International Journal of Entomology Research
ISSN: 2455-4758; Impact Factor: RJIF 5.24
Received: 01-10-2020; Accepted: 15-10-2020; Published: 03-11-2020
www.entomologyjournals.com
Volume 5; Issue 6; 2020; Page No. 31-39

The Influence of winter weather and clothes on the decomposition of rabbit carcasses and insect succession, in urbanized district of 6th October city, Egypt

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Abstract

After death, insects are attracted to the corpse in a specific organized order. This order is used by forensic entomologist to accurately estimate the post mortem interval (PMI). However, insects are greatly affected by many conditions surrounding the corpus that could change its normal arrival and decomposition pattern. Some of these conditions are related to the habitat and climate, in which the carcass is placed, desert habitat, cultivated land or urbanized district. Other conditions are related to the carcass itself such as burns, wounds, drug abuse, and presence or absence of clothes. Eight pairs of rabbit carcasses were divided into two groups. The first group included clothed rabbit carcasses, and the second group included non-clothed rabbit carcasses as control. Insect fauna was represented by Six species of adult flies were, namely *Chrysomya albiceps* (Wiedemann), *Chrysomya megacephala* (Fabricius), *Lucilia cuprina* (Wiedemann), *Musca domestica* L., *Sarcophaga* sp. as well as *Piophila casea* L. Entomofauna, also comprised 3 coleopteran species namely, *Necrobia rufipes* Fabricious, *Hister* sp. and *Dermestes maculates* De Geer. Clothes significantly delayed the durations of the stages decomposition. Taxa attracted to the two carcass groups and the pattern of visitation recorded during the decomposition process were the same. Clothes attracted more insects (*Pi= 0.54*) compared to the control carcasses (*Pi=0.46*).

Keywords: forensic entomology, PMI, insect succession, clothes, rabbit carcasses.

1. Introduction

Immediately after death, insects are attracted to the dead remains of the cadaver (Byrd & Castner 2010) [10]. However, insects follow no standard protocol when arriving at the body. The pattern of the insect attraction to the corpse is not always the same. There are many changes in the conditions surrounding the corpse (Shuisong *et al* 2013) [63]. Geographical location, temperature, wrapping or clothing, and many other conditions that usually affect the insect arrival to the corpse (Shuisong *et al* 2013) [63]. Insects, as entomological evidence, play an important role in criminal investigations, since they are mainly used to estimate the post mortem interval (PMI) of a cadaver (Touroo & Fitch 2016, Amendt *et al* 2005, and Verma & Paul 2013) [71, 5, and 72]. Also, insects can give information if the cadaver was drug abused or not (Tilstone *et al* 2006, De-Letter *et al* 2000, Catts & Goff 1992, Hedouin *et al* 1999, Sadler *et al* 1995, Tahoon & Abouzied 2017, and AbouZied 2016) [70, 24, 17, 37, 58, 68, and 2]. Species of flies and beetles are the most commonly found in a crime scene. Most flies are the first insects to arrive at a carrion (Byrd & Castner 2010) [10] either to lay eggs, or to feed on the flesh of the dead organism (Catts & Goff 1992) [17]. However some beetles arrive at late stages of post mortem decomposition, not to feed on the carrion itself, but to feed on eggs, larvae, and flies (Smith 1986, Korvarik & Centrino 2001, and Byrd & Castner 2010) [64, 44, and 10]. The corpse forms a complete ecosystem of predators that feed on each other, and on the carrion, till there is nothing of it is left (Zaria *et al* 2015, De Caravlho & Linares 2001, Dautartas 2009, Catts & Goff 1992, and Payne 1965) [77, 22, 19, 17, 55]. The estimation of (PMI) could be predicted by the forensic entomologist using two steps. The first is to observe the post mortem change of the body. Additionally, is to observe the types of adult flies and beetles present around the corpse. Finally, is to estimate how much time has this copse been exposed to the Environment (Carvalho *et al* 2004, Marchenko 2001) [15, 48]. The investigator is assigned to collect samples of the eggs and the larvae present on the corpse to identify the insect to the species level and the stage of development. Therefore, the time of the insect arrival to the corpse could be used to estimate how much time passed since this body has been dead (Carvalho *et al* 2004) [15]. Most homicides occur when human are frequently fully or partially clothed. It is expected that clothes have a direct effect on the insect successional pattern and the decomposition of the carcass (Rajagopal 2013) [56]. The impact of clothing on the rate and the pattern of decomposition had been carried out by many authors (Mashaly *et al* 2019; Card *et al* 2015, Matuszewski *et al* 2014, Voss *et al* 2011, and Miller 2002) [51, 13, 53, 75, and 54]. Furthermore, the activity of the insects is one of the main factors that affected the rate of decomposition. It is very important to examine how clothing may impact insect colonization and the rate of decomposition (Miller 2002) [54].

Therefore, the aim of the current study is to answer the following questions:

1. Whether the presence of clothing significantly affects the

rate of decomposition and colonization by necrophagous insects.
2. Whether clothed remains decomposed in a different pattern when compared to unclothed remains.
3. Whether the presence of the clothing was more or less attractive to insect microphagous fauna

2- Materials and Methods

The Study site

The study site was located in a very well urbanized area of the 6th October City, Giza (29° 57' 9.5544" N and 30° 55' 18.9084" E). The city was established in 1979 by the decree (504th) of President Anwar El Sadat. The City is 17 km from the great pyramids of Giza, and 32 km from Cairo downtown. The 6th of October City has a total area of (400 km^2). The current population is about (700 000) inhabitants. The City of 6th of October is considered as the satellite city of Cairo (http://6thoctobercity.weebly.com).

Climate of 6th October city

Köppen-Geiger climate classification system described 6th October City as hot desert. The daily meteorological data were obtained using a location detector of the website Climate-Data.org. The average temperature ranged from 17ºC during the fresh stage, reaching the stability (15ºC) during both the bloat stage, and the active decay stage. The lowest temperature (10ºC) was achieved during the dry decay stage (Fig 1).

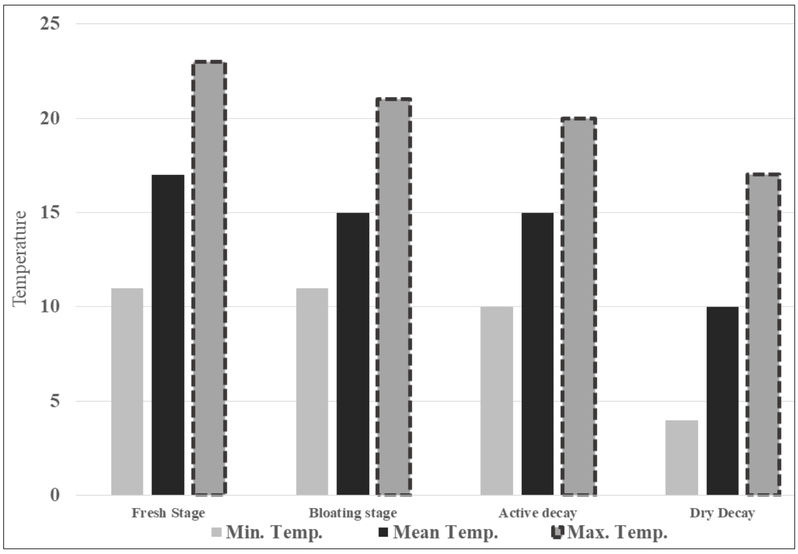

Fig 1: The fluctuations of the temperature (ºC) during the study period

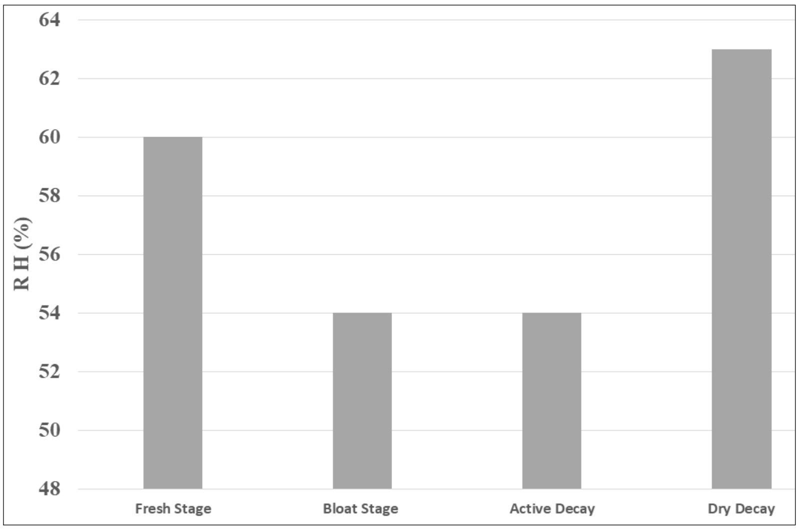

Fig 2: The change in the relative humidity values (RH %) during the study period

The relative humidity (RH %) had a narrow range of fluctuations from (54%) during the bloat stage, against (63%) during the dry decay stage (fig 2). In 6th of October city, no rainfall was available all year round.

Experimental design

Eight European domesticated rabbits (*Oryctolagus cuniculus*) weighing 1.5-1.6 Kg, were used as an animal model. All rabbits were taken to the sites of the experiment alive and were killed by slaughtering. After death, four rabbits were wrapped by cotton clothes while the other four rabbits were left unclothed (control). All of the eight rabbits were placed into metal mesh cages (L 36" x W12" x H 14") to prevent scavenging by large vertebrates and left exposed to natural conditions. Cages were distributed in pairs (clothed and control), one pair in the vicinity of Italian district. The second pair was located near the main market Mall of 6th October city. The third pair of cages was located in the Spanish district. The last pair was located nearby the Degla gardens. The animal cages were separated by approximately 150 meters, in each site. The experiment was repeated twice. The study period lasted from 30 November and continued up to the end of December.

The Committee of the Animal Use, Faculty of Science at Fayoum University, granted permission to use rabbits as an experimental animal. No specific permits were required, since rabbits are considered as animals of domestic consumption, following the protocols postulated by the European Union Committee of Animal Use in Research and Animal Welfare (Directive 2010/63/EU).

Carcass decomposition

In order to accurately determine the duration of each decomposition stage, carcasses were examined every hour during the 1st, and the 2nd, week; every 2-3 hours during the 3rd, 4th and 5th weeks. According to Gennard (2007) [30]. Four stages of decomposition were determined (fresh, bloated, active decay, and dry decay). In order to compare between the durations (in hours) of the four stages of decomposition of clothed and control rabbit carcasses, Students *t-test* was carried out using free online Quick Calcs graphpad analysis.
(*https://www.graphpad.com/quickcalcs/contMenu*).

Collection, sampling and identification

Two sticky traps (L25"xW18") were hanged (1.5 meter height), on opposite sides of each cage to facilitate the collection of adult flies. Observations of the onset of flies began early morning at 6 o'clock and end at sun set. The sticky traps were checked every two hours during the 1st, and the 2nd weeks. During the 3rd and 4th weeks, the sticky traps were examined 3 times a day. Adult beetles were collected using pit fall traps. Two concentric circles (5) traps each, 5 meters apart, were arranged around each cage. Collection of the adult beetles were carried out from each trap using wet brush, forceps and vial glasses. The number of adult insects collected were counted, and representative samples were preserved in 70% ethanol and taken to the laboratory for identification. Collection continued until apparent insect activity had ceased.

Identification and taxonomic determination of adult flies, were carried out according to Zumpt (1965) [78], Greenberg (1971) [33]. Shaumar *et al* (1989) [61], Carvalho & Mello-Patiu (2008) [16], and Szpilla *et al* (2010) [67]. The identification of the beetles to the possible species level were carried out according to Su *et al* (2013) [66] and Bala & Singh (2015) [9].

Data of the insect collection were expressed as the average no /trap/day. The relative abundance index (*pi*) was used to determine which carcass was more attractive, either the clothed or the control carcass. The relative abundance is calculated as the proportion of individuals of one particular species collected (n) divided by the total number of all individuals of all species caught (N).

3. Results

The effect of the clothes on the decomposition stages of rabbit carcasses

After (3.7 ± 0.58 days) the control carcasses started showing the first signs of bloating, while the clothed carcasses consumed a significantly longer time (5.75 ± 0.06 days; *df: 14*; *t=3.5157; P*=0.0034) to begin bloating (Table 1).

Table 1: Durations of the decomposition stages of rabbit carcass (Mean days ±SE), in 6th October city

Decomposition stages	Postmortem in days		(t) value	*P* value
	clothing	control		
Fresh stage	5.75 ± 0.06	3.7 ± 0.58	3.5157	0.0034
Bloat stage	12.58 ± 0.77	10.58 ± 0.51	2.1655	0.0481
Active decay	20.91 ± 0.08	18.69 ± 0.37	4.5134	0.0005
Dry decay	29.95 ± 1.39	26.31 ± 0.53	2.4469	0.0282

Number of rabbit carcasses (n) = 8, df= 14

The bloating lasted for (10.58 ± 0.51 days) in case of the control, until the first signs of active decay stage. On the other hand the bloating lasted for longer statistically significant time (12.58 ± 0.77days; *df: 14; t= 2.1655; P*=0.0481) in case of the clothed carcasses. The active decay stage was established within a significantly faster time (18.69 ± 0.37 days; *df: 14; t=4.5134; P=0.0005*) in case of the control carcasses, compared to (20.91 ± 0.08 days) in case of the clothed carcasses (Table1). In case of the control rabbits, the dry decay stage lasted for a significantly shorter period (26.31 ± 0.53 days; *df: 14*; *t=2.4469*; *P*=0.0282), compared to (29.95 ± 1.39 days), in case of the clothed carcasses (Table1).

Succession of the entomofauna of clothed and control carcasses on both of the clothed and the control carcasses, 9 taxa were detected. Six species of adult flies were noticed, namely *Chrysomya albiceps* (Wiedemann), *Chrysomya megacephala* (Fabricius), *Lucilia cuprina* (Wiedemann), *Musca domestica* L., *Sarcophaga* sp. as well as *Piophila casea* L. Additionally, 3 coleopteran species were collected using pitfall tarps namely, *and Necrobia rufipes* Fabricious, *Hister* sp., and *Dermestes maculates* De Geer.

During the fresh stage, adults of *M. domestica*, *Ch. albiceps*, *Ch. megacephala*, and *Sarcophaga* sp., represented the 1st wave, which invaded both of the control and clothed rabbit carcasses. The fore mentioned fly species continued visiting the carcass during the bloat and dry stages. During the bloat stage, both of *Cuprina* and *P. casea* adults arrived as the 2nd wave. It is noteworthy that the adults of *L. cuprina* continued to visit the carcasses up to the dry stage. During the active decay stage, a 3rd wave of the necrophagous insects belonged to adult Coleopteran comprising *N. rufipes*, *Hister* sp., and *D. maculates* were detected. Adults of *N. rufipes* continued to visit the two types of the carcasses to the end of the dry stage. Also, adult beetles of *Hister* sp., and *D. maculates* were the last visitors of the control carcasses as well as clothed carcasses, during both of the active and dry stages. Adults of *M. domestica* were the 1st colonizers, commonly attracted to the clothed carcass and the control carcasses. It lasted from early fresh, bloat until active decay, then disappeared. Adults of *M. domestica* peaked during the bloat stage (54 fly/trap/day) in case of the control and 75 (adults/fly/trap) in case of the clothed. During the fresh stage, the sticky traps caught the same average number of adult flies of *Ch. Albiceps* (3 adults/trap/day) from both of the clothed carcasses and the control carcasses. The attraction reached the peak of maximum increase during the bloat stage (37, and 53 adults/trap/day), in case of control and clothed carcasses, respectively. The attraction was then declined to 13 and 9 (adults/trap/day) for the clothed and controlled carcasses, respectively (Fig 3 and 4).

In case of adult *Ch. Megacephala*, a very weak numbers were collected from the controlled as well as clothed carcasses. During the fresh stage only 3 (adults/trap/day) against 2 (adult flies/trap/day), were collected from the control and the clothed carcasses, respectively. However, during the bloat stage 5 (adults/trap/day) of *Ch. Megacephala* were collected from the sticky traps, in case of the control carcasses, compared to 8 (adults/trap/day) in case of the clothed carcasses. An average of single (fly/trap/day) was caught from the control carcasses compared to an average of 3 adults/trap, in case of the clothed carcasses, during the active decay stage.

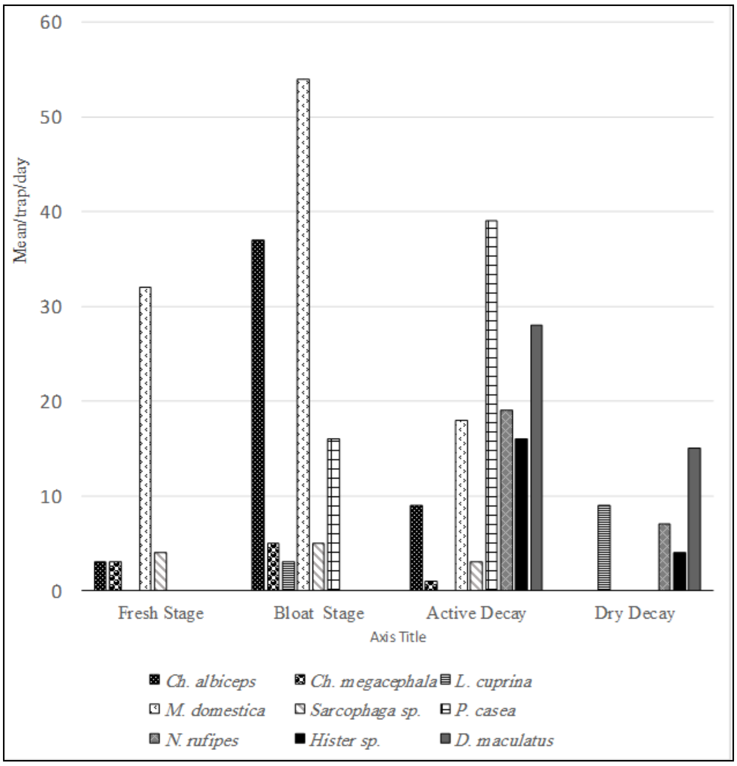

Fig 3: Insect succession on control rabbit carcasses

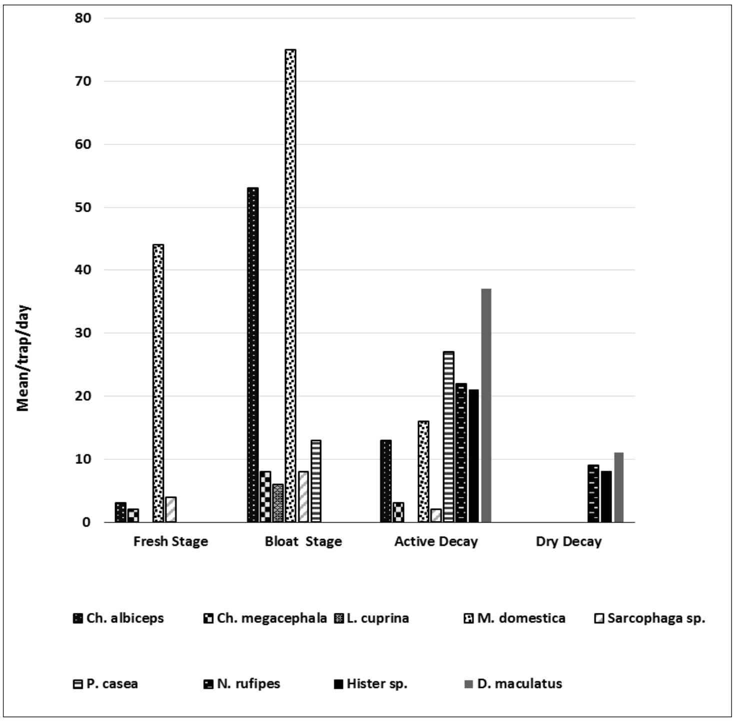

Fig 4: Insect succession on clothed rabbit carcasses

Furthermore, in case of the control and clothed carcasses, adult sarcophagi females showed a very poor existence during the fresh stage (4 adults/trap/day), peaked during the bloat (5 and 8 adults/trap/day) as well as during the active decay (3 and 2 adults/trap/day), respectively.

Adults of *P. casea* were restricted to the bloat and the active decay (13 and 27 adult/trap/day), in case of the clothed carcasses. On the contrary, it was represented by 16 and 39 adults/trap/day, in case of the control carcasses.

During the active decay stage, adult beetles of *N. rufipes*, *Hister* sp., and *D. maculates* showed the maximum peak (19, 16, and 28 adults/trap/day) in case of the control, respectively (Fig 3). On the other hand, the clothed carcasses trapped (22, 21, and 37 adults/trap/day), during the bloat stage for *N. rufipes*, *Hister* sp., and *D. maculates*, respectively (Fig 4). When carcasses entered the dry decay stage no flies were attracted to the remains and only beetles were found on or near the carcasses. However, some maggots were found inside the clothes of clothed carcasses, but no maggots were found on control carcasses. During this stage, 9 adults *N. rufipes* per trap, were collected nearby clothed carcasses, against 7 (adults/trap) were collected from control carcasses. Moreover, 8 adult *Hister* sp. per trap were collected from clothed carcasses, compared to 4 (adults/trap) in case of the control. However, 11 adult *D. maculates* per trap were caught from clothed carcasses against 15 (adults/trap) collected from control carcasses.

Relative Abundance of ntomofauna attracted to the clothed and the control carcasses

The calculated relative abundance index indicated that the clothed carcasses attracted more insect individuals (*Pi= 0.54*) compared to the control one (*Pi=0.46*). Following the same pattern of abundance, adult beetles as well as adult flies, were more attracted towards the clothed carcasses (*Pi=0.55 and 0.52*), respectively (Table 2).

Table 2: the relative abundance (Pi) of entomofauna associated with clothed and control rabbit carcass.

Order	Family	Species	Number of insects /trap/day Relative abundance (Pi)			
			clothed	Pi	control	Pi
Diptera	Calliphoridae	*Chrysomya albiceps*	35	0.58	25	0.42
		Chrysomya megacephala	6	0.55	5	0.45
		Lucilia cuprina	6	0.67	3	0.33
	Mean no of adult calliphorids		47	0.59	33	0.41
	Muscidae	*Musca domestica*	67.5	0.56	51.5	0.44
	Sarcophagidae	*Sarcophaga sp.*	15	0.56	12	0.44
	Piophilidae	*Piophila casea*	20	0.42	25	0.58
Average adult number of Diptera			140	0.52	131	0.48
Coleoptera	Celeridade	*Necrobia rufipes*	16	0.55	13	0.45
	Histeridae	*Hister sp.*	14	0.58	10	0.42
	Dermestidae	*Dermestes maculatus*	24	0.53	21.5	0.47
Average number of adult Coleoptera			54.5	0.55	44.5	0.45
Average adult insect fauna			241.5	0.54	208.5	0.46

Among the calliphorid taxa, the index of the relative abundance showed a higher value (*Pi= 0.59*) compared to (*Pi= 0.41*) in case of clothed and control carcasses, respectively. Adult *Ch. albiceps* (*Pi= 0.58*), were more abundant around the clothed carcasses compared to (*pi= 0.42*), in case of the control. Also, the calculated relative abundance of adults of *Ch. megacephala*, and *L. cuprina* were higher towards clothed carcasses (*Pi= 55* and *0.67*), respectively. However, in case of the controlled carcasses, the calculated indices were (*Pi*=0.45) for *Ch. megacephala* and (*Pi=0.33*) for *L. cuprina* (Table 2).

In case of the control carcasses, nearly the same low value of the abundance index was recorded for both of the adult muscoids and the adult sacophagids (*Pi=0.44*), compared to the clothed catch (*Pi=0.56*). The only case where adults were oriented to the control (*Pi=0.58*) more than the clothed carcass (*Pi=0.42*) was restricted for adult *P. casea*.

For the adult beetles attracted to the clothed carcasses, the relative indices were determined as (*Pi=0.53*, *0.55*, and *0.58*) *D. maculatus*, *N. rufipes*, and *Hister* sp., respectively. Additionally, the index for the histerid beetles attracted to the control carcasses was the least (*Pi=0.42*) compared to (*Pi=0.45* and *0.47*) clerid and dermestid beetles, respectively (Table 2).

4. Discussion

In most crime scenes, insects, hair, nails as well as body fluids (blood, semen, and saliva) represent the biological evidences (Kritsky 1991, and Haglund 1997) [45, 35]. In this study, the recorded insect fauna was very poor represented by 9 adult insect taxa. Similar to our results, Zeariya *et al* (2015) [77] recorded 9 entomofauna taxa from rabbit carcass against 11 species from dog carcasses, in Nasr City, Cairo, Egypt. Tantawi *et al* (1996) [69] recovered 11 carrion breeding dipterans, out of 100 arthropod species, from decomposing rabbit carcasses, in Alexandria. However, Abd El-Gawad *et al* (2019) [1] recorded 30 insect families from rabbit carcasees in urban area of Cairo, Egypt. Egypt. Aly *et al* (2017) [4] collected 18 species of necrophagous insect fauna during the decomposition of rabbit carcasses, in Qena Egypt. The change from the desert habitat to urbanized civil city seems to be the key factor for insect fauna reduction. Shuisong *et al* (2013) [63] stated that native insect populations have declined greatly in urban areas. The authors also revealed that the insect abundance decreased, since many insect species were extinct due to urbanization. Samways (1996) [59], and Davis (1978 & 1979) [20-21] reported that urbanization impoverished the biodiversity of insects. However, urbanization may eliminate some local endemic species or may increase the local and global occurrence of another species (Rentz 1993) [57].

Winter season (December-January) was selected to carry out this study. The effect of the temperature on the decomposition of the carcass and insect attraction was widely described in past studies (Goff 1993, De Carvalho & Linhares 2001, and Anderson 2000) [32, 22, and 6]. The time of decomposition, and the insect pattern of arrival in cold season, were relatively slower than in warmer seasons (Campobasso *et al* 2001) [12]. At low temperature of the winter season (averaged from 10-17ºC during this study) the bacterial activity and fermentation rate was decreased. Therefore, the production of gases leading to the balloon like shaped bloat stage was delayed. Also, low temperature largely affected the presence of insects in winter. It is expected that the dispersal of insects is lower compared to the case of summer season.

In our investigation, the decomposition stages of the control carcasses was faster when compared to clothed carcasses. Similarily, HauTEO *et al* (2013) [36] found that clothing delayed the decomposition of buried bodies. Card *et al* (2015) [13] reported that unclothed pig carcass decomposed faster than the clothed carcasses. Also, findings of Anderson (2009) [7], Kelly *et al* (2009) [41], and Voss *et al* (2011) [75] were largely in agreement with the results of this study. The delay in decomposition due to clothing, may be attributed to the protection of the carcasses from direct exposure to the sun. Some authors supported the fact that clothing prevented the insects from accessing desirable locations for oviposition on a corpse. Clothing protected decomposing tissues from the environmental factors such as sunlight or scavenging, which might affect the rate of decomposition (Goff 1992, Haglund 1997, Manhein 1997, and Komar & Beattie 1998) [31, 35, 46, and 43]. However, HauTEO *et al* (2013) [36] explained such delay in decomposition by the separation of the carcass from soil and the arthropods. Carter *et al* (2008) [14] found that direct exposure to the sun increases the rate of decomposition. Our data suggested that low air humidity (54%) favored the evaporation of body fluids during the bloat stage and active decay stage, leading to reach the dry decay stage. Water and other body fluids constitute a large amount of the body weight. When the evaporation rate increases, drought of the body could be reached faster. When the carcass was enveloped within a cotton piece, the rate of evaporation decreased compared to the rate of the naked control carcasses. The clothes absorbed most of the evaporated fluids, and provided the carcass a relatively cool, and shaded place for the insect oviposition. This hypothesis was supported by (Fiedler & Grow 2003 [27], Forbes *et al* 2005 [28], Kelly *et al* 2009 [41], and Voss *et al* 2011) [75]. Some other studies suggested that the water absorption by some types of cotton clothes resulted in fast dehydration of the carcasses tissues (Dautartas 2009, Schotsman's *et al* 2011, and Shirley *et al* 2011) [19, 60, and 62]. However, Mann *el al* (1990) [74], and Campobasso *et al* (2001) [12] reported that clothes increased the rate of carcass decomposition. In this study, the most dominant taxa were the dipteran flies, and the adult beetles. This finding matches the findings of previous studies (Greenberg 1991, Bala & Singh 2015, Kelly *et al* 2009, Voss *et al* 2011, Anderson 2000, Abouzied 2014, and Mashaly *et al* 2019) [34, 9, 41, 75, 6,3, and 51].

Additionally, Diptera species outnumbered the Coleoptera species. The overall insects attracted to clothed carcasses outnumbered that of the control carcasses. This observation goes along with the finding of (Voss *et al* 2011, Matuszewski *et al* 2016) [75, 52], and Dillon (1997) [25] who indicated that clothes increased the numbers and the diversity of insect succession. Similarly, Mashaly *et al* (2018) [50] found that clothed rabbit carcasses attracted more ant fauna compared to the unclothed and burnt carcasses. The possible reason for the clothed carcasses to attract more insects could be explained according to Kelly *et al* (2009) [41], and Caballero & Leon-Cortés (2014) [11] .The authors concluded that wet environment beneath the cotton envelop promoted high attraction of some insects, since the carcass can stay moist for a long time. Kelly *et al* (2009) [41] stated that the clothes didn't affect the pattern of arrival as the same species came at the same time. Also, clothes didn't affect diversity of the insects since, the same species were observed on both clothed and naked carcasses. However, the pattern of attraction of insects to the carcasses differed with each stage of decomposition. Observations during the fresh stage revealed the arrival of 4 dipteran fly species at the carcasses. Similar findings were reported by (Zeariya *et al* 2015) [77]. Our data also revealed that the higher average number of adults was attracted to the clothed carcass, compared to the naked carcass. The first fly arrived at the fresh stage was the house fly *M. domestica*. In contrast, Abouzied (2014) [3] diagnosed adult *M. domestica* around the rabbit carcasses during the bloat stage of the spring, the summer and the autumn, in mountains of Sothern KSA. Arnolds *et al* (2004) [8] found that adults of *M. domestica* was a dominant species, but during the summer season. Voss *et al* (2009) [75] reported that adult *M. domestica* would regularly visit carcasses, without diagnosing oviposition or larvae on the carcass body.

The second species that arrived at the carcasses was *Ch. Albiceps*. The third species that was attracted during the fresh stage was *Ch. Megacephala*. Meanwhile, the adult flesh fly (*Sarcophaga* sp.) was the last species collected during the fresh stage. Nearly the same average numbers of adult flies, were recorded for clothed, and naked carcasses. The low attraction of insets during this stage could be explained by the lack of necrotic odors coming out of the carcasses which makes the detection of the carcasses location very difficult. It could be also explained by the relatively low temperature (17- 20 ^{0}C) which reduced the insect activity. However in Alexandria, El-Samad (2016) [26] recorded adult *Ch. Megacephala* on rabbit carcasses, not during winter, but during warmer spring and summer seasons. Adult *Ch. albicePs*, *Ch. megacephala*, *L. cuprina*, *M. domestica*, and *P. casea* were more abundant around the clothed carcasses. In disagreement with our results, Mashaly *et al* (2019) [51], Kelly (2009) [41], and Card *et al* (2015) [13] indicated that, the richness of adult flies was not affected by the presence of clothes. However, Dillon (1997) [25], Kelly (2006) [39], and Kelly *et al* (2008 & 2009) [40-41] concluded that clothes provide a suitable wet media for rich oviposition and future maggot release. In both of the two cases of this study, adult *P. casea* was confined to both the bloat and the active decay. However, Abd El-Gawad *et al* (2019) [1], Arnolds *et al* (2004) [8], Martin-Vega (2011) [49], and Kofi *et al* (2018) [42] reported that *P. casea* was associated with the advanced stage of decay. During the active decay stage, adult *L. cuprina* disappeared while, adult *Ch. Albiceps*, *Ch. megacephala*, *M. domestica*, and *Sarcophaga* sp., were still existed between the clothed, and the naked carcasses. When carcasses entered the dry decay stage, no flies were attracted to the remains. Similarly, Cruise *et al* (2018) [18] stated that the insect activity increased during the bloat stage then decreased during the dry decay. The lack of flies during the dry decay stage could be explained by the disappearance of the odors of the volatile organic compounds emitted from the carcasses (Stensmyr *et al* 2002, Kalinová *et al* 2009, Frederickx *et al* 2012, Dekeirsschieter *et al* 2013, VonHoermann *et al* 2011, and VonHoermann *et al* 2013) [65, 38, 29, 23, 73, and 74] as well as, the consumption of the soft tissues which represents the main food supply of the maggots. Therefore, they stopped arriving at the carcass.

The adult beetles of *N. rufipes*, *Hister* sp., and *D. maculatus* were less abundant in case of naked carcasses compared to clothed carcasses. Similarly, Mashaly *et al* (2019) [51] indicated that clothed carcasses had a high number of beetles but not in a significant way. The adult beetle activities were first noticed during the active decay stage and continued visiting the carcasses up to the dry decay stage. Koffi *et al* (2018) [42] explained the presence of the Dermestidae during the advanced decomposition of pig carcass due to the dryness of the external parts of the corpse. However, the appearance of *N. rufipes*, and *Hister* sp. in the active decay stage may be due to the presence of maggots and fly eggs. Smith (1986) [64], Kovarik & Centerino (2001) [44], and Byrd & Castner (2010) [10] stated that maggots are known as suitable prey for the beetles feeding on them. Zeariya *et al* (2015) [77], De Carvalho & Linhares (2001) [22], Payne (1965) [55], and Catts & Goff (1992) [17] reported that beetles arrived at the carcass not only, to feed on the dead meat but also, to feed on other insect's eggs, larvae and adults that are presented around the body. Catts & Goff (1992) [17] concluded that beetles are the 4th caste of insects which prey on both of the carcasses and the insects associated with them. This conclusion was confirmed by (Zeariya *et al* 2015, Dautartas 2009, and Payne 1965) [77, 19, and 55].

In general, the lack of insect's attraction to the carcasses during the dry decay stage may be explained by the lack of odors coming out of the body also, the lack of soft tissues in which most of these insects feed and lay their eggs.

5. Conclusion

As a conclusion, this study indicated that there was no difference between clothed and control carcasses in terms of the pattern of insect arrival. However there was difference between clothed and non-clothed carcasses in time of decomposition and the number of insects attracted to the clothed and naked carcasses. The research published in this field is not enough to cover the obscured circumstances, questions, and cases which are considered as the essential guide for the legal investigations of the forensic team. Similar studies, in different seasons, are required to enrich the data to be compared with. The future step in this research is the molecular study of the forensically related insects in order to follow the recent development in science.

6. References

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