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Diversity, relative abundance and preference of blowflies to different food substrates in Qalyubiya Governorate, Egypt

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Abstract

Background: Blowflies are an important tool in forensic entomology by providing information for criminal investigations. **Methods:** The diversity and relative abundance of blowflies in summer and winter seasons in an urban and a rural area in Qalyubiya Governorate, Egypt were investigated. The preference of blowflies to different food substrates was also studied. **Results:** A total of 11,508 insects belonging to sixteen species from 10 families were collected. More insects were collected from the rural area (64.37%) than urban one (35.63%). Most (93.55%) of the collected insects belong to Order Diptera. *Chrysomya albiceps, Sarcophaga carnaria,* and *Lucilia sericata* made up 16.8%, 14.0%, and 12.5% of all the insects collected, respectively. Most adults were attracted to rabbit carcasses, followed by beef steaks and mouse carcasses. *Chrysomya albiceps, Chrysomya megacephala, Calliphora vicina,* and *Lucilia sericata* flies preferred rabbit carcasses, while *S. carnaria* and *Wohlfahrtia magnifica* flies preferred mouse carcasses. All flies' species were more abundant in the rural area except *S. carnaria* and *Drosophila melanogaster*. The relative abundance and diversity of *Chrysomya, Lucilia, Sarcophaga, Wohlfahrtia, Muscina, Musca, Drosophila,* and *Fannia* genera increased during the summer months. **Conclusions:** The abundance of insects on the rabbit carcasses may simulate conditions similar to human corpses. The present results may be helpful for legal investigations in the region and its surroundings.

Keywords: Forensic entomology, blowflies, food substrates, Egypt.

1. Introduction

Blowflies are attracted to corpses and are usually the first necrophagous fauna to find a cadaver, and it is believed that blowflies are attracted to certain corpses more than others due to stimuli or factors such as their natural temperature, substrate quality, tissue quality, speed of decomposition, and the amount of odor emitted [1]. Moreover, Woolridge et al. [2] and Ody et al. [3] referred to the fly's behavior in response to things like light and temperature in their environment, which may affect how responsive they are to oviposition.

A general understanding of the factors that influence the attraction of female calliphorid flies to oviposition on corpses is vital to enable forensic entomologists to address clandestine cadaver disposal situations and subsequently assess the onset of fly colonization [4].

In a previous study, Ibrahim et al. [5], employed eleven domestic guinea pig corpses as models for studying decomposition and insect succession in Benha city, Egypt. 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 the insect community increased as the state of decomposition advanced. Members of Dermistidae and Formicidae were the first coleopteran and hymenopteran colonizers in all seasons. *Sarcophaga, Wholfortia,* and *Chrysomya* were observed in spring and summer.

Most research on larval growth rates has focused on things like temperature [6], the number of larvae in a group and how crowded they are [7], and the effects of drugs [8]. In these and other studies, different types of meat have been used, such as mouse and rat carcasses [9], fish [10], and even fake foods containing whole milk powder, dried yeast powder, and wheat germ [11]. A multitude of forensic entomologists have utilized liver from animals, including sheep [12], cattle [13], and pigs [14], due to its accessibility and economic nature. Despite the extensive array of food substrates, there is only a scant amount of knowledge regarding the impact of frequently utilized feeding mediums on larval growth. Ibrahim et al. [15] studied the influence of larval density on some aspects of the population ecology and survival of *Chrysomya megacephala*, analyzing demographic aspects of adults kept under experimental conditions in Benha city. A positive effect of density on survival and the pre-oviposition period was observed.

The type and concentration of odors emitted during decomposition may affect the attraction of blowflies to the corpse [16]. Fly oviposition activity follows a circadian rhythm, delaying egg laying until low light conditions improve, as demonstrated by Woolridge et al. [2,17]. Additional factors impacting the accessibility of carrion or oviposition locations may also affect egg deposition. It is known that female *L. cuprina* lays more eggs in places where they have already laid them than in places that aren't being used [18]. Other species, like *Calliphora vomitoria*, have been seen probing dead bodies with their labellae and ovipositors to see how low the food supply is for larvae [19].

It is very important to look at fly preferences because they may help us figure out what a crime scene

object or human DNA has to do with the crime. If flies prefer a type of food found only during a crime (such as blood from violence), any traces of a less preferred food were deposited there prior to the crime and may not be relevant to the investigation.

This study examined the eating preferences of the blowflies when presented with various domestic foods, with particular emphasis on female attraction to oviposition through food sources. Also, the diversity and relative abundance of blowflies in a rural and an urban area in Benha City, Qalyubiya Governorate, were also recorded. The present results may be helpful for legal investigations in the region and its surroundings.

2. Methods

2.1 Study location

The study was conducted during the summer months of May, June, and July 2023, and winter months of October and November 2024, at two sites: the first on a college rooftop and in a corner of the garden of the Faculty of Science (30° 27' 53 N and 31° 11' 02 E), Benha, Qalyubiya Governorate, Egypt. The second site was a building rooftop within a residential area in Ramla village (30° 25' 27 N and 31° 09' 26 E), Qalyubiya Governorate. Environmental conditions (temperature and humidity) for the study area were obtained daily from the Egyptian Meteorological Authority.

2.2 Food substrates used

A variety of food substrates were used as insects' baits, including beef steaks, minced beef, beef livers, mackerel fish, rabbit carcasses, and mouse carcasses. All food substrates were purchased from the local market, portioned, and frozen fresh at -24 °C on the same day, except for the mouse carcass, which was used on the day of the experiment. All food sources were fresh and fit for human consumption at the time of the freeze. On the day of the experiment, the raw materials were removed from the refrigerator to bring to room temperature and portions. The baits (500 g) were placed in large plastic containers (30 cm in diameter; 12 cm in height) for fermentation, fly attractants, laying eggs, and growing larvae. A metal mesh cage was placed above the plastic containers to protect the baits and allow the flies to pass through.

2.3 Sample collection and identification

All insects attracted to the fermented baits were collected, along with many blowfly larvae. All insects, whether adults or larvae, were placed in Falcon 50 ml containing 75% alcohol and were sent to the laboratory for identification. Insects were examined and identified by using a LabMed CZM4 binocular optical microscope at the Entomology Department, Faculty of Science, using the following taxonomic keys: Thyssen [20] and Jones et al. [21].

2.4 Statistical analysis

The software SPSS V23 (IBM, USA) was used to analyze the data, and one-way analysis of variance (ANOVA) with the Post Hoc/Turkey's HSD test. X2 Test to evaluate the possible preferences of flies for type of environment (rural, urban) and baits. Paleontological statistics software "PAST" was used to elucidate the effects of environmental variables on the presence/abundance of species.

3. Results

General Faunistic Survey

A total of 11,508 specimens of insects were collected; most of them were collected from the rural area (64.37%), followed by 35.63% from the urban area (Fig. 1). Data presented in Table 1 and illustrated in Fig. 2 demonstrated the abundance of the prevalent families (n = 10), which have 16 species that were recorded in the study areas (Fig. 3). The most diverse order of insect species was Diptera (93.55% of the collected insects), with 10 species from five families, namely Calliphoridae, Sarcophagidae, Muscidae, Drosophilidae, and Fanniidae (Fig. 3a-j). Coleoptera came in second with three species from two families (4.1%) (Fig. 3k-m), and Hymenoptera came in third and last with three species from three families (2.3%) (Fig. 3n-p).

Insect preferences to different food substrates

Most insects were attracted to rabbit carcasses, followed by beef steaks and mouse carcasses (Table 1). *C. albiceps* was more abundant in the rural area (72.97%) than the urban one (27.03%) and preferred the rabbit carcass (Table 2 and Fig. 4). More Calliphora vicina was collected from the rural area (66.78%), and it preferred rabbit carcasses, followed by mackerel fish. *C. megacephala* was more abundant in the rural area (67.69%). Regarding bait type, it preferred rabbit carcass, followed by beef steak. More *L. sericata* (73.54%) was collected from the rural area, and it preferred rabbit carcasses, followed by mackerel fish.

No significant difference ($P < 0.01$) was found between the abundance of *S. carnaria* and *W. magnifica* in the urban and the rural area. Regarding the bait type, *S. carnaria* and *W. magnifica* preferred mouse carcass and beefsteak. Muscidae flies, *M. stabulans* and M. domestica, were more abundant in the rural area and preferred the liver bait and mackerel fish, respectively. Drosophila melanogaster was more abundant in the urban area (54.79%). Regarding bait type, it preferred the liver bait, followed by mackerel fish. More *Fannia* sp. (63.70%) was collected from the rural area. It preferred beef liver, followed by mackerel fish. Finally, we collected more *Dermestes frischii* from the rural area, which showed a preference for rabbit carcasses over other baits.

Generally, a positive and highly significant coefficient of correlation was found between the abundance of flies and the type of food ($P < 0.05$). Muscidae flies, *Drosophila*, and *Fannia* preferred mackerel fish, whereas *Calliphora vicina*, *Dermestes frischii*, *Chrysomya megacephala*, *Chrysomya albiceps*, and *Lucilia sericata* preferred rabbit carcasses. *Wohlfahrtia magnifica* and *Sarcophaga carnaria* were more attracted to beefsteak baits (Fig. 5).

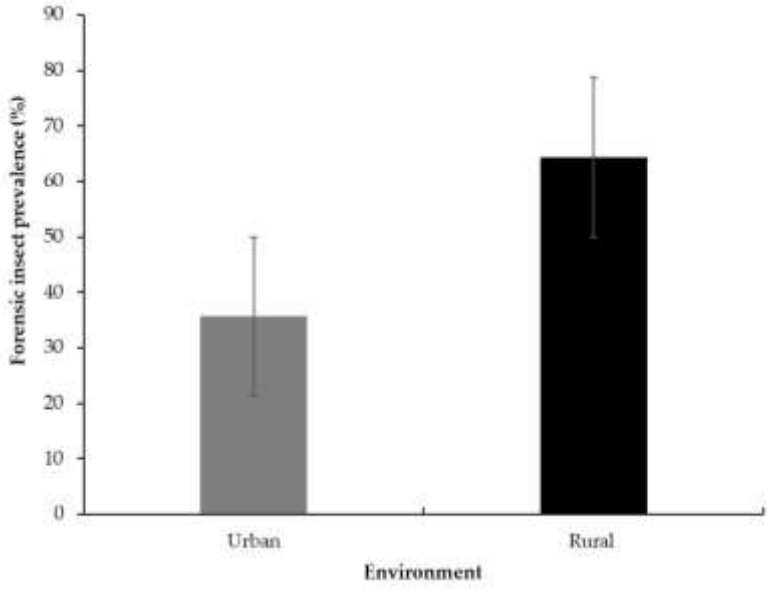

Fig. 1. Distribution of insects collected from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

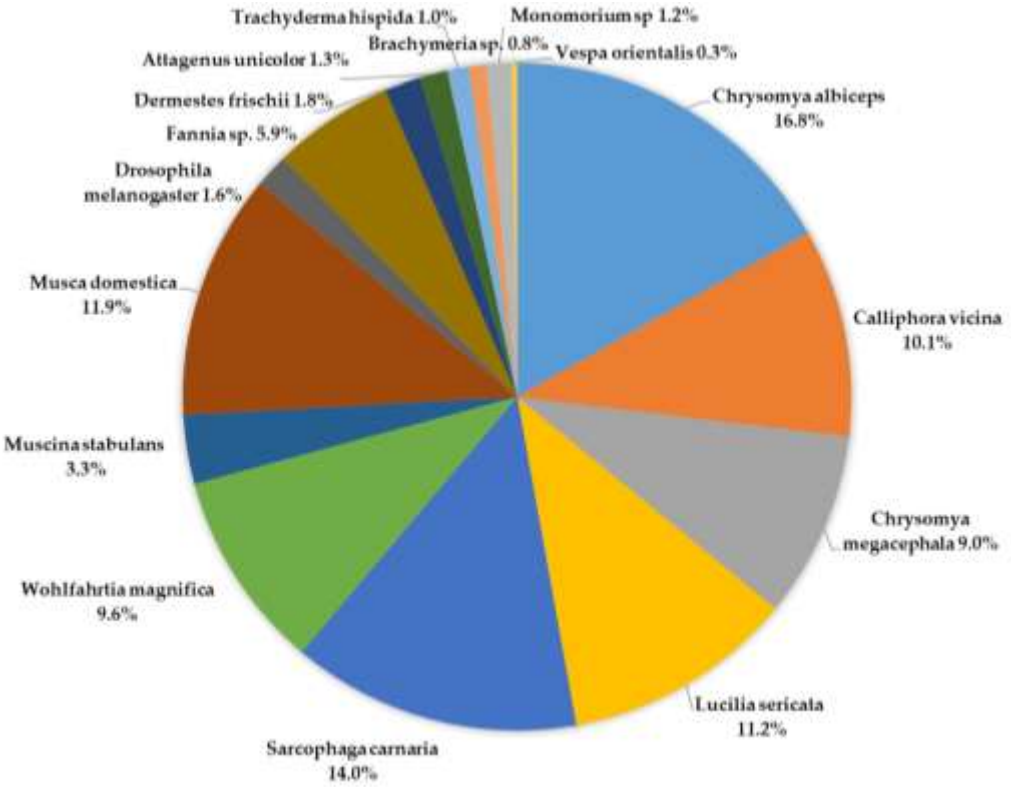

Fig. 2. Species diversity of the 10 insect families collected (n=11508) from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

Table 1. Insects collected from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

Order	Family	Species	Beef steak	Beef minced	Liver	Mackerel fish	Rabbit meat	Mouse carcass	Total (%)
Diptera	Calliphoridae	*Chrysomya albiceps*	420	350	170	150	665	180	1935 (**16.8**)
		Calliphora vicina	220	100	72	290	380	100	1162 (**10.1**)
		Chrysomya megacephala	250	130	80	120	350	110	1040 (**9.0**)
	Sarcophagidae	*Lucilia sericata*	280	240	190	150	420	160	1440 (**12.5**)
		Sarcophaga carnaria	300	200	150	130	360	470	1610 (**14.0**)
		Wohlfahrtia magnifica	190	150	110	70	240	350	1110 (**9.6**)
	Muscidae	*Muscina stabulans*	50	45	115	90	35	20	355 (**3.1**)
		Musca domestica	140	120	210	360	160	260	1370 (**10.9**)
	Drosophilidae	*Drosophila melanogaster*	14	17	80	45	22	10	188 (**1.6**)
	Fanniidae	*Fannia sp.*	50	75	210	160	100	80	675 (**5.9**)
Coleoptera	Dermestidae	*Dermestes frischii*	20	25	25	30	65	38	203 (**1.8**)
		Attagenus unicolor	8	15	20	36	45	30	154 (**1.3**)
	Tenebrionidae	*Trachyderma hispida*	24	18	14	10	35	19	120 (**1.0**)
Hymenoptera	Chalcididae	*Brachymeria sp.*	25	20	15	10	10	15	95 (**0.8**)
	Formicidae	*Monomorium sp.*	15	15	45	26	20	21	142 (**1.2**)
	Vespidae	*Vespa orientalis*	5	2	3	7	12	0	29 (**0.3**)
Total	**10 families**	**16 species**	**2011**	1522	**1509**	1684	**2919**	1863	11508 (**100**)

Table 2. Relative abundance and preference of Diptera species collected from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

	Fly species																	
	C. albiceps **(n= 1935)**		***C. vicina*** **(n= 1162)**		***C. megacephala*** **(n= 1040)**		***L. sericata*** **(n= 1440)**		***S. carnaria*** **(n= 1610)**		***W. magnifica*** **(n= 1110)**		***M. stabulans*** **(n= 355)**		***M. domestica*** **(n= 1250)**		***D. melanogaster*** **(n= 188)**		***Fannia sp.*** **(n= 675)**	
	%	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*
Environment																				
Urban	27.03	523	33.22	386	32.31	336	26.46	393	**52.80**	480	47.57	348	41.13	156	26.96	412	**54.79**	103	36.30	245
Rural	**72.97**	1412	66.78	776	67.69	704	**73.54**	897	47.20	830	52.43	762	58.87	229	**73.04**	958	45.21	85	63.70	430
Bait																				
Beef steak	21.71	420	18.93	220	24.04	250	19.44	280	18.63	280	17.12	190	14.08	50	11.20	140	7.45	14	7.41	50
Beef minced	18.09	350	8.61	100	12.50	130	16.67	240	12.42	200	13.51	150	12.68	75	9.60	120	9.04	17	11.11	75
Liver	8.79	170	6.20	72	7.69	80	13.19	190	9.32	150	9.91	110	32.39	115	16.80	210	42.55	80	31.11	210
Mackerel fish	7.75	150	24.96	290	11.54	120	10.42	150	8.07	130	6.31	70	25.35	90	28.80	360	23.94	45	23.70	160
Rabbit meat	34.37	665	32.70	380	33.65	350	29.17	420	22.36	360	21.62	240	9.86	35	12.80	160	11.70	22	14.81	100
Mouse carcass	9.30	180	8.61	100	10.58	110	11.11	160	29.19	470	31.53	350	5.63	20	20.80	260	5.32	10	11.85	80

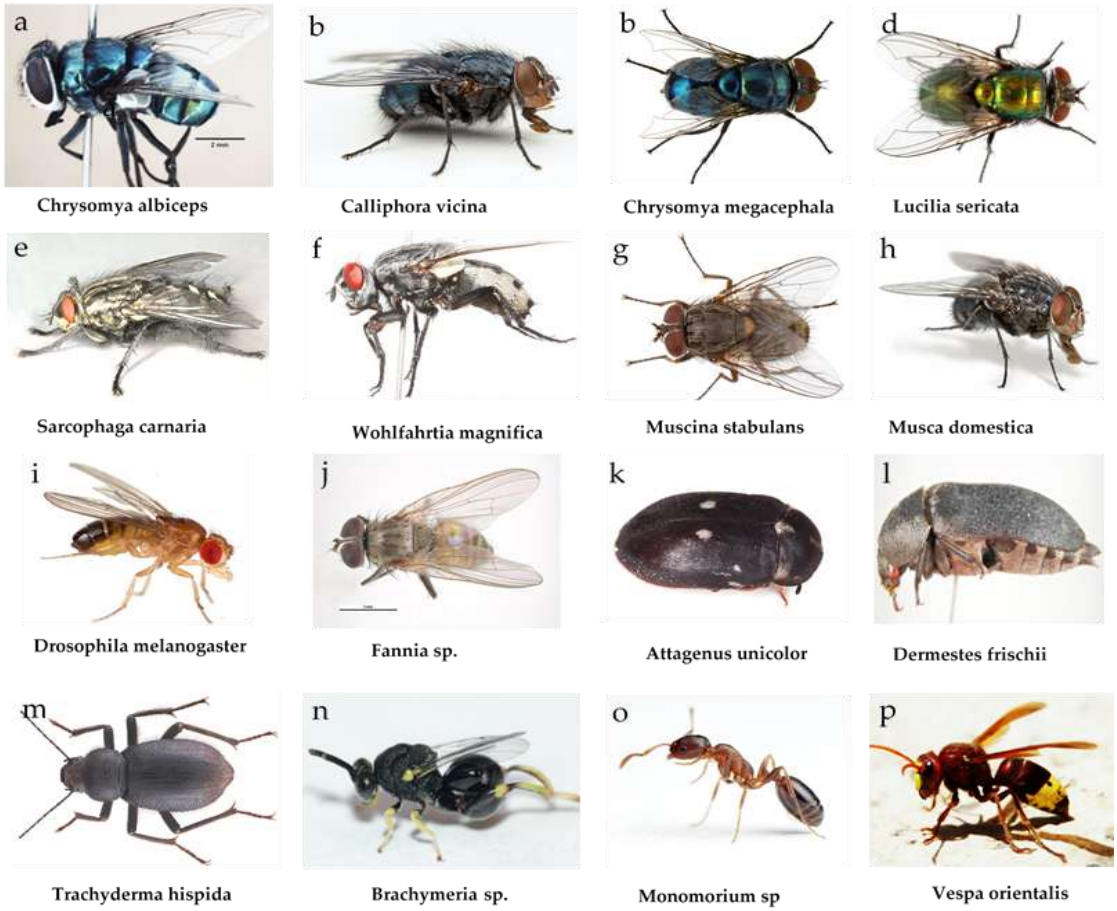

Fig. 3. Forensic insect species collected from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

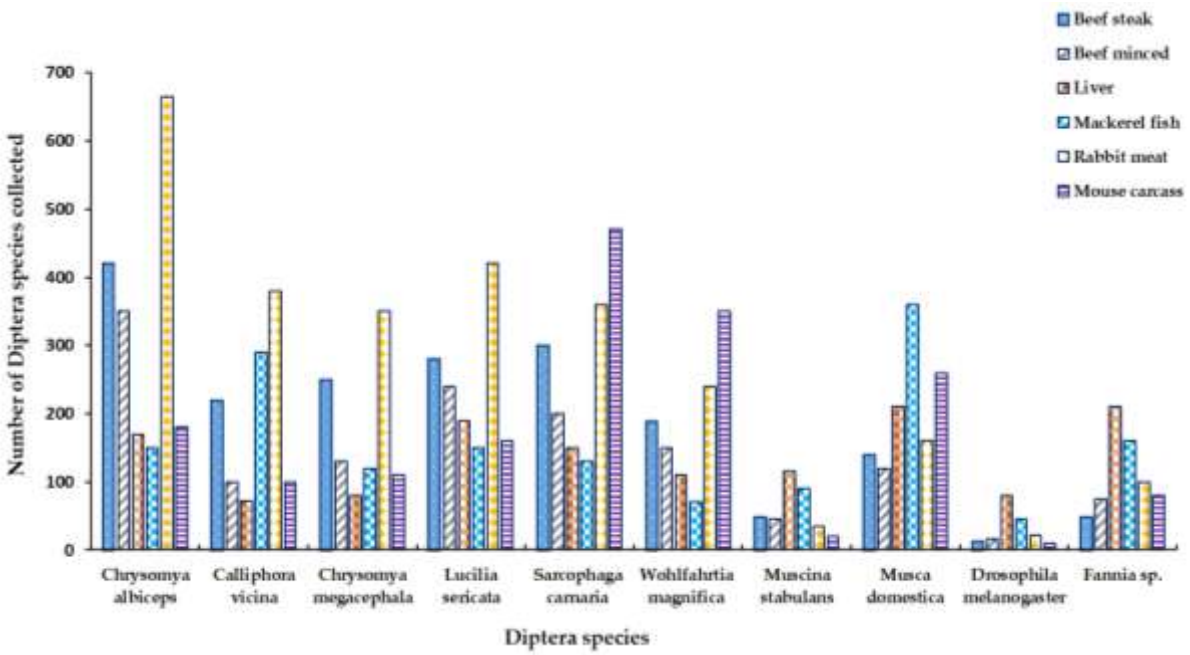

Fig. 4. Preferences of blowflies to different food substrates at Qalyubiya Governorate, Egypt.

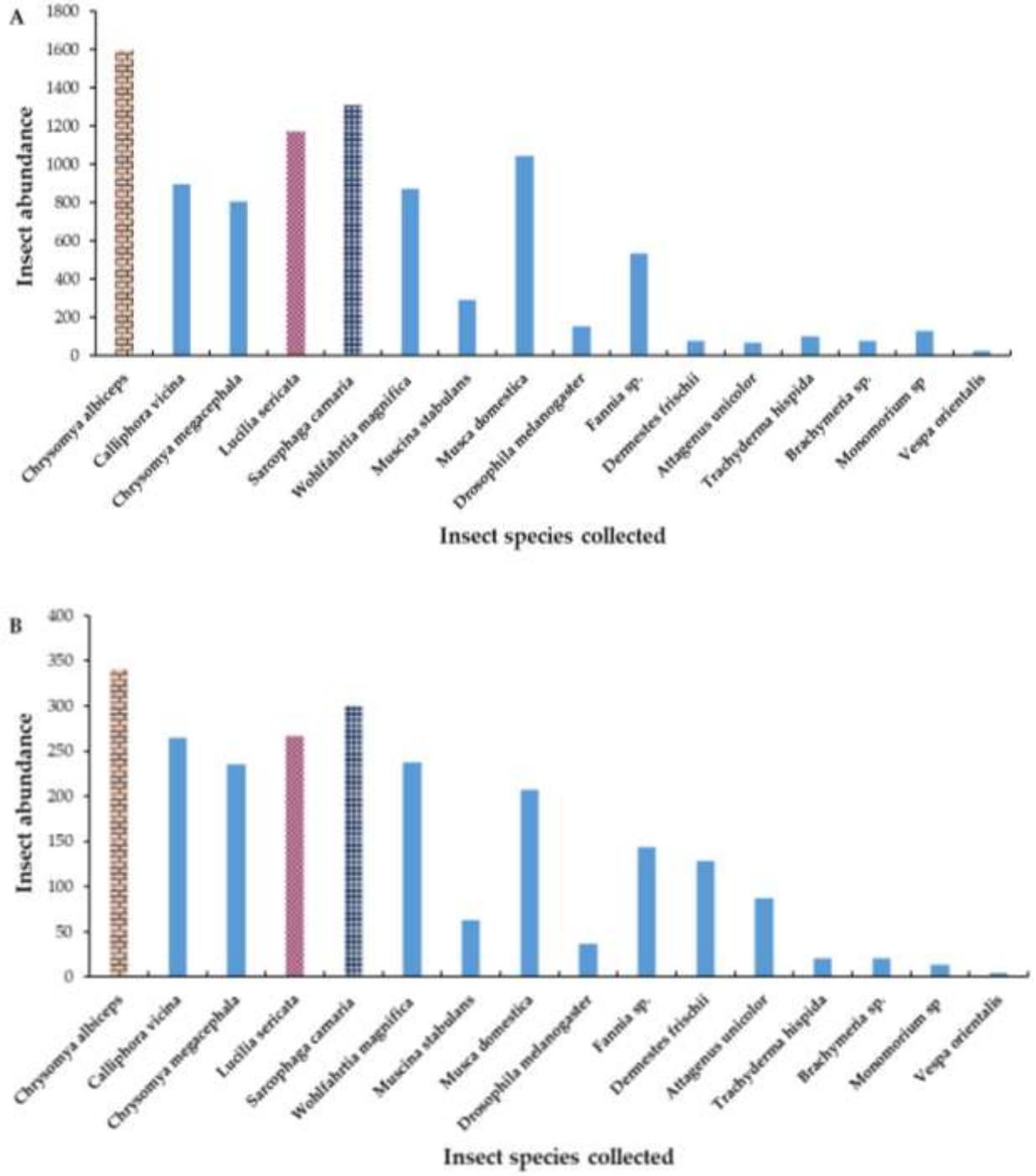

Fig. (5): The relative abundance and diversity of insects collected during summer (a) and winter (b) months from different baits in Benha city (urban area) and Ramla (rural area), Qalyubiya, Egypt during the years 2023/2024.

Relative abundance and diversity of blow flies

Table 1 presents the relative abundance and diversity of Calliphoridae, Sarcophagidae, and Muscidae flies in the study area. A total of 5427 Calliphoridae larvae from three genera (*Chrysomya, Calliphora*, and *Lucilia*) were collected during the study period. Collected flies belong to four species, namely, *Chrysomya albiceps, Calliphora vicina, C. megacephala,* and *L. sericata*. The genus *Chrysomya* exhibited greater diversity with two species, whereas Lucilia was represented by only one species. Data showed that Chrysomyinae insects constituted the majority, comprising 25.85% of the entire collection. Sarcophagidae flies occupied the second place in prevalence after blowflies and were represented by two species: *S. carnaria* and *Wohlfahrtia magnifica*. Muscidae flies were the least dense among the filth flies and were represented by Muscina stabulans and Musca

domestica. The relative abundance and diversity of *Chrysomya, Lucilia, Sarcophaga, Wohlfahrtia, Muscina, Musca, Drosophila,* and *Fannia* genera increased during the summer months, with a total number of 1595, 897, 805, 1173, 1310, 873, 292, 1043, 151, and 531, respectively (Fig. 5a). The highest abundance of *Chrysomya albiceps* (1595 flies), *Sarcophaga carnaria* (1310 flies), *Lucilia sericata* (1173 flies), and *Musca domestica* (1043 flies) was recorded in the summer months. Low abundance of *C. albiceps* (340 flies), S. carnaria (300 flies), *L. sericata* (267 flies), *Calliphora vicina* (266 flies), *W. magnifica* (237 flies), and *C. megacephala* (235 flies) were recorded in the winter period (Fig. 5b). The average recorded temperature in summer months was (32-34 °C), while the average recorded temperature in the winter months was (22-25 °C). The study area recorded moderate relative humidity (52% and 63% RH) during the summer and winter months of the year, respectively

4. Discussion

From an ecological perspective, a cadaver constitutes a transient yet abundant habitat that draws various groups of insects and other arthropods. These insects perceive volatile signals emitted by the decaying carcass, which serve as sources of nourishment, refuge, and oviposition sites [22]. An understanding of the biology and ethology of these insects, together with medical and ethnographic data, can elucidate the conditions surrounding death [1].

According to our data, the most important groups for breaking down dead bodies are Diptera, followed by some other insects like Coleoptera and Hymenoptera. Aspoas [23] also reported similar findings. Our results showed that the depletion of carcasses was mainly attributed to the larvae of blowflies and flesh flies, along with numerous other flies that appear as decomposition progresses. Blowflies are attracted to corpses within minutes or even seconds after exposure to carrion due to their intense physiological desire to access their food source and oviposition site [24]. Blowflies are reported by many investigators as the most frequently observed in the first few weeks after a body is found, so they may provide a more accurate picture of the shorter postmortem period compared to other carrion insects [19]. The high abundance of Calliphoridae in the present study may be attributed to the attraction of these flies to the carcass because newly decomposing tissue releases chemicals rich in ammonium and sulfur. Females' pheromones may also attract them to the body. Gravid females lay their eggs in mucosal openings and in sores and bodily wounds [25].

Results of the present work confirmed the presence of 16 species as the most diverse insects in the study area. Diptera species, namely, *Chrysomya albiceps, C. vicina, C. megacephala, L. sericata, S. carnaria, W. magnifica,* and *M. domestica* flies, were more abundant and the most prevalent among the collected insect species. Our data aligns with several studies, confirming that *Chrysomya albiceps* was the most common fly species during summer and winter months, and it was also the most prevalent on all baits, particularly rabbit meat and beef steak [26-29]. In a similar study, Ibrahim [5] used eleven domestic guinea pig carcasses as models to study decomposition and insect succession in Benha, Egypt. *Chrysomya albiceps, Sarcophaga carnaria,* and *Wohlfahrtia magnifica* were more common and were the first colonizers to breed on guinea pig corpses. The study proved that insect diversity is increased with the increase in corpse decomposition.

The highest abundances of *Chrysomya albiceps, Sarcophaga carnaria, Lucilia sericata,* and *Musca domestica* were recorded in the summer months. Differences in abundance at different temperatures may be attributed to the fact that different insect species have different temperature requirements and development needs depending on where they live [30]. This may indicate why developmental studies are important. Moreover, geographical location and season influence the species makeup and succession patterns of a deceased cadaver [31].

Our results declared that Calliphoridae larvae were the most common and plentiful collected insects. They were found on 86.66% of the carcasses and infested the remains in summer and winter months. The most common species, *Chrysomya albiceps,* was found on 73.33% of the bodies. The high abundance of *C. albiceps* may be due to its ability to decrease the densities of other species. *C. albiceps* functions as an intrigued predator during its larval stage and may consume the eggs and larvae of other insects, especially muscoid dipterans that are attracted to a cadaver, thereby influencing the faunal composition [27]. The competitiveness of C. albiceps and its ability to survive in harsh environments may help explain why this species' abundance is not only linked to environmental factors.

Similar findings were also reported in Egypt by other authors as Ibrahim et al. [5], Tantawi et al. [32], and [28]. In the Jazan region, Saudi Arabia, Alahmed et al. [33] carried out a survey of myiasis-inducing flies using red top flycatcher traps baited with either decomposing beef liver or a fishmeal-based lure. The authors identified seven species from the Calliphoridae family, which includes *Chrysomya, Lucilia,* and *Hemipyrella*. The other five were from the Sarcophagidae family, which includes *Sarcophaga*.

Our data showed that more insect species were collected from rural area than urban area, except for Sarcophaga carnaria and Drosophila melanogaster, which showed higher densities in urban area than rural one.

Many studies indicate that Calliphoridae, Sarcophagidae, and Muscidae families are of interest and are significant principal consumers of carrion and are frequently located on human remains. Their eating habits allow for the utilization of development rates to furnish temporal information in forensic investigations [34]. Blowflies are the initial insects to inhabit

carcasses and bodies following death and regional studies that show the link between changes in climate and the biological traits of insects are necessary to improve the accuracy of PMI assessments in local medical-legal investigations

5. Conclusion

Blowflies, or carrion flies, were abundant during both summer and winter months and in the urban and rural areas selected, this may be due to the moderate climate and humidity of the study area. The study sites revealed the abundance of various insects, especially blowflies. *Chrysomya albiceps* was the most common species, followed by *S. carnaria* and *L. sericata*. Generally, positive and highly significant coefficient of correlation was found between the abundance of flies and the type of food. The information presented here highlights the importance of this significant group of flies responsible for carrion attacks in both urban and rural areas of Qalyubiya Governorate, Egypt. Data obtained from this study may help in a more understanding of the ecology and host preference of blowflies. The abundance of blowflies on the rabbit carcasses which is more or less similar to human corpses may be helpful for legal investigations in the region and its surroundings.

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