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Comparitive Study on Outdoor and Indoor Forensic Insects encountered on Rabbit Corpses in Upper Egypt

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Abstract: *This work aims to illustrate the forensic insects, their succession patterns and decomposition stages of rabbit corpses in ecologically different sites. The present study was performed on two sites including outdoor, open or roof site, in addition to indoor, closed or ground site of the faculty of science in Qena city for four successive seasons. Results showed eighteen species of necrophagous, necrophilous, omnivorous and accidental insects, of them, five outdoor species, three indoor species and ten common species. The five corpse decomposition stages (fresh, bloating, active, advanced and dry stages) have been observed. Twelve species of Diptera and three species of Coleoptera and Hymenoptera were collected from the carcasses. The dipteran species were the predominant groups on the corpses, whereas the coleopterans occupied the 2nd. The most important forensic insects were represented by Sarcophaga carnaria, Wohlfahrtia magnifica, Chrysomya albiceps, Lucilia cuprina, Muscina stabulans, Megaselia scalaris and genus Nasonia. Moreover, the studied calliphorid and sarcophagid flies were the first colonizers to arrive and breed on rabbit carcasses. The rate of corpse decomposition was faster in summer and spring as compared to winter and autumn. Outdoor corpses decomposed faster than indoor corpses. On the other hand, the statistical analysis showed negative temperature and humidity correlation on Sarcophaga carnaria, while both Wohlfahrtia magnifica and Muscina stabulans were affected positively by temperature and humidity, respectively. Therefore, these results are recommended to be taken in Criminal investigations.*

Keywords: *Forensic entomology; Insect succession; Corpse decomposition; Outdoor; Indoor; Egypt.*

I. Introduction

Forensic entomology is the science interested with studying insects and other arthropods associated with carrions to help in solving criminal cases (Greenberg 1985; Lord *et al.,* 1986a; Lord *et al.,* 1986b; Kashyap & Pillai 1986; Goff *et al.,* 1986; Goff & Odom 1987; Goff *et al.,* 1988; Goff *et al.,* 1991; Goff & Flynn 1991; Lord *et al.,* 1992; Leclercq & Vaillant 1992; Goff 1992; Lord *et al.,* 1994; Anderson 1995; Anderson 1997). Insects are the first organisms to discovery and colonize a cadaver after death. For this reason the entomologists often use the insects and other arthropods associated with carrions in solving the violet crimes (Bonacci, 2016).

Pathologist can estimate the postmortem interval based on many biological parameters such as lividity, postmortem cooling, rigor mortis and changes in the chemical constituents of body, tissue autolysis, and decomposition due to the bacterial activity in corpse. However, these parameters are not reliable beyond about 72 hours after death (Henssge *et al.,* 1995). However, 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 & Pillai, 1989).

Insect succession and cadaver decomposition can be influenced by many factors such as temperature, humidity, season, habitat, time of day, corpse accessibility and its physical position (Williams and Richardson 1984; Tullis and Goff 1987; Hall and Doisy 1993; Tessmer and Meek 1996; Dillon 1997; Anderson 2000b). Many papers have studied the differential effects of season on necrophagous fly activity (Introna *et al.,* 1989 and Chen *et al.,* 1991), insect succession (Archer & Elgar, 2003) and decomposition (Mann *et al.,* 1990 and De Carvalho & Linhares, 2001). All these papers concluded that season and habitat have major effects on the assemblage of invertebrates discovered on carrion and the time of insect colonization. Consequently, it is crucial to study the insect activity on carrion in specific geographic areas and different habitats. The present study was designed for investigating the entomofauna associated with rabbit corpses and its succession pattern in relation to decomposition stages of corpse, climatic conditions, and habitats.

II. Materials And Methods

A) The Study Sites:

The study sites were located on the south valley university land in Qena city, Egypt. Study was conducted for one year at two different habitats. For each season, two sites were selected, one outdoor and the other indoor. Sites for carcass placement were chosen on the roof of faculty of science (outdoor environment)

and at room on the basement of the faculty (indoor environment).

B) Experimental Animals:

The rabbits, *Oryctolagus cuniculus*, are chosen to simulate the soft skin of a new baby and were characterized by a relatively uniform size. The mentioned rabbits were purchased locally with different colors but comparable in size. On the delivery day of each season, rabbits were weighed, and then euthanized with air injection to mimic the normal death case without any chemicals or drugs. After death, the animals were immediately delivered post-mortem to the research sites in an appropriate man-made plastic traps which were designed specifically to allow insect access, but prevent them escaping. A tray containing sawdust was placed under each cage to facilitate the collection of larvae leaving carrions for pupation.

C) Field Protocols:

Three experiments were conducted in each season. Four rabbit carcasses were placed in each experiment, two at the indoor habitat and two at the outdoor habitat. All efforts were made to keep cadaver disturbance to a minimum during taking samples. Observations, photographs, temperature, humidity readings and sample collections were made daily at varying times of the day according to each experiment. The temperatures and humidity readings were taken with digital thermometer.

D) Sample Handling and Preservation:

During collection days, representative samples of immature and adult insects were collected from and around the carrion. While all insects observed were sampled, there was a definite focus on flies and beetles. Adult flies were collected by separating the upper part of trap. Adult beetles, immature insects, and other hard-bodies crawling insects were collected by hand or with forceps and immersed in 70% alcohol. For each carrion, approximately 20 larvae were collected from every distinct maggot mass on the body.

E) Data and Statistical Analysis:

The Student's excel sheet was employed to compare between the temperature and humidity readings for each season separately. Analysis of Variance on SPSS software package (version 16) (SYSTAT statistical program) was used to test the present data. Pearson correlation coefficients and multiple regressions were applied in the present data. Stepwise multiple regressions were used to select the affected variable.

III. Results

1. Forensic Catches:

During the present study, eighteen species of necrophagous, necrophilous, omnivorous and accidental insects were collected from the indoor and outdoor rabbit corpses for one year from October 2013 to September 2014 and then were identified. These species belong to three orders and fourteen families as shown in (Table 1). Five species of insects of two orders and five families were collected from rabbit corpses placed outdoor only compared to three species of three orders and three families were collected from corpses placed indoor only. Ten species of forensic and non-forensic insects of three orders and eight families were collected from both carcasses placed outdoor and indoor. The most dominant forensic insect observed during the study was represented by the hymenopteran parasite species, *Nasonia* sp. (64.4%) of all collected insects and the dipteran forensic species *Sarcophaga carnaria* which existed all over the studied period.

2. Seasonal Corpse Decomposition Stages:

Decay rates of rabbit corpses in different seasons from October 2013 to September 2014 in Qena city, Egypt are shown in table (2). Although the process of decomposition and insect invasion were continuous, it was often described by separate stages, which was characterized by the insect activity at each point in decomposition. All decomposition stages prolonged the highest period in winter and the lowest period in summer. The process of corpse decomposition was divided into five stages as follows:

1) Fresh stage began with the moment of death and continues until the first signs of bloating. No odor or swelling. During this stage, flies of Calliphoridae and Sarcophagidae begin arrive to the corpse and lay their eggs or larvae. (Fig. 1, 2, a).

2) Bloating stage marked the beginning of putrefaction, begins when the abdomen bloat due to the autolysis of tissues and the activity of fungi and bacteria and ends when abdomen deflates due to the releasing of gases. (Fig. 1, 2, b).

3) Active decay stage started with releasing gases and deflating abdomen. A corpse odor was very strong (Fig. 1, 2, c).

4) Advanced decay stage had an odor that began to fade, most of the flesh has disappeared, some soft tissue still found in the abdomen and the coleopteran species are the predominant (Fig. 1, 2, d).

5) Dry stage was characterized by disappearing odor and the remains become consistent only of bones and hairs (Fig. 1, 2, e).

3. Seasonal Succession of Forensic Insects:

During this study, twelve experiments were conducted on forty-eight rabbit corpses at two different habitats to monitor the insect succession and corpse decomposition through the various seasons as follows:

A) Outdoor and indoor autumn experiments:

Data recorded in table (1) and fig. (3) showed that 93% of adult insect individuals representing 3 orders and 10 families were collected in autumn season 2013 from rabbit corpses placed outdoor. However, 7% of adult insect individuals representing 1 order and 4 families were collected from the corpses placed indoor. Diptera, Coleoptera and Hymenoptera comprised 37%, 2%, 61% of the insect collected from corpses placed outdoor. While Diptera comprised 100% of the insect collected from carrions placed indoor.

Two species of the adult Sarcophagids, *Sarcophaga carnaria* and *Wohlfahrtia magnifica*, were collected from all corpses in both habitats. *Sarcophaga carnaria* (Fig. 7) was collected in number of 82 and 18 individuals from carrions placed outdoor and indoor, respectively. However, 37 and 4 adult individuals of *Wohlfahrtia magnifica* (Fig. 8) were collected from carrions placed indoor.

Also two species of the calliphorid adults, *Chrysomya albiceps* and *Lucilia cuprina* were collected from all corpses in both habitats (outdoor and indoor). The number of occurrence was represented by 83 and 3 individuals of *Chrysomya albiceps* (Fig. 9) for carcasses placed outdoor and the other placed indoor, respectively. However, the number of occurrence recorded 56 and 2 individuals of *Lucilia cuprina* (Fig. 11) for carcasses placed outdoor and indoor, respectively.

One the muscid species, *Musca domestica* (Fig. 19) with 159 and 10 individuals were collected from corpses placed outdoor and indoor, respectively. While, *Megaselia scalaris* (Fig. 10) (Family: Phoridae) with 29 and 67 individuals were collected from corpses placed outdoor and indoor, respectively. *Physiphora demandata* (Fig. 22) (Family: Otitidae) was only collected from carcasses placed outdoor; 36 individuals were collected. Also *Anopheles coustani* (Fig. 23) (2 individuals) and *Scatella* sp. (1 individual) were collected only from corpses placed outdoor.

The coleopteran species collected were; *Saprinus gilvicornis* (Fig. 14) (12 individuals) and *Dermestes vulpinus* (Fig. 13) (13 individuals) from carcasses placed outdoor only. Of Hymenoptera only *Nasonia* sp. (Fig. 16) (Pteromalidae) was only collected from carrions placed outdoor (790 individuals) (Table 1 & Fig. 3).

B) Outdoor and indoor forensic insects during winter:

As shown from results given in table 1 and fig. 4, 90% of adult insect individuals representing 3 orders and 9 families were collected in winter season 2014 from rabbit corpses placed outdoor. However, 10% of adult insect individuals representing 3 orders and 6 families were collected from the corpses placed indoor. Diptera, Coleoptera and Hymenoptera comprised 14%, 2%, 84% and 63%, 35%, 2% of the insect collected from rabbit corpses placed outdoor and indoor, respectively.

One sarcophagid adult, *Sarcophaga carnaria* was collected from all corpses in both habitats. *Sarcophaga carnaria* was collected in number of 39 and 12 individuals from carrions placed outdoor and indoor, respectively. Also one species of adult Calliphoridae namely; *Chrysomya albiceps* was collected from corpses placed outdoor only with 14 individuals.

Two species of adult Muscidae namely; *Musca domestica* and *Muscina stabulans* were observed on the corpses during winter. *Musca domestica* with 47 and 8 individuals were collected from corpses placed outdoor and indoor, respectively. However, 3 adult individuals of *Muscina stabulans* (Fig. 12) were collected from carrions placed indoor only.

Megaselia scalaris (Family: Phoridae) with 145 and 96 individuals were collected from corpses placed outdoor and indoor, respectively. However, *Sepsis fissa* (Fig. 21) (Family: Sefsidae) was only collected from carcasses placed outdoor; 3 individuals were collected. One individual of *Anopheles coustani* (Family: Culicidae) was collected from both habitats (indoor and outdoor).

Three coleopteran species visited the corpses during winter namely; *Saprinus gilvicornis* (Family: Histeridae), *Dermestes vulpinus* ((Family: Dermestidae) and *Atheta* sp. (Family: Staphylinidae). *Saprinus gilvicornis* (22 individuals) and *Dermestes vulpinus* (5 individuals) were collected from carcasses placed outdoor only. While, *Atheta* sp. (Fig. 15) was collected from carcasses placed indoor only (66 individuals). The hymenopteran *Nasonia* sp. (Pteromalidae) was only collected from carrions placed outdoor (1472 individuals). *Camponotus maculates* (Fig. 18) (Hymenoptera: Formicidae) with 3 individuals were collected from corpses placed indoor only (Table 1 & Fig. 4).

C) Outdoor and indoor spring experiments:

Data given in table (1) and fig. (5) showed that 87% of adult insect individuals representing 3 orders and 8 families were collected in spring season 2014 from rabbit corpses placed outdoor. However, 13% of adult insect individuals representing 3 orders and 8 families were collected from the corpses placed indoor. Diptera, Coleoptera and Hymenoptera comprised 15%, 2%, 83% and 70%, 5%, 25% of the insect collected from rabbit corpses placed outdoor and indoor, respectively.

The sarcophagid species were represented by *Sarcophaga carnaria* and *Wohlfahrtia magnifica*. *Sarcophaga carnaria* was collected in number of 88 and 25 individuals from corpses placed outdoor and indoor, respectively. However, 3 adult individuals of *Wohlfahrtia magnifica* were collected from corpses placed outdoor only. One species of adult Calliphoridae namely; *Chrysomya albiceps* with 32 and 3 individuals were collected from corpses placed outdoor and indoor, respectively. Family Muscidae was represented by three species namely; *Musca domestica*, *Muscina stabulans* and *Atherigona varia*. *Musca domestica* was collected with individual numbers of 86 and 18 from rabbit carcasses placed outdoor and indoor, respectively. *Muscina stabulans* was collected from corpses placed indoor only (17 individuals). However, *Atherigona varia* was collected from corpses placed outdoor only (2 individuals). The number of 90 individuals of *Megaselia scalaris* (Family: Phoridae) was collected only from rabbit carcass placed indoor only. While, one individual of *Anopheles coustani* (Family: Culicidae) was collected from both corpses placed outdoor and indoor.

The coleopteran species were represented by two species namely, *Saprinus gilvicornis* and *Dermestes vulpinus*. The number of *Saprinus* adults collected from rabbit carcasses was 19 and 3 outdoor and indoor, respectively. *Dermestes* was collected with individual numbers of 14 and 5 from carcasses placed outdoor and indoor, respectively. *Nasonia* sp. (Hymenoptera: Pteromalidae) was represented by 1189 and 56 individuals collected from rabbit carcasses placed outdoor and indoor, respectively. *Chalcis* sp. (Hymenoptera: Chalcididae) with 50 individuals were collected from corpses placed outdoor only (Table 1 & Fig. 5).

D) Outdoor and indoor summer experiments:

As shown from results given in table 1 and fig. 6, 76% of adult insect individuals representing 2 orders and 6 families were collected in summer season 2014 from rabbit corpses placed outdoor. However, 24% of adult insect individuals representing 2 orders and 5 families were collected from the corpses placed indoor. Diptera and Coleoptera comprised 99%, 1% and 81%, 19% of the insect collected from rabbit corpses placed outdoor and indoor, respectively. Family Sarcophagidae was represented with two species, *Sarcophaga carnaria* and *Wohlfahrtia magnifica*. The number of *Sarcophaga* adults collected from rabbit carcasses was 10 and 13 outdoor and indoor, respectively. *Wohlfahrtia magnifica* was collected with individual numbers of 56 and 15 from rabbit carcasses placed outdoor and indoor, respectively. Only one calliphorid adult, *Chrysomya albiceps* was collected with individual numbers of 42 from rabbit carcasses placed outdoor only. On the other hand, *Musca domestica* was collected from rabbit carcasses placed outdoor and indoor. The number of adults collected was 92 and 15, respectively.

Megaselia scalaris (Phoridae) was collected with individual number of 36 from corpses placed indoor only. One Culicid adult, *Anopheles coustani* collected from rabbit corpses placed outdoor only (69 individuals) and the number of *Physiphora demandata* adults (Family: Otitidae) collected from rabbit carrions was 35 outdoor only. The Coleopteran species were represented by two species namely; *Saprinus gilvicornis* and *Dermestes vulpinus*. Three individuals of *Saprinus gilvicornis* adults were collected from both carcasses placed outdoor and indoor. The number of *Dermestes* adults collected from rabbit corpses placed indoor only was 15 (Table 1 & Fig 6).

IV. Statistical Analysis

a) Correlation between the environmental factors and the numbers of recorded species:

By applying the correlation analysis between the numbers of recorded species with the physical factors during the period of experiment (Table 3), it was concluded that the numbers of *Sarcophaga carnaria* maggots were negatively correlated with temperature. However, the numbers of *Wohlfahrtia magnifica* maggots were positively correlated with temperature and negatively correlated with humidity. The numbers of *Muscina stabulans* maggots were negatively correlated with temperature and positively correlated with humidity.

b) Stepwise multiple regression between the numbers of recorded species with the physical factors and the weight of corpse:

Stepwise multiple regression was applied to select a model in which all variables are significant (Table 4), it was concluded that the numbers of *Sarcophaga carnaria* maggots were affected by both of temperature and humidity and the numbers of *Wohlfahrtia magnifica* maggots were affected by temperature. However, the numbers of *Muscina stabulans* maggots were affected by humidity. The weight of corpse was affected by the numbers of *Sarcophaga carnaria*, *Chrysomya albiceps* and *Muscina stabulans* maggots.

V. Discussion

1. Forensic Catches:

The present results indicated that the maximum number of forensic species was represented by the dipterous insects (12 species). However, the second and third important forensic orders were represented by Coleoptera (3 species) and Hymenoptera (3 species), respectively. According to the species forensic importance, the insects recorded in this study were divided into four categories. The first category includes the greatest number of necrophagous individuals that fed directly on the cadavar. The most important necrophagous species were represented by *Chrysomya albiceps*, *Lucilia cuprina*, *Sarcophaga carnaria*, *Wohlfahrtia magnifica*, *Muscina stabulans*, *Megaselia scalaris* and *Dermestes vulpinus.* The second category comprises predators and parasites of the necrophagous species. Among the predators of particular significance were maggots of C*hrysomya albiceps*. C*hrysomya albiceps* maggots were not only fed on the cadavar but also were reported as predators on other larvae infesting the cadavar. These results are consistent with the results presented by Tantawi *et al.* (1996) and Pérez *et al.* (2005). This explains the occurrence of dead maggots of *Sarcophaga carnaria* and *Wohlfahrtia magnifica* near the cadavar throughout the experiments. Also predators include species in the families Staphylinidae and Histeridae. Parasites include species in the families Pteromalidae and Chalcididae. The third category includes the omnivorous species Formicidae ants such as *Camponotus maculatus* that fed on both cadavar and associated arthropods. The fourth category consists of incidental or adventives species having no direct relationship to the carcass. These results were consistent with those documented by (Payne, 1965).

Calliphorid and Sarcophagid flies were the first colonizers to arrive and breed on rabbit carcasses. This finding was consistent with the results of other studies in different geographic areas (Smith, 1986; Monteiro-Filho & Penereiro, 1987; Anderson & Van Laerhoven, 1996 and Hall, 2001). They are strong fliers that can follow an odor plume over long distance and easily arrive and enter to corpses found enter buildings or at outdoor habitats (Erzinclioglu, 2006).

The present study showed that *Sarcophaga carnaria* was the most important component of insect succession on rabbit carcasses during all seasons because it was the most abundant species in all experiments. Agreeable results were presented by (Denno & Cothran, 1976). In addition, larvae of *Sarcophaga carnaria* were collected in all seasons for two sites, larvae of *Wohlfahrtia magnifica* were collected in summer, spring and autumn at outdoor site and in summer and autumn at indoor site, larvae of *Chrysomya albiceps* were collected in spring and autumn and in summer and autumn at outdoor and indoor sites, respectively, larvae of *Lucilia cuprina* were collected in autumn only for two sites, larvae of *Muscina stabulans* were collected in autumn, winter and spring at indoor site only and larvae of *Megaselia scalaris* were collected at indoor autumn only.
Although Sarcophagid larvae were coexisting with those of Calliphoridae on the same cadavar, Calliphoridae maggots were responsible for minimum consumption of rabbit carrion. These results were convenient with Tantawi *et al.* (1996). However, contrary to our results, Early & Goff (1986) reported that the numbers of Sarcophagid larvae were much less than those of Calliphoridae. Consequently, calliphorid maggots ranked second regarding the reduction of carrion weight.

Sarcophagid species were frequently observed larvipositing on carcass at approximately the same time at the calliphorid species. This finding is consistent with the results of Early & Goff (1986). The emanating results from our study clarified that the development duration of larval and pupal stages in the blowflies was shorter than that in the flesh flies and hence, the time of development in blowflies is faster than in flesh flies. This finding is convenient with (Shiravi *et al.*, 2011). It is worthy to mention that not all species of flies visited the cadaver to put eggs or larvae. *Musca domestica* was found visiting, copulating, and feeding on the substrate or using it as an extension of its habitat. This observation was convenient with Dear (1978) and De Souza & Linhares (1997). Similarly, *Atherigona varia* (Muscidae), *Physiphora demandata* (Otitidae), *Anopheles coustani* (Culicidae), *Scatella* sp. (Ephydridae), *Sepsis fissa* (Sefsidae) were collected as adult only as they visited the carrion to feed not to breed.

The emanating results clarified that flies prefer an oviposition at natural body openings (mouth, nose, and anus) and also hairy areas of the body. This may be due to the high moisture and lower intensity of light. The preference of flies to these areas for oviposition was also observed by Norris (1965). However, injuries and blood on a cadaver are more attractive sites for fly colonization than the natural openings. This observation is convenient with (Rodriguez & Bass, 1983).

Megaselia scalaris is a common cosmopolitan species and more reported in indoor habitats and cooler seasons (Tantawi *et al.*, 1996; Greenberg & Wells, 1998; Reibe & Madea, 2010; Thevan *et al.*, 2010; Bugelli *et al.*, 2015). It was coexisted with other sarcosaprophagous dipterans on the same corpse (Kumara *et al.*, 2012; Bugelli *et al.*, 2015). Hence, in the absence of other sarcosaprophagous species, it can be a sole indicator to help in solving the criminal cases (Campobasso *et al.*, 2004; Bugelli *et al.*, 2015; zuha *et al.*, 2015). *Nasonia* sp. is a small polyphagous parasitic species, living in different habitats, and which may parasitize on several Cyclorrhapha dipterans and lay its eggs inside the pupae of flies. This is convenient with (Legner, 1967; Darling

& Werren, 1990; Blanchot, 1994/1995). If the time elapsed since death exceeds the immature developmental time of necrophagous species, *Nasonia* can estimate the time elapsed since death more precisely.

2. Seasonal Field Flacutations:

The diversity and density of insects collected in outdoor habitat was a slightly more than in indoor habitat. This result may be due to that the distribution of decay odors at outdoor was faster and easier than that in indoor and consequently the insects colonize the outdoor corpses faster than indoor corpses. However, this is contrary to Goff (1991) which observed more dipteran species in indoor compared to outdoor and Ahmed *et al.* (2011) which he recovered slightly more dipteran species in indoor habitat compared to outdoor. This may be due to the difference in study region.

In outdoor habitat, two families of coleoptera with two species of beetles were collected compared to three families of coleoptera with three species of beetles were in indoor habitat. This is convenient with the result of Ahmed *et al.* (2011). However, in contrast with Goff (1991) who reported more coleopteran species in outdoor habitat compared to indoor. Delaying of insect infestation to corpse resulted in significantly retarded and incomplete cadaver decomposition, consequently, there is inter-dependence between insect colonization and the decomposition rate. This observation was recorded by many researchers (Payne, 1965; Abell *et al.*, 1982; Anderson & Van Laerhoven, 1996; Simmons *et al.*, 2010). This could explain why the cadaver took more time for decomposition in winter rather than other seasons.

Season and cadaver microenvironment are also factors influencing the species composition and successional patterns during carcass decomposition (Hanski, 1987). In comparison to other studies have been done in spring and summer season in relation to the diversity number. The collected insect species were less in diversity than other authors (Reed, 1958; Payne, 1965; Rodriguez & Bass, 1983; Lord & Burger, 1984; Early & Goff, 1986; De Jong & Chadwick, 1999; Watson & Carlton, 2003; Grassberger & Frank, 2004 and Arnaldos *et al.*, 2004a) in the similar seasons. Such contrast agrees with Tentawi *et al.* (1996) and Galal *et al.* (2009) studies where they collected only 4-5 species during the hot summer. Therefore we could assume that the high temperature, which had been also recorded in the our current study, had accelerated the decomposition process, meaning that the cadaver is reduced to bones in a shorter time period leading to rapid depletion of food resource and reduction of arthropod colonization time particularly at outdoor habitat.

Decomposition rate of cadaver is affected by the changes in temperatures and humidity (Lopes de Carvalho & Linhares, 2001; Kočárek 2003; Matoba & Terazawa, 2008). In our study, there were no significant differences in humidity between seasons, unlike the temperature between seasons. The decomposition rate required longer time in seasons with lower temperatures. Consequently, we could deduced that humidity affected the decomposition rate less than temperature. This is convenient with (Kočárek, 2003). Temperature also affects the insect population dynamics and activity due to its control of growth and reproduction (de la Fuente *et al.*, 2006).

The decomposition rate of corpses at outdoor habitat was significantly faster than that at indoor habitat for all seasons. This is due to high temperature and early insect colonization at outdoor habitat than at indoor habitat. The speed of decomposition rate was determined by the insect colonization and climatic conditions particularly temperature (Anderson, 2009). Goddard & Lago (1985) stated that when temperature is high, the decomposition process becomes short. Results of the present study indicated that the carrions in summer and spring decayed at a much faster than those in fall and winter at both habitats. This result was convenient with Tantawi *et al.* (1996). In contrast with Ibrahim *et al.* (2013) which he stated that carrions in summer and fall decayed a much faster than in spring and winter.

In the present study, the total number of insect species collected in summer was a few less than in other seasons. The same as the results from Tantawi *et al.* (1996) and Watson & Carlton (2005). This is due to succession in warmer seasons was driven by the rapid resource depletion because the corpses decomposed faster due to the higher temperatures. However, succession in cooler seasons was much influenced by the cold temperatures and rainfall which retarded the corpse decomposition and also the insect succession, hence a larger numbers of insect species were attracted to cadaver (Tantawi *et al.*, 1996). However, in contrast with our results, Reed (1958), Johnson (1975) and Rodriguez & Bass (1983) found that the corpse fauna was richer in warmer seasons than in cooler seasons.

3. Statistical Analysis:

Statistical analysis of the present results clarified that *Sarcophaga carnaria* maggots were affected negatively by temperature and humidity. In this study, we found that *Sarcophaga carnaria* maggots have been dead when the exposure to high temperatures in summer up to 47.4°C and also at the exposure to low temperatures and high humidity up to 50%. As Woodmorappe (1998) stated, *Sarcophaga* sp. life development is temperature-dependent. Sam (2006) found that *Sarcophaga* sp. larvae that were exposed to the outside environment's cold temperature (low of 4^{O}C) all died the first night of initial exposure because no movement was

detected the next day. He suggested that *Sarcophaga* sp. cannot survive in a cold temperature climate unless there was some source to provide them heat or incubation, such as a dead body or animal carcass. Also, Ward's Manual (2001) stated that the developmental rates of *Sarcophaga* sp. are temperature and light dependent which Cooler temperatures and less light exposure will slow down the growth of development. From the present study, we found that *Wohlfahrtia magnifica* maggots were affected positively by temperature which the speed of development increased with the increasing of temperatures, thus, the developmental time decreased. This is consistent with (Tantawi *et al.*, 1996) who stated that *Wohlfahrtia* larvae in summer which temperature is high, developed rapidly and pupariated earlier. Our statistic results clarified that *Muscina stabulans* maggots were affected negatively by temperature and positively by humidity. Consequently, *Muscina* was observed at the indoor site only which temperature is low and humidity is high and due to the preference of *Muscina* to the shaded areas. This observation is agreement with the result of Patitucci (2010). In contrast with Linhares (1981) who observed the preference of *Muscina* to sunny areas. Studies on the succession of insects associated with dead bodies in special microenvironments are significant for their contribution in the development of forensic science, as well as their acting as a potential forensic tool in cases of human carrions found indoors and outdoors.

VI. **Conclusions**

This investigation demonstrated that the patterns of decomposition and insect succession varied across different seasons and habitats. Ambient temperature and humidity were critical factors in the determination of the rate of decay in various seasons. Furthermore, the seasonal distribution of insect species significantly impacted the species that were recovered from cadaver in different times of the year. Insect species arrive on the cadaver in a predictable sequence which depends on the stages of decomposition, although the pattern varied in different times of the year and in the different habitats. Although a large number of insect species were observed at the cadavers, relatively a few used the cadaver for breeding purposes. This indicates that the insect species differ in their ability to use the different resources provided by the carrion. Generally, the first species of flies to colonize the carcass had an important advantage over later arriving species, and their larvae had a greater chance to develop to the adult stage. Both of Calliphoridae and Sarcophagidae species demonstrated a preference for the dark putrefaction stage of decay (Stage III), although they were found in the early and late stages of decomposition.

The present study shows there are two species of Sarcophagidae (*Sarcophaga carnaria* and *Wholfahrtia magnifica*), also two species of Calliphoridae (*Chrysomya albiceps* and *Lucilia cuprina*), one species of Muscidae (*Muscina stabulans*) and one species of Phoridae (*Megaselia scalaris*), that can be considered of potential forensic importance and can be used as indicators of postmortem interval (PMI) in Qena governorate, Egypt because they are able to breed on a cadaver. However, the most important of these species was *Sarcophaga carnaria* because it was the most frequent and abundant and the primary colonizer on the decomposing rabbit cadavers in the various habitats. Coleopteran species such as (*Saprinus gilvicornis*, *Dermestes vulpinus* and *Atheta* sp.) and hymenopteran species such as (*Chalcis* sp. and *Nasonia* sp.) dominated in later stages of decay, although their presence and colonization times varied across season and habitats. Not all species visited the cadaver only to oviposit or larviposit, but some species were found visiting, copulating and feeding on the cadaver tissues. The involvement of the present study in legal investigation enabled the investigators and the officials to be familiar with and aware of the importance of forensic entomology and as well initiated their interest in more information and further studies in this field. This study also highlights the importance of forensic entomology in Qena city, Egypt.

Finally, we can conclude that this study represents the first step in presenting forensic entomology as a science and a new discipline in Qena city, Egypt. We hope that this work may through light on the important role of the entomologist and the value of entomological information in legal investigations to be used as evidence in the court. The data generated from this work are now available for homicide investigations in Qena city and similar biogeoclimatic regions.

VII. References

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Table (1): The collected forensic insects from the indoor and outdoor rabbit corpses during the different seasons from October 2013 to September 2014:

Species	Order & Family & Species	Outdoor station					Indoor station					Total of 2 stations
		Autumn	Winter	Spring	Summer	Total	Autumn	Winter	Spring	Summer	Total	
Outdoor insects	Order: Diptera											
	Family: Muscidae											
	Atherigona varia (Rondani, 1871)	0	0	2	0	2	0	0	0	0	0	2
	Family: Otitidae											
	Physiphora demandata (Fabricius 1798)	36	0	0	35	71	0	0	0	0	0	71
	Family: Ephydridae											
	Scatella sp. (Robineau 1830)	1	0	0	0	1	0	0	0	0	0	1
	Family: Sefsidae											
	Sepsis fissa (Becker 1903)	0	3	0	0	3	0	0	0	0	0	3
	Order: Hymenoptera											
	Family: Chalcididae											
	Chalcis sp. (Fabricius 1787)	0	0	50	0	50	0	0	0	0	0	50
Indoor insects	Order: Diptera											
	Family: Muscidae											
	Muscina stabulanus (Fallen 1817)	0	0	0	0	0	0	3	17	0	20	20
	Order: Coleoptera											
	Family: Staphylinidae											
	Atheta sp. (Thomson 1858)	0	0	0	0	0	0	66	0	0	66	66
	Order: Hymenoptera											
	Family: Formecidae											
	Camponotus maculates (Fabricius 1782)	0	0	0	0	0	3	3	0	0	6	6
Common insects	Order: Diptera											
	Family: Sarcophagidae											
	Sarcophaga carnaria (Linnaeus 1758)	82	39	88	10	219	18	12	25	13	68	287
	Wohlfartia magnifica (Schiner 1862)	37	0	3	56	96	4	0	0	15	19	115
	Family: Calliphoridae											
	Chrysomyia albiceps (Wied. 1819)	83	14	32	42	171	3	0	3	0	6	177
	Lucilia cuprina (Wied. 1830)	56	0	0	0	56	2	0	0	0	2	58
	Family: Muscidae											
	Musca domestica (Linnaeus 1758)	159	47	86	92	384	10	8	18	15	51	435
	Family: Phoridae											
	Megaselia scalaris (Loew 1866)	29	145	0	0	174	67	96	90	36	289	463
	Family: Culicidae											
	Anopheles coustani (Lavoran 1900)	2	1	1	69	73	0	1	1	0	2	75
	Order: coleopteran											
	Family: Histeridae											
	Saprinus gilvicornis (Erichson 1834)	12	22	19	3	56	0	0	3	3	6	62
	Family: Dermestidae											
	Dermestes vulpinus (Fabricius 1781)	13	5	14	0	32	0	0	5	15	20	52
	Order: Hymenoptera											
	Family: Pteromalidae											
	Nasonia sp. (Ashmead 1904)	790	1472	1189	0	3451	0	0	56	0	56	3507
		Total				4837	Total				611	5448

Table (2): Decay rates of rabbit corpses placed outdoor and indoor in different seasons from October 2013 to September 2014:

		Days postmortem				
Season	**Habitat**	**Fresh**	**Bloating**	**Active decay**	**Advanced decay**	**Dry**
Autumn	**Outdoor**	**0**	**1-2**	**3-4**	**5-9**	**10-25**
	Indoor	**0-1**	**2-4**	**5-7**	**8-14**	**15-30**
Winter	**Outdoor**	**0-5**	**6-10**	**11-14**	**15-20**	**21-45**
	Indoor	**0-5**	**6-12**	**13-18**	**19-27**	**28-49**
Spring	**Outdoor**	**0-1**	**2**	**3-4**	**5-7**	**8-22**
	Indoor	**0-1**	**2-3**	**4-5**	**6-11**	**12-24**
Summer	**Outdoor**	**0**	**1**	**2**	**3**	**4-16**
	Indoor	**0**	**1**	**2-3**	**4-6**	**7-19**

Table (3): Correlation coefficients for association between different species and physical factors during the period of experiment.

		Temperature	Humidity
Sarcophaga carnaria	R	-0.130	-0.057
	Sig.	**	NS
Wohlfahrtia magnifica	R	0.298	-0.144
	Sig.	**	**
Chrysomya albiceps	R	0.039	-0.045
	Sig.	NS	NS
Lucilia cuprina	R	0.013	-0.001
	Sig.	NS	NS
Muscina stabulans	R	-0.170	0.234
	Sig.	**	**
Megaselia scalaris	R	0.000	0.037
	Sig.	NS	NS

Table (4): Stepwise multiple regression between the numbers of different species with the physical factors:

Dependent variable	Selected variable	R	R2	Std. error of the Estimate	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
					B	Std. error	Beta		
Sarcophaga carnaria	(constant)	0.182	0.033	224.47725	372.292	61.880		6.016	0.000
	Temperature				-5.901	1.322	-0.193	-4.462	0.000
	Humidity				-4.735	1.440	-0.142	-3.290	0.001
Wohlfahrtia magnifica	(constant)	0.298	0.089	245.96585	-227.378	37.772		-6.020	0.000
	Temperature				10.298	1.302	0.298	7.909	0.000
Muscina stabulanus	(constant)	0.234	0.055	62.46069	-41.395	9.117		-4.541	0.000
	Humidity				2.199	0.360	0.234	6.109	0.000
Weight	(constant)	0.310	0.096	136.28949	194.601	5.867		33.167	0.000
	S. carnaria				0.151	0.024	0..241	6.385	0.000
	M. stabulanus				0.332	0.084	0.149	3.962	0.000
	C. albiceps				0.321	0.140	0.086	2.288	0.022

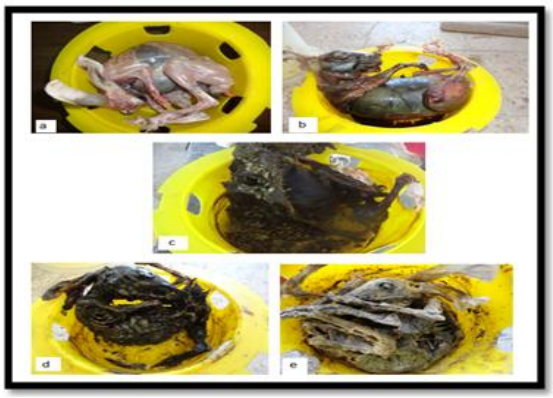

Fig. (1): Decomposition stages of rabbit corpse at outdoor environment from October 2013 to September 2014 in Qena governorate, Egypt. (a) Fresh stage. (b) Bloating stage. (c) Active decay stage. (d) Advanced decay stage. (e) Dry stage.

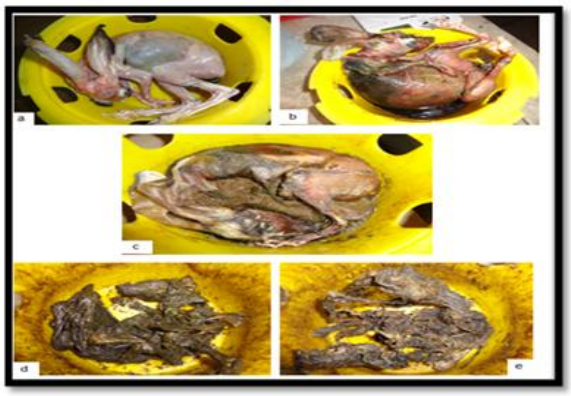

Fig. (2): Decomposition stages of rabbit corpse at indoor environment from October 2013 to September 2014 in Qena governorate, Egypt. (a) Fresh stage. (b) Bloating stage. (c) Active decay stage. (d) Advanced decay stage. (e) Dry stage.

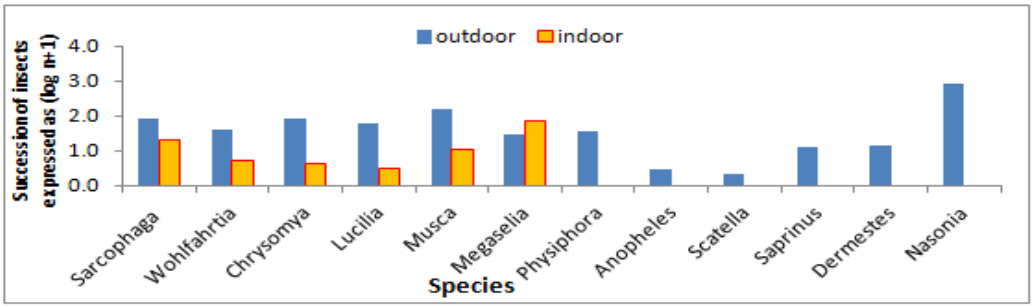

Fig. (3): succession of forensic insect species on rabbit corpses placed indoor and outdoor during autumn 2013.

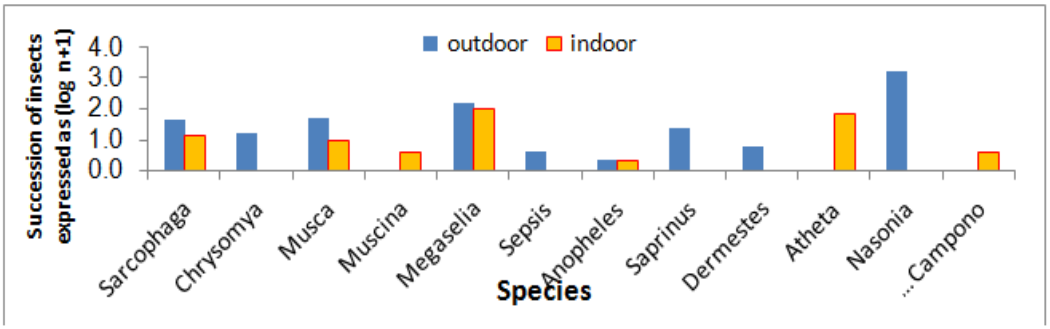

Fig. (4): Succession of forensic insect species on rabbit corpses placed indoor and outdoor during winter 2014.

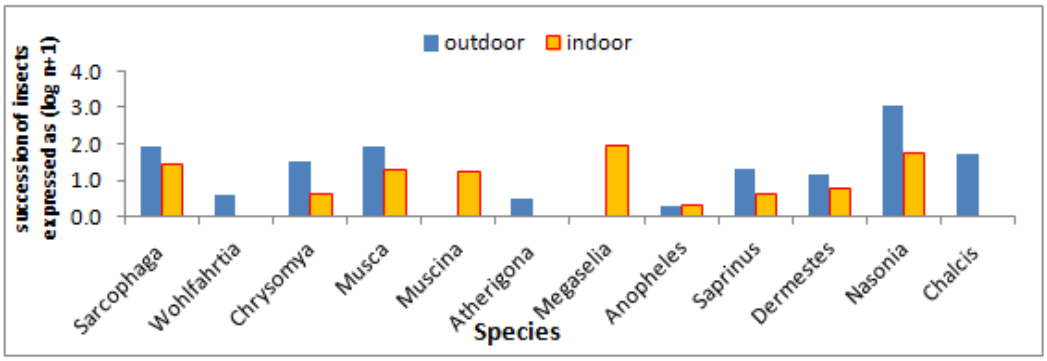

Fig. (5): Succession of forensic insect species on rabbit corpses placed indoor and outdoor during spring 2014.

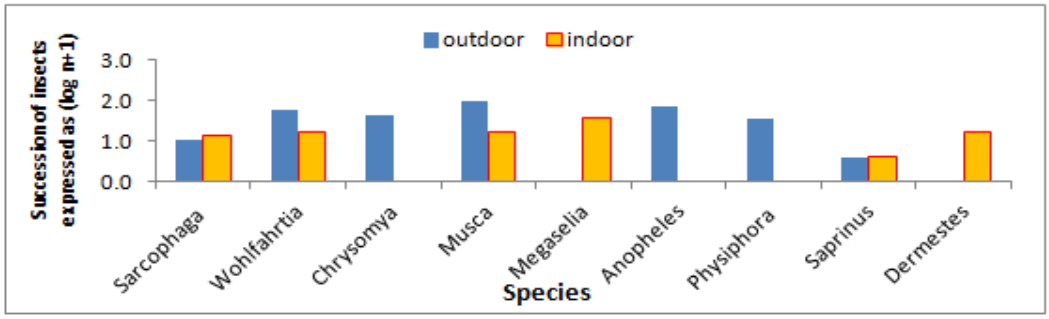

Fig. (6): Succession of forensic insect species on rabbit corpses placed indoor and outdoor during summer 2014.

Necrophagous species

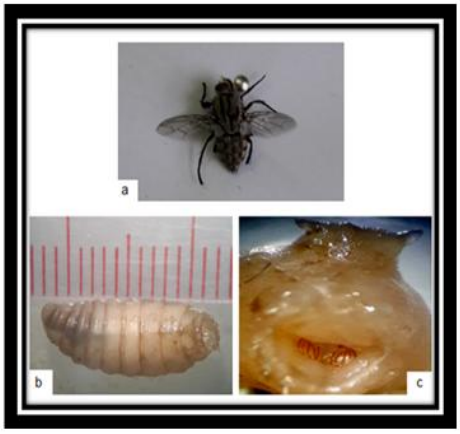

Fig.(7):*Sarcophaga carnaria* (Diptera)

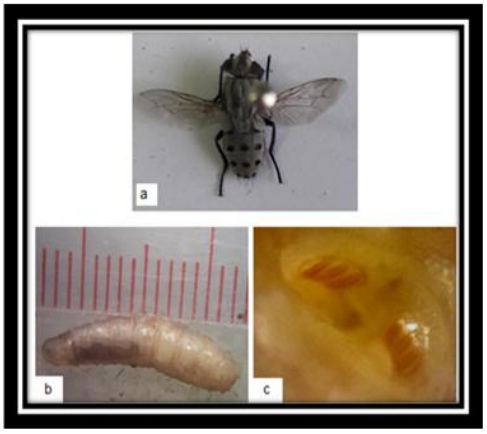

Fig.(8): *Wohlfahrtia magnifica* (Diptera)

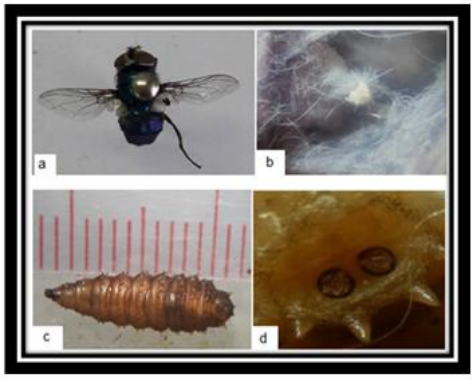

Fig.(9): *Chrysomya albiceps* (Diptera)

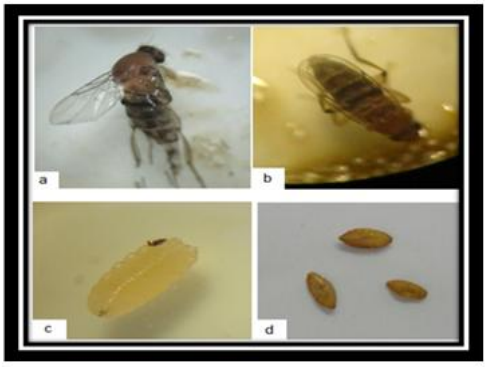

Fig.(10): *Megaselia scalaris* (Diptera)

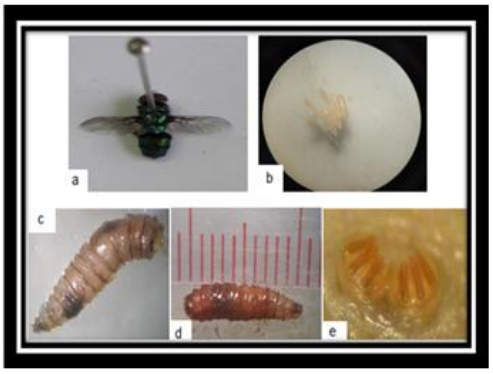

Fig.(11):*Lucilia cuprina* (Diptera)

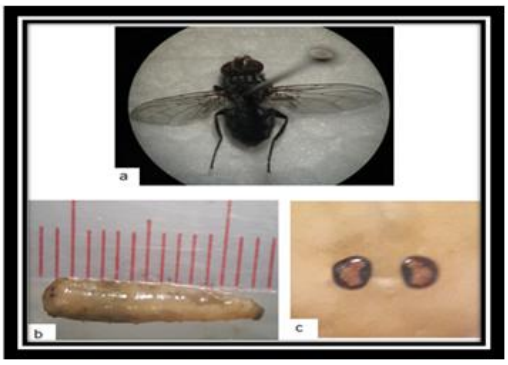

Fig.(12): *Muscina stabulans* (Diptera)

Fig.(13): *Dermestes vulpinus* (Coleoptera)

Necrophalous species

Fig.(14): *Saprinus gilvicornis* *(Coleoptera)*

Fig.(15): *Atheta* sp. *(Coleoptera)*

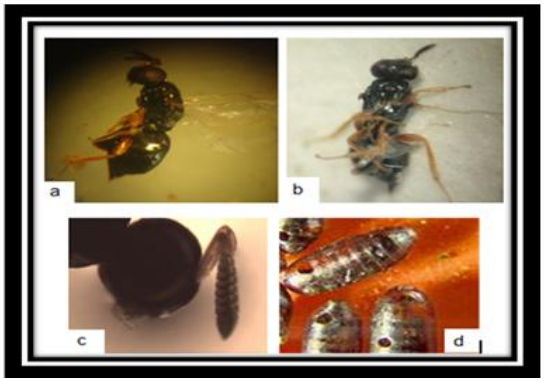

Fig.(16): *Nasonia* sp. (Hymenoptera)

Fig.(17): *Chalcis* sp. (Hymenoptera)

Omnivorous species

Fig.(18): ***Camponotus maculates*** **(Hymenoptera)**

Accidental species

Fig.(19): ***Musca domestica*** **(Diptera)**

Fig.(20): ***Atherigona varia*** **(Diptera)**

Fig.(21): ***Sepsis fissa*** **(Diptera)**

Fig.(22): ***Physiphora demandata*** **(Diptera)**

Fig.(23): ***Anopheles coustani*** **(Diptera)**

Fig.(24): ***Scatella sp.*** **(Diptera)**