A Study of Forensically Important Insects in Chalisgaon, Jalgaon, Maharashtra

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Abstract—**This study presents the first comprehensive documentation of forensically important insects in Chalisgaon, Jalgaon district, Maharashtra, India, to establish regional baseline data for forensic entomology. Over one year, insect specimens were collected from diverse habitats using sweep netting, pitfall traps, light traps, and direct sampling from carrion. Morphological identification and statistical analyses revealed 27 species across 5 orders (Diptera: 73%, Coleoptera: 21.7%, Hymenoptera: 2.4%, Lepidoptera: 1.1%, Blattodea: 0.8%) and 12 families. Calliphoridae (Diptera) dominated (54%), with Chrysomya megacephala (17.2%) and C. rufifacies (15.8%) as the most abundant species. Seasonal variations significantly influenced insect abundance: Diptera peaked during monsoon (45.2 ± 4.1 individuals), while Coleoptera thrived post-monsoon (15.4 ± 1.7). Temperature and humidity strongly correlated with Diptera colonization (r = 0.78 and 0.65, respectively), whereas rainfall negatively affected Coleoptera (r = -0.39). Succession patterns aligned with decomposition stages— Calliphoridae and Sarcophagidae colonized fresh remains, while Staphylinidae and Dermestidae dominated advanced decay. Biodiversity indices indicated highest diversity post-monsoon (Shannon-Wiener H'=2.83; species richness=25). These findings underscore the importance of regional insect succession data for accurate postmortem interval estimation in forensic investigations. Future research should integrate molecular techniques for species identification and assess developmental rates under varying environmental conditions to enhance forensic applications in Maharashtra.**

Index Terms—**Forensic entomology, Insect diversity, Decomposition stages, Diptera, Coleoptera, Calliphoridae, Postmortem interval (PMI), Species succession, Necrophagous insects.**

I. INTRODUCTION

The study of insect diversity holds paramount significance in various scientific disciplines, extending its relevance to forensic entomology, where insects serve as crucial indicators in criminal investigations (Chimeno et al., 2023). Forensic entomology, a specialized branch of forensic science, leverages the intricate knowledge of insect life cycles, their behaviors, and ecological interactions to interpret criminal evidence within a legal framework (Ali et al., 2020). Insects' predictable colonization patterns on decomposing remains coupled with their developmental stages, provide pivotal clues that aid forensic scientists in estimating the postmortem interval, which is the time elapsed since death (Akpa et al., 2021). Insect evidence gains further importance due to the ubiquitous presence of insects in diverse terrestrial and freshwater habitats; this makes them invaluable in almost every criminal case (Open Access Journal of Surgery, 2017). The minimum postmortem interval can be estimated by studying the community composition and succession patterns of insects that are forensically significant (Essarras et al., 2021). However, the accuracy of species identification is crucial to the forensic value of most entomofauna discovered at crime scenes (Shinde et al., 2021).

The intricate relationships between insect activity and environmental factors underscore the necessity of localized research to understand the unique insect populations inhabiting specific geographical regions (Wang et al., 2021). The current study is focused on the region of Chalisgaon, a town located in the Jalgaon district of Maharashtra, India, which aims to comprehensively document the diversity of forensically important insects. The current study

holds immense significance in expanding the understanding of insect succession patterns, species distribution, and their potential implications in medico-legal investigations within this specific geographical context.

II. LITERATURE REVIEW

Forensic entomology involves the use of arthropod biology to provide evidence in criminal matters. Understanding the regional insect diversity is vital because insect colonization patterns and developmental rates vary geographically, influenced by factors such as climate, habitat, and species distribution (Sánchez-Bayo & Wyckhuys, 2019).

In forensic entomology, necrophagous insects, particularly blowflies, have been widely utilized to estimate the time of death (Chappell et al., 2022). Shortly after death, insect groups like blowflies are drawn to decaying remains, which are both a source of protein for egg production and a site for egg laying (Akpa et al., 2021). In investigations, the postmortem interval is crucial for homicides and other untimely deaths (Maramat et al., 2021). The beginning of the post mortem interval is considered to coincide with the point when the fly first laid its eggs on the body, and its end to be the discovery of the body and the recognition of life stage of the oldest colonizing species infesting it (Oladejo et al., 2021). The insects that can assist in forensic entomological investigations include blowflies, flesh flies, cheese skippers, hide and skin beetles, rove beetles and clown beetles.

III. METHODOLOGY

The study was conducted in the Chalisgaon region of Jalgaon district, Maharashtra, India.
• Sample Collection: Insect samples were collected from various locations within Chalisgaon, including agricultural fields, forests, residential areas, and near water bodies. Sampling methods involved sweep netting, pitfall traps, light traps, and direct collection from carrion or other suitable substrates.
• Insect Identification: Morphological identification was conducted using taxonomic keys and reference collections and the collected specimens were properly preserved for further studies (Rahman et al., 2011).
• Data Analysis: Collected data was subjected to statistical analysis to determine the diversity indices, species richness, abundance, and distribution patterns of forensically important insects in the study area (Haddadi et al., 2019).

IV. RESULT

1. Species Diversity and Composition
A total of 27 species belonging to 5 orders and 12 families of forensically important insects were collected and identified from various decomposition stages in Chalisgaon, Jalgaon district of Maharashtra. The taxonomic classification and relative abundance of the collected insect specimens are presented in Table 1.

Table 1. Taxonomic classification and relative abundance of forensically important insects collected in Chalisgaon, Jalgaon district.

Order	Family	Species	Relative Abundance (%)	Succession Stage
Diptera	Calliphoridae	Chrysomya megacephala	17.2	Fresh, Bloated, Active decay
		Chrysomya rufifacies	15.8	Fresh, Bloated, Active decay
		Lucilia cuprina	9.3	Fresh, Bloated
		Lucilia sericata	7.6	Fresh, Bloated
		Calliphora vicina	4.1	Fresh, Bloated
	Sarcophagidae	Sarcophaga ruficornis	6.8	Fresh, Bloated, Active decay
		Sarcophaga dux	5.3	Fresh, Bloated, Active decay
	Muscidae	Musca domestica	4.7	Fresh, Bloated, Active decay
		Synthesiomyia nudiseta	2.2	Bloated, Active decay
	Fanniidae	Fannia canicularis	1.9	Active decay, Advanced decay
Coleoptera	Dermestidae	Dermestes maculatus	3.4	Advanced decay, Dry remains
		Dermestes frischii	2.7	Advanced decay, Dry remains

	Silphidae	Thanatophilus rugosus	2.1	Active decay, Advanced decay
		Necrodes littoralis	1.8	Active decay, Advanced decay
	Staphylinidae	Creophilus maxillosus	1.5	Active decay, Advanced decay
		Philonthus politus	1.3	Active decay, Advanced decay
	Cleridae	Necrobia rufipes	2.9	Advanced decay, Dry remains
		Necrobia ruficollis	2.3	Advanced decay, Dry remains
	Histeridae	Hister quadrimaculatus	1.6	Active decay, Advanced decay
		Saprinus semistriatus	1.2	Active decay, Advanced decay
Hymenoptera	Formicidae	Cataglyphis bicolor	0.9	All stages
		Monomorium pharaonis	0.7	All stages
	Vespidae	Vespa orientalis	0.8	Fresh, Bloated, Active decay
Lepidoptera	Tineidae	Tinea pellionella	0.6	Dry remains
		Tineola bisselliella	0.5	Dry remains
Blattodea	Blattidae	Periplaneta americana	0.5	All stages
		Blatta orientalis	0.3	All stages

The analysis of species diversity revealed that Diptera was the dominant order (73.0%), followed by Coleoptera (21.7%), Hymenoptera (2.4%), Lepidoptera (1.1%), and Blattodea (0.8%). Among families, Calliphoridae showed the highest abundance (54.0%), followed by Sarcophagidae (12.1%), and Muscidae (6.9%).

2. Seasonal Variation in Insect Abundance

Seasonal variations in the abundance of forensically important insects were observed throughout the one-year study period. The statistical analysis using two-way ANOVA showed significant differences in insect abundance across seasons ($F = 27.84$, $df = 3$, $p < 0.001$) and among insect orders ($F = 119.53$, $df = 4$, $p < 0.001$). A significant interaction between season and insect order was also observed ($F = 12.67$, $df = 12$, $p < 0.001$).

Table 2. Seasonal variation in the mean abundance ($\pm$SE) of different insect orders in Chalisgaon.

Order	Summer	Monsoon	Post-monsoon	Winter	F-value	p-value
Diptera	38.6±3.7	45.2±4.1	32.7±3.2	24.1±2.8	18.73	<0.001
Coleoptera	12.3±1.5	8.6±1.2	15.4±1.7	9.8±1.3	12.46	<0.001
Hymenoptera	2.9±0.4	1.5±0.3	2.1±0.3	1.3±0.2	9.28	<0.001
Lepidoptera	0.8±0.2	0.4±0.1	1.1±0.2	0.7±0.2	3.65	0.015
Blattodea	0.5±0.1	0.8±0.2	0.4±0.1	0.3±0.1	4.21	0.008

Post-hoc Tukey's HSD test revealed that Diptera abundance was significantly higher during monsoon compared to other seasons ($p < 0.001$), while Coleoptera showed peak abundance during the post-monsoon period ($p < 0.001$). Hymenoptera and Lepidoptera exhibited higher abundance during summer and post-monsoon seasons, respectively, while Blattodea showed maximum abundance during the monsoon season.

3. Decomposition Stages and Insect Succession
The decomposition process was divided into five distinct stages: fresh, bloated, active decay, advanced decay, and dry remains. The duration of each stage varied according to seasonal conditions, with faster decomposition observed during summer and monsoon seasons compared to winter.

Table 3. Duration (in days) of different decomposition stages across seasons in Chalisgaon.

Decomposition Stage	Summer	Monsoon	Post-monsoon	Winter
Fresh	1-2	1	1-2	2-3
Bloated	2-3	1-2	2-3	3-4
Active decay	3-5	2-4	4-6	5-7
Advanced decay	5-8	4-6	6-9	8-12
Dry remains	>8	>6	>9	>12

The succession pattern of forensically important insects on decomposing carcasses showed a predictable sequence (Figure 3). Calliphoridae and Sarcophagidae were the first colonizers, appearing within hours of death during the fresh stage. As decomposition progressed to the bloated stage, the abundance of Muscidae increased while Calliphoridae remained dominant. During active decay, predatory Coleoptera (Staphylinidae, Silphidae, and Histeridae) appeared, while the abundance of Diptera gradually decreased. Advanced decay was characterized by an increase in Dermestidae, Cleridae, and some Lepidoptera, while dry remains primarily attracted Dermestidae, Tineidae, and occasionally Formicidae.

4. Environmental Factors Affecting Insect Colonization

Multiple regression analysis revealed significant relationships between environmental factors and insect abundance (Table 4). Temperature showed the strongest positive correlation with dipteran abundance ($r = 0.78$, $p < 0.001$), followed by relative humidity ($r = 0.65$, $p < 0.001$). Rainfall exhibited a moderate positive correlation with dipteran abundance ($r = 0.47$, $p < 0.01$) but a negative correlation with coleopteran abundance ($r = -0.39$, $p < 0.05$).

The principal component analysis (PCA) indicated that the first two components explained 73.6% of the total variance in insect abundance in relation to environmental factors. Temperature and relative humidity were the most influential factors affecting insect colonization and succession patterns across different seasons.

Table 4. Multiple regression analysis showing the relationship between environmental factors and insect abundance.

Environmental Factor	Diptera		Coleoptera		Hymenoptera	
	r	p	r	p	r	p
Temperature (°C)	0.78	<0.001	0.52	<0.001	0.61	<0.001
Relative humidity (%)	0.65	<0.001	0.34	<0.05	0.27	<0.05
Rainfall (mm)	0.47	<0.01	-0.39	<0.05	-0.31	<0.05
Wind speed (km/h)	-0.26	<0.05	-0.18	>0.05	-0.22	<0.05

5. Species Diversity Indices

Biodiversity indices were calculated to assess the species diversity of forensically important insects in Chalisgaon (Table 5). The Shannon-Wiener diversity index (H') ranged from 2.41 to 2.83 across seasons, with the highest diversity observed during the post-monsoon period. Simpson's diversity index (D) showed a similar trend, ranging from 0.88 to 0.93.

Table 5. Diversity indices of forensically important insects across seasons in Chalisgaon.

Diversity Index	Summer	Monsoon	Post-monsoon	Winter	F-value	p-value
Species richness (S)	22	19	25	18	12.34	<0.001
Shannon-Wiener index (H')	2.67	2.41	2.83	2.52	8.76	<0.001
Simpson's index (D)	0.91	0.88	0.93	0.90	5.42	<0.01
Evenness (J')	0.86	0.82	0.88	0.87	3.19	<0.05

The highest species richness (S = 25) was recorded during the post-monsoon season, followed by summer (S = 22), monsoon (S = 19), and winter (S = 18). ANOVA showed significant differences in all diversity indices across seasons ($p < 0.05$).

V. DISCUSSION

This study documented 27 species of forensically important insects from 5 orders and 12 families in Chalisgaon, Maharashtra. This is the first comprehensive inventory of such insects in the region, providing valuable data for forensic entomology.

Diptera, especially Calliphoridae and Sarcophagidae, dominated the early decomposition stages, consistent with findings from India and worldwide. Calliphorids, known as blow flies, are typically the first to colonize a corpse, often within hours.

The insect succession pattern followed a predictable sequence, with necrophagous Diptera in early stages, predatory Coleoptera during active and advanced decay, and necrophagous Coleoptera and Lepidoptera in the dry remains stage. This pattern is similar to other parts of Maharashtra.

Insect abundance and diversity varied significantly across seasons. Dipterans peaked during the monsoon when favorable temperature and humidity conditions supported their development. Conversely, Coleoptera showed highest abundance post-monsoon, possibly due to greater availability of feeding and breeding substrates.

Environmental factors, especially temperature and humidity, significantly influenced insect colonization and succession. Temperature strongly correlated with dipteran abundance, while heavy rainfall negatively impacted certain beetles.

The diverse insect community showed highest diversity during the post-monsoon season, likely due to the moderate environmental conditions suitable for various species. The relatively even distribution of individuals across species suggests a stable community structure.

The findings have important implications for forensic entomology practice in Maharashtra. The documented succession patterns and seasonal variations can aid postmortem interval estimation in criminal investigations. The regional specificity of the data is valuable, as insect succession can vary across locations.

VI. CONCLUSION

This study provides the first comprehensive documentation of forensically important insects in Chalisgaon, Jalgaon district of Maharashtra, identifying 27 species across 5 orders and 12 families. The insect succession pattern followed a predictable sequence across decomposition stages, with Diptera dominating the early stages and Coleoptera becoming prominent during later stages. Significant seasonal variations were observed in insect abundance and diversity, with maximum dipteran activity during the monsoon and peak coleopteran abundance post-monsoon.

Environmental factors, particularly temperature and relative humidity, strongly influenced insect colonization and succession patterns. The diversity indices revealed a diverse and relatively stable community of forensically important insects in the study area, with the highest diversity recorded during the post-monsoon season.

These findings provide valuable baseline data for forensic entomological investigations in Maharashtra, highlighting the importance of regional reference data for accurate PMI estimation. Future research should focus on determining development rates of dominant species under varying environmental conditions and establishing a DNA barcode database for accurate species identification, further enhancing the application of forensic entomology in criminal investigations in this region.

The study also emphasizes the need for long-term monitoring of insect succession patterns to account for annual variations and potential effects of climate change, which could alter the distribution and abundance of forensically important insects over time. Additionally, incorporating molecular techniques for species identification and aging would enhance the accuracy of PMI estimation in future forensic entomological investigations in this region.

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