Insect faunal succession on decaying rabbit carcasses in urban area at Jeddah city, Kingdom of Saudi Arabia

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Abstract: The entomofauna associated with rabbit carcasses (*Lepus cuniculus);* and their succession patterns were investigated at urban habitat in autumn season in Jeddah city, west region of the kingdom of Saudi Arabia. Four stages of rabbit carcass decomposition were recognized: fresh, bloated, decay, and dry at minimum, maximum temperature and relative humidity 24.42^{0}C, 32.42^{0}C and 57.67%, respectively. The fresh stage began with death and ended when bloated stage was initiated, for a period of two days, while bloated stage started by the bulging of the carrions and lasted for two days. Decay stage initial by release of gases from the carrions and characterized by strong odor of decomposition for a period of 5-6 days. The dry stage was the final stage at which the odor started to fade and the carcasses consisted of only dry skin and bone and lasted 3-4 days. A total of 9 insect species belonging to six families and three orders (Diptera, Coleoptera and Isoptera) were recorded. Two species of each families Calliphoridae, Sarcophagidae and Muscidae were observed on rabbit carcasses. Representatives of tow Coleopteran families, Dermestidae and Cleridae and only one Isoptera family; Termitidae were recorded. Family Muscidae collected with the largest numbers of insects (539), followed by Chliphoridae (118), then Sarcophagidae (12). While both families of beetles; Dermestidae and Cleridae recorded the lowest numbers of insects (4 and 2, respectively). *Mus. sorbens* recorded as the highest insect number (460), followed by *Ch. albiceps* (84)and *Mus. domestica* (79) then each of *Ch. megacephala* (34) and *Sar. ruficornis* (11). While the species *Der. frischii, Nec. rufipes* and *Sar. heritipes were* recorded as the lowest number (4, 2and 1, respectively).
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1. Introduction:

Forensic entomology is a branch of forensic science used insects in legal and criminal investigations. After death, the body undergoes natural changes, starts firstly through the action of microorganisms such as fungi and bacteria, followed by the action of a series of arthropods (Nuorteva, 1977). The dead body going through different stages of decomposition that are attractive to sarcosaprophagous insects which arrive in a determined sequence. The information derived from either the succession of arthropods on carrions or the temperature-dependent development of insects used to estimate postmortem interval (PMI)(Hall, 2001). Both methods require knowledge of the composition of the local carrion fauna and life stages of the species which reared on a dead body. These data vary according many factors, one of the most important being the biogeoclimatic zone which includes the habitat, vegetation, soil type and meteorological conditions of the area (Anderson, 2010). This sort of information is obtained from experimental studies on animal carcass (Wells &LaMotte, 2001). Flies (Diptera) are known as the most important insects which associate with the corpses. They attract to the dead body within minutes after death and complete their life cycle on it, they used to determine the age of corpse from duration of a few hours to a few weeks (Tabor *et al.,* 2005). Coleopterais the second decomposers, become the most important forensic indicators during later stages of decomposition, as they feed upon the dry tissues, skin and hairs (Lord, 1990; Boucher, 1997). There are rarely studies about insects associated with carrions in Arabic Gulf region. Al-Mesbah (2010) conducted a study about necrophagous insects on rabbit carcasses at different habitats in Kuwait, she found fly species from families Challiphoridae, Sarcophgidae and Muscidae, she also recorded Colepteran families on the carcasses. In the mountains of Al-Baha at the southwest of the kingdom of Saudi Arabia, Abouzied (2014) recorded fly species of families Challiphoridae, Sarcophagidae, Muscidae and Coleopteran families; Dermestidae, Cleridae, Histeridae on rabbit carcasses. So far no studies on arthropod succession and carrion decomposition have been conducted in Jeddah city. The objective of this research was to obtain preliminary data concerning stages and rate of carrion decomposition as well as composition and succession of carrion entomofauna in Jeddah city, kingdom of Saudi Arabia.

2. Materials & Methods:

2.1. Study site:

The study was conducted in backyard of a house at north of Jeddah city which located on the west coast of the Kingdom of Saudi Arabia (latitude 29.21 north & longitude 39.7 east), in the middle of the eastern shore of the Red Sea. This area was chosen to simulate the case of presence human corpse in the house.

2.2. Study time:

The experiment was carried out in autumn season during the period from 6 to 19 November, 2015. The duration of the experiment was approximately 14 days (until the carcass was consumed).

2.3. Experimental animals and cages:

We used 10domestic rabbits (*Lepus cuniculus*), which obtained from local animal shops. Carcasses were of different colors but comparable in size weight, (approximately 1.4-2.5 kg). Each rabbit carcass was placed in a man-made metal cage (65x55x45 cm^3), all sides of the cage made of metal surface with 2cm^2 mesh to keep out scavengers and allow insects access. Inside this cage there were 4 metal frames covered with nylon surfaces with minutes mesh to act as a small internal cage. This surface sallow ventilation and prevent insect escaping. The top of tow cages were opened in its middle (9 cm diameter) for the fixation of a water bottle to act as a collection chamber. One side of each tow cages had a hinged opening (20cm x 15cm) to allow placing and taking out of the rabbit carcass. Two holes (2cm^2) were made on two sides of the inner cage to allow access for the insects to oviposit on the carcass, but on attempts to escape, they made their way to the bottle fixed on the top of the cage to be collected (fig.1, 2).

2.2. Experimental design.

The rabbits were taken alive to the study site and killed by cutting the trachea without decapitation (according to Islamic principle). After death, animals were immediately weighed and placed in the cages. Then, the caged carcasses were divided into two groups (a; b) which were distributed 10m apart in two lines, each line include 5 cages. Cages within the same line were located about 2 m from each other. A sticky trap was handled half a meter from each caged carcass and about 1 meter from the ground. The carcasses were observed daily to determine duration of decomposition stages. The study site was visited after 2, 4, 7, 10, 14 days. At each visit, two carcasses, one from each group were weighed, and the collection bottle with the corresponding sticky traps were removed and transferred to the laboratory for entomological examinations. Adult Coleoptera were collected in 70% ethanol using hand picking forceps. The numbers of adult insect collected were counted and representative samples were preserved in 70% ethanol for identification. Daily weather data of temperature and relative humidity were obtained using digital the rmohygrometer.

2.5. Identification of insects

The insects were examined using dissecting stereomicroscope from Leica Company (Leica M205 C stereomicroscope). Digital photographs of the specimens were taken with Leica IC80 HD camera adapted to a Leica M205 C stereomicroscope. Flies specimens were identified according to the keys given by James (1947), Whitworth (2006, 2010) and Marshall *et al.* (2011). Where as beetles were identified using keys by Bousquet (1990), Leaven good (2008) and Peacock (2013).

Fig. 1: Experimental cage.

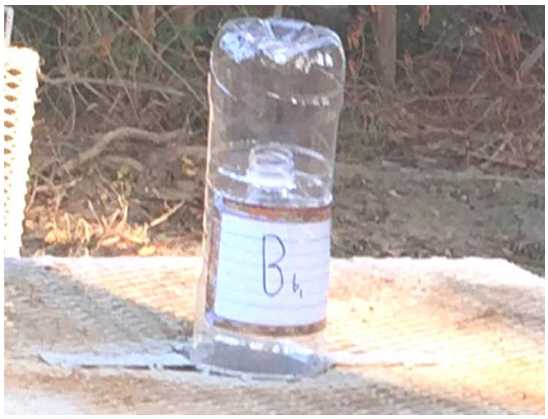

Fig. 2: Magnified view for insect collection bottle

3. Results:

3.1. Carcass decomposition:

The carcasses in the site went through four decomposition stages; fresh, bloated, decay and dry, which were determined by the physical and weight changes of the carrions (table1).

3.1.1. Fresh stage: This stage began on 6 November, at the moment when the rabbits were killed and lasted until the onset of the bulge, for a period of two days. Carcasses were characterized by their normal intact bodies, pliant skin, movable limbs and soft fur. There were neither gross morphological changes nor odor of decay. The mean of air minimum, maximum temperature and relative humidity during this stage were 26^0C, 32.8^0C and 53.5%, respectively.

3.1.2. Bloated Stage: It began at 8 November on the third day of death and lasted until the fourth day (for 2 days duration). This stage started by the bulging of the carrions, and odor of decay became noticeable. Decomposition fluids were oozing beneath the carrions. The mean of air minimum, maximum temperature and humidity were 24.3^0C, 32.6^0C and 58%, respectively.

3.1.3. Decay Stage. It lasted from 10 to 15 November for a period of 5-6 days. This stage was characterized by the release of gases from the carrions and the strong odor of decomposition. In this stage hundreds of maggots feeding on rabbit carcass. The skin is usually cracked in one or more places by feeding dipterous larvae. Hair loss is conspicuous, especially in areas where maggots manifest great activity. Daily weather data for air minimum, maximum temperature and relative humidity were 23.76^0C, 32.73^0C and 56.66%.

3.1.4. Dry stage. It began at 16 November, and included the period from the 11^{th} day of death to the 14^{th} day (3-4 days duration). It is the final stage at which most of the fleshy tissue disappeared. The odor started to fade and the carrions consisted of only dry skin and bone. Later after decaying of all the soft tissues the skeletalization occurred. Climatic conditions were 23.6^0C, 31.55^0C and 62.5%.

As shown from table (2), after 2 days of death a little of carcasses weight were loosed (96.88% of the bio-mass). But throughout different stages of decomposition carcasses weight decreased consistently. Only 87.61 % and 48.44 from carcasses were remained at 4^{th} and 7^{th} days of death, respectively. By the end of decomposition in dry stage, only approximately 21.88 % of total biomass waspresent.

Table (1): Duration of decomposition stages of rabbit carcasses in urban habitat during autumn, 2015

Stage	Date	Duration (days)	Ambient temperature (^{0}C)			Relative Humidity (R.H.) %
			Minimum ± SD	Maximum ± SD	Average	
Fresh	6-7 Nov. 2015	2	26	32.8	28.9	53.5
Bloated	8-9 Nov. 2015	1-2	24.3	32.6	28.1	58
Decay	10-15 Nov. 2015	5-6	23.76	32.73	28.1	56.66
Dray	16-19 Nov. 2015	3-4	23.6	31.55	27.25	62.5
The Mean			24.42	32.42	28.1	57.67

Table (2): Percentage of bio-mass remaining of rabbit carcasses with the postmortem interval

Postmortem interval (Days)	Decomposition stage	Pio-mass remaining (%)
2	fresh	96.88
4	bloated	87.61
7	decay	48.44
10	dry	21.88

3.2. Insect Diversity:

Table (3) shows the succession pattern of insect species in urban habitat which included three Orders; Diptera, Coleoptera and Isoptera. Because Diptera and Coleoptera only important in forensic investigations, we will focus on insects of theses tow orders. A total of 669 individuals from 6 species of Diptera belong to three families, and 6 individuals from tow species of Coleopterabelong to tow families were collected from the site. The Diptera families were Challiphoridae, Sarcophagidae and Muscidae, whereas, Coleoptera families were Dermestidae and Cleridae. Figure (3) demonstrates that, in general Diptera familiescollected in higher numbers than Coleoptera. Family Muscidae with the largest numbers of insects (539), followed by Chliphoridae (118), then Sarcophagidae (12). While both families of beetles; Dermestidae and Cleridae recorded the lowest numbers of insects (4 and 2, respectively) in the site. Figure (4) clears that in urban habitat *Mus. sorbens* recorded as the highest insects (460), followed by *Ch. Albiceps* (84) and *Mus. domestica* (79) then each of *Ch. megacephala* (34) and

Sar. ruficornis (11). While the species*Der. frischii*, *Nec. rufipes* and*Sar. heritipeswere* recorded as the lowest numbers (4, 2and 1, respectively).

Table (3). Insect succession on rabbit carcasses through four decomposition stages, in urban habitat during autumn, 2015

Order	Family	Species	Decomposition stages				Total
			Fresh	Bloated	Decay	Dray	
Deptira	Calliphoridae	*Chrysomya albiceps*	25	2	6	51	84
		Chrysomya megacephala	1	0	0	33	34
	Total		**26**	**2**	**6**	**84**	**118**
	Sarcophagidae	*Sarcophaga ruficornis*	3	0	0	8	11
		Sarcophaga hirtipes	0	0	0	1	1
	Total		**3**	**0**	**0**	**9**	**12**
	Muscidae	*Musca sorbens*	118	15	187	140	460
		Musca domestica	30	0	49	0	79
	Total		**148**	**15**	**236**	**140**	**539**
Total			**177**	**17**	**242**	**233**	**669**
Coleoptera	Dermestidae	*Dermestes frischii*	0	0	0	4	4
	Total		**0**	**0**	**0**	**4**	**4**
	Cleridae	*Necrobia rufipes*	0	0	0	2	2
	Total		**0**	**0**	**0**	**2**	**2**
Total			**0**	**0**	**0**	**6**	**6**
Isoptera	Termitidae	Termites (not identified beyond family)	0	0	0	6	6

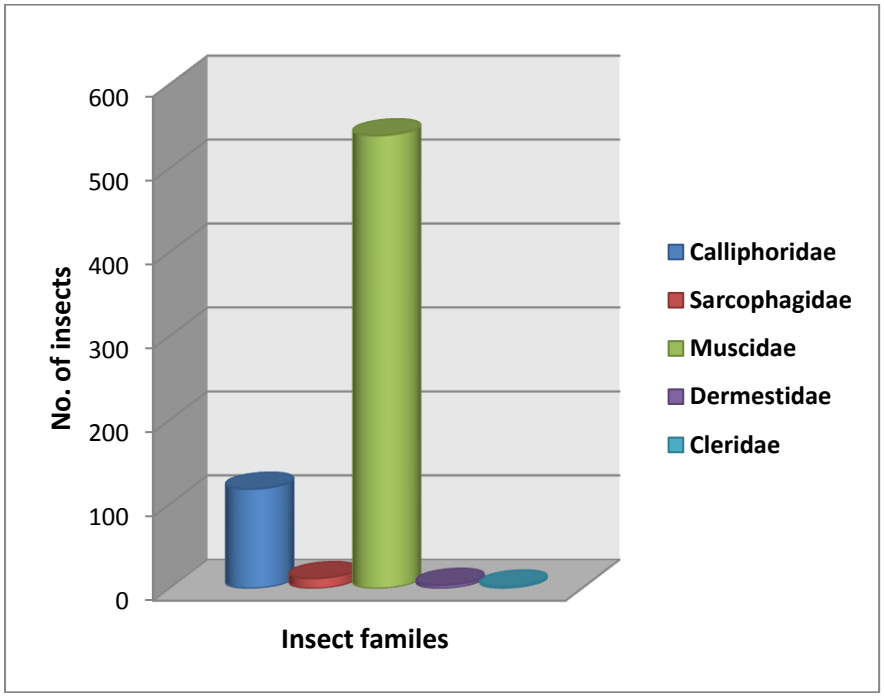

Fig. (3): Frequency of forensic insects on rabbit carcasses by families in urban habitat during autumn, 2015

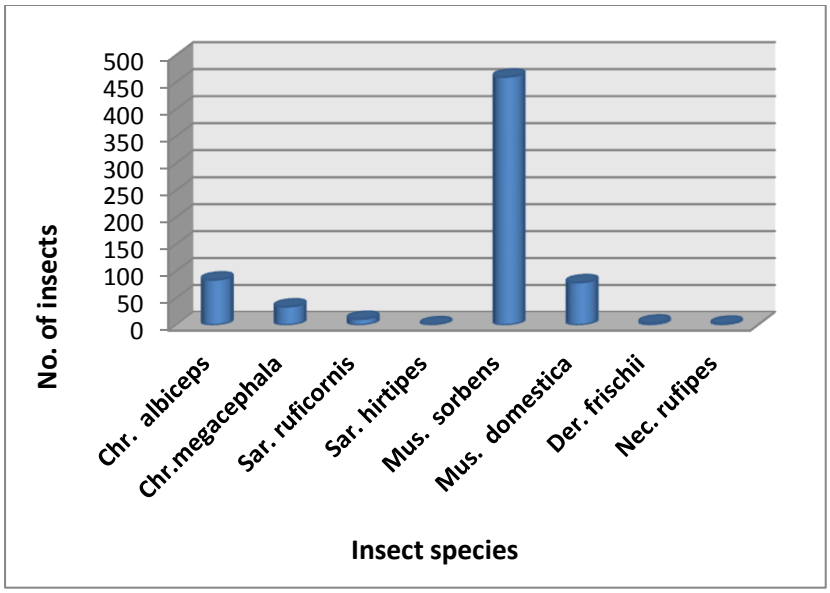

Fig. (4): Frequency of forensic insects on rabbit carcasses by species in urban habitat during autumn, 2015

3.3. Succession pattern in decomposition stages:

3.3.1. Based on families:

As shown from table (3) and figure (5), in the fresh stage of decomposition Challiphorid flies were the first insects coming to colonize the carrions although their total numbers (26) were lower than total umbers of Muscid flies (148) which were the most numerous in this stage. Only very few adult Sarcophagids were captured (3). No Coleopteran insects were observed at fresh stage. While the bloated stage characterized by drop of insect numbers, and only flies from families Muscidae and Challiphoridae visited carrions (15 & 2, respectively). In decay stage**,** Muscid flies were found to constitute the highest number (236) from other insect families, while Challiphorid flies were in low number (6). As in the previous stage, neither Sarcophagids nor beetles were captured in the decay stage. Whereas in dry stage, Musid flies were decreased to140 insect, unlike Challiphorids which rose to 48 insects, while Sarcophagids were presented in this stage (9). The first observed of adult beetles Dermistade and Cleridae was in this stage although both were in lower numbers than other insects (4 and 2, respectively). Many Dipteran's pupae and empty pupal cases were seen underneath the carrion and in between the carrion's bones. Termites of unidentified species were collected in this stage.

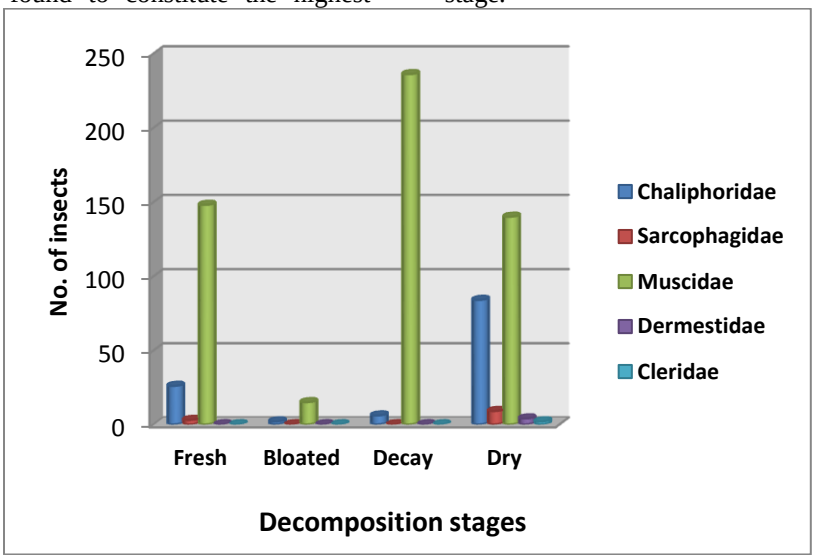

Fig. (5): Frequency of forensic insects on rabbit carcasses by families through four decomposition stages, in urban habitat.

3.3. 2. Based on species:

As shown from results given in table (3) and figure (6) in fresh stage *Mus. sorbens* species was found in higher number (118) than each of *Mus. domestica* (30) and *Ch. albcips* (25), but each of *Sar. ruficorn* and *Ch. megacephala* were counted in low number (3 and 1, respectively). Whereas in bloated stage there were only two species collected *Mus. sorbens* (15) and *Ch. Albcips* (2). But in decay stage the species which collected were *Mus. sorbens* (187), *Mus. domestica* (49) and *Ch. albcips* (6). In dry stage, most fly species that have characterized this area available, *Mus. sorbens* (140), *Ch. Albcips* (51), *Ch. megacephala* (33), *Sar. Ruficorn* (8) and a few of *Sar. hirtips* (1). Coleopteran species *Der. freschi* and *Nec. rufipes* were collected in this stage but in low numbers (4 and 2, respectively).

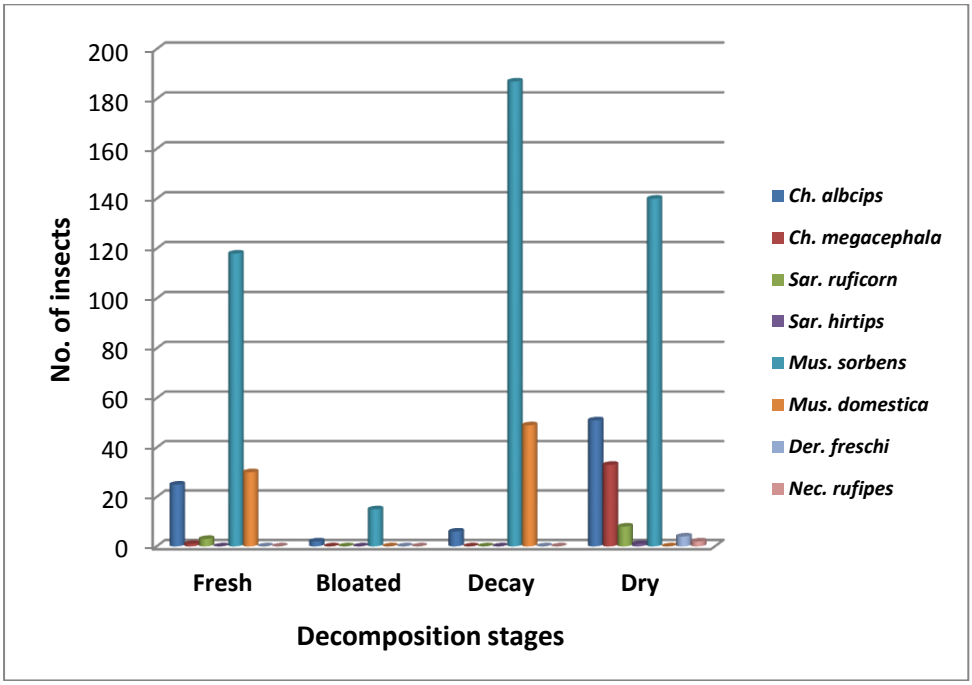

Fig. (6): Frequency of forensic insect on rabbit carcass by species through four decomposition stages, in urban habitat.

4. Discussion:

Knowledge of the insect species found in association with decomposing carrions have been used to solve many problems in legal and criminal investigations, and has proven valuable as a tool in helping to establish PMI (Goff,1993; Morris & Dadour, 2005; Amendt *et al*., 2007). Entomological estimates of PMI are based on known succession patterns of insects and the developmental age of immature insects collected from the decomposing body, this knowledge can be predictable (Catts & Goff, 1992; Voss *et al.*, 2011). Many factors influence the rate of decomposition and insect succession onto remains including geographic location (Campobasso *et al.*, 2001; Voss *et al*., 2009), climatic conditions (Archer, 2004), season (Tabor & Brewster, 2004), habitat (Eberhardt & Elliot, 2008) the physical state of the remains (Avila & Goff, 1998). Therefore, entomological estimates of PMI require baseline reference data about the expected pattern of insect succession onto carrions for a given set of parameters (Voss *et al*., 2011).

In this study observation of the urban habitat experiment during the interval of 6th to 19th November 2015, yielded significant information concerning the sequence and composition of the local fauna on rabbit carcasses during the autumn season as well as the duration of decomposition stages in Jeddah city, Kingdom of Saudi Arabia.

4.1. Carcass decomposition:

In the recent study, the fresh stage on rabbit carcasses took 2 days at minimum temperature26^{0}C, maximum temperature 32.8^{0}C, and relative humidity 53.5%, which close to that record in India by Bharti (2003) (1.5 days, on rabbit carcass in urban area, at 16±1.8^{0}C, 31.3±1.4 ^{0}C and 59.6 % R.H). This stage took 0-0.5 day on rabbit carcass at 22^{0}C, 33^{0}C and 56% R.H. in Egypt (Zeariya *et al.*, 2015).

Bloated stage in the present study lasted1-2 days (at 24.3^{0}C, 32.6^{0}C and 58% R.H.) similar to that recorded by Zeariya *et al.* (2015) in Egypt (1-2 days at 22^{0}C, 32^{0}C and 60% R.H.). This stage reported as 31-87 hours (1.29-3.63 days) at 16±1.8^{0}C, 31.3±1.4 ^{0}C and 59.6 % in India (Bharti, 2003).

In this study the decay stage was 5-6 days (at 23.76^{0}C, 32.73^{0}C and 56.66%) asymptotic to that noticed by Bharti (2003) in India, which was 88-166 hours (3.67-6.916 days) at 16±1.8^{0}C, 31.3±1.4 ^{0}C and 59.6 %.

The dry stage in the recent study took 3-4 days at 23.6^{0}C, 31.55^{0}C and 62.5% R.H. was shorter than recorded by each of Bharti (2003) (6.96 days at 16±1.8^{0}C, 31.3±1.4 ^{0}C, 59.6 %) and Zeariya *et al.* (2015) (19-30 days at 23^{0}C, 37^{0}C, 53%).

This study proved that, duration of rabbit carcasses to complete decomposition was about 14 days at minimum, maximum temperature 24.42^{0}C, 32.42^{0}C, respectively and 57.67 R.H. Al-Mesbah (2010) reported that rabbit carcasses lasted 14 days to reach dry stage at 17.40^{0}C, 20.55^{0}C and 73.43% R.H. at urban area in Kuwait. But Azmi & Lim (2013) in Malysia recorded this duration as 10 days on the same carcasses in tow different sites at 27.5 ^{0}C and 28.2 ^{0}C.

In the recent study, from fresh to decay stage after 7 days of death the remaining bio-mass of rabbit carcasses was48.44 % (at mean temperature 28.1^{0}C). Whereas, on day 10 approximately 21.88 % of the carcasses was present (at mean temperature 27.25 ^{0}C). Azmi & Lim (2013) found that from fresh to active decay stage (after 6 to 9 days of the rabbit's death), Only 20% of total biomass remained in a site at 28.2^{0}C, but in other site at 27.5^{0}C the biomass still remained approximately 50%, while by the end of the same study, on day 14, only 12.8% was left of the carrion. In Kuwait, Al-Mesbah (2010) found that after 7, 10, 14 days of rabbit death the percentage of carcasses weight loosing were 6.36, 14.55 and 53.91% respectively. The ambient temperature has a direct influence on decomposition processes and insect activity. Cold temperatures slow down organic matter putrefaction, inhibiting bacterial proliferation and preserving corpse tissues longer. Warm temperatures speed up the putrefaction process increasing bacterial proliferation (Papp, 2002). Shean *et al.* (1993) and Moura *et al.* (1997) stated that maximum temperature is more important than minimum temperature in affecting on decomposition rates, humidity was also an important factor influence on decomposition rates.

4.2. Insect Diversity:

Previous studies have shown that in the absence of vertebrate scavengers, arthropods arrive at remains in definite and predictable patterns (Bornemissza, 1956; Payne, 1965; Peschke *et al.*, 1987; Kentner, 1990) and play a major role in carrion decomposition. In the present study different insect species were collected from rabbit carcasses in urban habitat at Jeddah city, Kingdom of Saudi Arabia. These species were a few fairly; (6 species of Diptera belonging to 3 families, tow species of Coleoptera belong to tow families and one species of Isoptera). This result may be explained based on the size of dead body, the small size of a carcass leads to rapid consumption by early invaders giving no chance to later colonizers, and induced faster decomposition rates and shorter postmortem interval, here rabbits weighing 1600 to 2200 kilogram were used. The low diversity of insects was observed by Tomberlin & Adler (1988) and Zeariya *et al* (2015) which related with present small carrions. Moura *et al.* (1997) in urban habitat at Brazil, in autumn season collected three species of Challiphoridae, one species of Sarcophagidae and three species of Coleoptera on rat crcass. Micozzi (1991) found that the composition of insect community did not show significant differences between human and pig but the amount of carrion biomass strongly influenced the postmortem interval.

The overwhelming majority of the insects were flies and beetles, which formed a complex food web within the carcasses. Blowflies are attracted to carrions within minutes after death (Nuorteva, 1977; Erzinclioglu, 1983; Erzinclioglu, 1996). They can go a great distance to reach up their lay down places (Macleod & Donelly, 1963). They detect carcasses primarily by odor, but the attractiveness varies with the degree of decomposition (Nuorteva, 1977). Coleopteran families were collected from the later stages of decomposition. Bana & Bearslan (2012) stated that Coleopteran species were absent in fresh and bloated stages but were seen in active decay stage; advanced decay stage and dry stage of each of pig carcass and internal organs of bovine in Turkey.

In the recent study *Mus. Sorbens*, *Mus. domestica* and *Ch. Albiceps* were the most numerous flies present on rabbit carcasses, then *Chr. Megacephala* and *Sar. Ruficornis* both collected in moderate numbers, but each of *Sar. Hirtips* and Coleopteran species *Der. frischii* and *Nec. Rufipes* were collected in low numbers. On rabbit carcass in autumn Bharti (2003) recorded 4 species of Sarcophagidae included *Sarcophaga hirtipes*, he also found *Mus. domestica* and *Mus. sorbens* in urban area in India. Voss *et al.* (2008) reported *Ch. megacephala*, *Mus. domestica*, Sarcophagids and *Necrobia rufipes*on pig carcasses in Australia. Al-Mesbah (2010) conducted a study about necrophagous insects on rabbit carcasses in Kuwait, she found *Ch. albcipes, Ch. megacephal, Mus. domestica, Mus. sorbens and Parasarcophaga ruficornis.* Azmi & Lim (2013) collected *Ch. megacephala*, *Mus. domestica* and *Sarchophaga* sp.

from rabbit carcasses in Malysia. Zeariya *et al.* (2015) found *Ch. albiceps*, *Mus. domestica* and *Der. macultus* on rabbit carcass in Egypt.

The first wave of insects attracted to the rabbit carcasses was adult of *Ch. albiceps*. Similar observation was documented by Tantawi *et al* (1996) and Bharti (2003). In contrast to Grassberger & Frank (2004) and Arnaldos *et al.* (2005) where they found *Ch. Albiceps* only in the bloated stage. In the kingdom of Saudi Arabia, *Ch. albiceps*had been mentioned as one of the most important carrion breeding fly in Jeddah city by Al-Shareef & Al-Qurashi (2016), and in Al-Baha Province by Abouzied (2014). It was also reported as one of the most important forensic insects in different geographical area; in Egypt by Omar (1995); Tantawi *et al.* (1996); Adham *et al.* (2001); Attia (2002). Because *Ch. albiceps* attracts to the corpses within minutes after death it could serve as a key species in estimating post mortem interval (PMI) (Carvalho *et al*., 2004; Reibe *et al*., 2009; Niederegger & Spiess, 2012).

Ch. Megacephala and Sarcophagid species were collected in low number than *Ch. albiceps* in the recent study. This result was also reported by Al-Mesbah (2010) in Kuwait. Hanski (1987a, b) observed that Sarcophagid females have less fecundity than Calliphorid, beside *Ch. albiceps* larvae were known to have predatory activity on larvae of other fly and themselves as described by Tantawi *et al*. (1996), Del Bianco Faria *et al. (*1999), Bartholo *et al.* (2002) and Grassberger & Frank (2004).

In this study *Sarcophaga ruficornis* associated with the carcasses in fresh and dry stage and small number of *Sarcophaga hirtips* was found in dray stage. Sarcophagids were known to act as primary invaders of carrion in tropical and subtropical regions (Payne, 1965; Early &, 1986; Tantawi *et al.,* 1996). Bharti (2003) recorded Sarcophagids to reach and colonize the carrion during the first two days in all the seasons, and he found *Sarcophaga hirtipes* to colonize rabbit carcass throughout the year.

In the recent study, *Mus. sorbens* and *Mus. domestica* were collected with most numerous than other fly species although they visited the carcasses after Challiphorids, this result agreement with Al-Mesbah (2010) in Kuwait where she reported flies of family Muscidae in more density than each of Challiphoridae and Sarcophagidae. Several authors recorded Muscid species on animal carcasses; Emerson *et al.* (2001) found *M. sorbens* on monkey carcasses in an oil palm plantation in Malaysia. *M. domestica* was collected from pig carcasses by Barbosa *et al.* (2009), from decomposing vertebrate tissues by Tüzün *et al.* (2010), and from dog and rabbit carcasses by Zeariya *et al.* (2015).

In general, Coleoptera in the recent study were present during later stages of decomposition, as has been observed by the earlier workers (Nuortova, 1970; Payne, 1970; Early & Goff; 1986; Tantawi *et al.*, 1996). The *Dermestes* spp. well known by feeding on dried tissues, hair, feathers and skin (Kulshrestha & Satpathy, 2001; Schroeder *et al*., 2002). A single Clerid species, *Necrobia rufipes* was recovered from the rabbit carcasses in our study. Adults were observed to feed on Dipteran larvae as well as on carrion, similar observations have been made by Simmons & Ellington, 1925. Bana & Beyarslan (2012) recorded Cleridae (*Necrobia violacea*) and Dermestidae (*Dermestes* f*rischii*) in advanced decay and dry stages of decomposition of pig carcass and internal organs of bovine in Turkey.

Conclusions:

Four stages (fresh bloated decay and dry) were detected during rabbit carcasses decomposition at autumn season in Jeddah city, Kingdom of Saudi Arabia. A total of 9 insect species belonging to three orders and 6 families were associated with rabbit carcasses throughout these stages. Diptera, Coleoptera, and a little number of Isoptera orders were recognized. Family Muscidae collected with the largest numbers of insects followed by Chliphoridae then Sarcophagidae. While both families of beetles; Dermestidae and Cleridae recorded the lowest numbers. *Mus. sorbens* recorded the highest number of insect, followed by *Ch. Albiceps* and *Mus. domestica* then each of *Ch. megacephala* and *Sar. ruficornis*. While the species *Der. frischii*, *Nec. rufipes* and *Sar. Heritipes* were collected in the lowest numbers.

References:

1. Abouzied EM (2014). Insect colonization and succession on rabbit carcasses in Southwestern mountains of the kingdom of Saudi Arabia. J Med Entomol. 1: 51 (6): 1168-1174.
2. Adham FK, Abdel MA, Tawfik MA, El-Khateeb RM (2001). Seasonal incidence of the carrion breeding blowflies *Lucilia sericata* (Meigen) and *Chrysomya albiceps* (Wied.)(Diptera: Calliphoridae) in Abu-Rawash Farm, Giza, Egypt". J. Vet. Med., 49:377-383.
3. Al-Mesbah H (2010). A Study of forensically important necrophagous diptera in Kuwait. Master thesis, University of Central Lancashire. 136 pp.
4. Al-Shareef LAH, Al-Qurashi SID (2016). Study of some biological aspects of the blowfly *Chrysomya albiceps* (Wiedemann 1819) (Diptera: Calliphoridae) in Jeddah, Saudi Arabia. Egyptian Journal of Forensic Sciences. 6, 11–16.

5. Amendt J, Campobasso CP, Gaundry E, Reiter C, LeBlance H, Hall M (2007). Best Practice in Forensic Entomology: Standards and Guidelines. International Journal of Legal Medicine, 121:90-104.
6. Anderson GS (2010). Factors that influence insect succession on carrion. Forensic Entomology: The utility of arthropods in legal investigations (ed. by J.H. Byrd & J.L. Castner), pp. 201-250. CRC Press, Boca Raton, Florida.
7. Archer MS (2004). Rainfall and temperature effects on the decomposition rate of exposed neonatal remains. Science & Justice, 44(1):35-41.
8. Arnaldos MI, Garcia MD, Romera E, Presa JJ, Luna A (2005). Estimation of postmortem interval in real cases based on experimentally obtained entomological evidence". Forensic Sci. Int., 149: 57-65.
9. Attia RAH (2002). Studies on some cyclorraphous flies in Assiut Governorate. M.Sc. Thesis, Assiut University.
10. Avila FW, Goff ML (1998). Arthropod succession patterns onto burnt carrion in two contrasting habitats in the Hawaiian Islands, J Forensic Sci.; 43(3):581-586.
11. Azmi WA and Lim SP (2013). Comparative Study of Dipteran Species Diversity and Their Succession on Rabbit Carrion in Two Different Mangrove Areas of Peninsular Malaysia. Journal of Insects Volume 2013, Article ID 398159, 9 pages.
12. Bana R, Beyarslan A (2012). Determination of Copleoptera species of pig carcasses and internal organs of bovine in Edirne city of Turkey BEU J. Sci., 1(2): 122-126.
13. Bartholo JA, Rocha FA, Rodrigues P, Rosa GS, Del Bianco FL, Zuben VCJ, Rossi MN, Godoy WA (2002). Larval dispersal and predation in experimental populations of *Chrysomya albiceps* and *Cochliomyia macellaria* (Diptera: Calliphoridae)". Memorias do Instituto Oswaldo Cruz, 97: 1137-1141.
14. Bharti M (2003). Insect faunal succession on decaying rabbit carcasses in Punjab, India. J Forensic Sci, Vol. 48, No. 5.
15. Bornemissza GF (1956). An analysis of arthropod succession in carrion and the effect of its decomposition on the soil fauna, Aust. J. Zool 5; 1–12.
16. Boucher J (1997). Succession and life traits of carrion feeding *Coleoptera* associated with decomposing carcasses in the Central Free State University. M. Sc. thesis, Central Free State University of Technology, South Africa, 11-20.
17. Bousquet Y (1990). Beetles associated with stored products in Canada: An identification guide. Research Branch Agriculture Canada Publication 1837.
18. Campobasso CP, Vella DG, Introna F (2001). Factors affecting decomposition and Diptera colonization. Forensic Sci. Int, 120(1):18-27.
19. Carvalho L, Thyssen P, Goff M, Linhares A (2004). Observations on the succession patterns of necrophagous insects on a pig carcass in an urban area of Southeastern Brazil. Aggrawal's Internet J Forensic Med Toxicol 5:33-39.
20. Catts EP, Goff ML (1992). Forensic entomology in criminal investigations. Annual Review of Entomology, 37:253-272.
21. Del Bianco FL, Orsi L, Trinca LA, Godoy WAC (1999). Larval predation by *Chrysomya albiceps* on *Cochliomyia macellaria*, *Chrysomya megacephala* and *Chrysomya putoria*. Entomol Exp Applic 90:149–155.
22. Eberhardt TL, Elliot DA (2008). Apreliminary investigation of insect colonization and succession on remains in New Zealand. Forensic Science International, 176(2):217-223.
23. Erzinclioglu YZ (1983). The application of entomology to forensic medicine". Med. Sci. Law, 23 (1):57-63.
24. Early M, Goff ML (1986). Arthropod succession patterns in exposed carrion on the Island of O'ahu, Hawiian Islands, USA. J Med Entomol, 23: 520–31.
25. Erzinclioglu, YZ (1996). Blowflies. Naturalist Handbook. The Richmond Publishing Co. Ltd, P.P. 33-44.
26. Goff ML (1993). Estimation of postmortem interval using arthropod development and successional patterns. Forensic Science Review, 5:81-94.
27. Grassberger, M, Frank C (2004). Initial study of arthropod succession on pig carrion in central European urban habitat". J. Med. Entomol., 41(3): 511-523.
28. Hall RD (2001). Introduction: perceptions and status of forensic entomology," in Forensic Entomology: The Utility of Arthropods in Legal Investigations, J. H. Byrd and J.L. Castner, Eds., pp. 1–15, CRC Press, Boca Raton, Fla, USA.
29. Hanski I (1987a). Nutritional ecology of drug and carrion-feeding insects. In: Nutritional Ecology of Insects, Mites, Spiders, and Related Invertebrates. Sansky, F.; Rodriguez, J.G. (Eds.), Wiley, New York, P.P. 837-884.
30. Hanski I (1987b). Colonization of ephemeral habitats. In: Colonization, Succession and Stability. Gray, A.J.; Crawley, M. J.; Edwards, P. (Eds.), Blackwell, London, P.P. 155-185.

31. James MT (1947). The flies that cause muaisis in man. Misc. Publication 631, U.S. Depart. of Agriculture.
32. Kentner E, Streit B (1990). Temporal distribution and habitat preference of congeneric insect species found at rat carrion, Pedobiologia 34, 347–357.
33. Kulshrestha P, Satpathy DK (2001). Use of beetles in forensic entomology. Forensic Sci. International., 15(2): 15-7.
34. Leavengood JM (2008). The Checkered beetles (Coleoptera: Cleridae) of florida. A thesis presented to the graduate school of the University of Florida in partial fulfillment of the requirements for the degree of Master of Science.
35. Lord, WD (1990). Case Histories of Use of Insects in Investigations. In Entomology and Death, A procedural guide. Catts EP and Haskell NH, Eds. Joyce's Print Shop, South Carolina. Ed 1, 9-37.
36. Macleod J, Donelly J (1963). Dispersal and interspersal of blow fly populations". J. Anim. Ecol., 31: 1 -32.
37. Marshall SA, Whiteworth T, Roscde L (2011). Blow flies (Diptera: Calliphoridae) of eastern Canada with a key to Calliphoridae subfamilies and genera of eastern North America, and a key to the eastern Canadian species of Calliphorinae, Lucilinae and Chrysomyiinae. Canadian Journal of Arthropod Identification No. 11.
38. Micozzi MS (1991). Postmortem change in human and animal remains," American Journal of Human Biology, vol. 4, pp. 695–696.
39. Morris B, Dadour IR (2005). Insects and their uses in legal cases. Expert Evidence Chapter 91a (ed. Freckleton, I. and Selby, H.)The Law Book Company Limited 2005, 8- 5291-8 5381.
40. Moura MO, Carvalho CJB, Monteiro-Filho ELA (1997). A Preliminary Analysis of Insects of Medico-legal Importance in Curitiba, State of Paraná. Mem Inst Oswaldo Cruz, Rio de Janeiro, Vol. 92(2): 269-274, Mar./Apr.
41. Niederegger S, Spiess R (2012). Cuticular muscle attachment sites as a tool for for species determination in blowfly larvae. Parasitol Res 110: 1903-1909.
42. Nuorteva P (1977). Sarcosaprophagous insects as forensic indicators. In CG Tedeschi, WG Eckert & LG Tedeschi (eds), Forensic Medicine: a Study in Trauma and Environmental Hazards, Vol. II, WB Saunders, New York, p.1072-1095.
43. Nuortova P (1970). Histerid beetles as predators of blowflies (Diptera, Calliphoridae) in Finland. Ann Zool Fennici, 7:195–8.
44. Omar AH (1995)."Cannibalism and predation behaviour of the blowfly, Chrysomyia albiceps (Wiedemann) larvae (Diptera Calliphoridae)". J. Egypt Soc. Parasitol., 25: 729-743.
45. Papp L (2002). Dipterous guilds of small-sized feeding sources in forests of Hungary," Acta Zoologica Academiae Scientiarum Hungaricae, vol. 48, supplement 1, pp. 197–213.
46. Payne JA (1965). A summer carrion study of the baby pig *Sus scrofa* Linnaeus, Ecology 46: 592–602.
47. Payne JA (1970). King EW. Coleoptera associated with pig carrion. Entomologists Monthly Magazine, 105:224–32.
48. Peacock ER (2013). Adult and larvae of hide, larder and carpet beetles and their relatives (Coleoptera: Dermestidae) and of Derodontid beetles (Coleoptera: Derodontidae). Handbooks for the identification of British insects. Vol. 5, Part 3.
49. PeschkeK, Krapf D, Fuldner D (1987). Ecological separation, functional relationships, and limiting resources in a carrion insect community, Zool. Jb. Syst 114, 241–265.
50. Reibe S, Schmitz J, Madea B (2009). Molecular identification of forensically important blowfly species (Diptera: Calliphoridae) from Germany. Parasitol Res 106: 257-261.
51. Schroeder H, Klotzbach H, Oesterhelweg L, Puschel K (2002). Larder beetles (Coleoptera, Dermestidae) as an accelerating factor for decomposition of a human corpse". Forensic Sci. Internat., 17: 231-236.
52. Shean BS, Messinger L, Papworth M (1993). Observations of differential decomposition on sun exposed v. shaded pig carrion in coastal Washington State, Journal of Forensic Sciences, 38:938-949.
53. Simmons P, Ellington GW (1925). The ham beetle Necrobia rufipes DeGeer. Journal of Agricultural Research 30: 845-863.
54. Tabor KL, Fell RD, Brewster CC (2005). Insect fauna visiting carrion in Southwest Virginia," *Forensic Science International*, vol. 150, no. 1, pp. 73–80, 2005.
55. Tantawi TI, El-kady EM, Greenberg B, El-Ghaffar HA (1996). Arthropod succession on exposed rabbit carrion in Alexandria, Egypt". J. Med. Entmol., 33: 566-590.
56. Tomberlin JK, Adler PH (1988). Seasonal colonization and decomposition of rat carrion in water on land in an opened field in South Carolina". J. Med. Entomol., 35(5): 704-709.
57. Voss SC, Forbes SL, Dadour IR (2008). Decomposition and insect succession on cadavers inside a vehicle environment. Forensic Sci Med Pathol (2008) 4:22–32.

58. Voss SC, Cook DF, Dadour IR (2011). Decomposition and insect succession of clothed and unclothed carcasses in Western Australia. Forensic Science International, 211:67-75.
59. Voss SC, Spafford H, Dadour IR (2009). Annual and seasonal patterns of insect succession on decomposition remains at two locations in Western Australia. Forensic Science International, 193(1):26-36.
60. Tabor KL, Brewster CC, Fell RD (2004). Analysis of the successional patterns of insects on carrion in southwest Virginia. Journal of Medical Entomology, 41(4):785-795.
61. Wells JD, LaMotte LR (2001). Estimating the postmortem interval, in: J.H. Byrd, J.L. Castner (Eds.), Forensic Entomology. The Utility of Arthropods in Legal Investigations, CRC Press, Boca Raton, pp. 263–285.
62. Whitworth T (2006). Keys to the genera and species of blow flies (Diptera: Calliphoridae) of America north of Mexico. Proc Entomol Soc Wash 108:689–725.
63. Whitworth T (2010). Keys to the genera and species of blow flies (Diptera: Calliphoridae) of America North of Mexico. Proc. Entomol. Soc. Wash. 108 (3), pp. 689-725.
64. Zeariya MGM, Hammad KM, Fouda MA, Al-Dali AG, Kabadaia MM (2015). Forensic insect succession and decomposition patterns of dog and rabbit carcasses in different habitats. Journal of Entomology and Zoology Studies, 3(5): 473-482.

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