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Entomofauna Associated with Certain Animal Carcasses as A human Model in Cairo, Egypt

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ABSTRACT

The current study was carried out to investigate the forensic insects associated with two animal carcasses namely; dog (*Canis lupus familiaris*) and rabbit (*Lepus cuniculus*) during the summer season. A total of 687 adult insect specimens representing 9 families were collected 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 % and 7 % of insects collected from dog carcasses placed outdoor and 59 %, 37 % and 4 % of insects placed 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. The insect succession on dog and rabbit carcasses 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 has appeared that the diversity and numbers of forensic insects which colonize dog or rabbit carcasses were increased outdoor and decreased indoor. Moreover, forensic insects were higher in numbers on dog carcasses than on rabbit carcasses.

INTRODUCTION

Forensic entomology is the use of the knowledge of insects in investigations of crimes or even civil disputes; it also includes the application of the study of insects and other arthropods to legal issues, especially in a court of law. Forensic entomology is divided into 3 sub-fields: Urban Forensic entomology, stored products forensic entomology and medico-legal (medico-criminal) forensic entomology. The aspect of emphasis worldwide is the medico-legal forensic entomology which has to do with arthropod involvement in events surrounding felonies or serious crimes; these are usually violent crimes like rape, suicide, murder and other aspects of crime, such as physical abuse and contraband trafficking (Catts and Goff, 1992).

The type and composition of taxa that are attracted to a carcass usually change in a predictable pattern as decomposition progresses through the different stages (Smith, 1986). Also, the pattern of succession of insects is specific to the location and environmental conditions in which a carcass occurs (Payne, 1965). Because taxa can vary greatly with locale, it is important for precise estimation of the PMI to identify the forensically important insects that are specific to an area (Anderson, 2000).

Insects on cadavers can be categorized as necrophagous (those that feed directly on the corpse), predators and parasitoids (that feed on necrophagous insects), omnivores (that feed on the cadaver and other resources, including associated fauna) and accidental (insects that use the cadaver as source of refuge or shelter and whose presence is due to chance) (Smith, 1986).

This study aimed to investigate the entomofauna associated with dog and rabbit carcasses, and its succession pattern in relation to decomposition stages of carcass, type of carcass and size, climatic conditions, and habitat. The main objective was to provide entomological data that can be employed in forensic cases in Egypt.

MATERIALS AND METHODS

Study Site:

The study site was located in University of Al-Azhar, Nasr city, Cairo, Egypt. Nasr city is considered a 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 experiment was carried out in summer season during the period from July 16, 2014 to September 23, 2014, the duration of the experiment was approximately 70 days. The experiment was continued until the entire carcass was consumed. The 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

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 the 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. The sand was placed under each cage to facilitate the collection of larvae, leaving carcasses to pupate.

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 was collected using hand picking forceps and vial glasses.

Identification and taxonomic determinations were made by using current keys (Greenberg, 1971; Mosallam, 1980; Shaumar et al., 1989; Whitworth, 2006 and Carvalho and Mello-Patiu, 2008), and by specialists in Cairo University and Agriculture Research Centre, 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.

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.

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.

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.

RESULTS

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 1 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 1 postmortem, while the maximum temperature was 31°C on day 20 postmortem. The average relative humidity recorded 53 % indoor (Table 2).

Decomposition Patterns of Animal Carcasses:

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

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

The advanced decay stage begins when the flesh of carcass is removed at extremities (head, limbs, and anus), the 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. 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 (Fig. 1d & Fig. 2d).

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. 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 (Fig. 1e & Fig. 2e).

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

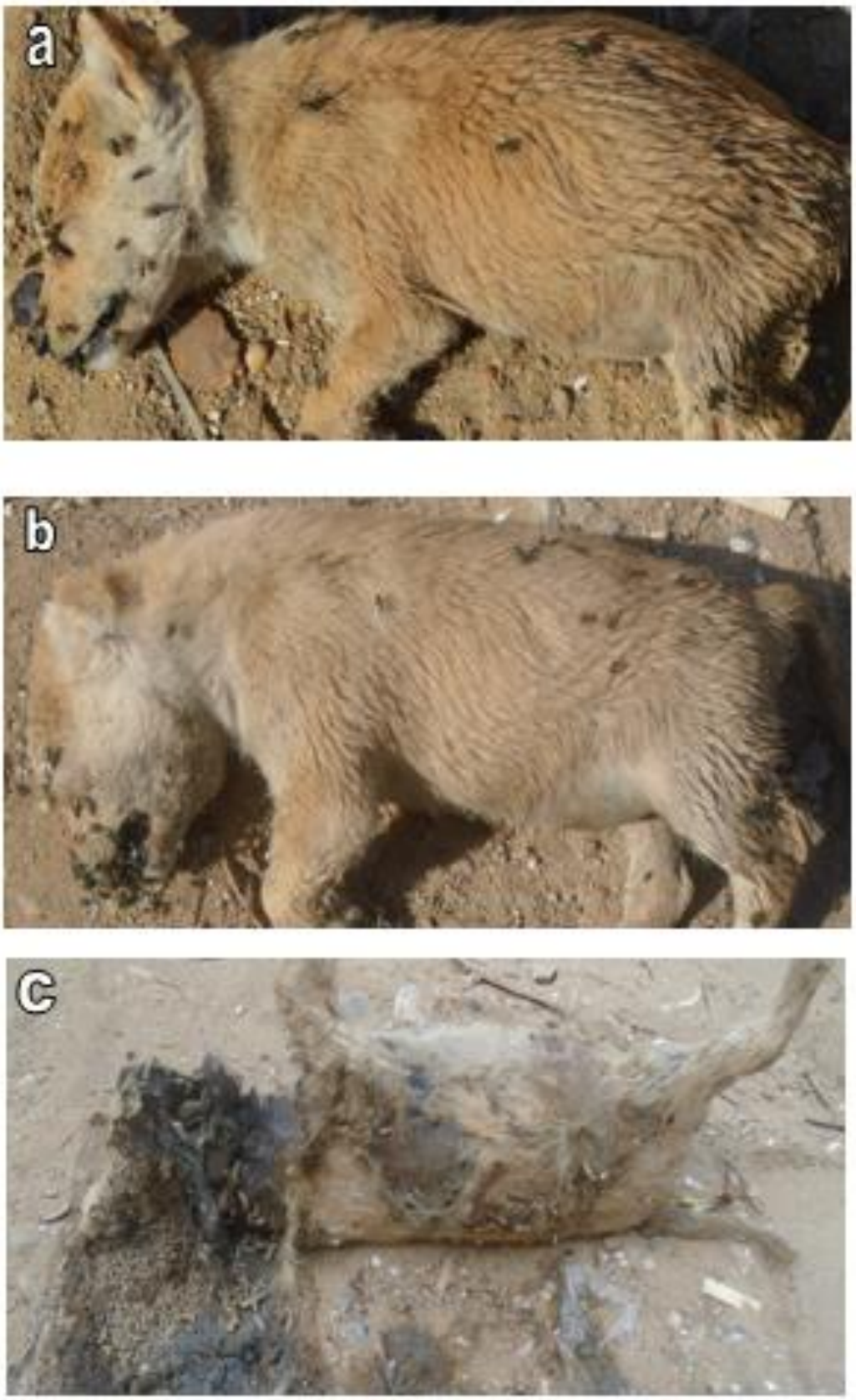

Fig. 1a-c. Decompositional stages of dog carcass during summer season from July 16, 2014 to September 23, 2014. (a) - fresh stage, (b) - bloated stage, (c) - decay stage.

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.

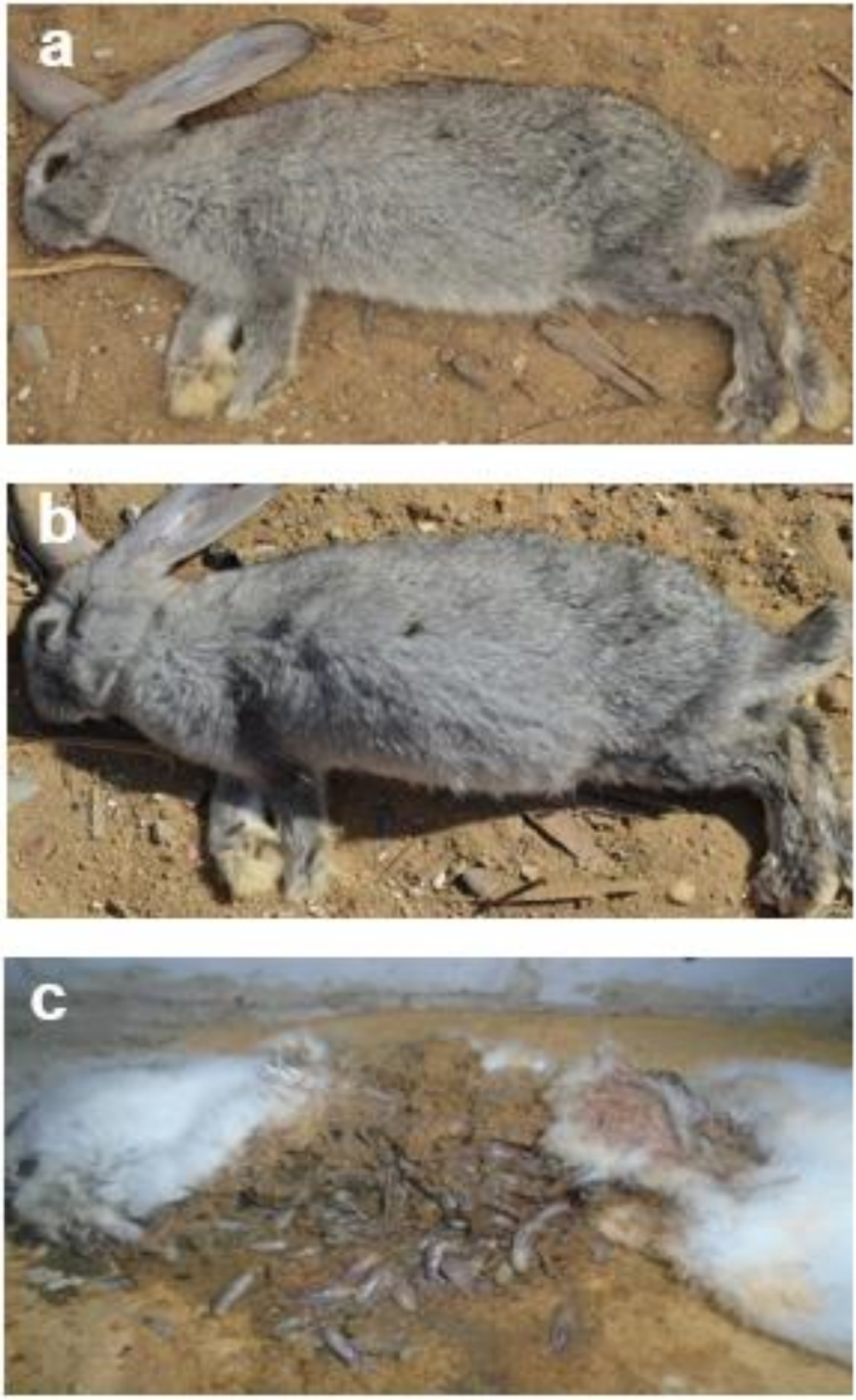

Fig. 2a-c. Decompositional stages of rabbit carcass during summer season from July 16, 2014 to September 23, 2014. (a) - fresh stage, (b) - bloated stage, (c) - decay stage.

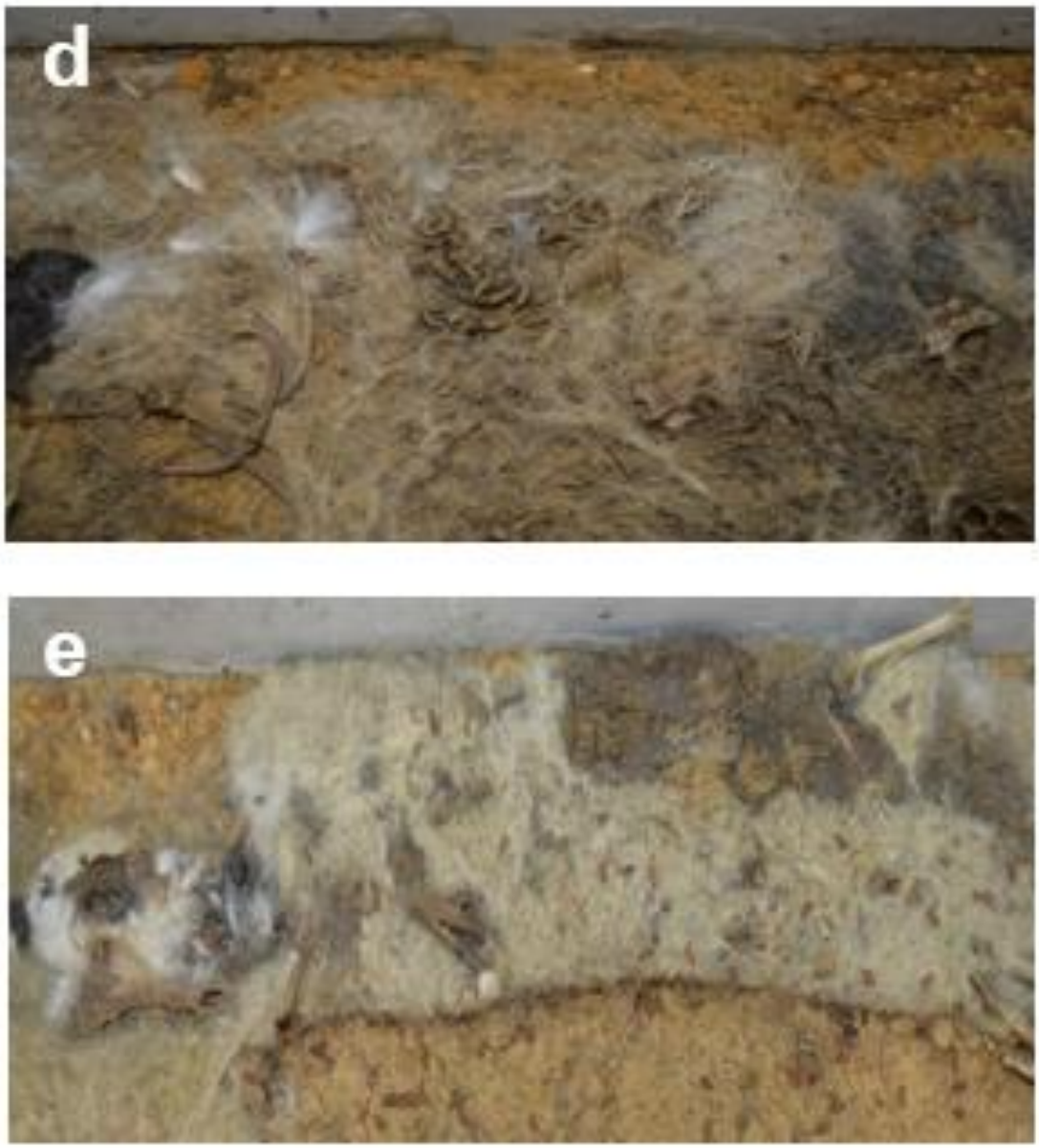

Fig. 2d, e. Decompositional stages of rabbit carcass during summer season from July 16, 2014 to September 23, 2014. (d) - advanced decay stage, (e) - dry stage.

Insect Fauna Associated With Animal Carcasses:

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 in Table 3 and Fig. 3 only one species of adult Calliphoridae namely; *Chrysomya albiceps* was collected from dog carcass in both habitats (outdoor or indoor). The number of occurrences 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
	Celeridae	*Necrobia rufipes*	20	44
Hymenoptera	Vespidae	*Dolichovespula* sp.	9	0
	Formicidae	*Monomorium pharoensis*	40	14
Total			**687**	**342**

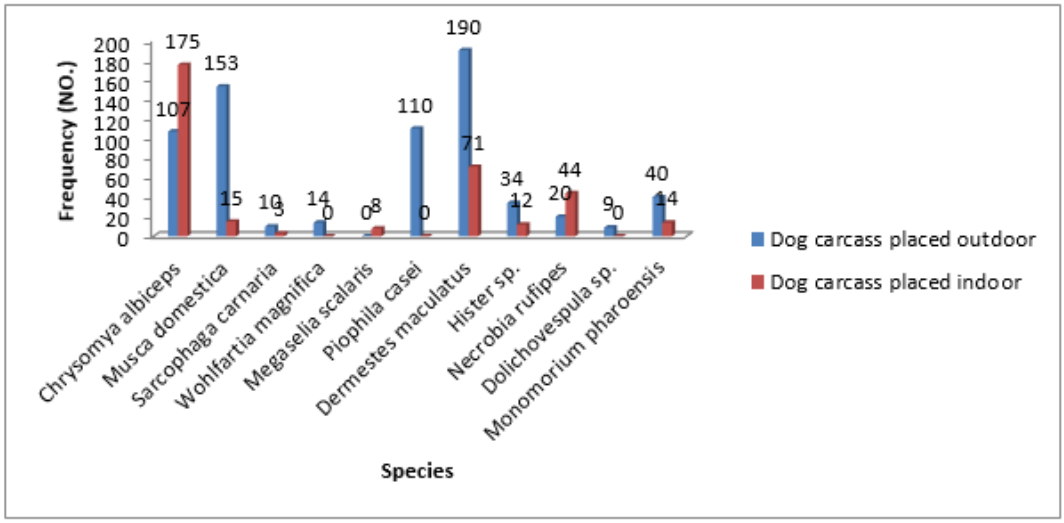

Fig. 3. Frequency of forensic insect species on dog carcass placed indoor and outdoor during summer season 2014.

2. Rabbit Carcass:

As shown from the results given in Table 4 and Fig. 4 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 adults collected was 42.

Family Sarcophagidae was represented by one species namely; *Wohlfahrtia magnifica* collected from rabbit carcass placed outdoor (18 individuals).

Three individuals of *Megaselia scalaris* (Family: Phoridae) were collected only from rabbit carcass placed indoor (8).

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	
			Outdoor	Indoor
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**

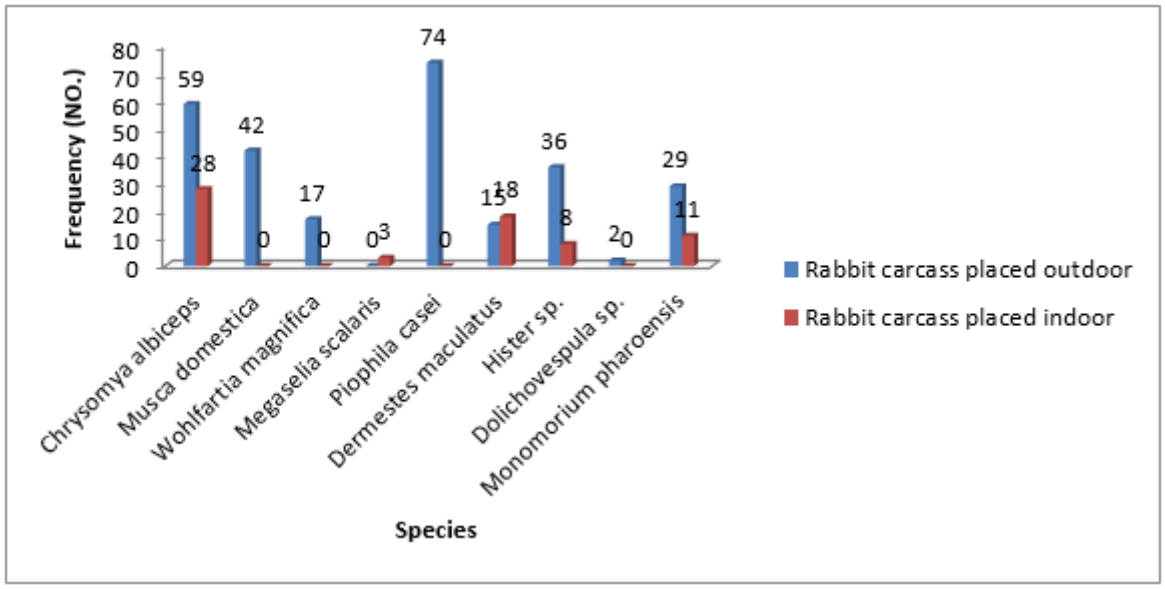

Fig. 4. Frequency of forensic insect species on rabbit carcass placed indoor and outdoor during summer season 2014.

Insect Succession:

1. On Dog Carcass:

The succession of forensic insects on dog carcasses placed outdoor and indoor during summer season 2014 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 bloated 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 were found to be attracted to bloated and decay stages of dog carcass placed indoor, and only to bloated 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 bloated, 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 bloated 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
	Celeridae	*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
	Celeridae	*Necrobia rufipes*	0	0	1	5	38	44
Hymenoptera	Formicidae	*Monomorium pharoensis*	0	0	0	14	0	14
Total								**342**

2. On Rabbit Carcass:

As shown from the 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, *Megaselia 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 has appeared that the diversity and numbers of forensic insect species that 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	*Dermests 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

DISCUSSION

The establishment of a post-mortem interval (PMI) of victims of unexplained death is a vital step in many forensic investigations (Morris and Dadour, 2005). 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 (Goff, 1993; Amendt *et al.*, 2007). 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 (Putman, 1978). 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 (Voss *et al.*, 2011).

Entomological estimates of PMI are typically based on known patterns of insect succession and the developmental age of

immature insects collected from the body (Catts and Goff, 1992).

Many abiotic and biotic factors influence the rate of decomposition and insect succession onto remains including geographic location (Campobasso et al., 2001; Voss *et al.,* 2009), climatic conditions (Archer, 2004), season (Tabor *et al.,* 2004), habitat (Eberhardt and Elliot, 2008), the physical state of the remains (Avila and Goff, 1998) and the decomposition environment (Voss et al., 2008).

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 (Voss *et al.*, 2011).

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

1. Type of Animal Carcass:

Forensic insects associated with different animal carcasses have been studied; for example, on cats (Rodriguez and Bass, 1983), dog (Introna *et al.,* 2001), pigs (Sabanoglu and Sert, 2010), guinea pigs (Bourel *et al.,* 2001), mice (Whitworth, 2006), foxes (Riberio and Carvalho, 1998; Carvalho and Mello-Patiu, 2008), lizards and toads (Pape, 1996), turtles (Bonacci et al., 2009), rabbits (Manhoff *et al.,* 1991), elephants (Pai *et al.*, 2007).

Watson and Carlton (2003), compared species composition on the corpses of black bear, white tailed deer, alligator and swine. Also, Azwandi *et al.*, (2013) 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 Azwandi *et al.*, (2013) attributed this variation attributed to the physical characters of animal carcass, such as size, the thickness of fur and also, the diet and site specific factors. Moreover, the low number of carcass samples could be a possible cause for the fewer numbers of insect species collected. This observation agrees with Tullis and Goff, (1987) who used only three carcasses.

In the present study, the 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 the period of decomposition. For example, dog carcass (which is larger and has more tissue) provide a 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 Voss *et al.,* (2009) 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*, (Fam: 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 by Kökdener and Polat (2014), from dog carcasses in Turkey.

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 the 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 Catts and Goff (1992).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 Payne (1965), and Carvalho and Linhares (2001).

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 in consistence with those obtained by Monteiro-Filho and Penereiro (1987), using rat carcasses, and Carvalho and Linhares (2001) 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 Payne (1965), declaring the role of insects in carcass decomposition.

As shown in 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 Matuszewski *et al.,* (2013), studying the insects colonizing pig carcasses in open and forest habitats of Central Europe. However, Hymenoptera (Formicidae) observed throughout the decomposition process has appeared to have no impact on the decomposition process. This agrees with Matuszewski *et al.,* (2013), but is contrary to the observations made by Morreti *et al.,* (2013), where ants fed on carcasses and maggots.

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. Anderson and Vanlaerhoven (1996), Tabor *et al.,* (2004) and Hobischak *et al.,* (2006).

Shean *et al.,* (1993) and Dillon and Anderson (1996) 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. Shean *et al.,* (1993) 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 Okiwelu *et al.,* (2008) and

Matuszewski et al., (2013) working on pig carrion placed in the 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 of insect species and a greater number of each species, compared to indoor (Shaded) carcasses.

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ARABIC SUMMARY

الفونة الحشرية المصاحبة لجثث حيوانات معينة كنموذج لجثة الإنسان في القاهرة، مصر

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أجريت الدراسة الحالية لفحص الحشرات الجنائية المرتبطة بجثتي نوعين من الحيوانات وهما: الكلب (*Canis lupus familiaris*) والأرنب (*Lepus cuniculus*) خلال موسم الصيف. تم جمع 687 حشرة يافعة تمثل 9 عائلات حشرية من جثة الكلب التي وضعت في الهواء الطلق، بينما تم جمع 342 حشرة يافعة تمثل 8 عائلات حشرية من جثة الكلب التي وضعت في المكان المغلق. مثلت كلاً من رتبة ثنائية الأجنحة وغمدية الأجنحة وغشائية الأجنحة 57%، 36%، 7% على التوالي الحشرات التي تم جمعها من جثة الكلب التي وضعت في الهواء الطلق، ومثلت 59%، 37%، 4% على التوالي الحشرات التي تم جمعها من جثة الكلب التي وضعت في المكان المغلق. تم جمع 274 حشرة يافعة تمثل 8 عائلات حشرية من جثة الأرنب التي وضعت في الهواء الطلق، بينما انخفض عدد الحشرات اليافعه التى تم جمعها من جثة الأرنب التى وضعت فى المكان المغلق حيث كان العدد 68 حشره فقط تمثل 5 عائلات حشرية. مثلت كلاً من رتبة ثنائية الأجنحة وغمدية الأجنحة وغشائية الأجنحة 70%، 19%، 11% على التوالي الحشرات التي تم جمعها من جثة الأرنب التي وضعت فى الهواء الطلق, ومثلت 46%، 38%، 16% على التوالي الحشرات التي تم جمعها من جثة الأرنب التي وضعت فى المكان المغلق. أظهر تعاقب الحشرات على جثث الكلاب والأرانب في جميع مراحل التحلل أن ذبابة *Chrysomya albiceps* كانت أول ذبابة انجذبت إلى المراحل المبكرة من التحلل. وبشكل عام، فإن تنوع وأعداد الحشرات الجنائية التي تتغذى على جثث الكلاب أو الأرانب قد ازدادت في الهواء الطلق وانخفضت في الأماكن المغلقة. علاوة على ذلك، كانت الحشرات الجنائية أكثر عدداً على جثث الكلاب منها على جثث الأرانب.