



## Original article

## Forensic insects attracted to human cadavers in a vehicular environment in Riyadh, Saudi Arabia

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## ABSTRACT

Insect fauna attracted to cadavers at the crime scene can be identified and used to estimate the post-mortem interval (PMI). In the current study, insects associated with two human cadavers in a vehicular environment were collected and analysed. The first cadaver was found five days' post mortem in a garage. The second cadaver was found in a car ten days after his death. The weather conditions were obtained from the nearest weather station located to the scenes of the death. During the study, six adults, 32 larvae and egg batches were collected from case 1 and identified as *Chrysomya albiceps* Wiedemann (Diptera: Calliphoridae). From the second case, two larvae of *Megaselia scalaris* Loew (Diptera: Foridiae) and seven larvae of *Musca domestica* L. (Diptera: Muscidae) were identified. mPMI ranged from five to twelve days. This information expands the knowledge on the insect fauna in the vehicular environment, which could be used to assist estimation of the PMI.

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## 1. Introduction

Arthropods usually attack a corpse shortly after death and their succession follows predictable patterns (Anderson and VanLaerhoven, 1996; Shalaby et al., 2000). Environmental factors such as temperature, moisture and rainfall are known to affect the rates and patterns of insect invasion and thus should be taken into account when estimating the post mortem interval (PMI). Studies have also highlighted other factors related to the characteristics of the cadaver and its environment, such as body mass, geographical region, season and habitat of decomposition (Perez et al., 2015; Iancu et al., 2016; Mashaly 2016; Mashaly and Al-Mekhlafi, 2016; Martín-Vega et al., 2017; McIntosh et al., 2017; Wang et al., 2017). In addition to the abovementioned factors, drugs and toxins in the decomposing tissues, burning and hanging of cadavers, or wrapping them in several layers of clothing have been found to

affect both initial time of appearance of insects and their succession (Goff et al., 1991; Catts and Goff, 1992; Avila and Goff, 1998).

Cars and other vehicles provide an interesting environment that may affect the decomposition of bodies and associated succession patterns of insects. Vehicles act as a shelter which protects insects from rain and predators, and also affect temperature and humidity (Anderson, 2001). The warm temperature inside vehicles encourages insect development and oviposition. It has been reported that the temperature within a vehicle parked in the sun can be up to 20 °C higher than the ambient temperature. This difference in temperature varies depending on the colour and the location of the vehicle, which in turn affect PMI estimates (Dadour et al., 2011).

Insects collected from different parts of the car such as the radiator grill, bonnet or the windshield may provide details of a cadaver movement. The number of adult flies accessing the vehicle is dependent on the population size, fly species and the available portal for flies' entry into the cabin (Dadour et al., 2011). In a vehicle environment, the access to the corpse is delimited to the holes in windshield, cracks in a car trunk, or openings of ventilation. Smaller diptera are therefore likely to be able to get into the vehicle and colonize the corpse in larger numbers than coleoptera. Nonetheless, factors other than size may influence access because in many cases medium to large size adult sarcophagids have been reported in large numbers in indoor cadavers (Byrd and Castner, 2010).

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Although Anderson (2010) observed that large numbers of blowflies can access a vehicle, the numbers are still usually less than would be expected on exposed remains and oviposition takes a longer time. For example, flies belonging to the Calliphoridae usually take only one hour to reach outdoor carcasses and oviposition occurs within six to eight hours after death (Voss et al., 2008). In contrast, the same fly species takes some 16–18 h to reach carcasses inside vehicles and oviposition takes 24–28 h in total. Regarding the succession pattern of insects, Voss et al. (2008) reported very similar succession patterns between vehicle and outdoor environments, although the colonization time varied between the two environments.

This study aimed to investigate the insect species attracted to two human cadavers in a vehicular environment in Riyadh, Saudi Arabia.

## 2. Materials and methods

### 2.1. Study procedures

All procedures were performed in accordance with the terms of the Committee of Graduate Studies and Scientific Research, Department of Zoology, College of Sciences, King Saud University. The characteristics of the cadavers were recorded in table (1) including cause of death, sex, age, estimated PMI, location, latitude and longitude, and the stage of insect development.

Samples were collected from cases during autopsy procedures conducted at the Institute of Legal Medicine at King Saud Hospital. Samples were preserved in 70% ethanol in vials labelled with the date and time of collection. The collected insect specimens were sorted and initially identified in the entomology laboratory in the department of Zoology, College of Sciences, King Saud University using specialized taxonomic keys; for flies Büttiker et al. (1979), Greenberg and Kunich (2002) and Setyaningrum and Al Dhafer (2014) and for beetles Borror et al. (1989) and Catts and Haskell (1990). Further molecular identification was performed in order to confirm the morphological identification (see Alajmi et al., 2016). Climatic data were obtained from the meteorological stations closest to the scenes of death (Figs. 1 and 2). Different photos of cases were given with approval by the Institute of Legal Medicine at King Saud Hospital.

## 3. Case Reports:

### 3.1. Case report 1

On 15/12/2016, a 35-year-old man (Fig. 3a) was found in the early stage of decay in the garage of his house in Qurtubah district in the north east of Riyadh. He was lying on the floor under an old

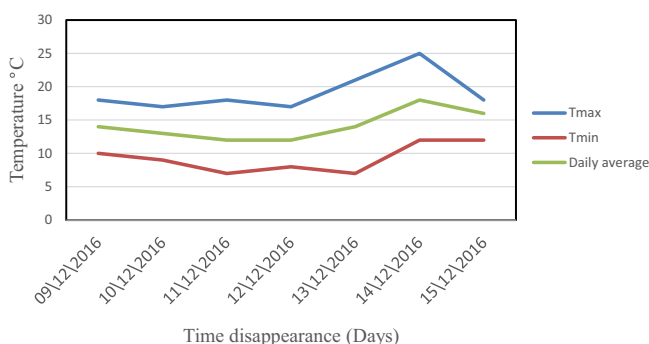


Fig. 1. In case 1: temperatures recorded by the nearest weather station for the seven days before the body discovery (Tmax: 25 °C; Tmin: 11 °C).

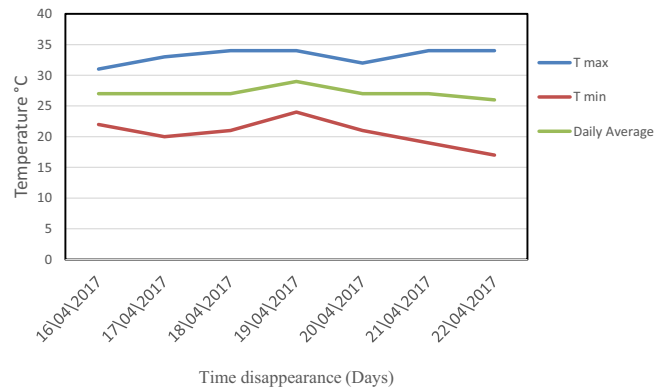


Fig. 2. In case 2: temperatures recorded by the nearest weather station for the seven days before the body discovery (Tmax: 33 °C; Tmin: 21 °C).

car. He was wearing a white shirt, undershirt, white trousers, underpants, black socks and blue plastic gloves. The door of the garage was open. He was alone since his family had travelled for a vacation. The average temperature recorded in the week before the body's discovery, was  $21 \pm 2.0$  °C, with a maximum of 25.0 °C. The corpse was transferred to the Institute of Forensic Medicine at King Saud Hospital. According to police investigations, death was caused by the car falling on the upper part of the body whilst it was being repaired. Examination of the body showed restriction to the chest leading to difficulty breathing and cardiac arrest, respiratory failure and shock. From the police investigation, the time of death was estimated as about five days before the discovery of the body.

### 3.2. Case report 2

A 53-year-old man (Fig. 3b) was found dead in his car in the area beside King Khalid International Airport in the north of Riyadh. The body was found on the driver's seat dressed in a long dress and long trousers. One of the front windows of the car was opened about 10 cm. The body was at the early stage of decomposition. The cause of death was presumed to be natural. The mean surrounding ambient temperature was  $32 \pm 2$  °C. The corpse was taken to the Institute of Legal Medicine at King Saud Hospital on the 23th March 2017. According to police investigations, the time of death was estimated as having occurred ten days before the body was discovered.

## 4. Results

The two human corpses with insect specimens were referred to the Institute of Forensic Medicine at King Saud Hospital. The age distribution of the referred corpses was between 35 and 53 years old. Medical or scientific evidence other than entomological data determined PMIs ranging from five to twelve days for the corpses, and this difference could affect the diversity of insects found on the cadavers (Table 1).

The morphological identification of insects concurred with the identification based on partial sequencing of the mt COI gene. A total of 6 adults, 41 larvae and egg batches specimens representing two orders and four families were recorded on the two human cadavers. The flies comprised one Calliphoridae species, *Chrysomya albiceps* (Wiedemann 1819), one Phoridae species, *Megaselia scalaris* (Loew 1866), and one Muscidae species; *Musca domestica* (Linnaeus, 1758).

The entomological evidence from the cadaver in the first case was collected during an autopsy performed on the 16th December

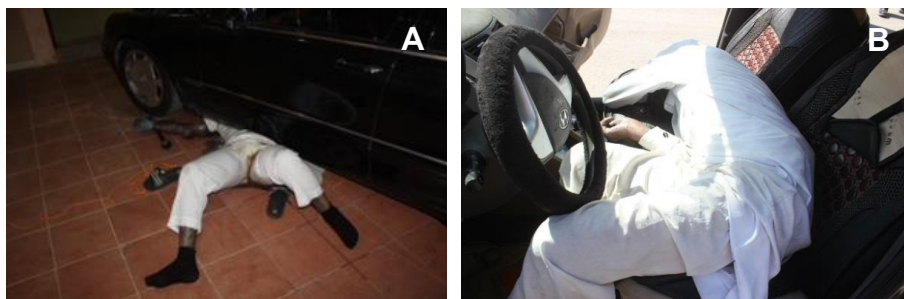


Fig. 3. Indicates the two cases: A: Case 1; B: Case 2.

**Table 1**

Details of the human cadavers and the insects found on them in Riyadh, Saudi Arabia.

Case no.	Gender	Age (yr)	Location	Cause of death	PMI estimation (day)	Decomposition stage	Development stage of insects	Order/Family	Species	Reference accession No
1	Male	35	Córdoba district	Cardiac arrest, respiratory failure	5–6	Early decay	6 adult, 32 larvae (L1), egg-batches	Diptera/Calliphoridae	<i>Chrysomya albiceps</i>	KM407601.1
2	Male	53	Airport district	Natural death	10–12	Early decay	2 larvae (L1) 7 larvae (L1)	Diptera/Phoridae Diptera/Muscidae	<i>Megaselia scalaris</i> <i>Musca domestica</i>	JQ941745.1 KX161460.1

2016 (the body had been maintained at 4 °C before the autopsy). Fly eggs and alive larvae (L1, post-feeding 3 mm, N = 32) were present on the neck area and inside the oral cavity, and from the inside of the bag used to transport the corpse to the autopsy room. Dead adult flies (N = 6) were collected from the folds of the clothes on the corpse. Specimens were identified as *C. albiceps*. The mPMI was estimated according to the police investigation to have occurred five days before the discovery of the corpse.

Entomological evidence was collected from the second human cadaver during the autopsy performed on 24th March 2017 (the body had been maintained at 4 °C before the autopsy). Alive fly larvae (N = 9) were present inside the oral cavity, eyes and nose. Larvae were identified as *M. domestica* (L1, post-feeding 3 mm, N = 7) and *M. scalaris* (L1, post feeding 4 mm, N = 2). The legal investigation estimated the mPMI as about ten days prior to the discovery of the body.

## 5. Discussion

The rate of decomposition of cadavers is controlled by several environmental and non-environmental factors (Soon et al., 2017). Factors of environmental origin include weather conditions (e.g. temperature, moisture) and cadaver conditions (e.g. indoor or outdoor, buried, underwater, above ground). Non-environmental factors are mostly related to the cadaver itself such the body mass/size, wrapped or unwrapped, and entomological effects. In the current study, the impact of a vehicular environment on the insect species attracted to the human cadavers was investigated.

The effect of vehicle environment was evaluated in the two cases, noting that there was a degree of exposure to the air in each case. In the first case, the door of the garage was found opened, and the body was outside the car but located beneath it. In the second case, the cadaver was inside the car but the front car window was opened, allowing relatively easy access to insects. Any location that restricts entry without preventing all insect colonization has the capacity to affect the species composition of the forming carrion community (Dadour et al., 2011). The rate of decomposition in the first case may have been affected by the higher temperature of the cadaver because half of the corpse was under the vehicle.

In the second case, the corpse was inside the car with only one window opened. In this case the temperature inside the car would be expected to be higher than outside the vehicle.

The vehicle provided some degree of a barrier, although a number of adult flies had obviously entered the vehicle for oviposition. Due to solar radiation absorption, the interior of a vehicle usually has an elevated temperature than the ambient. The degree of elevated temperature varies based on the composition and colour of the vehicle. Cadavers will also have an elevated temperature outdoors if they are exposed to direct sunlight and thus the body will cool more slowly than those in partial or full shade (Joy et al., 2006). The mechanism by which the heat is entrapped within the vehicle is similar to that of a greenhouse. The glass of the windshield and windows permits short wavelengths of visible light to get inside the vehicle and be absorbed by the seats, dashboard, and other objects (Dadour et al., 2011).

This study indicated that the two cadavers did not attract any insect species in common. This is likely to be due to the differences in the habitats between the two sites. Previous studies have indicated that the habitat type has an effect on the species richness on cadavers (Campobasso et al., 2001; Anderson, 2010; Mashaly and Al-Mekhlafi, 2016). Insects attracted to the first case were *Ch. albiceps*, which are widely distributed in different regions of the world (Zumpt, 1965; Laurence, 1981; Grassberger et al., 2003; Charabidze et al., 2014; Benecke, 2015; Moemenbellah-Fard et al., 2018). This species has been reported previously in Saudi Arabia (Büttiker et al., 1979; Al-Eneszy, 2012), and is also recognized as being among the first wave of the faunal succession on human cadavers (Smith, 1986; Anderson, 2001; Higley and Haskell, 2009; Bugelli et al., 2015). *Musca domestica* and *Me. scalaris* were collected from the second cadaver, with many previous studies having recorded both species as forensic insects on human bodies (Reibe and Madea, 2010; Bugelli et al., 2015; Bernhardt et al., 2018).

## 6. Conclusion

Habitat is one of the factors that affects insect attraction to cadavers. The habitat within a vehicle is characterized by an

increased temperature, which affects insect prevalence on the corpses. In the presented cases there was no temperature data from the body recovery sites themselves, so we used the data from the closest meteorological station. In the current study, two human cadavers in the vehicle habitat were studied. Results indicated the presence of insect species which are known as forensic insects from many previous studies. These insects include *Ch. albiceps*, *Me. scalaris* and *M. domestica* from Diptera, which could be used as forensic indicators in crime scene investigation.

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