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# Forensic - insect succession and decomposition patterns of dog and rabbit carcasses in different habitats

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**Abstract**
The entomofauna associated with two animal carcasses namely; dog (*Canis lupus familiaris)* and rabbit (*Lepus cuniculus);* and their succession patterns were investigated. This study was carried out at the Department of Zoology and Entomology, Faculty of Science, Al-Azhar University, Nasr city, Cairo, Egypt. The fresh stage of carcass decomposition began with death and ended when bloated stage was initiated. It lasted 12 h for dog and rabbit carcasses placed outdoor (Mean temperature 29 °C and RH 54%), while it lasted one day and 12 h for dog and rabbit carcasses placed indoor, respectively. The bloated stage was on day one postmortem for dog and rabbit carcasses placed outdoor, while it was on day 2 and on day one postmortem for dog and rabbit carcasses placed indoor, respectively. The active decay stage was on day 4 and on day 3 postmortem for dog and rabbit carcasses placed outdoor, respectively. While it was on day 3 postmortem for each dog and rabbit indoor. The advanced decay stage arrived on day 7 and on day 5 postmortem for dog and rabbit carcasses placed outdoor, respectively. Meanwhile, it was on day 6 and on day 5 postmortem for dog and rabbit carcasses placed indoor, respectively. The final stage of decomposition (dry stage) was arrived on day 22 and on day 19 postmortem for dog and rabbit carcasses placed outdoor, respectively. While it was arrived on day 31 and on day 16 postmortem for dog and rabbit carcasses placed in door, respectively.
A total of 687 adult insect specimens representing 9 families were collected from dog carcasses placed outdoor, while 342 adult insect specimens representing 8 families were collected from dog carcass placed indoor. Diptera, Coleoptera and Hymenoptera comprised 57%, 36% and 7% of insects collected from dog carcasses placed outdoor and 59%, 37% and 4% of insects placed indoor. The insect succession on dog and rabbit throughout the decompositional stages showed that the Calliphorid fly, *Chrysomya albiceps* was the first fly attracted to the early stages of decomposition. In general, it was appeared that the diversity and numbers of forensic insect species which colonize dog or rabbit carcasses were increased outdoor and decreased indoor. Moreover, they were higher in numbers on dog carcasses than on rabbit carcasses.

**Keywords:** Entomofauna; Carcass; Outdoor; Indoor; Postmortem; Dog; Rabbit

## 1. Introduction
Forensic entomology deals primarily with insects and other arthropods which infest human remains. Insects lay eggs on or in human remains, as well as utilize the corpse for food or habitat. Insect development and successional patterns can be an indication of the postmortem interval (PMI) when time of death is unknown.
Decomposition of terrestrial animals, including humans, involves not only the actions of organisms such as bacteria and fungi, but also those of a large number of arthropod species, particularly the saprophagous insects [1]. The rate at which decomposition progress is further influenced by a variety of environmental factors, including temperature, humidity, precipitation, and the degree of isolation, and also by the composition of the carrion-associated fauna and the circumstances of death [2]. However, the most valuable use of forensic insects associated with the corpse is the estimation of the postmortem interval or the time that elapsed since death [3].
Pathologists can estimate the time of death based on several biological parameters: lividity, rigor mortis, postmortem cooling, changes in the chemical constituents of body, autolysis of tissue, and decomposition due to bacterial activity in the body. However, these parameters are not reliable beyond about 72 hours after death [4]. The entomological method of determining PMI was found to be statistically more reliable and superior when compared to other pathological methods, particularly during later stages of decay [5].

There are two methods to estimate the PMI; first using the developmental stages of flies found on corpse as they first lay eggs on body [6]. A second method uses the succession patterns of carrion- arthropods, the type and composition of fauna change in predictable pattern as decomposition progresses through different stages [7].

**This study aimed to**

1. Investigate the entomofauna associated with certain animal carcasses as human model, and its succession pattern in relation to decomposition stages of carcass, type of carcass and size, climatic conditions, and habitat.
2. The main objective was to provide entomological data that can be employed in forensic cases in Egypt.

## 2. Materials and Methods

### 2.1. Study site

The study site was located in University of Al-Azhar, Nasr city, Cairo, Egypt. Nasr city is considered semi-arid urban region. It has four distinct seasons; winter, spring, summer and autumn. According to meteorological station, summer is hot and dry, winter is cool and rainy, spring and autumn are mild in temperatures and rainfall, the experiments were carried out in summer season during the period from July 16, 2014 to September 23, 2014, the duration of the experiments was approximately, 70 days. Each experiment was continued until the entire carcass was consumed. Sites for carcass placement were chosen in a botanical garden (outdoor) of the animal house and in laboratory (indoor) at the Department of Zoology and Entomology, Faculty of Science, Al-Azhar University.

### 2.2. Experimental design

Two dogs (*Canis lupus familiaris*), weighing approximately 3 kg each, and two rabbits (*Lepus cuniculus*), weighing approximately 1.300 kg each were used. One dog and one rabbit carcasses were placed in the laboratory (indoor) and other two carcasses were placed in a botanical garden (outdoor) of the animal house.

The dogs and rabbits were taken alive to the study site and killed with a blow on the head. Care was taken to prevent external bleeding that might alter the attractiveness of the carcasses to flies or provide alternate sites for oviposition or larviposition. After death, animals of outdoor experiments were immediately placed into mesh cages to prevent scavenging by large vertebrates and left exposed to natural conditions. The animal carcasses were separated by approximately 4 m indoor and 10 m outdoor. Sand was placed under each cage to facilitate the collection of larvae, leaving carcasses to pupate.

### 2.3. Collection, sampling and identification

Adult insects were collected on a daily basis until apparent insect activity had ceased. Insect collection was carried out twice daily, one in the morning from 8 to 9 am and the other collection was in the afternoon before sunset, from 4 to 5 pm. The numbers of adult insect collected were counted and representative samples were preserved in 70% ethanol and taken to the laboratory for identification. Adult Diptera and Hymenoptera were collected using a hand net, while adult Coleoptera were collected using hand picking forceps and vial glasses.

Identification and taxonomic determinations were made by using current keys [8-12], and by specialists in Cairo University and insect collection of Ministry of Agriculture, Dokki, Giza, Egypt. All insects were identified to the minimum of the family level. All efforts were made to identify Diptera and Coleoptera to the species level as they were considered for forensic importance.

### 2.4. Carcass decomposition

Carcasses were examined twice daily; in the morning and afternoon in order to determine the duration of each decompositional stage. Images of carcasses throughout decomposition study were captured using a digital camera.

### 2.5. Climatic conditions

The ambient conditions of temperature and relative humidity in outdoor habitat (in Nasr city) were obtained monthly from the meteorological station of Kobri El-Kobba in Cairo, Egypt. Temperatures and relative humidity indoor were daily measured using max. /min. thermometer and hygrometer.

### 2.6. Insect succession tables

Insect succession tables were developed by combining data from sweeping nets and hand collections. The different insect species that collected from each carcass were distributed according to the decomposition stages of carcasses i.e. according to postmortem interval (PMI) giving their numbers.

## 3. Results

### 3.1. Climatic conditions (temperature and humidity)

The minimum and maximum temperatures outdoor were varied from 22 to 39 °C with an average of 29 °C. While, the relative humidity varied from 7% to 98% with an average of 54% (Table 1). The minimum temperature outdoor recorded 22 °C on day one postmortem, while the maximum temperature recorded 39 °C on day 50 postmortem.

On the other hand, the minimum temperature indoor was 22 °C on day one postmortem, while the maximum temperature was 31 °C on day 20 postmortem. The average relative humidity recorded 53% indoor (Table 2).

### 3.2. Decomposition patterns of animal carcasses

The fresh stage of animal carcasses began with death and ended when bloating was initiated. Results given in Tables (1) and (2) indicated that the 1st stage of decomposition (fresh stage) lasted 12 h postmortem for each dog and rabbit carcasses placed outdoor. While this stage lasted from day 0 to day 1 and from day 0 to 12 h postmortem for dog and rabbit carcasses placed indoor, respectively (Fig. 1a).

The beginning of bloated stage (Fig. 1b) for dog and rabbit carcasses placed outdoor was on day 1 postmortem, respectively. While this stage began on day 2 and on day one postmortem for dog and rabbit carcasses placed indoor, respectively. The end of the bloated stage and beginning of the active decay stage was evidence of liquefaction. Evidence of liquefaction first occurred on day 3 and on day 4 postmortem for dog and rabbit carcasses placed outdoor, respectively (Fig. 1c). However, the evidence of liquefaction first occurred on day 3 postmortem for dog and rabbit carcasses placed indoor, respectively.

The advanced decay stage begins when flesh of carcass is removed at extremities (head, limbs, and anus), odor becomes moderate, tissues dehydrated and bone becomes evident at extremities. This stage was arrived on day 7 and on day 5 postmortem for dog and rabbit carcasses placed outdoor, respectively (Fig. 1d). While in case of carcasses placed indoor, this stage was arrived on day 6 and on day 5 postmortem for dog and rabbit carcasses, respectively.

The final stage of decomposition is the dry stage which is characterized by little or no odor, hardened, dried, wrinkled skin, exposed bone and tissue remnants whitish- grey (Fig. 1e). This stage was arrived on day 22 and on day 19 postmortem for dog and rabbit carcasses placed outdoor, respectively. While, for dog and rabbit carcasses placed indoor, this stage was arrived on day 31 and on day 16 postmortem, respectively.

**Table 1:** Decompositional stages of dog carcass in summer 2014

| Decompositional Stages | Habitat | Days postmortem | Temp. (°C ) | | | R.H.% (Average) |
|---|---|---|---|---|---|---|
| | | | Max. | Min. | Average | |
| Fresh | Indoor | 0-1 | 29 | 22 | 26 | 46 |
| | Outdoor | 0-0.5 | 33 | 22 | 28 | 56 |
| Bloated | Indoor | 2 | 29 | 22 | 26 | 50 |
| | Outdoor | 1-3 | 32 | 22 | 27 | 58 |
| Active decay | Indoor | 3-5 | 29 | 23 | 26 | 50 |
| | Outdoor | 4-6 | 34 | 23 | 28 | 52 |
| Advanced decay | Indoor | 6-30 | 31 | 23 | 27 | 60 |
| | Outdoor | 7-21 | 37 | 23 | 29 | 52 |
| Dry | Indoor | 31-70 | 30 | 22 | 26 | 60 |
| | Outdoor | 22-70 | 39 | 22 | 29 | 53 |

**Table 2:** Decompositional stages of rabbit carcass in summer 2014

| Decompositional stages | Habitat | Days postmortem | Temp. (°C ) | | | R.H. % (Average) |
|---|---|---|---|---|---|---|
| | | | Max. | Min. | Average | |
| Fresh | Indoor | 0 - 0.5 | 29 | 22 | 26 | 59 |
| | Outdoor | 0 - 0.5 | 33 | 22 | 28 | 56 |
| Bloated | Indoor | 1 - 2 | 29 | 22 | 26 | 64 |
| | Outdoor | 1- 2 | 32 | 22 | 27 | 60 |
| Active decay | Indoor | 3 - 4 | 29 | 23 | 26 | 64 |
| | Outdoor | 3 - 4 | 33 | 23 | 28 | 53 |
| Advanced decay | Indoor | 5 - 15 | 30 | 25 | 28 | 62 |
| | Outdoor | 5 - 18 | 37 | 23 | 29 | 53 |
| Dry | Indoor | 16- 50 | 31 | 29 | 30 | 61 |
| | Outdoor | 19 - 30 | 37 | 23 | 30 | 53 |

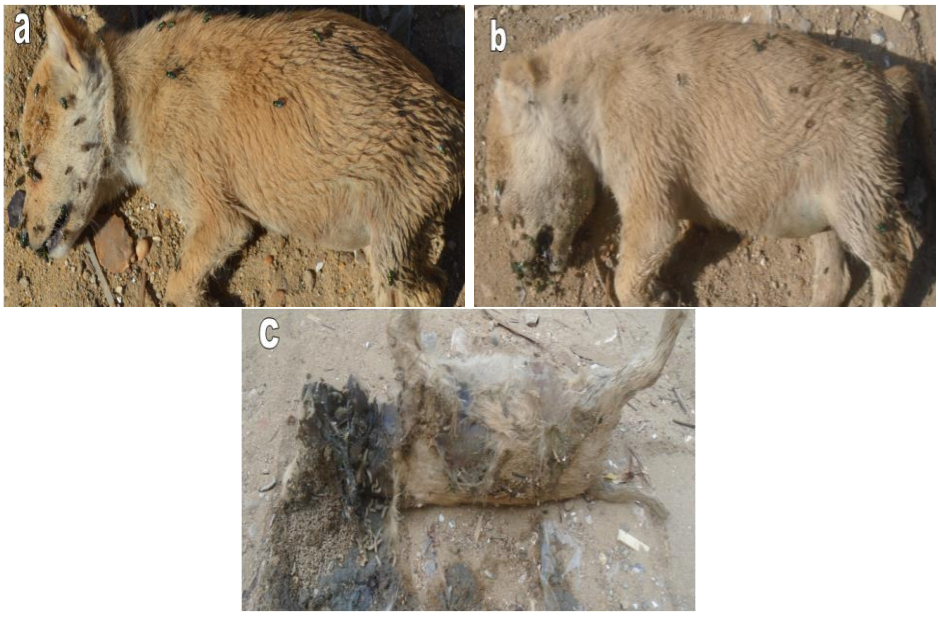


**Fig 1a-c:** Decompositional stages of dog carcass during summer season from July 16, 2014 to September 23, 2014. (a)- fresh stage, (b)- bloated stage, (c)- decay stage

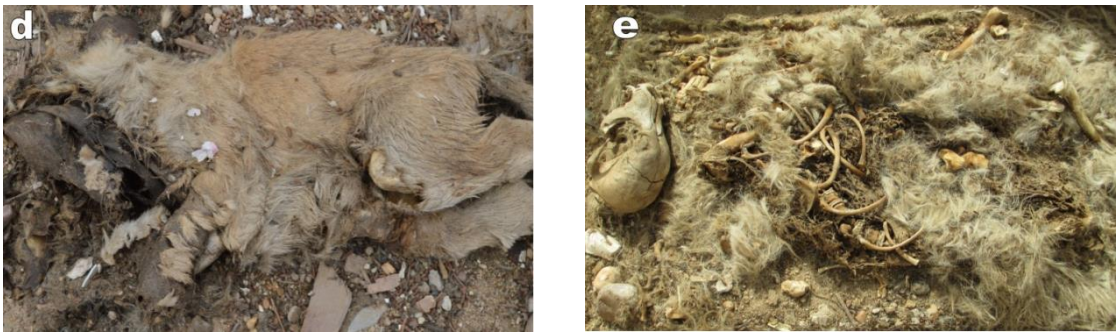


**Fig 1d, e:** Decompositional stages of dog carcass during summer season from July 16, 2014 to September 23, 2014. (d)- advanced decay stage, (e)- dry stage

### 3.3. Insect fauna associated with animal carcasses

#### 3.3.1. Dog carcass

Data given in Table 3 showed that a total of 687 adult insect specimens representing 9 families were collected in summer season 2014 from dog carcass placed outdoor. While 342 adult insect specimens representing 8 families were collected from dog carcass placed indoor. Diptera, Coleoptera and Hymenoptera comprised 57%, 36%, 7% and 59%, 37%, 4%; of the insect collected from dog carcass placed outdoor and indoor, respectively.

As shown from Table 3 and Fig. 2 only one species of adult Calliphoridae namely; *Chrysomya albiceps* was collected from dog carcass in both habitats (outdoor or indoor). The number of occurrence recorded 107 and 175 individuals for dog carcass placed outdoor and the other placed indoor, respectively.

Also, one species of adult Muscidae namely, *Musca domestica* with 153 and 15 individuals were collected from dog carcass placed outdoor and indoor, respectively.

Two species of adult Sarcophagidae namely; *Sarcophaga carnaria* and *Wohlfahrtia magnifica* were collected in numbers of 10 and 3 individuals from dog carcasses placed outdoor and indoor, respectively. While, 14 adult specimens of *Wohlfahrtia magnifica* were collected from dog carcass placed outdoor.

*Megaselia scalaris* (Family: Phoridae) was only collected from dog carcass placed indoor; 8 individuals were collected.

The Coleopteran species collected were; *Dermestes maculatus* (190 and 71 individuals), *Hister* sp. (34 and 12 individuals) and *Necrobia rufipes* (20 and 44 individuals) from dog carcasses placed outdoor and indoor, respectively.

From Hymenoptera only *Dolichovespula* sp. (Vespidae) was only collected from dog carcass placed outdoor (8 individuals). *Monomorium pharoensis* (Hymenoptera: Formicidae) with 40 and 14 individuals were collected from dog carcass placed outdoor and indoor, respectively.

**Table 3:** Entomofauna associated with dog carcass placed outdoor and indoor during summer season 2014

| Order | Family | Species | Summer season | |
|---|---|---|---|---|
| | | | Dog | |
| | | | Outdoor | Indoor |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 107 | 175 |
| | Muscidae | *Musca domestica* | 153 | 15 |
| | Sarcophagidae | *Sarcophaga carnaria* | 10 | 3 |
| | | *Wohlfahrtia magnifica* | 14 | 0 |
| | Piophilidae | *Piophila casei* | 110 | 0 |
| | Phoridae | *Megaselia scalaris* | 0 | 8 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 190 | 71 |
| | Histeridae | *Hister* sp. | 34 | 12 |
| | Celeridade | *Necrobia rufipes* | 20 | 44 |
| Hymenoptera | Vespidae | *Dolichovespula* sp. | 9 | 0 |
| | Formicidae | *Monomorium pharoensis* | 40 | 14 |
| Total | | | 687 | 342 |

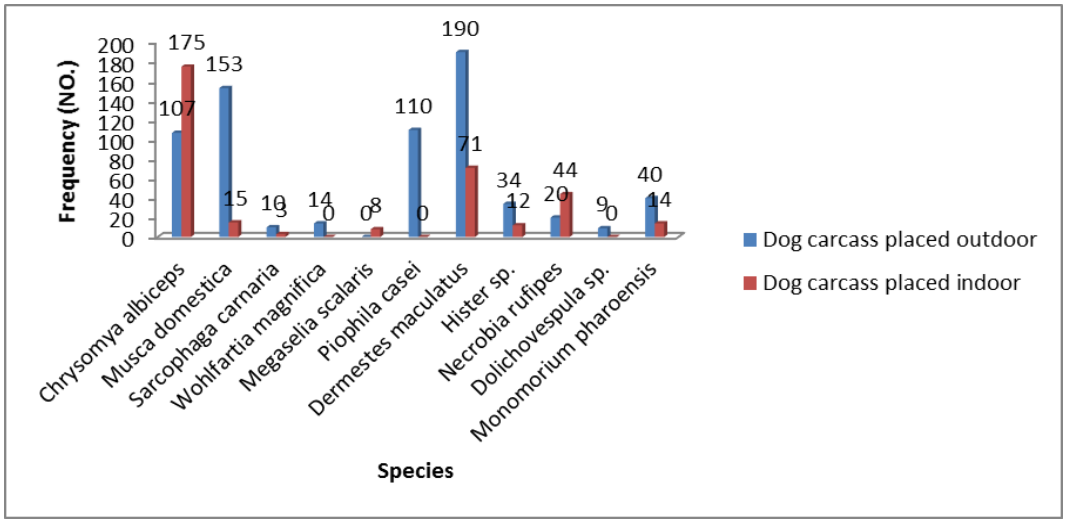


**Fig 2:** Frequency of forensic insect species on dog carcass placed indoor and outdoor during summer season 2014.

### 3.3.2. Rabbit carcass

As shown from results given in Table 4 and Fig. 3 the numbers of adult specimens of insects collected from rabbit carcass placed outdoor or indoor were less than those collected from dog carcass placed outdoor or indoor. A total of 274 adult insect specimens representing 8 families were collected from rabbit carcass placed outdoor, while 68 adult insect specimens representing 5 families were collected from rabbit carcass placed indoor. Diptera, Coleoptera and Hymenoptera comprised 70%, 19%, 11% and 46%, 38%, 16%; of the insect collected from rabbit placed outdoor and indoor, respectively.

Only one species of adult Calliphoridae namely, *Chrysomya albiceps* was collected with individual numbers of 59 and 28 from rabbit carcasses placed outdoor and indoor; respectively.

On the other hand, *Musca domestica* was collected only from rabbit carcass placed outdoor. The number of the adults collected was 42.

Family Sarcophagidae was represented by one species namely, *Wohlfahrtia magnifica* collected from rabbit carcass placed outdoor (17 individuals).

Three individuals of *Megaselia scalaris* (Family: Phoridae) were collected only from rabbit carcass placed indoor.

The Coleopteran species were represented by two species namely, *Dermestes maculates* and *Hister* sp. The number of *Dermestes* adults collected from rabbit carcass was 15 and 18 outdoor and indoor, respectively. *Hister* sp. was collected with individual numbers of 36 and 8 from rabbit carcasses placed outdoor and indoor, respectively.

The Hymenopteran, *Dolichovespula* sp. (Family: Vespidae) was represented by two individuals collected from rabbit carcass placed outdoor.

**Table 4:** Entomofauna associated with rabbit carcass placed outdoor and indoor during summer season 2014

| Order | Family | Species | Summer season | |
|---|---|---|---|---|
| | | | Rabbit | |
| | | | Out door | In door |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 59 | 28 |
| | Muscidae | *Musca domestica* | 42 | 0 |
| | Sarcophagidae | *Wohlfahrtia magnifica* | 17 | 0 |
| | Piophilidae | *Piophila casei* | 74 | 0 |
| | Phoridae | *Megaselia scalaris* | 0 | 3 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 15 | 18 |
| | Histeridae | *Hister* sp. | 36 | 8 |
| Hymenoptera | Vespidae | *Dolichovespula* sp. | 2 | 0 |
| | Formicidae | *Monomorium pharoensis* | 29 | 11 |
| Total | | | 274 | 68 |

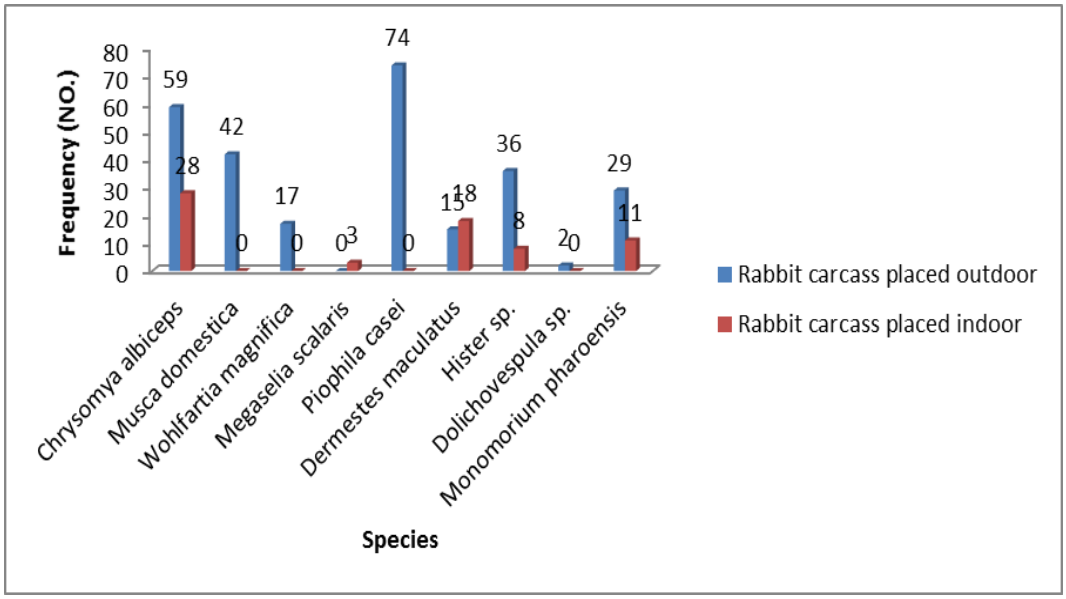


**Fig 3:** Frequency of forensic insect species on rabbit carcass placed indoor and outdoor during summer season 2014.

### 3.4. Insect succession

#### 3.4.1. On dog carcass

The succession of forensic insects on dog carcasses placed outdoor and indoor is presented in Tables 5 and 6, respectively. As shown from the results, the blow fly *Chrysomya albiceps* was the most abundant fly attracted firstly to the dog carcasses in both habitats during the boated stage of carcass decomposition. However, it was also attracted to decay stage (3-5 days postmortem) and to the advanced decay stage (6-30 days postmortem) of dog carcass placed indoor.

*Musca domestica* adults was found to be attracted to bloat and decay stages of dog carcass placed indoor, and only to bloat stage of dog carcass placed outdoor. The first adult fly has been seen on the dog carcass was *Wohlfahrtia magnifica* as it was attracted to the fresh (0 to 12 h postmortem) and bloated (1-3 days postmortem) stages for dog carcass placed outdoor. *S. carnaria* was detected during the advanced decay stage of dog carcass placed indoor and during bloated, decay and dry stages of dog carcass placed outdoor.

*Megaselia scalaris* (Family: Phoridae) was detected only during the decay stage of dog carcass placed indoor.

*Piophila casei* was only detected on dog carcass placed outdoor during bloated, decay, advanced decay and dry stages.

The coleopteran; *Dermestes maculatus*, *Hister* sp. and *Necrobia rufipes* were firstly detected during decay stage and then during advanced decay and dry stages of dog carcass placed indoor.

On the other hand, *Dermestes maculatus*, *Hister* sp. appeared during bloated, decay, advanced decay and dry stages of dog carcass placed outdoor. *Necrobia rufipes* firstly appeared during the decay stage then during the advanced and dry stages on dog carcass placed outdoor.

The ants, *Monomorium pharoensis* firstly seen during the advanced decay stage of dog carcass placed indoor and during bloat, decay and advanced decay stages of dog carcass placed outdoor.

The wasp, *Dolichovespula* sp. (Vespidae) was detected only on the dog carcass placed outdoor during bloat and decay stages

**Table 5:** Insect succession on dog carcass placed outdoor in summer season 2014

| Order | Family | Species | Decompositional stages/Days postmortem | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | Fresh | Bloated | Active decay | Advanced decay | Dry | |
| | | | 0-0.5 | 1-3 | 4-6 | 7-21 | 22-70 | |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 0 | 107 | 0 | 0 | 0 | 107 |
| | Muscidae | *Musca domestica* | 0 | 153 | 0 | 0 | 0 | 153 |
| | Sarcophagidae | *Sarcophaga carnaria* | 0 | 4 | 3 | 0 | 3 | 10 |
| | | *Wohlfahrtia magnifica* | 3 | 4 | 1 | 4 | 2 | 14 |
| | Piophilidae | *Piophila casei* | 0 | 58 | 7 | 5 | 40 | 110 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 0 | 6 | 31 | 30 | 123 | 190 |
| | Histeridae | *Hister* sp. | 0 | 4 | 22 | 7 | 1 | 34 |
| | Celeridade | *Necrobia rufipes* | 0 | 0 | 7 | 6 | 7 | 20 |
| Hymenoptera | Vespidae | *Dolichovespula* sp. | 0 | 4 | 5 | 0 | 0 | 9 |
| | Formicidae | *Monomorium pharoensis* | 0 | 15 | 8 | 17 | 0 | 40 |
| Total | | | | | | | | 687 |

**Table 6:** Insect succession on dog carcass placed indoor in summer season 2014

| Order | Family | Species | Decompositional stages/Days postmortem | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | Fresh | Bloated | Active decay | Advanced decay | Dry | |
| | | | 0-1 | 2 | 3-5 | 6-30 | 31-70 | |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 0 | 50 | 9 | 116 | 0 | 175 |
| | Muscidae | *Musca domestica* | 0 | 5 | 10 | 0 | 0 | 15 |
| | Sarcophagidae | *Sarcophaga carnaria* | 0 | 0 | 0 | 3 | 0 | 3 |
| | Phoridae | *Megaselia scalaris* | 0 | 0 | 8 | 0 | 0 | 8 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 0 | 1 | 16 | 34 | 20 | 71 |
| | Histeridae | *Hister* sp. | 0 | 0 | 8 | 4 | 0 | 12 |
| | Celeridade | *Necrobia rufipes* | 0 | 0 | 1 | 5 | 38 | 44 |
| Hymenoptera | Formicidae | *Monomorium pharoensis* | 0 | 0 | 0 | 14 | 0 | 14 |
| Total | | | | | | | | 342 |

### 3.4.2. On rabbit carcass

As shown from results given in Table 7, the bloated stage (1-2 day postmortem) was the 1st decompositional stage which attracts insects, where *Chrysomya albiceps* was detected during this stage. Also, *Chrysomya albiceps* was distributed on rabbit carcass placed indoor during decay (3-4 days postmortem) and advanced decay (5-15 days postmortem) stages. The phorid, *Megselia scalaris* was only seen during the decay stage. On the other hand, two coleopteran species namely, *Dermestes maculatus* and *Hister* sp. were detected during decay, advanced decay and dry stages and during decay and advanced decay stages, respectively.

Ants (Family: Formicidae) were represented by *Monomorium pharoensis* which was detected during the advanced decay stage of rabbit carcass placed indoor.

The insect species attracted to rabbit carcass placed outdoor showed high diversity as compared with those attracted to rabbit carcass placed indoor, (Tables 7 and 8).

From the dipteran species that firstly attracted to the carcass was *Chrysomya albiceps* and *Wohlfahrtia magnifica*, where they were collected during the fresh (0 to 0.5 day postmortem) stage. *Chrysomya albiceps* was seen on bloated and decay stages, while *Wohlfahrtia magnifica* was only detected during bloated stage. Also, *Piophila casei* was collected from the rabbit carcass during the fresh, bloated and decay stages of the carcass decomposition.

On the other hand, the beetles, *Hister* sp. was collected during decay (3-4 days postmortem) and advanced decay (5-18 days postmortem) stages, while, *Dermestes maculatus* was distributed on the rabbit carcass placed outdoor until the dry (19-30 days postmortem) stage.

Hymenoptera was represented by only two specimens of *Dolichovespula* (Vespidae) during the decay stage, and *Monomorium pharoensis* (Formicidae) during the bloated and advanced decay stages.

From the aforementioned results it is appeared that the diversity and numbers of forensic insect species which colonize dog or rabbit carcasses were increased outdoor and decreased indoor. Also, they were higher in numbers on dog carcass than on rabbit carcass.

**Table 7:** Insect succession on rabbit carcass placed outdoor in summer season 2014

| Order | Family | Species | Decompositional stages/Days postmortem | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | Fresh | Bloated | Active decay | Advanced decay | Dry | |
| | | | 0-0.5 | 1-2 | 3-4 | 5-18 | 19-30 | |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 3 | 27 | 29 | 0 | 0 | 59 |
| | Muscidae | *Musca domestica* | 0 | 38 | 4 | 0 | 0 | 42 |
| | Sarcophagidae | *Wohlfahrtia magnifica* | 11 | 4 | 0 | 2 | 0 | 17 |
| | Piophilidae | *Piophila casei* | 3 | 44 | 27 | 0 | 0 | 74 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 0 | 0 | 10 | 2 | 3 | 15 |
| | Histeridae | *Hister* sp. | 0 | 0 | 25 | 11 | 0 | 36 |
| Hymenoptera | Vespidae | *Dolichovespula* sp. | 0 | 0 | 2 | 0 | 0 | 2 |
| | Formicidae | *Monomorium pharoensis* | 0 | 11 | 0 | 18 | 0 | 29 |
| Total | | | | | | | | 274 |

**Table 8:** Insect succession on rabbit carcass placed indoor in summer season 2014

| Order | Family | Species | Decompositional stages/Days postmortem | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | | Fresh | Bloated | Active decay | Advanced decay | Dry | |
| | | | 0-0.5 | 1-2 | 3-4 | 5-15 | 16-50 | |
| Diptera | Calliphoridae | *Chrysomya albiceps* | 0 | 11 | 4 | 13 | 0 | 28 |
| | Phoridae | *Megaselia scalaris* | 0 | 0 | 3 | 0 | 0 | 3 |
| Coleoptera | Dermestidae | *Dermestes maculatus* | 0 | 0 | 2 | 12 | 4 | 18 |
| | Histeridae | *Hister* sp. | 0 | 0 | 3 | 5 | 0 | 8 |
| Hymenoptera | Formicidae | *Monomorium pharoensis* | 0 | 0 | 0 | 11 | 0 | 11 |
| Total | | | | | | | | 68 |

## 4. Discussion

The establishment of a post-mortem interval (PMI) of victims of unexplained death is a vital step in many forensic investigations [13]. Knowledge of the biology, behavior and distribution of insect species found in association with decomposing remains has proven invaluable to investigators as a tool in helping establish PMI and/or indicating post-mortem movement of the body [14, 15]. Decomposing remains represent a temporary, changing habitat, offering both food and shelter resources to numerous arthropod species. The activity of insect species that utilize this resource gradually alters the state of the carcass, such that different species are attracted to, and colonize remains at different time periods and stages of decomposition [16]. The timing of insect colonization, development and departure from decomposing remains is a predictable and orderly process for a given set of conditions and is closely linked to the progress of carcass decomposition [17].

Entomological estimates of PMI are typically based on known patterns of insect succession and the developmental age of immature insects collected from the body [18].

Many abiotic and biotic factors influence the rate of decomposition and insect succession onto remains including geographic location [19, 20], climatic conditions [21], season [22], habitat [23], the physical state of the remains [24] and the decomposition environment [25].

Therefore, entomological estimates of PMI require baseline reference data detailing the expected pattern of insect succession onto decomposing remains for a given set of parameters [17].

In this study, the results of insects associated with different animal carcasses (dog and rabbit) and their succession pattern are discussed in relation to type of animal carcass, decompositional stages of carcass, habitat of carcass and climatic conditions.

### 4.1. Type of animal carcass

Forensic insects associated with different animal carcasses have been studied; for example, on cats [26], dog [27], pigs [28], guinea pigs [29], mice [11] foxes [12, 30], lizards and toads [31], turtles [32], rabbits [33], elephants [34]. [35] Compared species composition on the corpses of black bear, white tailed deer, alligator and swine. Also, [36] compared the arthropod taxon richness on rat, rabbit and long tail monkey carcasses. They proved differences in species number collected. Such variation was also found in the present study with lesser species and individual numbers in rabbit carcass compared to dog carcass. This variation is not fully understood, however [36] this variation attributed to the physical characters of animal carcass, such as size, thickness of fur and also, the diet and site specific factors. Moreover, low number of carcass samples could be a possible cause for the fewer numbers of insect species collected. This observation agrees with [37] who used only three carcasses. In the present study, insects' community on the animal carcasses used was found to differ between animal types. This could be attributed to two reasons as we believed the size of animal and period of decomposition. For example, dog carcass (which is larger and has more tissue) provide large amount of food (e.g. from body fluid and tissue) to many necrophagous insect species and these subsequently supported predators and parasites making carrion microhabitat become enriched significantly. Dog carcass also decomposed slower than rabbit carcass thereby prolonging the time of residency, thus more entomofauna were collected during the study period. These explanations of the results obtained in the present study are consistent with those previously described by [20] on pig carcasses in Western Australia.

Although a smaller number of insect species were collected in the present study (6 species of Diptera belonging to 5 families, 3 species of Coleoptera belonging to 3 families and 2 species of Hymenoptera belonging to 2 families) from dog and rabbit carcasses during the study period, which were of forensic importance. The following species were identified; Diptera: *Chrysomya albiceps*, (Family: Calliphoridae), *Musca domestica*, (Family: Muscidae), *Sarcophaga carnaria*, *Wohlfahrtia magnifica* (Family: Sarcophagidae), *Piophila casei* (Family: Piophilidae), and *Megaselia scalaris* (Family: Phoridae), Coleoptera: *Dermestes maculatus* (Family: Dermestidae), *Hister* sp. (Family: Histeridae), *Necrobia rufipes* (Family: Celeridae), and Hymenoptera: *Dolichovespula* sp. (Family: Vespidae), *Monomorium pharoensis* (Family: Formicidae).

These insect species that associated with animal carcasses tested could be comparable with those collected by [38], from dog carcasses in Turkey.

### 4.2. Carcass decomposition

Insects arrive on a carcass in a predictable sequence which depends on the stages of decomposition. The results of the present study indicated that carcass decays very quickly in summer but quite slowly in winter. Therefore it could be said that decomposition rate of carcass is directly proportional to temperature.

Not all species visited the carcass only to oviposit or larviposit, some species were found visiting, copulating and feeding on the corpse tissues.

Insects colonizing the carcasses could be separated into four ecological categories as noted by **[18]**.The first category which contained the greatest number of individuals and is of high significance in determining time since death; necrophagous species that feed directly on the carcass. The second category was predators and parasites of the necrophagous species. The third category consisted of omnivorous species (wasps, ants and some beetles) that fed on both carcass and associated insects. The fourth category was comprised of incidental species having no relationship to the carcass. These results agree with those documented by [39] and [40].

The present study indicated that while the Calliphoridae were more abundant during the earlier stages of decomposition, the Sarcophagidae were predominant during the later stages. These results are inconsistence with those obtained by [41], using rat carcasses, and [40] using pig carcass.

Blow flies, especially *Chrysomya albiceps* played a fundamental role in the carcass decomposition. These flies, confirming their role as major factors in carcass decomposition. These findings were in agreement with [41], declaring the role of insects in carcass decomposition.

As shown from the present study Calliphoridae (Diptera) were the first insects attracted to the fresh and bloated stages of carcass decomposition. During the post decay stage of decomposition, the carcasses were showing signs of dryness. Hence, the number of flies visiting the carcasses began to decrease. On the other hand, beetles (Coleoptera) were the

most common during this stage. *Dermestes maculatus* was the dominant beetles being collected from the decay to the dry stages of carcass decomposition. These findings are consistent with those obtained by [42], studying the insects colonizing pig carcasses in open and forest habitats of Central Europe. However, Hymenoptera (Formicidae) that observed throughout the decomposition process were appeared to have no impact on the decomposition process. This agrees with [42], but is contrary to the observations made by [43], where ants fed on carcasses and maggots.

### 4.3. Variable habitat

Previous research on the effect of habitat on carrion and insects associated with it has been sparse. However, some authors studied the relationship between habitats of the carrion and insect succession e.g. [22, 44, 45]. [46, 47] Found that shaded site temperatures were typically higher in evenings and fluctuated less than sun- exposed sites in all seasons in Washington state, U.S.A. and northern British Colombia regions, respectively. Comparable to these findings temperatures outdoor (sun- exposed sites) and indoors (shaded sites) used in the present study in Nasr city, Egypt were nearly similar. [46] Concluded that ambient temperature was a chief factor influencing carrion decomposition. These findings are confirmed by the present study, as the decay rate of carcasses placed outdoors was faster in summer season than indoors.

Generally, the sequence and duration of insect succession on carcasses placed outdoor or indoor sites followed the same general pattern. These observations are confirmed by [42, 48] working on pig carrion placed in sun and shaded sites, and in opens and forest habitats, respectively. In addition, habitat variations affected species diversity. Outdoor (sun-exposed) carcasses attracted a greater diversity insect species and a greater number of each species, compared to indoor (Shaded) carcasses.

## 5. References


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