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Seasonality of Insect Succession and Dog Carcass Decomposition in Different Habitats

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ABSTRACT

The different collected insect species were distributed on the carcasses according to the decomposition stages or postmortem intervals (PMI). In the winter season, the insect succession showed that carcasses placed outdoor attracted the greatest numbers and highest diversity of insect species. The calliphorid fly; *Chrysomya albiceps* was first attracted to the bloated and decay stages. In both habitats (outdoor and indoor), the numbers and diversity of insect species on carcasses were decreased during the advanced decay stage and then increased again during the dry stage. In the spring season, *Chrysomya albiceps* was the first fly attracted to the fresh or bloated stage of dog carcass in both habitats. Moreover, calliphorid flies were disappeared during the advanced decay stage in both habitats. While Coleopteran insects appeared during the decay and advanced decay stages. In the summer season, the forensic insect species showed nearly the same distribution of the different decomposition stages. Also, *Chrysomya albiceps* was the first fly attracted to the early stages of decomposition. In general, it appeared that the diversity and numbers of forensic insect species, which colonize dog carcass, were increased outdoor and decreased indoor. In the autumn season, carcasses placed outdoor attracted the greater numbers and higher diversity of forensic insects. The calliphorid fly, *Chrysomya albiceps*, and housefly, *Musca domestica* were first attracted to the fresh and bloated stages, especially of carcasses placed outdoor. The adult beetles, *Dermestes maculatus*, *Necrobia rufipes* and *Hister* sp. were early seen during bloated, decay and advanced decay stages.

INTRODUCTION

The 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 (Nuorteva et al., 1974). 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 (Smith, 1986). 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 (Hall, 2001).

Pathologists can estimate the time of death based on several biological parameters: lividity, rigor mortis, postmortem cooling, changes in the chemical constituents of the 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 (Hennsge et al., 1995). 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 (Kashyap and Pillai, 1989).

The present study aimed to investigate the entomofauna associated with certain animal carcass as a human model, and its succession pattern in relation to decomposition stages of carcass, type of carcass and size, climatic conditions, and habitat.

MATERIALS AND METHODS

Study Site:

The study site was located at the Department of Zoology and Entomology, Faculty of Science, Al-Azhar University, 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 experiments were carried out in four different seasons between December 2013 and, December 2014, the duration of the experiments was approximately 90 days during winters, 50 days during spring, 70 days during summer and 60 days during autumn. 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 the laboratory (indoor).

Experimental Design:

For each of the four experiments two dogs (*Canis lupus familiaris* Linnaeus, 1758), weighing approximately 3 kg each were used. One dog carcass was placed in the laboratory (indoor) and the other carcass was placed in a botanical garden (outdoor) of the animal house. The dogs 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 sand was placed under the 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 Coleopera were collected using hand picking forceps and vial glasses. Identification and taxonomic determinations were made using current keys (Greenberg, 1971; Mosallam, 1980; Shaumar et al., 1989; Whitworth et al., 2006; Carvalho and Mello-Patiu, 2008), and by taxonomists in Cairo University and Agriculture Research Center, Ministry of Agriculture, Dokki, Giza, Egypt. All insects were identified at least to the family level. All efforts were made to identify Diptera and Coleoptera to the species level as they were considered of 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 the 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

Insect succession on dog carcass tested is divided into four seasonal experiments (Table 1). The results are discussed in relation to the decompositional stages of carcass, habitat and climatic conditions of each season.

Insect succession tables (2-9) were developed for the four seasons throughout the study period (Table 1). The different insect species collected were distributed on the carcasses according to decomposition stages, i.e. according to postmortem intervals (PMI) indoor and outdoor.

Table (1): Dates of experiments.

Animal carcass / Season	Dog		Average of Temperature (°c)		Average of Relative humidity (%)	
	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
Winter 2013	From December 10, 2013 to March 1, 2014	From December 15, 2013 to March 4, 2014	15	22	57	60
Spring 2014	From March 31, 2014 to May 19, 2014	From March 31, 2014 to May 19, 2014	23	26	45	54
Summer 2014	From July 16, 2014 to September 23, 2014	From July 16, 2014 to September 23, 2014	29	27	54	53
Autumn 2014	From October 21, 2014 to December 19, 2014	From October 21, 2014 to December 19, 2014	20	24	56	65

As shown from the results in winter season, the blowfly *Chrysomya albiceps* was the most abundant fly attracted firstly to the dog carcasses in both habitats during the bloated stage of the carcass decomposition. The number of the adult fly was 70 and 66 for dog carcass placed indoor and dog carcass placed outdoor, respectively. However, this number increased to 210 for dog carcass placed outdoor and decreased to 8 for dog carcass placed indoor during the active decay stage.

In both habitats, the bloated and active decay stages attracted the highest diversity and greatest numbers of insects (Tables 2 & 3). Also, the calliphorids remained the most numerous flies in both habitats. However, the number and diversity of insect species were decreased during the advanced decay stage on dog carcasses in both habitats. On the other hand, the number of adult insect species collected from the dog carcass placed indoor was found to increase greatly during the dry stage of decomposition. This stage attracted a great number of *Musca sorbens* (191). For dog carcass placed outdoor, the dry stage of the carcass decomposition was characterized by high diversity of adult insect species collected (Table 2).

Table (2): Insect succession on dog carcass placed outdoor in winter season, 2013.

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0- 10	11-22	23-47	48-70	71-82	
Diptera	Calliphoridae	*Chrysomya albiceps*	0	66	210	13	3	292
		Chrysomya megacephala	0	8	19	0	0	27
		Lucilia sericata	0	0	5	6	2	13
		Calliphora sp.	0	3	11	8	3	25
		Phormia regina	0	0	3	0	0	3
		Musca domestica	0	3	1	0	2	6
	Muscidae	*Musca sorbens*	0	9	11	10	46	76
		Stomoxys calcitrans	0	3	0	0	0	3
	Sarcophagidae	*Sarcophaga carnaria*	0	13	12	4	3	32
	Phoridae	*Megaselia scalaris*	0	9	14	9	2	34
Coleoptera	Dermestidae	*Dermestes maculatus*	0	2	0	21	8	31
Total								542

Table (3): Insect succession on dog carcass placed indoor in winter season, 2013

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0-7	8-15	16-30	31-50	51-80	
Diptera	Calliphoridae	*Chrysomya albiceps*	0	70	8	0	0	78
	Muscidae	*Musca sorbens*	0	2	1	0	191	194
	Sarcophagidae	*Sarcophaga carnaria*	0	2	0	0	10	12
	Phoridae	*Megaselia scalaris*	0	20	6	4	11	41
Coleoptera	Dermestidae	*Dermestes maculatus*	0	4	3	6	12	25
Hymenoptera	Pteromalidae	*Nasonia vetripennisis*/	0	0	0	0	39	39
Total								389

In spring season, the succession of forensically significant insects on dog carcasses placed outdoor and indoor is presented in tables (4) and (5), respectively. As shown from the results, the calliphorid fly *Ch. albiceps* was the most abundant blowfly attracted firstly to the dog carcasses in both habitats (Outdoor and indoor) during the fresh and bloated stages of carcass decomposition. 35 flies were collected during the bloated stage from dog carcass placed indoor vs. 27 and 578 individuals collected during the fresh and bloated stages of dog carcass placed outdoor, respectively. However, *M. domestica, M. sorbens* and *S. carnaria* adult flies were detected during the fresh stage of dog decomposition (From 0 to 1 day postmortem) for dog carcass placed outdoor. The decay stage (6-8days postmortem) of dog carcass placed indoor attracted a great diversity of insect species especially of dipterous species. Then the diversity of dipterous was decreased during the advanced decay stage carcasses placed indoor and outdoor. On the other hand, the diversity of Coleopteran beetles was increased during the advanced decay and dry stages for dog carcasses placed in both habitats (Tables 4 & 5).

Table (4): Insect succession on dog carcass placed outdoor in spring season, 2014.

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0-1	2-4	5-7	8-10	11-50	
Diptera	Calliphoridae	*Chrysomya albiceps*	27	578	0	0	25	630
		Lucilia sericata	0	7	0	0	0	7
		Calliphora sp.	0	15	3	1	0	19
	Muscidae	*Musca domestica*	25	398	0	0	0	423
		Musca sorbens	2	3	0	0	0	5
		Stomoxys calcitrans	0	4	0	0	0	4
	Sarcophagidae	*Sarcophaga carnaria*	2	12	0	0	1	15
		Wohlfahrtia magnifica	0	15	0	0	7	22
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	63	28	39	130
	Histeridae	*Hister* sp.	0	0	12	32	17	61
	Celeridae	*Necrobia rufipes*	0	0	13	9	10	32
	Staphylinidae	*Creophilous maxillosous*	0	2	11	1	0	14
Hymenoptera	Pteromalidae	*Nasonia vetripennis*	0	0	0	21	33	54
	Formicidae	*Cataglyphis bicolor*	0	0	0	2	4	6
		Monomorium pharoensis	0	0	0	0	29	29
Total								1451

Table (5): Insect succession on dog carcass placed indoor in spring season, 2014.

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0-2	3-6	7-9	10-21	22-50	
Diptera	Calliphoridae	*Chrysomya albiceps*	0	35	20	2	16	73
		Calliphora sp.	0	1	2	1	1	5
	Muscidae	*Musca domestica*	0	0	5	0	0	5
		Musca sorbens	0	1	4	0	0	5
	Sarcophagidae	*Sarcophaga carnaria*	0	1	2	0	0	3
		Wohlfahrtia magnifica	0	0	2	0	0	2
	Phoridae	*Megaselia scalaris*	0	0	4	0	0	4
Coleoptera	Dermestidae	*Dermestes maculatus*	0	0	43	42	85	170
	Histeridae	*Hister* sp.	0	0	7	8	1	16
	Celeridae	*Necrobia rufipes*	0	0	0	0	4	4
	Staphylinidae	*Creophilous maxillosous*	0	0	0	3	0	3
Hymenoptera	Pteromalidae	*Nasonia vetripennis*	0	0	83	145	112	340
	Formicidae	*Monomorium pharoensis*	0	0	0	0	26	26
Total								656

In the summer season, the succession of forensic insects on dog carcasses placed outdoor and indoor is presented in tables (6) and (7), respectively. As shown from the results, the blowfly *Ch. 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 the decay stage (3-5 days postmortem) and to the advanced decay stage (6-30 days postmortem) of dog carcass placed indoor.

M. domestica adults were found to be attracted to bloat and decay stage 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.) and bloat (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 bloat, decay and dry stages of dog carcass placed outdoor. *Megaselia scalaris* (Fam. Phoridae) was detected only during the decay stage of dog carcass placed indoor. *Piophila casei* was only detected on dog carcass placed outdoor during bloat, decay, advanced decay and dry stages. The coleopteran; *Dermestes maculatus*, *Hister* sp. and *Necrobia rufipes* were firstly detected during the decay stage and then during the advanced decay and dry stages of dog carcass placed indoor.

On the other hand, *D. maculatus*, *Hister* sp. appeared during bloat, 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* were 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 (6): 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 (7): 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

In the autumn season, succession tables for forensically significant insects for dog carcasses placed in two different habitats (outdoor and indoor) are presented in tables (8) and (9), respectively. As shown from the results, the blowfly, *Ch. albiceps* was the most abundant fly attracted firstly to the dog carcasses in both habitats, where (77) and (505) individuals were collected during the bloated stage of dog carcasses placed indoor and outdoor respectively. Also, the first insect attracted to dog carcass indoor were; *Ch. Albiceps* (77), *M. domestica* (10), *S. carnaria* (3) and *Megaselia scalaris* (4), where they detected during the bloated stage (2-4 postmortem) unexpected observation was to detect the beetle, *D. maculatus* (9) during the bloated stage of dog carcass placed indoor. However, *D. maculatus* adults were also seen during decay, advanced decay and dry stages of dog carcass placed indoor with individual numbers of 8, 8 and 13, respectively. *Hister* sp. was present during decay and advanced decay stages of dog carcass placed indoor. *N. rufipes* (2) was seen only during the advanced decay stage. The parasitic Hymenopteran, *Nasonia vetripennis* (Pteromalidae) was found during all stages of decomposition except the fresh stage.

Table (8): Insect succession on dog carcass placed outdoor in autumn season, 2014.

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0-1	2-5	6-8	9-19	20-60	
Diptera	Calliphoridae	*Chrysomya albiceps*	8	505	63	0	74	650
		Chrysomya megacephala	0	4	0	0	0	4
	Muscidae	*Lucilia sericata*	0	9	0	0	0	9
		Musca domestica	28	439	95	6	1	569
		Stomoxys calcitrans	0	0	2	0	0	2
	Sarcophagidae	*Sarcophaga carnaria*	3	0	0	0	0	3
		Wohlfahrtia magnifica	0	5	0	0	0	5
	Piophilidae	*Piophila casei*	6	55	49	4	0	114
Coleoptera	Dermestidae	*Dermestes maculatus*	0	4	10	17	35	66
	Histeridae	*Hister* sp.	0	3	9	10	0	22
	Celeridae	*Necrobia rufipes*	0	0	3	7	7	17
Hymenoptera	pteromalidae	*Nasonia vetripennis*	0	0	0	5	0	5
	Vespidae	*Vespa orientalis*	0	10	5	0	0	15
	Formicidae	*Monomorium pharoensis*	0	10	0	8	0	18
Total								1499

Table (9): Insect succession on dog carcass placed indoor in autumn season, 2014.

Order	Family	Species	Decompositional stages / Days postmortem					Total
			Fresh	Bloated	Active decay	Advanced decay	Dry	
			0-1	2-4	5-7	8-15	16-60	
Diptera	Calliphoridae	*Chrysomya albiceps*	0	77	0	5	51	133
	Muscidae	*Musca domestica*	0	10	1	0	0	11
	Sarcophagidae	*Sarcophaga carnaria*	0	3	0	0	0	3
	Phoridae	*Megaselia scalaris*	0	4	0	0	0	4
Coleoptera	Dermestidae	*Dermestes maculatus*	0	9	8	8	13	38
	Histeridae	*Hister* sp.	0	0	2	2	0	4
	Celeridae	*Necrobia rufipes*	0	0	0	2	0	2
Hymenoptera	pteromalidae	*Nasonia vetripennisis*	0	2	91	55	44	192
Total								387

On the other hand, the dog carcass placed outdoor was characterized by high diversity and high numbers of insect species associated with it. The 1st insect species attracted to dog carcass outdoor were; *Ch. albiceps* (8), *M. domestica* (28), *S. carnaria* (3) and *Piophila casei* (6) as they found during the fresh stage (0-1 day postmortem). The bloated stages of carcass decomposition was characterized by a great number of insect specimens, were 505, 439 and 55 adult individuals of *Ch. albiceps, M. domestica* and *Piophila casei*, respectively were collected. Other insect species associated with bloated stage were *Ch. megacephala* (4), *Lucilia sericata* (9), *W. magnifica* (5), *D. maculatus* (4), *Hister* sp. (3), *Vespa orientalis* (10), *Monomorium pharoensis* (10) and with decay stage (6-8 postmortem) were found to be *Ch. albiceps* (63), *M. domestica* (95), *Stomoxys calcitrans* (2), *Piophila casei* (49), *D. maculatus* (10), *Hister* sp. (9), *N. rufipes* (3), *Nasonia vetripennis* (5) and *Monomorium pharoensis* (8). The dry stage (20-60 postmortem) was found to be associated with the adult beetles; *D. maculatus* (35) and *Hister sp.* (7). However, *Ch. albiceps* (74) were also collected during this stage. The appearance of *Ch. albiceps* during this late stage of decomposition was due to the emerged pupae on the dog carcass.

DISCUSSION

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 carcasses during the study period, they were of forensic importance. The following species were identified; Diptera: *Chrysomya albiceps*, (Fam. Calliphoridae), *Musca domestica*, (Fam. Muscidae), *Sarcophaga carnaria*, *Wohlfahrtia magnifica* (Fam. Sarcophagidae), *Piophila casei* (Fam. Piophilidae), and *Megaselia scalaris* (Fam. Phoridae), Coleoptera: *Dermestes maculatus* (Fam. Dermestidae), *Hister* sp. (Fam. Histeridae), *Necrobia rufipes* (Fam. Celeridae), and Hymenoptera: *Dolichovespula* sp., (Fam. Vespidae), *Monomorium pharoensis* (Fam. Formicidae).

These insect species that associated with dog carcasses tested could be compared with those collected from dog carcasses in Turkey (Kökdener and Polat, 2014).

The present study indicated that while Calliphorids were more abundant during the earlier stages of decomposition, Sarcophagids were predominant during the later stages. These results are in consistency with those obtained by Monteiro-Fiho and Penereiro (1987) using rat carcasses, and Carvalho and Linhares (2001) using pig carcass.

Blowflies, especially *Ch. 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) that observed throughout the decomposition process was 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.

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 the 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. Such results, 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.

Most species demonstrated longer periods of colonization on carcasses placed indoors. This result was similar to that obtained by Sharanowski et al., (2008) as they observed longer periods of colonization on shaded carrion. They attributed this to the potential of the carcass to remain an appropriate resource for insects and not to the slower rate of decay.

The minimum temperature (5 ^{o}C) during the study period was recorded during the winter season, while the maximum temperature (39 ^{o}C) was recorded in summer season. The temperature was ranged from 39 to 12^{o}C in spring and from 33 to 11^{o}C in autumn. Relative humidity was ranged from 100 to 4 %, from 94 to 4 %, from 98 to 7 % and from 100 to 9 % in winter, spring, summer and autumn, respectively.

A low number of insects and the lowest temperature (5 ^{o}C) were recorded during the winter season, while the highest temperatures (39, 39 and 33 ^{o}C) were recorded during the spring, summer and autumn, respectively, when the insects were more numerous and the decomposition process required 50 days in spring, 70 days in summer and 60 days in autumn. These results are inconsistent with those obtained by Sharanowski et al., (2008) and Carvalho and Linhares (2001) studying the effects of season and habitat on pig-carcass decomposition and pattern of insect succession on this carcass.

However, irrespective to season and habitat, the adults of Diptera were the initial colonizer of dog carcasses (indoors and outdoors). These observations are inconsistent with those obtained by Carvalho et al., (2004), Sharanowski et al., (2008) and Voss et al., (2009). Also, the appearance of insect species on the carcasses studied was varied from season to another. However, the blowfly *Chrysomya albiceps* was the predominant species collected and reared from carcasses in all seasons.

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ARABIC SUMMARY

موسمية تعاقب الحشرات وتحلل جثث الكلاب في بيئات مختلفة

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تم توزيع الأنواع المختلفة للحشرات التي تم جمعها من على جثث الكلاب وفقاً لمراحل التحلل أو فترات ما بعد الوفاة (PMI). في فصل الشتاء، أظهر تعاقب الحشرات أن الجثث الموضوعة في الهواء الطلق جذبت أكبر عدداً وتنوعاً أعلى من الحشرات. كانت عائلة Calliphoridae وخاصة ذبابة *Chrysomya albiceps* هى التى انجذبت إلى مرحلتي الانتفاخ والتحلل أولاً. انخفضت أعداد وأنواع الحشرات على الجثث فى كل من البيئتين (الهواء الطلق والمكان المغلق) خلال مرحلة التحلل المتقدم ثم زادت مرة أخرى خلال المرحلة الجافة. فى موسم الربيع, كانت *Chrysomya albiceps* هى أول ذبابة انجذبت إلى المرحلتين الطازجه والمنتفخة من جثث الكلاب فى كلتا البيئتين. علاوة على ذلك، فقد اختفى ذباب عائلة Calliphoridae خلال مرحلة التحلل المتقدم فى كلتا البيئتين. بينما ظهرت الحشرات غمدية الأجنحة خلال مرحلتى التحلل والتحلل المتقدم للجثة. في موسم الصيف، أظهرت أنواع الحشرات الجنائية تقريباً نفس التوزيع على مراحل التحلل المختلفة. أيضاً، كانت *Chrysomya albiceps* أول ذبابة انجذبت إلى المراحل المبكرة من التحلل. بشكل عام، يبدو أن تنوع وأعداد الحشرات الجنائية التي تستعمر جثث الكلاب قد ازدادت في الهواء الطلق وانخفضت في الأماكن المغلقة. في موسم الخريف، جذبت الجثث الموضوعة في الهواء الطلق أعدادًا أكبر وتنوعاً أعلى من الحشرات الجنائية. كانت الذبابة النافحة *Chrysomya albiceps* والذبابة المنزلية *Musca domestica* هما الذبابتين اللتين انجذبتا أولاً إلى المراحل الطازجة والمنتفخة، خاصة للجثث الموضوعة فى الهواء الطلق. شوهدت الخنافس اليافعة مثل خنافس الجلود *Dermestes maculatus* ، *Necrobia rufipes* ، *Hister* sp. مبكراً خلال مراحل الانتفاخ والتحلل والتحلل المتقدم.