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Insect succession associated with corpse's decomposition of the guinea pig *Cavia porcellus* in Benha city, Egypt

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ABSTRACT

Eleven domestic guinea pig corpses were employed as models for studying decomposition and insect succession in Benha city, Egypt, from April 2009 to March 2010. Ambient temperature, faunistic succession over time, and the rate of decay in different seasons were all compared. Results indicated that ambient temperature is the chief factor determining the seasonal variations in decay rate. The diversity of insect community increased as the state of decomposition advances. Members of Dermistidae and Forrmicidae were the first coleopteran and hymenopteran colonizers in all seasons. *Sarcophaga, Wholfortia and Chrysomya* was observed in spring and summer. Meanwhile, *species* of *Wholfortia* were absent in winter and *Crysomya* species were absent in fall. Patterns of insect succession occurred in a predictable sequence that varied across different seasons. The rate of corpse's decomposition was faster in summer and autumn as compared to spring and winter

Keywords: Forensic entomology; Insect succession; Corpse; Postmortem interval; Decomposition; Egypt.

INTRODUCTION

Insect colonization of corpses has been demonstrated to occur in a predictable sequence Payne (1990), Rodriguez & Bass (1983), Early & Goff (1986), Goff (1993), Anderson & Van Laerhoven (1996), Van Laerhoven & Anderson (1999) and Tabor *et al.*, (2004). The specific period of colonization of certain insects on corpses can be established as forensically significant. Insects are either attracted to specific products of decomposition or are predators on these necrophagous insects Smith (1986), Catts & Haskell (1990) and Anderson (2001). If the sequence of insect succession on corpse is known for a given geographical region and a specific set of variables, it can be compared against collected species from bodies of unknown time of death to yield the postmortem interval, provided circumstances are similar Anderson (2001).

However, intervals based on succession patterns require knowledge of insect fauna in the geographic region in which the Corpse is discovered, as species vary widely with geographic region (Anderson and Van Laerhoven 1996). Ambient temperature, season, and microclimate of the postmortem habitat also play major roles in the determination of the invertebrate assemblage on corpse (Smith, 1986 and Catts & Haskell, 1990). Several researchers have examined the differential effects of season on necrophagous fly activity (Introna *et al.*, 1989 and Chen *et al.*, 1991), decomposition (Mann *et al.* (1990) and De Carvalho & Linhares (2001) and insect succession (Archer & Elgar, 2003). These investigators concluded that season has a major effect on the invertebrate assemblage discovered on corpse and the time of insect colonization. Thus, it is crucial to examine seasonal insect activity on

corpse in specific geographic regions and various habitats within these regions.

Locally generated data on arthropod succession and development increases the precision of postmortem interval estimations Goff (1993). The present study was designed for studying decomposition and insect succession of domestic guinea pig under the environmental conditions of Benha city in different seasons. Results of the present work may provide entomological data that can be employed in forensic cases in Benha and other similar biogeoclimatic regions.

MATERIALS AND METHODS

Study site

The study was conducted in a walk-in insectary, in the entomological lab, Faculty of science, Benha University (30°27'34"N 31°11'8"E). This lab was designed to mimic a normal room in a home.

Experimental animals

Guinea pigs of a relatively uniform size were chosen to simulate the soft skin of a new baby.

On the delivery day of each season, guinea pigs 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 postmortem to the research site in a covered plastic box and prepared for placement at the chosen study site. Then, animals were immediately placed into plastic cages and left exposed to natural conditions. Each Guinea pig was placed on its side within 1 h of the time of death. A tray containing sawdust was placed under each cage to facilitate the collection of larvae, leaving corpses for pupation.

Field protocols

Experimental protocols were modified from that of Anderson & Van Laerhoven (1996). The experiments have been modified for cost-effectiveness, without sacrificing validity. Thus, two, three or four guinea pig corpses were employed per season (3 experiments in spring, 4 experiments in summer and 2 experiments in both autumn & winter). All precautions were made to keep corpse disturbance to a minimum during sampling. Observations and sample collections were made daily at varying times according to each experiment.

During collection days, representative samples of immature and adult insects were collected from and around the corpse. While all insects observed were sampled, there was a definite focus on flies and beetles.

Adult flies were collected with an aspirator and preserved as it is in a glass vials for identification. Flies were labeled as teneral adults if the cuticle was relatively pale and soft compared to the mature adult. Adult beetles, immature insects and other hard-bodied crawling insects were collected by hand or with forceps and immersed in 70% alcohol.

For each corpse, approximately 20 larvae were collected from every distinct maggot mass on the body. Approximately half of the specimens collected were preserved in a glass vials while the other half were kept alive for rearing. The live specimens were placed in jars containing a piece of beef liver. The jars were covered with paper towel, secured with rubber bands and left in the same lab.

All samples were labeled with the date and time of collection, the corpse number, the sampling site from the corpse of and the stage of development at the time of collection.

Dipteran and Coleopteran members were identified to the species level, other insects were identified to the to the minimum of the family level with several entomological keys: Hall (1948), White (1985), Erzinelioglu (1985), Anderson & Peck(1985), MeAlpine (1987), Lieu & Greenberg (1989), Downie & Arnett (1996), Floate & Gill (1998), Bousquet

(2002) and Ratcliffe & Jameson (2005).

The temperatures were obtained from the nearest weather station.

Analyses

Excel sheet was employed to compare between the maximum, minimum and mean temperature for each season separately.

For each excel sheet, the mean temperatures were derived from the average of every temperature reading on an hour-basis for a 24-h period from 12 am to 11:59 pm each day.

RESULTS

Eleven laboratory experiments were performed to monitor insect succession and rate of decomposition of guinea pig corpses at room conditions in different seasons of the year.

Although the processes of decomposition and insect invasion were continuous, they were often described by discrete stages, which were characterized by the insect activity at each point in decomposition.

The processes of decomposition were divided into following stages:

1) Fresh stage. A corpse is considered to be in the fresh stage from the moment of death until the first signs of bloating. This is the stage during which the blow flies (Calliphoridae) and flesh flies (Sarcophagidae) arrive at the corpse and begin laying eggs or larvae (Fig. 1, a).

2) Bloating stage. This stage marks the beginning of putrefaction. Anaerobic bacteria produce gases as the result of metabolic processes, which cause bloating. Bloating usually occurs first in the abdomen, although the corpse may later assume a fully inflated appearance (Fig. b).

3) Active decay stage. This stage begins when gasses escape and the remains deflate. During this stage, dipteran larvae forming large maggot masses were predominant. Large numbers of coleopterans also begin to arrive. By the end of the decay stage, most of the flesh has been removed from the corpse and most of the Calliphoridae and Sarcophagidae have departed from the remains to pupate (Fig. c).

4) Advanced decay stage. The coleopterans (particularly dermestids) usually are the predominant species during this stage when the remains have been reduced to skin, cartilage, and bones (Fig. d).

5) Dry stage. In this stage, the remains consist of only of hair and bones. Most of the previous taxa will have disappeared, leaving mainly mites as the useful indicators of the PMI during this stage (Fig. e).

Spring experiments

Decomposition of corpse

The defining characteristics of each stage of decay, along with the associated ambient temperature readings are summarized in Table (1).

Table 1: Ambient temperatures during decomposition stages of the guinea pig *Cavia porcellus porcellus* in different seasons of the year 2009/ 2010 in Benha city, Egypt.

	Ambient temperature range (°C) (average)				
Season	Fresh	Bloating	Active decay	Advanced decay	Dry
Summer	23–34 (28.5)	24-32 (28)	23–33 (28)	24-35 (29.5)	22-36 (29)
Autumn	22–33 (28.5)	20-32 (28)	21–29 (28)	20-31 (29.5)	19-38 (28.5)
Winter	9–24 (16.5)	10-28 (19)	11–25 (18)	9-26 (17.5)	6-34 (20)
Spring	17–32 (24.5)	17-43 (30)	18–37 (26.5)	22-41 (31.5)	17-41 (29)

In spring, Fresh stage began with death and ended when bloating was initiated. Fresh stage lasted from day 0 to day 2 for all corpses. The beginning of the bloating stage was in 3rd day and continued to 7th day. Active decay stage lasted 6 days from 8th day to 13th day. Advanced stage was observed in the 14th and 15th day. Dry stage began with the 16th day and lasted till the 37th day (Table 2).

Table 2: Decay rates of the guinea pig *Cavia porcellus porcellus* in different seasons of the year 2009/ 2010 in Benha city, Egypt.

	Days postmortem				
Season	Fresh	Bloating	Active decay	Advanced decay	Dry
Summer	0-1	2	3-4	5-6	7-23
Autumn	0-1	2	3-4	5-7	8-28
Winter	0-5	6-10	11-23	24-28	29-50
Spring	0-2	3-7	8-13	14-15	16-37

Insect succession

Table (3) showed the insect succession of forensically important insects on the corpse during spring season.

Larvae and adults of Diptera and Coleoptera as well as Formicidae adults were observed on the corpse throughout the experimental time. Flies appeared from the 1st day as adults and continued their development in all decomposition stages of the corpse. Five dipteran species were observed during the experiment (*Musca domestica*, *Sarcophaga carnaria*, *Wholfortia magnefica*, *Drosophila melanogaster* and *Chrysomya albiscepes*).

Sarcophaga carnaria was the most abundant fly throughout the experiment. All its developmental stages (larvae to adults) were observed on the corpse. It appeared as adult from the 2nd day (Fresh stage) to the 4th day (Bloating stage). They also visited the corpse occasionally in both days 17 and 25 (Dry stage). *Sarcophaga* larvae were collected from the 4th day (100%) (Bloating stage) to the 9th day (92.86%) (Active decay stage). Its pupae were observed at the 10th day (Active decay stage) to 29th day (Dry stage). Adult emergence of *Sarcophaga* was recorded at the 27th day to 29th day (Dry stage). Adult *Chrysomya albiscepes* appeared at the first 4 days of the experiment (Fresh and Bloating stages). Also, they visited the corpse occasionally at day 36 (Dry stage). *Chrysomya* larvae were collected only in 6th day (7.04%) (Bloating stage).

Drosophila melanogaster appeared on the corpse as adult from 5th day (Bloating stage) to 37th day (Dry stage). *Musca domestica* were observed as adults in 3 different stages of corpse decomposition (Fresh, Bloating and Dry stages).

Wholfortia magnefica were observed as larvae only from 3rd day (Bloating stage) to 9th day (Active decay stage). Two coleopteran species were observed during the experiment (*Attagenus pictus and Dermestes castaneus*). *Attagenus pictus* was the most abundant beetle throughout the experiment. Its adults and larvae were observed on the corpse. It appeared as adult from 5th day (Bloting stage) to 37th day (Dry stage). *Attagenus* larvae dominated itself (100%) from 18th day to 37th day (Dry stage), Wherase, *Dermestes castaneus* were observed on the corpse as adult from 5th day (Bloating stage) to 9th day (Active decay stage) and from 16th day to 20th day (Dry stage).

Table 3: Occurrence of forensically important insects collected from guinea pig carrion in the Spring, 2009 of Benha city, Egypt.

Decomposition stages	Day	Flies					Beetles		Ants
		***Musca* sp.**	***Sarcophaga* sp.**	***Wholfortia* sp.**	***Drosophila* sp.**	***Ch. albicepes***	***Attagenus pictus***	***Dermestes castaneus***	***Monomorium phoraensis***
Fresh	**1.**	Adult	-	-	-	Adult	-	-	Adult
	2.	Adult	Adult	-	-	Adult	-	-	Adult
		Eggs of different flies + Larvae of different flies							
Bloating	**3.**	Adult	Adult	-	-	Adult	-	-	-
		Larvae							
				(100%)					
	4.	Adult	Adult	-	-	Adult	-	-	-
		Larvae							
			(100%)						
	5.	-	-	-	Adult	-	Adult	Adult	-
		Larvae							
			(55.56%)	**(44.44%)**					
	6.	-	-	-	Adult	-	Adult	Adult	-
		Larvae							
			(78.57%)	**(14.29%)**		**(7.04%)**			
	7.	-	Adult	-	Adult	-	Adult	Adult	Adult
		Larvae							
			(78.57%)	**(21.43%)**					
Active	**8.**	-	-	-	Adult	-	Adult	Adult	Adult
		Larvae							
			(93.01%)	**(6.99%)**					
	9.	-	-	-	Adult	-	Adult	Adult	Adult
		Larvae							
			(92.86%)	**(7.14%)**					
	10.	-	-	-	Adult	-	Adult	-	Adult
		Pupa							
	11.	-	-	-	Adult	-	Adult	-	Adult
		Pupa							
	12.	-	-	-	Adult	-	Adult	-	Adult
		Pupa							
	13.	-	-	-	Adult	-	Adult	-	Adult
		Pupa							
Advanced	**14.**	-	-	-	Adult	-	Adult	-	Adult
		Pupa							
	15.	-	-	-	Adult	-	Adult	-	Adult
		Pupa							

Table 3: Continued.

Decomposition stages	Day	Flies					Beetles		Ants
		Musca sp.	*Sarcophaga sp.*	*Wholfortia sp.*	*Drosophila sp.*	*Ch. albicepes*	*Attagenus pictus*	*Dermestes castaneus*	*Monomorium phoraensis*
Dry	**16.**	Adult	-	-	Adult	-	Adult	Adult	Adult
		Pupa							
	17.	-	Adult	-	Adult	-	Adult	Adult	Adult
		Pupa							
	18.	Adult	-	-	Adult	-	Adult	Adult	Adult
		Pupa					Larva		
	19.	Adult	-	-	Adult	-	Adult	Adult	Adult
		Pupa					Larva		
	20.	Adult	-	-	Adult	-	Adult	Adult	Adult
		Pupa					Larva		
	21.	-	-	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	22.	-	-	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	23.	-	-	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	24.	-	-	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	25.	-	Adult	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	26.	-	-	-	Adult	-	Adult	-	Adult
		Pupa					Larva		
	27.	-	Adult	-	Adult	-	Adult	-	Adult
		Pupa + Emergence of Sarcophaga sp					Larva		
	28.	-	Adult	-	Adult	-	Adult	-	Adult
		Pupa + Emergence of Sarcophaga sp					Larva		
	29.	-	Adult	-	Adult	-	Adult	-	-
		Pupa + Emergence of Sarcophaga sp					Larva		
	30.	-	-	-	Adult	-	Adult	-	-
							Larva		
	31.	-	-	-	Adult	-	Adult	-	-
							Larva		
	32.	-	-	-	Adult	-	Adult	-	-
							Larva		
	33.	-	-	-	Adult	-	Adult	-	-
							Larva		
	34.	-	-	-	Adult	-	Adult	-	-
							Larva		
	35	-	-	-	Adult	-	Adult	-	-
							Larva		
	36.	Adult	-	-	-	Adult	Adult	-	-
							Larva		
	37.	-	-	-	Adult	-	Adult	-	-
							Larva		

One Formicidian species was observed during the experiment (*Monomorium phoraensis*). It appeared only as adult during the 1st two days (Fresh stage). Also, it was observed again from 7th day (the end of Bloating stage) to 28th day (Dry stage).

Summer experiment

Decomposition of corpse

The defining characteristics of each stage of decay, along with the associated ambient temperature readings are summarized in Table (1).

In summer, Fresh stage began with death and ended when bloating was initiated. Fresh stage lasted from day 0 to day 1 for all corpses. The beginning of the bloating stage was in 2rd day only. Active decay stage lasted 2 days (3rd and 4th day). Advanced stage was observed in the 5th and 6th day. Dry stage began with the 7th day and lasted till the 23th day (Table 2).

Insect succession

Table (4) showed the insect succession of forensically important insects on the corpse during summer season.

Larvae and adults of Diptera and Coleoptera as well as Formicidae adults were observed on the corpse throughout the experimental time. Flies appeared from the 1st day as adults and continued their development in all decomposition stages of the corpse. Four dipteran species were observed during the experiment (*Musca domestica, Sarcophaga carnaria, Wholfortia magnefica.* and *Chrysomya albiscepes*).

Table 4: Occurrence of forensically important insects collected from guinea pig carrion in Summer, 2009 of Benha, Egypt.

Decomposition stages	Day	Flies					Beetles		Ants
		Musca sp.	*Sarcophaga sp.*	*Wholfortia sp.*	*Drosophila sp.*	*Ch. albicepes*	*Attagenus pictus*	*Dermestes castaneus*	*Monomorium phoraensis*
Fresh	**1.**	Adult	Adult	Adult	-	Adult	-	-	Adult
Bloat	**2.**	Adult	Adult	-	-	Adult	Adult	Adult	Adult
		Egg of different flies + Larva of different flies							
Active	**3.**	Adult	Adult	-	-	Adult	Adult	Adult	-
		Larva							
			(53.19%)	**(46.81%)**					
	4.	-	-	-	-	-	Adult	Adult	-
		Larva							
			(39.13%)	**(32.61%)**		**(28.26%)**			
Advanced	**5.**	-	-	-	-	-	Adult	Adult	-
		Larva							
			(39.58%)	**(39.58%)**		**(20.84%)**			
	6.	-	-	-	-	-	Adult	Adult	-
		Larva + Pupa							
			(56.25%)	**(29.17%)**		**(14.58%)**			
Dry	**7.**	-	-	-	-	-	Adult	Adult	Adult
		Larva + Pupa							
			(100%)						
	8.	-	-	-	-	-	Adult	-	Adult
		Pupa							
	9.	-	-	-	-	-	Adult	-	Adult
		Pupa							
	10.	-	-	-	-	-	Adult	-	Adult
		Pupa							
	11.	-	-	-	-	-	Adult	-	Adult
		Pupa							
	12.	-	-	-	-	-	Adult	-	Adult
		Pupa							
	13.	-	-	-	-	-	Adult	-	Adult
		Pupa					Larva		
	14.	-		-	-	-	Adult	-	Adult
		Pupa					Larva		

Table 4: Continued.

<table>
<tr><th rowspan="2">Decomposition stages</th><th rowspan="2">Day</th><th colspan="5">Flies</th><th colspan="2">Beetles</th><th>Ants</th></tr>
<tr><th>Musca sp</th><th>Sarcophaga sp.</th><th>Wholfortia sp.</th><th>Drosophila sp.</th><th>Ch. albicepes</th><th>Attagenus pictus</th><th>Dermestes castaneus</th><th>Monomorium phoraensis</th></tr>
<tr><td rowspan="20">Dry</td><td rowspan="2">15.</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td>Adult</td><td>Adult</td><td>-</td><td>Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Wholfortia sp + Emergence of Blow fly</td><td colspan="2">Larva</td><td>Adult</td></tr>
<tr><td rowspan="2">16.</td><td>-</td><td>Adult</td><td>Adult</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td>Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Sarcophaga sp + Emergence of Wholfortia sp</td><td colspan="2">Larva</td><td>Adult</td></tr>
<tr><td rowspan="2">17.</td><td>-</td><td>Adult</td><td>Adult</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td>Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Sarcophaga sp + Emergence of Wholfortia sp</td><td colspan="2">Larva</td><td>Adult</td></tr>
<tr><td rowspan="2">18.</td><td>-</td><td>Adult</td><td>Adult</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td>Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Sarcophaga sp + Emergence of Wholfortia sp</td><td colspan="2">Larva</td><td>Adult</td></tr>
<tr><td rowspan="2">19.</td><td>-</td><td>Adult</td><td>Adult</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td rowspan="2">Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Sarcophaga sp + Emergence of Wholfortia sp</td><td colspan="2">Larva</td></tr>
<tr><td rowspan="2">20.</td><td>-</td><td>Adult</td><td>-</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td rowspan="2">Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Sarcophaga sp</td><td colspan="2">Larva</td></tr>
<tr><td rowspan="2">21.</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td>-</td><td>Adult</td><td>-</td><td rowspan="2">Adult</td></tr>
<tr><td colspan="5">Pupa + Emergence of Wholfortia sp</td><td colspan="2">Larva</td></tr>
<tr><td rowspan="2">22.</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td>Adult</td><td>-</td><td rowspan="2">Adult</td></tr>
<tr><td colspan="2">Larva</td></tr>
<tr><td>23.</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Larva</td><td>-</td><td>Adult</td></tr>
</table>

Sarcophaga carnaria were observed on the corpse as adults, larvae and Pupae. *Sarcophaga* appeared as adults from the 1st day (Fresh stage) to the 3rd day (Active stage). *Sarcophaga* larvae were collected from the 3rd day (53.19%) (Active stage) to the 7th day (100%) (Dry stage). Its pupae were observed at the 6th day (Advanced decay stage) to 20th day (Dry stage). Adult emergence of *Sarcophaga* was recorded at the 16th day to 20th day (Dry stage). *Wholfortia magnefica* were observed on the corpse as adults, larvae and Pupae. *Wholfortia* were observed as adults in the 1st day only. Its larvae were collected from the 3rd day (46.81%) (Active stage) to the 6th day (29.17%) (Advanced stage). Its pupae were observed at the 6th day (Advanced decay stage) to 21th day (Dry stage). Adult emergence of *Wholfortia* was recorded at the 15th day to 21th day (Dry stage). *Chrysomya albiscepes* were observed on the corpse as eggs, larvae and adults. Adult *Chrysomya* appeared at the first 3 days of the experiment (Fresh, Bloating and Active stage). *Chrysomya* eggs were collected in the 2nd day (Bloating stage).

Larvae were observed from the 4th day (28.26 %) (Bloating stage) to 6th day (14.58%) (Advanced stage). Its pupae were observed at the 6th day (Advanced decay stage) to 15th day (Dry stage). Adult emergence of *Chrysomya* was recorded at the 15th day (Dry stage). *Musca domestica* appeared at the first 3 days of the experiment (Fresh, Bloating and Active stage).

Two coleopteran species were observed during the experiment (*Attagenus pictus and Dermestes castaneus*). *Attagenus pictus* was the most abundant beetle throughout the experiment. Its adults and larvae were observed on the corpse. It appeared as adults from 2nd day (Bloting stage) to the end of the summer experiment (Dry stage). *Attagenus* larvae dominated itself

100% from 13th day to 23th day (Dry stage). Whereas *Dermestes castaneus* were observed on the corpse as adults from 2nd day (Bloating stage) to 7th day (the beginning of Dry stage).

One Formicidian species was observed during the experiment (*Monomorium phoraensis*). It appeared only as adults during the 1st two days (Fresh stage). Also, they were observed again from 7th day (the beginning of Dry stage) to 23th day (Dry stage).

Fall experiment

Decomposition of corpse

The defining characteristics of each stage of decay, along with the associated ambient temperature readings are summarized in Table (1).

The rate of decomposition resembled that in the summer except that advanced decay prolonged one day than summer. This stage lasted 3 days from (5th day to 7th day). Also, dry stage prolonged 21 day from (8th day to 28th day) (Table 2 and Fig. 6).

Insect succession Table 5: showed the insect succession of forensically important insects on the corpse during autumn season.

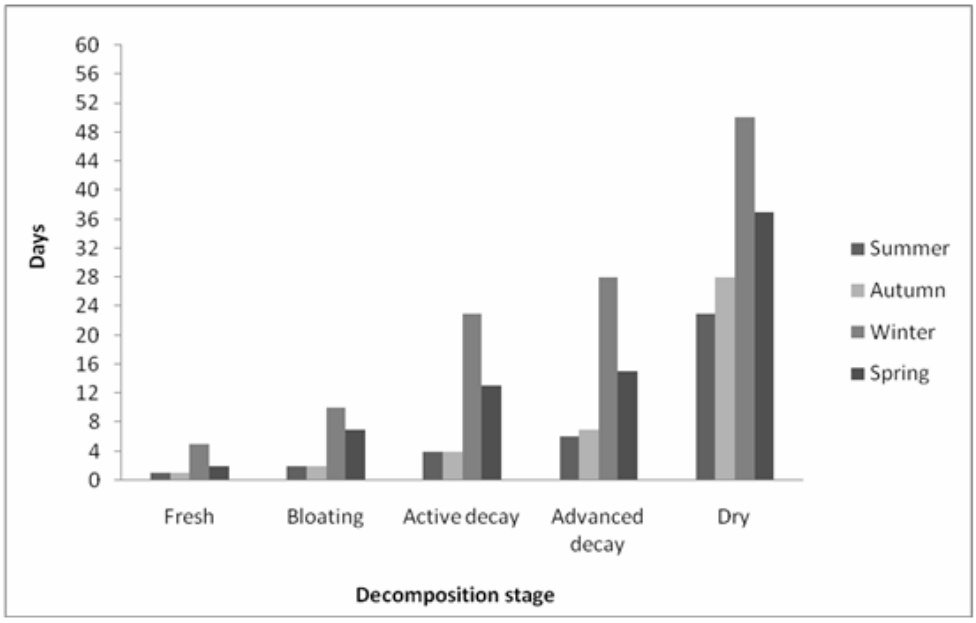

Fig. 6: Comparison of decay rates of guinea pig *Cavia porcellus porcellus* in different seasons of the year 2009/ 2010 in Benha city, Egypt.

Table 5: Occurrence of forensically important insects collected from guinea pig carrion in the Autumn, 2009 of Benha, Egypt.

Decomposition stages	Day	Flies					Beetles		Ants	
		Musca sp.	*Sarcophaga sp.*	*Wholfortia sp.*	*Drosophila sp.*	*Ch. albicepes*	*Attagenus pictus*	*Dermestes castaneus*	*Monomorium phoraensis*	*Camponotus maculatus*
Fresh	**1.**	-	-	-	-	-	-	-	Adult	
Bloat	**2.**	-	-	-	-	-	-	Adult	Adult	Adult
Active	**3.**	-	-	-	-	-	Adult	Adult	Adult	Adult
		Eggs of different flies + Larvae of different flies								
	4.	-	-	-	-	-	Adult	Adult	Adult	Adult
		Larvae of different flies								
Advanced	**5.**	-	-	-	-	-	Adult	Adult	-	-
		Larvae								
			(70.59%)	**(29.41%)**						
	6.	-	-	-	-	-	Adult	Adult	Adult	-
		Larvae								
			(65%)	**(35%)**						
	7.	-	-	-	-	-	Adult	Adult	Adult	-
		Larvae								
			(88%)	**(12%)**						
Dry	**8.**	-	-	-	-	-	Adult	Adult	Adult	-
		Larvae + Pupa								
			(66.67%)	**(33.34%)**						
	9.	-	-	-	-	-	Adult	Adult	Adult	Adult
		Larvae + Pupa								
			(91.3%)	**(8.7%)**						
	10.	-	-	-	-	-	Adult	Adult	Adult	-
		Larvae + Pupa								
			(90.91%)	**(9.09%)**						
	11.	-	-	-	-	-	Adult	Adult	Adult	-
		Larvae + Pupa					Larvae			
			(90.91%)	**9.09%)**						
	12.	-	-	-	-	Adult	Adult	Adult	Adult	Adult
		Pupa + Emergence of *Ch. albicepes*					Larvae			
	13.	-	-	-	-	Adult	Adult	Adult	Adult	-
		Pupa + Emergence of *Ch. albicepes*					Larvae			
	14.	-	-	-	-	Adult	Adult	-	Adult	-
		Pupa + Emergence of *Ch. albicepes*					Larvae			

Larvae and adults of Diptera and Coleoptera as well as Formicidae adults were observed on the corpse throughout the experimental time.

Flies appeared from the 3rd day as eggs and larvae and continued their development in all decomposition stages of the corpse. Three dipteran species were observed during the experiment (*Sarcophaga carnaria*, *Wholfortia magnefica* and *Chrysomya albiscepes*).

Sarcophaga carnaria were observed on the corpse as adults, larvae and Pupae. *Sarcophaga* larvae were collected from the 5th day (70.59%) (Advanced stage) to the 11th day (90.91%) (Dry stage). Its pupae were observed at the 8th day (Dry stage) to 22th day (Dry stage). Adult emergence of *Sarcophaga* was recorded at the 18th day to 22th day (Dry stage). *Wholfortia magnefica* were observed on the corpse as adult, larva and Pupa. *Wholfortia* larvae were collected from the 5th day (29.41%) (Advanced stage) to the 11th day (9.09%) (Dry stage). Its pupae were observed at the 8th day (Dry stage) to 22th day (Dry stage). Adult emergence of *Wholfortia* was recorded at the 20th day to 22th day (Dry stage). *Chrysomya*

albiscepes were observed on the corpse as eggs, larvae and adults. *Chrysomya* eggs were not collected or observed but its pupae were observed at the 8th day (Dry stage) to 14th day (Dry stage). Adult emergence of *Chrysomya* was recorded at the 12th to 14th day (Dry stage).

Table 5: Continued.

Decomposition stages	Day	Flies					Beetles		Ants	
		Musca sp	*Sarcophaga sp*	*Wholfortia sp*	*Drosophila sp*	*Ch. albicepes*	*Attagenus pictus*	*Dermestes castaneus*	*Monomorium phoraensis*	*Camponotus maculatus aegypticus*
Dry	15.	-	-	-	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	16.	-	-	-	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	17.	-	-	-	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	18.	-	Adult	-	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	19.	-	Adult	-	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	20.	-	Adult	Adult	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	21.	-	Adult	Adult	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	22.	-	Adult	Adult	-	-	Adult	-	Adult	-
		Pupa					Larvae			
	23.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			
	24.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			
	25.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			
	26.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			
	27.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			
	28.	-	-	-	-	-	Adult	-	Adult	-
							Larvae			

Two coleopteran genera were observed during the experiment (*Attagenus pictus* and *Dermestes castaneus*). *Attagenus pictus* was the most abundant beetle throughout the experiment. It appeared as adult from 3rd day (Active stage) to 28th day (Dry stage). *Attagenus* larvae dominated itself 100% from 12th day to 28th day (Dry stage). Wherase, *Dermestes castaneus* were observed on the corpse as adults from 2nd day (Bloating stage) to 13th day (Dry stage).

Two Formicidian species were observed during the experiment (*Monomorium phoraensis* and *Camponotus maculatus*). *Monomorium phoraensis* was the most abundant ant throughout the experiment. They appeared only as adults during all time of the experiment. *Camponotus maculatus* was observed from 2nd day (Bloating stage) to 4th day (Active stage). Also, they were observed in the Dry stage at the (9th and 12th day).

Winter experiment

Decomposition of corpse

The defining characteristics of each stage of decay, along with the associated ambient temperature readings are summarized in Table (1).

In winter, Fresh stage began with

death and ended when bloating was initiated. Fresh stage lasted from day 0 to day 5 for all corpses. The beginning of the bloating stage was in 6th day and continued to 10th day. Active decay stage lasted 13 days from 11th day to 23th day. Advanced stage was observed from the 24th till the 28th day. Dry stage began with the 29th day and lasted till the 50th day (Table 2).

Insect succession: Table (6) showed the insect succession of forensically important insects on the corpse during winter season.

Table 6: Occurrence of forensically important insects collected from guinea pig carrion in the Winter season, 2010 of Benha, Egypt.

Decomposition stages	Day	Flies					Beetles	Ants	Butterfly
		Musca sp	*Sarcophaga sp*	*Wholfortia sp*	*Drosophila sp*	*Ch. albicepes*	*Attagenus pictus*	*Monomorium phoraensis*	*Spodoptera littoralis*
Fresh	1.	-	-	-	-	-	-	Adult	-
	2.	-	-	-	Adult	-	-	-	-
	3.	-	-	-	Adult	-	-	-	-
	4.	Adult	-	-	Adult	Adult Egg	-	-	-
	5.	-	-	-	Adult	Egg	-	Adult	-
Bloat	6.	Adult	-	-	Adult	Adult	-	Adult	Adult
	7.	Adult	-	-	Adult	-	-	Adult	-
		Larva of different flies							
	8.	Adult	-	-	Adult Larva	Adult	-	Adult	-
		Larva							
			(100%)						
	9.	Adult	-	-	Adult Larva	Adult	-	Adult	-
		Larva							
			(100%)						
	10.	-	-	-	Adult Larva	-	-	-	-
		Larva							
			(100%)						
Active	11.	-	-	-	Adult	-	-	-	-
		Larva							
			(100%)						
	12.	-	-	-	Adult	-	-	-	-
		Larva							
			(94.74%)			**(5.26%)**			
	13.	-	-	-	Adult	-	-	-	-
		Larva							
			(84.62%)			**(15.38%)**			
	14.	-	-	-	Adult	Adult	-	-	-
		Larva							
			(90.48%)			**(9.52%)**			
	15.	-	-	-	Adult	-	-	-	-
		Larva							
			(84.21%)			**(15.79%)**			
	16.	-	-	-	Adult	-	-	Adult	-
		Larva							
			(87.5%)			**(12.5%)**			
	17.	-	-	-	Adult	-	-	Adult	-
		Larva + Pupa of different flies							
			(100%)						
	18.	-	-	-	Adult	-	-	Adult	-
		Larva + Pupa of different flies							
			(100%)						
	19.	-	-	-	Adult	-	-	Adult	-
		Larva + Pupa of different flies							
			(100%)						
	20.	-	-	-	Adult	-	-	Adult	-
		Larva + Pupa of different flies							
			(100%)						

Table 6: Continued.

Decomposition stages	Day	Flies					Beetles	Ants	Butterfly
		Musca sp	*Sarcophaga sp*	*Wholfortia sp*	*Drosophila sp*	*Ch. albicepes*	*Attagenus pictus*	*Monomorium phoraensis*	*Spodoptera littoralis*
Active	**21.**	-	-	-	Adult	-	-	Adult	
		Pupa of different flies							
	22.	-	-	-	Adult	-	-	Adult	
		Pupa of different flies							
Advanced	**23.**	-	-	-	Adult	-	-	Adult	
		Pupa of different flies							
	24.	-	-	-	Adult	-	-	Adult	
		Pupa of different flies							
	25.	-	-	-	Adult	-	-	Adult	
		Pupa of different flies							
	26.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	27.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	28.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
Dry	**29.**	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	30.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	31.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	32.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	33.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	34.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	35.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	36.	-	-	-	Adult	-	Adult	Adult	
		Pupa of different flies							
	37.	-	-	-	Adult	-	Adult	-	
		Pupa of different flies							
	38.	-	-	-	Adult	-	Adult	-	
		Pupa of different flies							
	39.	-	-	-	-	-	Adult	Adult	
		Pupa of different flies					Larva		
	40.	-	-	-	-	-	Adult	Adult	
		Pupa of different flies					Larva		
	41.	-	-	-	-	-	Adult	Adult	
		Pupa of different flies					Larva		
	42.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		

Table 6: Continued.

Decomposition stages	Day	Flies					Beetles	Ants	Butterfly
		Musca sp	*Sarcophaga sp*	*Wholfortia sp*	*Drosophila sp*	*Ch. albicepes*	*Attagenus pictus*	*Monomorium phoraensis*	*Spodoptera littoralies*
Dry	43.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	44.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	45.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	46.	-	Adult	-	Adult	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	47.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	48.	-	Adult	-	-	-	Adult	Adult	
		Pupa of different flies + Emergence of *Sarcophaga* sp					Larva		
	49.	-	-	-	-	-	-	-	
	50.	-	-	-	-	-	-	-	

Larvae and adults of Diptera and Coleoptera as well as Formicidae adults were observed on the corpse throughout the experimental time.

Flies appeared from the 2nd day as adults and continued their development in all decomposition stages of the corpse. Four dipteran species were observed during the experiment (*Musca domestica, Sarcophaga carnaria, Drosophila sp* and *Chrysomya albiscepes*). *Sarcophaga carnaria* were observed on the corpse as adults, larvae and Pupae. *Sarcophaga* larvae were collected from the 8th day (100%) (Bloating stage) to the 20th day (100%) (Active decay stage). Its pupae were observed at the 17th day (Active decay stage) to 48th day (Dry stage). Adult emergence of *Sarcophaga* was recorded at the 42th day to 48th day (Dry stage).

Chrysomya albiscepes were observed on the corpse as eggs, larvae and adults. *Chrysomya* eggs were collected in the 4th & 5th day (Bloating stage). Larvae were observed from the 12th day (5.26 %) to the 16th day (12.5%) (Active stage). Its pupae were not observed. *Drosophila sp*. appeared on the corpse as adult from 2nd day (Fresh stage) to 38th day (Dry stage). They were re-observed in the 46th day. Its larvae were observed from the 8th day to the 12th day (Bloating stage). *Musca domestica* were observed as adults from the 4th day (Fresh stage) to the 9th day (Bloating stage).

One coleopteran species was observed during the experiment (*Attagenus pictus*). It appeared as adults from 26th day (Advanced stage) to 48th day (Dry stage). *Attagenus* larvae were observed from 39th day to 48th day (Dry stage).

One Formicidian species was observed during the experiment (*Monomorium phoraensis*). It appeared only as adults during the all stages of corpse decomposition.

Accidentally, *Spodoptera littoralis* appeared on the corpse in the 6th day (Bloating stage).

DISCUSSION

Five species of adult flies belonging to four dipteran families were collected from corpses throughout the four seasons: *Chrysomya albiceps* (Calliphoridae), *Sarcophaga carnaria* (Sarcophagidae), *Wholfortia magnifica*

(Sarcophagidae), *Drosophila melanogaster* (Drosophilidae) and *Musca domestica* (Muscidae).

Calliphorid and Sarcophagid flies were the first colonizers to breed on guinea pig corpses. 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).

Sarcophagid flies were predominant to other flies during all seasons. Similar results were presented by Payne (1965), Early & Goff (1986) and Tantawi *et al.* (1996).

Our results clarified that flies showed an oviposition preference for 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 in these areas for oviposition was also observed by Norris (1965).

The present study showed that *Sarcophaga carnaria* was the most important component of insect succession on guinea pig corpse during all seasons because it was the most abundant species in all experiments. Convenient results were presented by Denno and Cothran (1975). In addition, larvae of *Sarcophaga carnaria* were collected in all seasons, larvae of *Wholfortia magnifica* were collected in summer, spring and autumn, larvae of *Chrysomya albiceps* were collected in summer, spring and winter and larvae of *Drosophila melanogaster* were collected in winter only. It is worthy to mention that not all species visited the corpse to lay eggs or larvae. *Musca domestica* was found visiting, copulating, and feeding on the substrate or using it as an extension of their habitat. This observation was convenient with Dear (1978) and De Souza & Linhares (1997).

Although Sarcophagid species were coexisting with *Chrysomya albiceps* on the same corpse, *Chrysomya albiceps*, was responsible for minimum guinea pig corpse consumption. These results confirmed results presented by Tantawi *et al.* (1996). Contrary to our results, Early and Goff (1986) reported that the numbers of sarcophagid maggots were much less than those of Calliphoridae. Consequently, calliphorid flies ranked second regarding the reduction of corpse weight.

Insect colonizers on the corpse could be separated into four ecological categories. The first category, including the greatest number of necrophagous individuals that fed directly on the corpse is of the highest significance in determining PMI. This includes species in the families Calliphoridae, Sarcophagidae and Dermestidae. Predators and parasites of the necrophagous species comprised the second category. Among the predators of particular significance were larvae of C*hrysomya albiceps*. C*hrysomya albiceps* larvae were not only fed on the corpse but also were reported as predators on other larvae infesting the corpse. These results are consistent with the results presented by Tantawi *et al.* (1996) and Pérez *et al.* (2005). This explains the occurrence of dead larvae of *Sarcophaga carnaria* and *Wholfortia magnifica* near the corpse throughout the experiments. The third category consisted of the omnivorous species, Formicidae ants as *Monomorium phoraensis* and *Camponotus maculatus* that fed on both corpse and associated arthropods. The fourth category was comprised of incidental or adventives species having no direct relationship to the corpse as cotton leafworm, *Spodoptera littoralis*. These results generally agree with those documented by (Payne, 1965).

Regarding corpse decomposition in relation to fly activity, calliphorid and sarcophagid flies (1st colonizers) played a fundamental role in corpse decomposition. Delaying of insect

infestation resulted in significantly retarded and incomplete corpse decomposition (Payne, 1965 and Anderson & Van Laerhoven, 1996). This could explain why the corpse took more time for decomposition in winter rather than other seasons. Composition and abundance of the corpse-related fauna was interpreted regarding the influence of temperature (Goddard & Lago, 1985 and Tantawi *et al.*, 1996).

Season and corpse microenvironment are also factors influencing the species composition and successional patterns during decomposition (Hanski, 1987). In comparison to other studies done in spring and summer season in relation to the diversity number. The collected arthropods species were less in diversity than other authors (Reed, 1958; Rodriguez & Bass, 1983; Lord & Burger, 1984 and Arnaldos *et al.*, 2004) in similar seasons. Such contrast agrees with Tentawi *et al.*, (1996); Galal *et al.*, (2009) and Chittaro *et al.*, (2005) who collected only 4-5 species during the hot summer. Therefore we could assume that the high temperature, which had been also recorded in the current study, had accelerated the decomposition process, meaning that the corpse is reduced to bones in a shorter time period leading to rapid depletion of food resource and reduction of arthropod colonization time.

CONCLUSIONS

This investigation demonstrated that the patterns of decomposition and insect succession varied across different seasons (Fig. 6). Ambient temperature was a critical factor in the determination of the rate of decay in various seasons (Table 1).

Furthermore, the seasonal distribution of insects' significantly impacted the species that were recovered from corpse in different times of the year. Several families of insects arrived in a predictable sequence, although the pattern varied in different times of the year and in different habitats.

Although a large number of insect species were observed at corpses, relatively few used the corpse for breeding purposes. This indicates that species differ in their ability to use the various resources provided by the corpse. Generally, the first fly species to colonize the corpse had an advantage over later arriving taxa, and their larvae had a greater chance to develop to the adult stage. Both the Calliphoridae and Sarcophagidae demonstrated a preference for the dark putrefaction stage of decomposition (Stage III), although they were present in early and late stages. Other coleopteran taxa, such as members of the Dermistidae and Scarabaeidae dominated in later stages of decay, although their presence and colonization times varied across season.

Further research is needed on the biological and ecological characteristics of the particular species associated with corpses in the Benha Ecozone. The data generated from this research are now available for homicide investigations in Benha and Similar biogeoclimatic regions.

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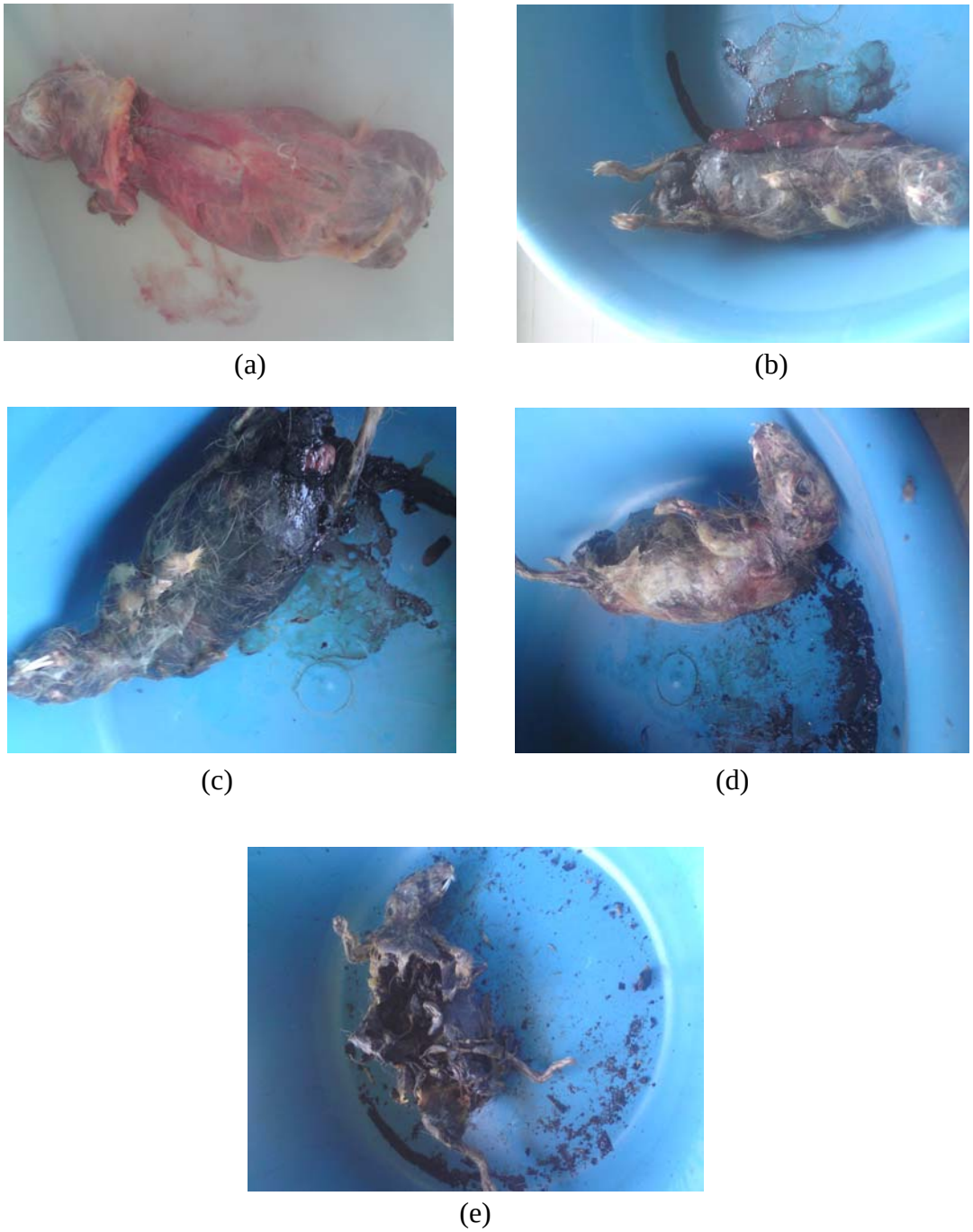

Fig. 1: Decomposition stages of guinea pig *Cavia porcellus* in different seasons of the year 2009/ 2010 in Benha city, Egypt. (a) Fresh stage. (b) Bloat stage. (c) Active decay. (d) Advanced decay. (e) Dry stage.