moyses* were the most abundant species on the rabbit carcasses in all habitats. *S. semipunctatus* had the highest abundance value in the agricultural habitat, followed by *D. maculatus*, *Saprinus* sp. and *S. semipunctatus*. In the desert habitat, *S. moyses* was the most abundance species followed by *D. maculatus*. In the urban habitat, meanwhile, *D. maculatus* had the highest species abundance value, followed by *N. rufipes* and *S. moyses* (Fig. 3).

Saprinus moyses was the most prevailing species in the fresh stage, while *D. maculatus* was the most prevailing species in the bloat and decay stages. *M. insanabilis* were not present in any of the stages except the bloat stage. *O. nitidulus* was present in the

bloat and decay stages but absent in the fresh and dry stages. All types of beetle were represented in the bloat stage (Fig. 4).

4. Discussion

In the present study the decaying process was evident in the form of four succession stages (fresh, bloated, decay, dry) as described before by Rodriguez and Bass (1983) and Tantawi et al. (1996). The decomposition rate was 12 days in the agricultural habitat but six days in desert and urban habitats. The process was apparently mainly affected by the ambient temperature, as has been described before by Matuszewski et al. (2010a). In a similar study in Kuwait, Al-Mesbah et al. (2012) stated that the decaying rate of rabbit carcasses was faster in urban habitat than other habitats (agricultural, coastal or desert). Goddard and Lago (1985) stated that when temperatures are high, the process of decomposition becomes shorter. In a study in Egypt, Tantawi et al. (1996) found that rabbit

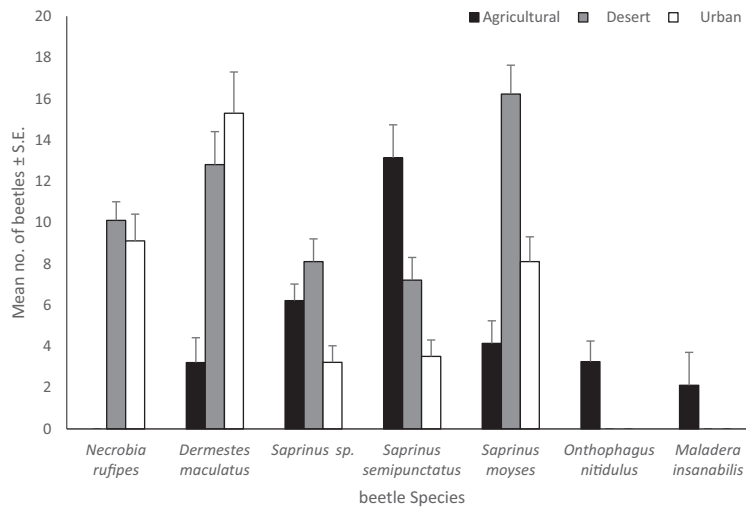


Figure 3 Mean values of beetle abundance according to the habitat.

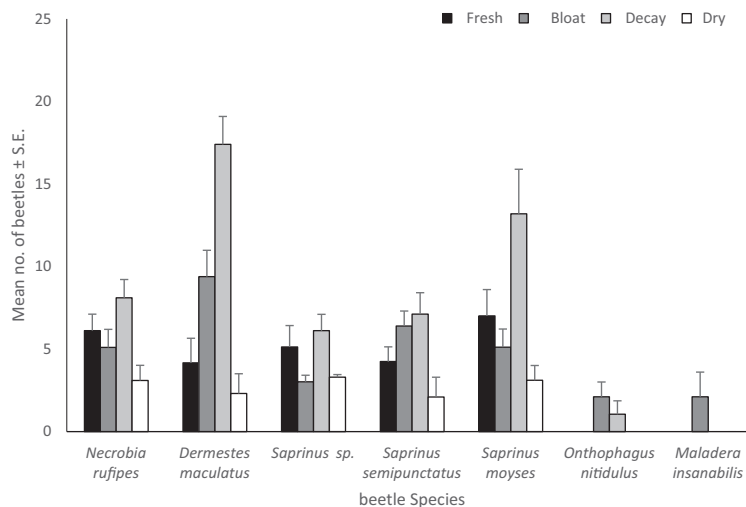


Figure 4 Mean values of beetle abundance according to the decomposition stage.

carcasses took only 4.5 days to reach the dry stage when average daily temperatures were 28 °C. The decomposition rate may also be affected by the small size of carcasses (about 1.5 kg in this study) as indicated by Simmons et al. (2010), where small carcasses decomposed faster than large carcasses. Hewadikaram and Goff (1991), however, stated that the carcass size was not important in terms of insect succession patterns. In this same study, direct contact between the rabbit and site surface increased the temperature and thus the decomposition rate. Abouzied (2014), in an experiment conducted in Al-Baha Province, south-western Saudi Arabia, noted that a lack of direct exposure of the rabbit carcasses to the natural substrate because of the cage design may have influenced decomposition.

The PMI can be determined when the pattern of insect succession in a certain geographical region is known, and if the insect fauna on a carcass are then analysed (Grassberger and Frank, 2004; Matuszewski et al., 2010b). The species involved in this study differ from other studies in other habitats and geographic areas (Anton et al., 2011; Dekeirsschieter et al., 2013; Castro et al., 2013; Caballero and León-Cortés, 2014; Martín-Vega et al., 2015). The regional biodiversity of beetle species has been described by Al-Ahmadi and Salem (1999), and Abouzied (2014) recorded some similar species in the mountains of Al-Baha Province, specifically *D. maculatus* (Dermestidae), *S. moyses* (Histeridae) and *N. ruficollis* (Cleridae). In studies in Egypt, beetles belonging to two families were collected, Dermestidae and Histeridae (Abd El-bar and Sawaby, 2011; Aly et al., 2013).

Overall, in this study, seven species of beetles were directly attracted to the rabbit carcasses throughout the study. In the agricultural habitat, six species were present but there were the lowest number of individuals (32) compared to the desert and urban habitats. Hegazi et al. (1991) collected beetles belonging to four families in a study in the Egyptian desert, namely: Dermestidae, Histeridae, Scarabaeidae, and Tenebrionidae.

The presence of Scarabaeidae only in agricultural habitats reflected the preference of the habitat of this species. Also, in the agricultural habitat the species abundance was concentrated in the bloat and decay stages rather than the fresh and dry stages. In urban and desert habitats the same five species were collected, with 39 and 54 individuals, respectively. In the desert habitat the species abundance was concentrated in the fresh stage followed by the bloat stage and was very low in dry stage. Adult beetles of Dermestidae reported early at the end of the bloat stage until the beginning of the dry stage (Abouzied, 2014) as also observed in other studies by Galal et al. (2009) and Valdes-Perezgasga et al. (2010). In this study, there was no correlation between any single species and any particular decomposition stage. This has also been described by Schoenly and Reid (1987). The study also recorded a higher abundance of beetles in the decay stage, as described by Castro et al. (2013).

In conclusion, this is, to my knowledge, the first forensic entomological study in Riyadh investigating patterns of beetle succession on rabbit carcasses. The study recorded a total of 125 individuals, seven species and four families with Histeridae being the dominant beetles. The decaying process and rate of beetle abundance was affected by the habitat type. Finally, these results should be considered when collecting those samples in the proximity of a cadaver and estimating PMI.

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