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## Population, Diversity, and distribution of Fruit Flies (Diptera: Tephritidae: *Bactrocera spp.*) in Mango Orchards of Lucknow, Saharanpur and Meerut districts of Uttar Pradesh, India

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### Abstract

The extensive damage caused by fruit flies to mango crops throughout the country leads to substantial decrease in the productivity of mango which leads to heavy financial losses to the farmers. To address this issue, a recent study utilizing advanced morphological techniques was conducted to examine the diversity and distribution of fruit flies in different mango farms at different locations viz, Behat, Nakur, Sadholi Quadeem, Malihabad, Kakori, Shahjahanpur and Mawana of three districts Saharanpur, Lucknow, and Meerut of Uttar Pradesh. The research identified a total of 10 fruit fly species of genus *Bactrocera* with species *Bactrocera dorsalis*, *Bactrocera zonata*, and *Bactrocera correcta* emerging as the most abundant species with mean population per month 200.88, 151.13 and 63.38 respectively for the year 2022 and 246.13, 210.50 and 47.88 respectively for the year 2023. Notably, the distribution of these pests was uneven, with higher concentrations observed on the orchard peripheries. The study revealed significant spatio-temporal fluctuations in both the quantity and diversity of fruit flies, with a notable surge in infestations during the post-monsoon season. There was yearly total catch of 3790 and 4146 of fruit flies for 2022 and 2023 respectively. All these species were found to be active throughout the fruity season (Apr-Oct) but comparatively a large number was accumulated in the peak months of July and August for both the years. A large part of the total count was collected from district Lucknow followed by Saharanpur and Meerut. The findings of this research hold a substantial value for farmers and researchers engaged in fruit fly management, providing crucial insights for devising effective pest control strategies. The identification of prevalent species opens avenues for targeted interventions, potentially curbing financial losses for mango growers.

**Keywords:** Diptera, taxonomy, *Bactrocera*, Uttar Pradesh, Diversity, Mango

### Introduction

Mango (*Mangifera indica*), popularly known as the "King of Fruits," is one of the most significant fruits produced in India. It belongs to the Anacardiaceae family, genus *Mangifera*, and species *indica*. Indian mangoes are well-known for their flavour, scent, and taste in a variety of forms, sizes, and colours. It is abundantly cultivated at sea level of 1500m in India's tropical and subtropical regions. Temperatures around 27 degrees Celsius are ideal for quality growth of mangoes. There is a yearly output of 12750 thousand metric tons across an area of 2300 thousand hectares, accounting over 55 percent of the world's total production [1]. Uttar Pradesh, located in northern India, is India's second-largest mango producer, contributing to about 23 percent of total mango production. Mango farming is widely practiced in Saharanpur, Bulandshahar, Lucknow, Faizabad, and Varanasi. Because of its dense mango orchards, the Saharanpur district was formerly recognized as the largest fruit belt in the country, producing 259460 metric tons across an area of 259460 hectares [2]. This region's primary cultivars include Chausa, Dashehari, and Langra. There are, however, several plantations of Mallika and Amrapali varieties also.

From past few years the mango production rate has seen a dip due to infestation of mango farms by a large numbers of fruit fly species. Fruit flies are one of the most damaging insect pests to tropical and subtropical mango fruits and vegetables. They are highly polyphagous and are known to infest over 250 plant species from 40 different families [3,4]. These flies are found in all biogeographic zones except the extreme desert and Polar Regions, where their hosts are few or absent [5].

There are approximately 44,000 species of fruit flies in the Tephritidae family, and around 200 of these are known to be pest of crops [6]. They are considered major and dangerous pests due to their ability to cause significant damage to horticulture crops [7,8]. Their infestations can result in early fruit drop, fruit rot, and diminished fruit size and weight. The economic impact of fruit fly infestations is substantial, with annual losses of 144.4 million pounds of fruits and vegetables [9].

Present study aims to identify the different species of genus *Bactrocera* Fruit Flies found in mango plantations in three districts of Uttar Pradesh and investigates their impact on mango production. The use of methyl-eugenol based parapheramone trapping was employed to record the diversity of fruit fly species in these areas. We record a 10 species of genus *Bactrocera* from these districts as primary pests that damage mangoes, citrus, guavas, and cucurbits. The findings of this study will give significant insights into the diversity of fruit flies in Uttar Pradesh and will help in the development of effective pest control strategies to improve mango production in the region.

## Materials and Methods

### 2.1 Location sites

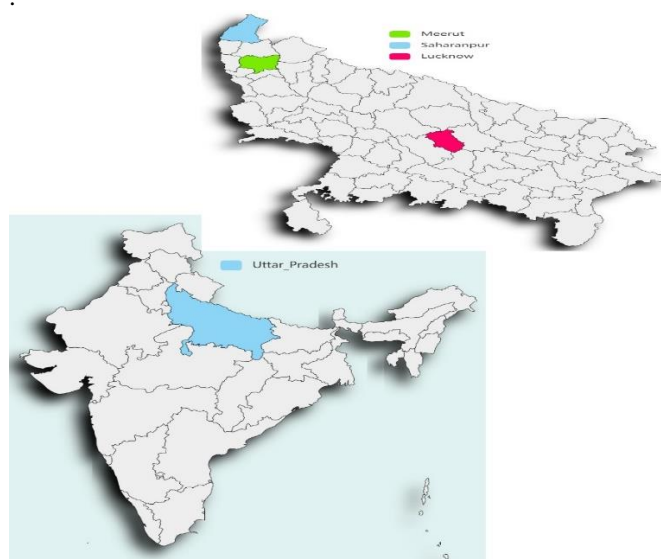
Study on fruit flies was conducted in several mango farms in different locations namely Behat, Nakur, Sadholi Quadeem, Malihabad, Kakori, Shahjahanpur and Mawana of three districts Lucknow, Saharanpur, and Meerut of Uttar Pradesh for an eight-month duration (Apr-Nov) over a period of two years 2022 and 2023. We have captured the latitudes and longitudes of the above said places and have been given in Table 3.3 in results and discussion section. A view of location of the state Uttar Pradesh and the three districts can be seen from Fig 2.1 and google map view of these places along with the mango farms can be seen in Fig 2.2.

### 2.2 Fruit fly traps and Methy-Eugenol Parapheramone

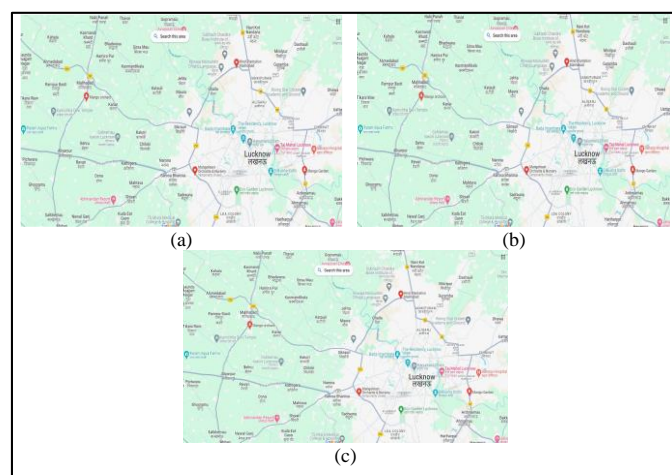
The trapping of fruit flies was carried using fruit fly traps namely 'FARM LOCK trap', purchased online (100 peices) from India Mart from Farmroot Agritech Private Limited Hebbal, Bengaluru, Karnataka. It is a plastic trap made up of UV Stabilized Plastic Polymer consisting two interlocking sections - a yellow Lid and base with a transparent cup with small entrance at the top for insects, with a transparent and a hook to hold the pheromone dispenser. The dimensions of the trap are 16 cm (height) x 13 cm (Dia). The lure included Methyl eugenol and Malathion, which was put on cotton given in the trap. Attracted by the pheromone lure stored in the hanging hook within, flies enter the trap through the aperture at the top of the transparent cup-shaped base. Once inside the trap, the light coming in through the transparent top and the pheromone attraction keep them there. A typical view of this trap is given in Fig 2.3 (a).

A total of 70 traps were placed at these locations with 10 traps per orchard. All the traps were set around lowers wings, above a height of one and half metres from the ground in shaded settings in various orchards and gardens (see Fig 2.3 (b)). The traps were checked after two weeks, collecting the trapped flies, cleaning them, and placed back to their positions. The alive trapped flies were killed using chloroform. All the collection were transported to the laboratory and preserved in 80% ethanol before identification. The identification of fruit fly species was carried out in the laboratory using a stereo-microscope with a binocular lens. After identification of all the species they were labelled and

kept in the laboratory for future purposes. A small section of this collection can be seen from Fig 2.3 (c).



**Fig 2.1:** shows map of India with zoomed view of state Uttar Pradesh showing three districts Lucknow, Saharanpur and Meerut.



**Fig 2.2:** Shows map view of different mango orchards in the three districts. (a) Lucknow. (b) Saharanpur (c) Meerut.

### 2.3 Calculation of Diversity Indices and Species Richness

Additional investigation of species richness and diversity was conducted using the overall data of both the years. The following formulae were used to calculate species richness, which is the number of distinct species in each region, and diversity using Shannon's diversity index [10].

$$H = - \sum_{j=1}^f p_j \ln p_j$$

Where ' $H$ ' is the Shannon diversity index, ' $p_j$ ' is the probability of ' $j^{th}$ ' species, ' $f$ ' is the total number of species. The likelihood that any two randomly chosen members of a limited size community would be members of the same species is referred to as the Simpson's index [11] given by the formula viz

$$D = \sum_j \left( \frac{n_j(n_j - 1)}{N(N - 1)} \right)$$

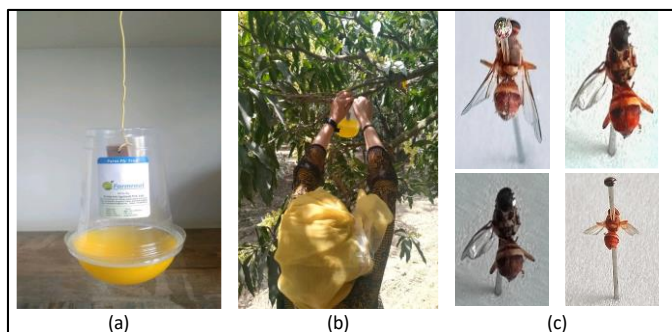
Where 'D' is referred as Simpson's Index, 'n<sub>j</sub>' represents the number of members of 'j<sup>th</sup>' species, 'N' denotes the total population in a region.

Species evenness was computed to determine the degree of similarity between the abundance of various species and to assess the equitable treatment factor in diversity<sup>[10, 12]</sup>

$$J = \frac{H}{\ln(S)}$$

Where 'J' denotes Species richness, 'H' is the Shannon Index and 'S' is the total number of species.

Table 3.3, shows the diversity indices and species richness for three districts Lucknow, Saharanpur, and Meerut



**Fig 2.3:** (a) shows a typical fruit fly trap. (b) shows installation of a fruit fly trap on a mango tree. (c) shows different types of fruit flies captured in these traps

## Results and Discussions

During the year 2022 and 2023 a total of 10 species of genus *Bactrocera* were identified to be infesting different mango orchards of the three districts of Uttar Pradesh. A total catch of 3790 and 4146 was trapped in the two years 2022 and 2023 respectively. For the year 2022 *B. dorsalis* was found to be the most abundant species found in all the three districts. They were recorded with a total catch of 1607 and a mean (per month) population of 200.88 for the year 2022. In the year 2023 they were recorded with a total catch of 1969 and mean (per month) population of 246.13. The next dominant species was observed to be *B. zonata* with a total catch of 1209 and 1684 and mean population of 151.13 and 210.5 for the year 2022 and 2023 respectively. The rest of species were comparatively smaller in number and the detailed observation of number of flies trapped per month for both the years is given in Table 3.1. These species were seen to be active throughout the fruity season but a maximum catch of 985 and 1152 were recorded for the peak month of August for 2022 and 2023 respectively. From Fig 3.1 we can see that *B. dorsalis* and *B. zonata* are most prevalent with a percentage of 42.40 & 47.48 and 31.90 & 40.61 respectively for years 2022 & 2023. Comparing our results with the research findings of Neerja Agarwal and M Deepa (2013)<sup>[13]</sup> we find that they

have also reported *B. dorsalis*, *B. zonata* and *B. correcta* as most abundant fruit fly species from Kanpur Central. Jitendra Mishra (2012)<sup>[14]</sup> recorded *B. dorsalis* most abundant species in Uttar Pradesh. Mohammad Khan et al<sup>[15]</sup> reported *B. zonata* followed by *B. dorsalis* as most abundant species in guava and mango orchards. Dale and Patel (2010)<sup>[16]</sup> also reported *B. zonata* and *B. dorsalis* as most abundant species in Sardarkrushinagar, Gujarat, India. Stanley Jhonson et al (2015)<sup>[17]</sup> have reported *B. zonata* and *B. dorsalis* as most abundant species in Himalyas. Abraham Verghese et al (2004)<sup>[18]</sup> have reported *B. dorsalis* as major insect pest of mango in India. Kalmath, Basavaraj, et al (2023)<sup>[19]</sup> have reported *B. dorsalis* as most dominant species from North Eastern region of Karnataka. Dil Mahjoora Majeed et al (2024)<sup>[20]</sup>, have reported *B. dorsalis* and *B. zonata* as major insect pests of guava from Saharanpur, Uttar Pradesh. Mariadoss A (2018)<sup>[21]</sup> have reported *B. dorsalis* and *B. zonata* as most abundant species in mango orchards of Ranga Reddy District of Telangana State, India. Nage, Sonal, et al (2023)<sup>[22]</sup> have also recorded *B. dorsalis* as the most prominent species found in Vidarbha region of Maharashtra, India.

Out of the total flies captured during 2022 and 2023 most of the catches were from Lucknow followed by Saharanpur and Meerut. From Lucknow a total number of 1572.91 and 1574.69 was recorded for the two years 2022 and 2023 respectively. From Saharanpur a total catch of 1286.31 and 1311.25 was recorded. For Meerut a total 930.78 and 1260.06 was trapped in two years. The details of total number (Mean per month) of flies corresponding to each species trapped from these places is tabulated in Table 3.2. From the observation table it is observed that the species *B. nigrotibalis* were not found in Saharanpur district. Fig 3.2 shows the percentage of total catch in the three districts for year 2022 and 2023. Lucknow was found to be comprising of 41.46% and 37.97% of the total flies trapped in 2022 and 2023 respectively.

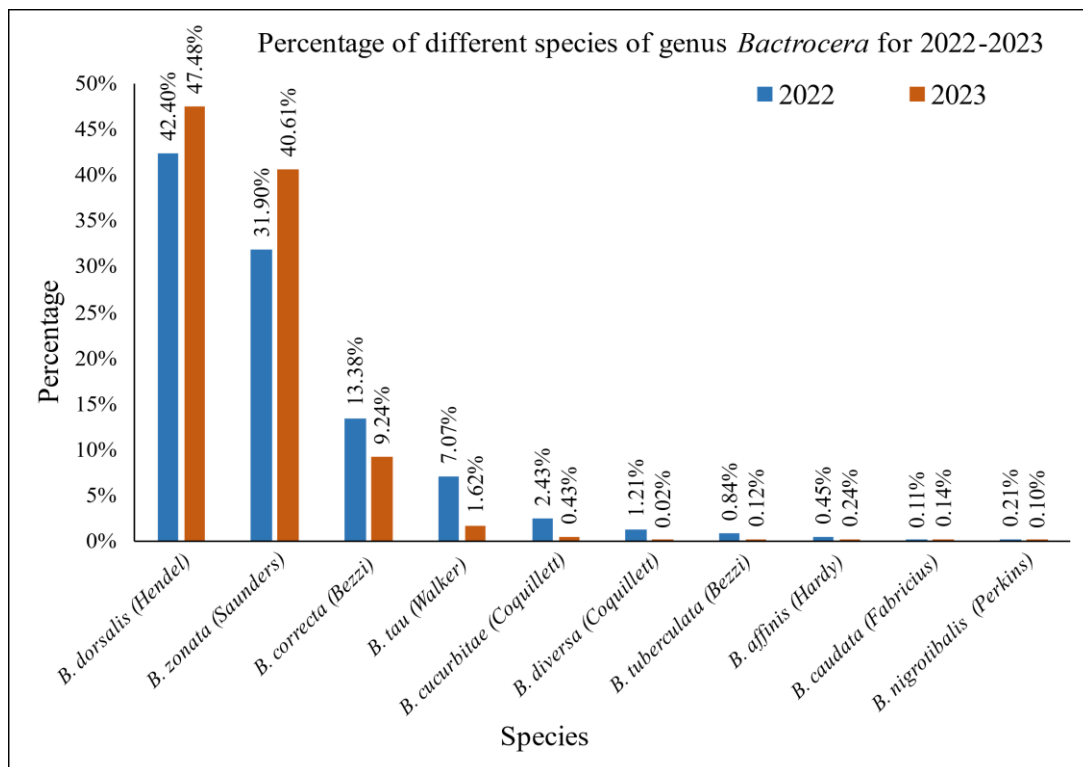
Fruit fly richness and diversity indices were computed for every district as shown in Table 3.3. With a Shannon index of 1.320, the Lucknow district has the highest value, followed by Meerut district ( $H = 1.222$ ) and Saharanpur ( $H=1.188$ ). The Shannon index indicates that all species are included in a group of selected population and that the population was chosen at random. Fruit fly diversity was recorded minimal in both Saharanpur and Meerut districts, which had higher Simpson indexes of  $D = 0.367$  and  $D = 0.355$  respectively. Lucknow district was recorded with maximal fruit fly diversity with  $D = 0.285$ . The Simpson index is adopted as a measure of dominance, as it gives more weight to common or dominant species. From our observations we conclude that Fruit fly biodiversity (species richness, evenness, and biodiversity index) was higher in Lucknow district as compared to the other two districts.

**Table 3.1:** shows total catch of *Bactrocera* species corresponding to different months for the year 2022 and 2023

2023								
Species/Month	Apr	May	June	July	Aug	Sep	Oct	Nov
<i>B. dorsalis</i> (Hendel)	50	102	89	250	629	450	210	189
<i>B. zonata</i> (Saunders)	14	52	103	350	389	446	150	180
<i>B. correcta</i> (Bezzi)	16	23	49	80	92	66	27	30
<i>B. tau</i> (Walker)	1	0	0	29	24	4	9	0
<i>B. cucurbitae</i> (Coquillett)	0	0	0	4	2	9	3	0
<i>B. diversa</i> (Coquillett)	0	0	0	0	1	0	0	0
<i>B. tuberculata</i> (Bezzi)	0	0	0	1	3	0	1	0



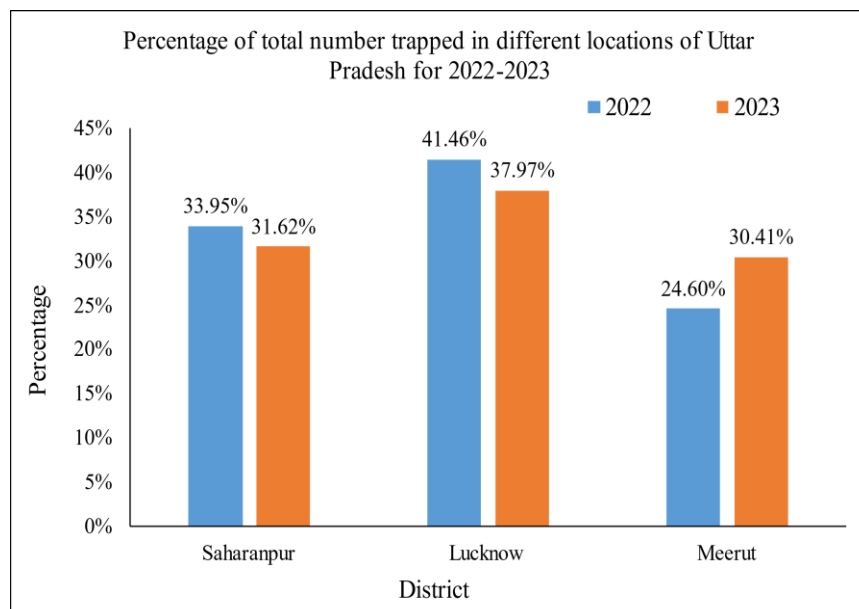
<i>B. affinis</i> (Hardy)	0	0	1	0	7	1	0	1
<i>B. caudata</i> (Fabricius)	0	0	1	2	3	0	0	0
<i>B. nigrotibialis</i> (Perkins)	0	0	0	0	2	1	1	0
Total	81	177	243	716	1152	977	401	400
<b>2022</b>								
<b>Species/Month</b>	<b>Apr</b>	<b>May</b>	<b>June</b>	<b>July</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Nov</b>
<i>B. dorsalis</i> (Hendel)	62	88	102	207	498	312	239	99
<i>B. zonata</i> (Saunders)	22	75	149	176	236	277	189	85
<i>B. correcta</i> (Bezzi)	8	15	45	62	110	150	66	51
<i>B. tau</i> (Walker)	0	0	36	45	102	66	11	8
<i>B. cucurbitae</i> (Coquillett)	0	0	0	11	22	26	30	3
<i>B. diversa</i> (Coquillett)	0	0	0	1	4	20	16	5
<i>B. tuberculata</i> (Bezzi)	0	0	0	0	2	16	8	6
<i>B. affinis</i> (Hardy)	1	0	1	3	8	4	0	0
<i>B. caudata</i> (Fabricius)	0	1	0	0	1	1	0	1
<i>B. nigrotibialis</i> (Perkins)	0	0	0	0	2	5	1	0
Total	93	179	333	505	985	877	560	258



**Fig 3.1:** shows percentage of different species of genus *Bactrocera* trapped in different months of the fruity season of mango.

**Table 3.2:** Shows the total population of fruit flies of *Bactrocera spp* captures in the three districts of Lucknow, Saharanpur, and Meerut for 2022-2023

Species/Location	2022			2023		
	Saharanpur	Lucknow	Meerut	Saharanpur	Lucknow	Meerut
<i>B. dorsalis</i> (Hendel)	594.59	658.87	353.54	630.08	728.53	610.39
<i>B. zonata</i> (Saunders)	423.15	447.33	338.52	522.04	656.76	505.2
<i>B. correcta</i> (Bezzi)	131.82	258.57	116.61	126.39	134.05	122.56
<i>B. tau</i> (Walker)	99.16	104.52	64.32	22.78	28.81	15.41
<i>B. cucurbitae</i> (Coquillett)	18.4	38.64	34.96	5.76	7.74	4.5
<i>B. diversa</i> (Coquillett)	17.02	12.42	16.56	0	1	0
<i>B. tuberculata</i> (Bezzi)	0.64	31.04	0.32	2	3	0
<i>B. affinis</i> (Hardy)	1.53	9.52	5.95	2.2	5.8	2
<i>B. caudata</i> (Fabricius)	0.36	2.24	1.4	0	6	0
<i>B. nigrotibialis</i> (Perkins)	0	8	0	0	3	1



**Fig 3.2:** shows the percentage of total number of flies captured in respective districts for the year 2022 and 2023

**Table 3.3** shows the geographical location of different places in the three districts and the respective diversity indices and species richness

District	Localities	Latitude (degrees)	Longitude (degrees)	Elevation (metres)	Species Richness	Shannon Index (H)	Simpson's Index (D)	Species Evenness (J)
Saharanpur	Behat	30.1714	77.6164	345	9	1.188	0.367	0.516
	Nakur	29.9199	77.3066	261				
	Sadholi Quadeem	30.219115	77.5763	284				
Lucknow	Malihabad	26.92223	80.71078	128	10	1.320	0.335	0.574
	Kakori	26.8694	80.7852	121				
Meerut	Shahjahanpur	28.8544	77.9610	111	10	1.222	0.355	0.531
	Mawana	29.0970	77.9205	221				

## Conclusion

The present study is based on specimens collected from different locations of three districts Lucknow, Saharanpur, and Meerut of Uttar Pradesh. A total of ten species of genus *Bactrocera* were identified. Moreover, during the entire study *Bactrocera dorsalis*, *Bactrocera zonata*, and *Bactrocera correcta* emerged as the most abundant pest insect species invading mango orchards. The results obtained from this study will give significant insights into the diversity of fruit flies in these districts and will help in the development of effective pest control strategies to improve mango production in the region.

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