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## Diversity and species succession of forensic fauna associated with normal & burned fish carcasses in Gujarat, India

Dipak Kumar Mahida<sup>1</sup>, Deepak Kaldhone<sup>1</sup>, Aamir Matli<sup>2</sup>, Nidhi Gondaliya<sup>3</sup>, Ankita Patel<sup>4\*</sup>

<sup>1</sup> Research Scholar, Department of Biochemistry & Forensic Science, Gujarat University, Ahmedabad, Gujarat, India

<sup>2</sup> Navrachna University, Vadodara, Gujarat, India

<sup>3</sup> Assistant Professor, Department of Life Science, Gujarat University, Ahmedabad, Gujarat, India

<sup>4</sup> Assistant Professor, Department of Biochemistry & Forensic Science, Gujarat University, Ahmedabad, Gujarat, India

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### Abstract

An implication of insects in criminal investigations is not a new field. Forensic entomology developed through the 13<sup>th</sup> century. It deals with the application of insects and arthropods to solve crimes. It provides many helpful outputs about cadavers which can lead us to solve the committed crime. Proper identification of insects and analysis of succession is important to utilize these insects for estimating postmortem interval (PMI). In this article, a comparative study of biodiversity and species succession of Forensic fauna associated with normal and burned fish carcasses is reported. This study was conducted in a rural area, near Palitana city located in the Saurashtra region, Gujarat, India. The period of study was 20 days of the winter season from 7<sup>th</sup>-26<sup>th</sup> February 2020. 22 species of three orders namely Diptera, Coleoptera, and Hymenoptera were developed on the carcasses. The pattern of their success concerning the decomposition of carcasses was also noted. On the carcasses, ants are predominant in this area and one member of Chalcididae namely *Brachymeria podagrica* was also observed as a parasite.

**Keywords:** forensic science, forensic entomology, biodiversity, species succession, decomposition

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### Introduction

Carrion ecology study is an interdisciplinary field of forensic entomology as well as forensic anthropology (Byrd *et al.*, 2019)<sup>[3]</sup>. Animal models are used for understanding decomposition patterns and affective factors in human cadavers (Finley *et al.*, 2015)<sup>[8]</sup>. In forensic science, it is very common to find decomposed bodies at the crime scene by the investigators. After death, carrion develops their ecology which depends upon biological, chemical, and environmental factors (Catts *et al.*, 1992)<sup>[5]</sup>. Decomposition is a natural process that starts instantly as soon as the animal dies. The odor released out of the decaying organism attracts many Necrophagous. Speaking in Forensic terms, they are the first visitors to the crime scene. Their identification and study of their arrival pattern are very helpful in the estimation of post-mortem interval (PMI) (Rivers *et al.*, 2014)<sup>[14]</sup>. They can also provide information about a primary or secondary crime scene. The area i.e., urban, suburban or rural matters in determining the pattern of succession (Amendt *et al.*, 2011)<sup>[1]</sup>. Some bacteria, fungi, flies, beetles, ants, wasps, and moths play a major role in the decomposition of the organism (Byrd *et al.*, 2019)<sup>[3]</sup>. Here, we present a study of the carrion ecology of normal and burned fish carcasses. As an objective, the rate and features of decomposition were also noted during this study. Normal and burned carcasses don't need to attract different species of insects but the status of the cadaver also matters in the succession pattern of insects (Campobasso *et al.*, 2001)<sup>[4]</sup>. In burned cadavers, an odor of decay merges with the smell of combustible materials which were used for burning it. Insects cannot detect the odor of decaying organisms until the combustible material has completely volatilized (Gunn *et al.*, 2019)<sup>[10]</sup>. Burned dead bodies are usually found in crimes committed under revenge or violence, such as murder, suicide, arson, dowry death, etc. In such cases, the identification and investigation of burned bodies are very challenging. By estimating post-mortem interval (PMI), corpus delicti can be established and crime can be solved (Vij *et al.*, 2011)<sup>[18]</sup>.

Decomposers which include small insects to big scavengers are the natural environmental activists because they are playing a predominant role in the cleaning environment naturally by eating the dead bodies. Some of these natural decomposers also contribute to solving crime which developed a new branch in the forensic domain known as Forensic Entomology; an important field where basic arthropod science and the judicial system interact (Byrd *et al.*, 2001). Although the insects are small in size, they contribute to lions share in forensic entomology because insect evidence sometimes provides more crucial information than autopsy (Goff *et al.*, 1988)<sup>[9]</sup>. Forensic entomologist should have a keen knowledge of the local fauna, especially of insects, their variety, and their succession; because Insects tells the story about the elapsed time since the death of a particular dead body. The surrounding environment or regional condition plays a vital role in the estimation of accurate PMI as species

succession mostly depends upon the Surrounding environment. Chung Yen Pai *et al* (2007) <sup>[13]</sup> based on experimentally calculated PMI from the information of the maggots from the burned pig corpse, successfully measured the actual PMI for the burned human body (Pai *et. al.*, 2007) <sup>[13]</sup>. V.K. Kashyap and V.V. Pillay (1988) <sup>[11]</sup> also did experiments on insect-infested cadavers to find out the reliability of the entomological method in the estimation of postmortem interval by comparing the medicolegal methods and entomological evidence and found that the entomological method is statistically more reliable and superior than any other methods (Kashyap *et. al.*, 1989) <sup>[11]</sup>. In some cases, insects are completely absent. The absence of insect can be used for the estimation of PMI (Wells, 2019) <sup>[19]</sup>. M. Lee Goff *et al* (1988) <sup>[9]</sup> studied three different habitats of Hawaiian island *viz.* xerophytic, mesophotic and swamp for the estimation of postmortem interval by using a computer-assisted entomological technique and they found that the xerophytic habitat causes fewer decomposition changes as compared to swamp habitat which causes drastic decomposition change in carcasses (Goff *et. al.*, 1988) <sup>[9]</sup>.

## Materials and method

### 1. Location of Study

This study was performed from 7<sup>th</sup>-26<sup>th</sup> February 2020 in a rural area, near Palitana city located in the Saurashtra region of Gujarat, India. It is a rural residential area with an average elevation of 67 meters. The average temperature of this area is 31.5°C from May to August and the lowest average temperature from December to January is noted to be 19.8°C. With average annual rainfall is 24 inches. The actual site selected for this study was a garden (NL -21°31'38", EL - 71°48'44") because of free from disturbance and away from public activities. This site was characterized by the vegetation of native shrubs and lemon trees.

### 2. Material used

In this study, freshwater fish- the Pool barb fish (*Puntius sophore*) was selected. The four fish carcasses with the nearly same weight (250-300 grams) were used out of which two fish were burned using petrol at the site of the study. The main purpose of using petrol to burn fish is the easy availability of petrol and it is commonly used as combustible material in violent crimes. Normal and Burned carcasses were placed at the same site but in a different place. Protective cages made by using wooden frames covered with wire mesh were used to protect the fish from scavengers. The size of the mesh was much enough to pass for insects. In this study, every 4 hours during the day (7 am-7 pm) each carcass was checked, and observations were noted.

### 3. Collection and identification of specimen

Samples of insects were collected by using various entomological tools (Insect Net, Forceps, and acrylic paint brush). Flies and beetles were killed by using chloroform and preserved using the pinning method. While ants and premature stages were directly placed in vials containing 40% formalin (Lord *et. al.*, 1983; Schauff *et. al.*, 2001). The unidentified larvae were reared in net baskets till their adult stages for their proper identification. All the collected larvae were observed under the light microscope and identified by using various taxonomic keys (Thyssen *et. al.*, 2009; Falk *et. al.*, 2016; Dodge *et. al.*, 1953) <sup>[16, 7, 6]</sup>.

## Results and Discussion

### 1. Decomposition

All normal and burned carcasses were decomposed in four different stages: Fresh, Bloated, Decay, and Dry (Bharti *et. al.*, 2003) <sup>[2]</sup>. In all carcasses, the pattern of decomposition was likely to be the same. Differences can be delimited by the duration hours of each stage taken by normal and burned carcasses.

**Fresh stage:** It is the first stage in which all fish bodies were seen intact and not any prominent sign of decomposition was found. Only skin became dry and fins became tuff. The duration of the fresh stage lasted from 0-44 hrs and 0-29 hrs for normal and burned carcasses respectively.

**Bloated stage:** In this stage carcasses became swollen with a strong odor and seeping of liquid through the body openings. The duration of the bloated stage lasted from 44-48 hrs and 29-48 hrs for normal and burned carcasses respectively.

**Decay stage:** The maggots started piercing the skin of carcasses. The typical smell became weak. Scattered scales of body and pulverized soil due to insect activities were also observed. The duration of the decay stage lasted from 48-168 hrs and 48-255 hrs for normal and burned carcasses respectively.

**Dry Stage:** Carcasses consisted of dry skin only, scattered scales, and skeletal remains. In large numbers, Coleopteran larvae were found around cadavers. Puparia of the Sarcophagus was also found during this stage. The duration of the dry stage was from 120 hrs and 48 hrs onwards for normal and burned carcasses respectively.

**Table 1:** Duration hours of each stage of Decomposition

Sr. No.	Stage of Decomposition	Duration in hours	
		Normal Carcasses	Burned Carcasses
1	Fresh	44	29
2	Bloated	48	48

3	Decay	168	255
4	Dry	120 onwards	48 onwards

## 2. Diversity of Species

Here, the diversity of insects on both, normal and burned carcasses has remained the same during the whole study. As shown in table-2, a total of 22 species belonging to 10 families of 3 orders (Diptera, Coleoptera, and Hymenoptera) were observed on cadavers.

**Table 2:** List of Forensic Fauna associated with Normal and Burned carcasses

Order	Family	Species
Diptera	Muscidae	<i>Musca domestica</i>
		<i>Hydrotaea capensis</i>
	Calliphoridae	<i>Chrysomya megacephala</i>
		<i>Chrysomya rufifacies</i>
		<i>Lucilia sericata</i>
		<i>Lucilia illustris</i>
		<i>Calliphora vomitoria</i>
		<i>Calliphora vicina</i>
		<i>Cochliomyia machellaria</i>
	<i>Comptosyiops sp.</i>	
	Sarcophagidae	<i>Sarcophaga albiceps</i>
<i>Sarcophaga hirtipes</i>		
<i>Sarcophaga bullata</i>		
Coleoptera	Cleridae	<i>Necrobia rufipes</i>
	Tenebrionidae	<i>Genocephalum sp.</i>
		<i>Scleron sp.</i>
	Dermestidae	<i>Dermester meculatus</i>
	Histeridae	<i>Saprinus sp.</i>
Staphylinidae	<i>Philonthus sp.</i>	
Hymenoptera	Cachidadae	<i>Brachymeria podagrica</i>
	Formicidae	<i>Pheidole sp.</i>
		<i>Dorymyrmex sp.</i>



**Fig 1:** Some important species (1)*Chrysomya megacephala* (2)*Musca domestica* (3)*Scleron sp.* (4)*Brachymeria podagrica* (5)*Pheidole sp.* (6)*Sarcophaga bullata*

### 3. Species Succession

#### 3.1 Diptera

The first visitors after the carcasses were placed were observed to be Flies. A total of 13 species belonging to three families (Muscidae, Calliphoridae, and Sarcophagidae) of the order Diptera were found on both normal and burned carcasses (Vasconcelos *et al.*, 2013)<sup>[17]</sup>.

On normal carcasses, *Musca domestica* was the first one to arrive. It arrived only within four hours of placing the carcass and was seen during the whole study. It was followed by *Chrysomya megacephala*, which reached on the first day and remained till the 11<sup>th</sup> day (decay stage). *Comptosomyiops sp.* arrived on the 3<sup>rd</sup> day and remained till the last day of study. It was not seen during the fresh stage. *Calliphora vomitoria* arrived on the first day but it lasted for 10 days only. *Chrysomya rufifacies* were also noted on the 1<sup>st</sup> day till the 8<sup>th</sup> day. Three species namely *Lucilia sericata*, *Cochliomyia machellaria*, and *Sarcophaga bullata* arrived on the 3<sup>rd</sup> day (bloated stage) and lasted till the end. Other species were observed as opportunistic visitors and in less quantity.

On burned carcasses, *Musca domestica* was the first Dipteran that arrived and lasted till the end of the study. On the 2<sup>nd</sup> day, *Calliphora vomitoria* were observed which remained till the 7<sup>th</sup> day. *Chrysomya megacephala* was observed during the 3<sup>rd</sup> to 8<sup>th</sup> day. *Comptosomyiops sp.* arrived on the 3<sup>rd</sup> day but it lasted till the dry stage only. *Calliphora vicina* was observed only once which was on the 6<sup>th</sup> day. Other species, which were observed in the normal carcass were rarely seen during the study.

#### 3.2 Coleoptera

Coleoptera is the second dominant order in carrion ecology study. Six species belonging to five families namely Cleridae, Tenebrionidae, Dermestidae, Histeridae, and Staphylinidae were observed. Beetles mainly come as finishers. They play an important role in the dry stage and the decomposition of the skeletal remains (Byrd *et al.*, 2019)<sup>[3]</sup>.

On normal carcasses, Beetles started arriving on the 5<sup>th</sup> day of study. It was an early decay stage. *Necrobia rufipes* was the most dominant beetle in this area. It was seen from the 5<sup>th</sup> day till the end of the study. *Genocephalum sp.* arrived on the 6<sup>th</sup> day and remained till the end. *Dermester maculatus* came on the 8<sup>th</sup> day and remained till the last day. Other 3 species, namely *Scleron sp.*, *Philonthus, sp.*, and *Saprinus sp.* came as fish reached in dry stage only.

On burned carcasses, *Necrobia rufipes* were the dominant species which was seen from the 5<sup>th</sup> day till the end of the study. *Genocephalum sp.* and *Dermester maculatus* were also seen till the end which arrived the on 7<sup>th</sup> and 8<sup>th</sup> day respectively. *Sceleron sp.*, *Philonthus sp.*, and *Saprinus sp.* arrived and remained the same as normal carcasses.

#### 3.3 Hymenoptera

Hymenopterans are usually observed as parasites (Byrd *et al.*, 2019)<sup>[3]</sup>. Two species of Formicidae and One of Chalcididae were observed. Ants are predominant in this area. *Brachymeria podagrica* remained the same in both, normal and burned carcasses. All three species were observed to be feeding on larvae of flies.

On normal carcasses, *Dorymyrmex sp.* was the most dominant and most abundant among all species. It was observed throughout the study. A maximum number of individuals of *Dorymyrmex sp.* was seen on the first day of the decay stage. *Pheidole sp.* was seen throughout the study but abundance was less than *Dorymyrmex sp.* *Brachymeria podagrica*, a parasitoid wasp arrived on the 4<sup>th</sup> day and remained till the end.

On burned carcasses, *Pheidole sp.* was most dominant and most abundant among all species. It was present throughout the study. *Dorymyrmex sp.* and *Brachymeria podagrica* came on the 4<sup>th</sup> day and remained till the end of the study.

The occurrence of numbers of species on normal and burned carcasses as well as the appearance of various species during the decomposition stage in both the carcasses are shown in Tables 3 and 4 respectively.

**Table 3:** Occurrence of numbers of species

Sr. no.	Name of species	Normal Carcasses		Burned Carcasses	
		Numbers	Percentage (%)	Numbers	Percentage (%)
1.	<i>Musca domestica</i>	21	16.03	16	12.59
2.	<i>Hydrotae acapensis</i>	03	2.29	02	1.57
3.	<i>Chrysomya megacephala</i>	05	3.81	04	3.14
4.	<i>Chrysomya rufifacies</i>	03	2.29	02	1.57
5.	<i>Lucilia sericata</i>	02	1.52	02	1.57
6.	<i>Lucilia illustris</i>	02	1.52	02	1.57
7.	<i>Calliphora vomitoria</i>	03	2.29	02	1.57
8.	<i>Calliphora vicina</i>	01	1.52	02	1.57
9.	<i>Cochliomyia machellaria</i>	02	2.29	02	1.57
11.	<i>Comptosomyiops sp.</i>	06	4.58	06	4.72
11.	<i>Sarcophaga bullata</i>	04	3.05	03	2.36
12.	<i>Sarcophaga albiceps</i>	02	1.52	03	2.36
13.	<i>Sarcophaga hirtipes</i>	05	3.81	03	2.36

14.	<i>Necrobia rufipes</i>	10	7.63	13	10.23
15.	<i>Genocephalum sp.</i>	07	5.34	06	4.72
16.	<i>Scleron sp.</i>	02	1.52	01	0.78
17.	<i>Dermester maculates</i>	09	6.87	09	7.08
18.	<i>Saprinus sp.</i>	02	1.52	01	0.78
19.	<i>Philonthus sp.</i>	04	3.05	02	1.57
20.	<i>Brachymeria calliphorae</i>	08	6.1	09	7.08
21.	<i>Pheidole sp.</i>	13	9.92	24	18.89
22.	<i>Dorymyrmex sp.</i>	27	20.61	13	10.23
	Total	131		127	

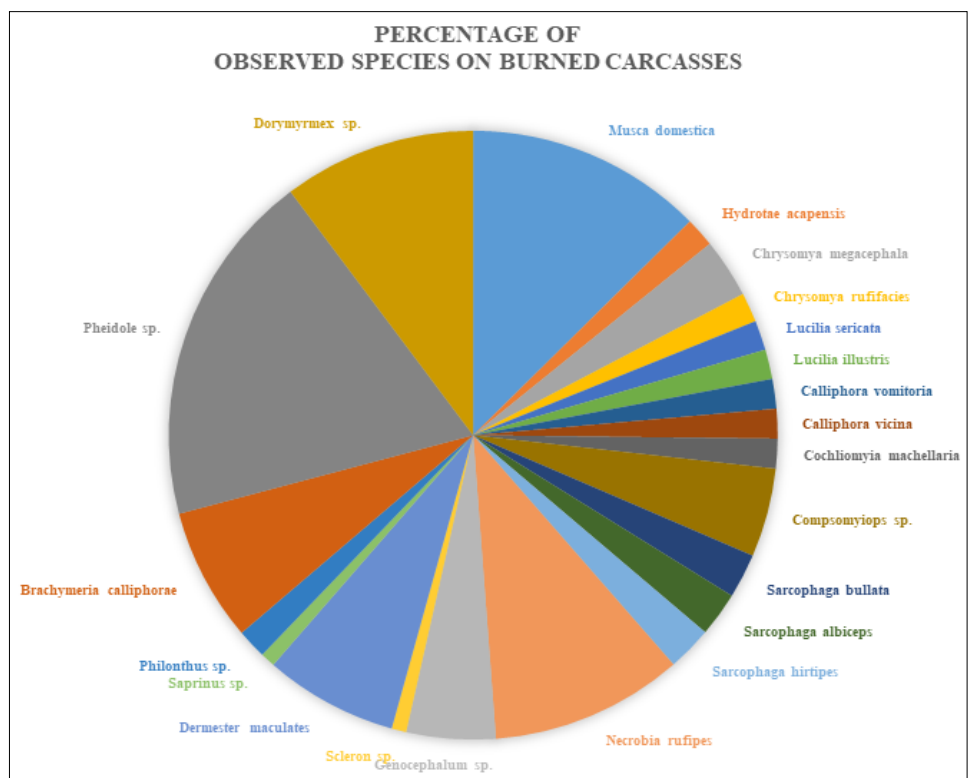
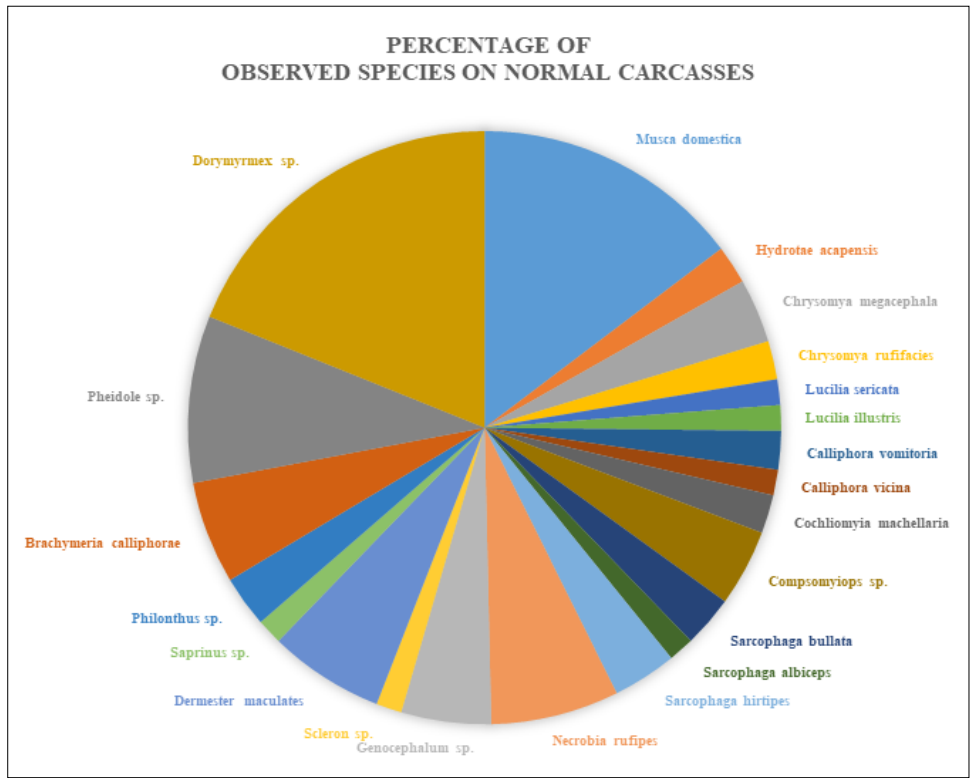


Fig 2: Occurrence of percentages of observed species

**Table 3:** Appearance status of various species during Decomposition stages.

Sr. no.	Species	Normal Cadavers				Burned Cadavers			
		Fresh	Bloated	Decay	Dry	Fresh	Bloated	Decay	Dry
1	<i>Musca domestica</i>	✓	✓	✓	✓	✓	✓	✓	✓
2	<i>Hydrotaea capensis</i>	✗	✓	✓	✗	✗	✗	✓	✗
3	<i>Chrysomya megacephala</i>	✓	✓	✓	✓	✓	✓	✗	✗
4	<i>Chrysomya rufifacies</i>	✓	✓	✓	✗	✗	✓	✓	✗
5	<i>Lucilia sericata</i>	✓	✓	✓	✗	✗	✗	✓	✗
6	<i>Lucilia illustris</i>	✗	✗	✓	✗	✗	✗	✓	✗
7	<i>Calliphora vomitoria</i>	✓	✓	✓	✓	✓	✓	✓	✗
8	<i>Calliphora vicina</i>	✗	✓	✓	✗	✗	✗	✓	✗
9	<i>Cochliomyia machellaria</i>	✗	✓	✓	✗	✗	✗	✓	✗
10	<i>Comptosyriops sp.</i>	✓	✓	✓	✓	✓	✓	✓	✓
11	<i>Sarcophaga albiceps</i>	✗	✓	✓	✗	✗	✗	✓	✗
12	<i>Sarcophaga hirtipes</i>	✗	✓	✓	✗	✗	✗	✓	✗
13	<i>Sarcophaga bullata</i>	✗	✓	✓	✗	✗	✗	✓	✗
14	<i>Necrobia rufipes</i>	✗	✓	✓	✓	✗	✓	✓	✓
15	<i>Genocephalum sp.</i>	✗	✗	✓	✓	✗	✗	✓	✓
16	<i>Scleron sp.</i>	✗	✗	✓	✓	✗	✗	✓	✓
17	<i>Dermester meculatus</i>	✗	✗	✓	✓	✗	✗	✓	✓
18	<i>Saprinus sp.</i>	✗	✗	✓	✓	✗	✗	✓	✓
19	<i>Philonthus sp.</i>	✗	✗	✗	✓	✗	✗	✗	✓
20	<i>Brachymeria podagrica</i>	✗	✓	✓	✓	✗	✓	✓	✓
21	<i>Pheidole sp.</i>	✓	✓	✓	✓	✗	✓	✓	✓
22	<i>Dorymyrmex sp.</i>	✓	✓	✓	✓	✗	✗	✓	✓

### Conclusion

This study provides the baseline data to Forensic Entomologists for the Saurashtra region, Gujarat. Normal and burned Carcasses contained the same diversity of Forensic insect fauna. Interestingly the rate of decomposition of burned carcasses was seen to be much slower than the normal carcass. Also, insects were observed to take more time to colonize on burned carcasses in comparison to the normal carcasses. This may be because of the availability of more flesh in the normal carcasses as compared to the burned ones. According to our study Hymenopterans were predominant in this area. They can influence the estimation of post-mortem interval (PMI) due to their parasitic habits.

### Conflict of interest

The authors declare no conflicts of interest.

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