



Methyl Eugenol (Parapheromone) Trapping System on Diversity of Fruit Flies and Influence of Weather Parameters on Trap Catches in Mango and Guava Cropping Systems

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Studies on species diversity and influence of weather parameters on methyl eugenol (parapheromone) trap catches were carried out in mango and guava orchards at Coimbatore and Dindigul Districts of Tamil Nadu from Standard Meteorological Week (SMW) 16th to SMW 25th. Species diversity indices were calculated, and the methyl eugenol trap catches were correlated with the weather parameters. The results revealed that four fruit fly species viz., Oriental fruit fly, *Bactrocera dorsalis* (Hendel), Guava fruit fly, *B. correcta* (Bezii), *B. caryeae* (Kapoor), and Peach fruit fly, *B. zonata* (Saunders), were attracted to the parapheromone methyl eugenol traps. Among them the population of *B. dorsalis* was higher in both mango and guava orchards of Coimbatore and Dindigul Districts. The highest species diversity indices for fruit flies viz., Shannon H' (0.936) and Simpsons D' (0.593), evenness (0.468), and richness (0.482) were observed in guava orchard located in Coimbatore District, and the minimum diversity indices Shannon H' (0.254), Simpsons D' (0.921), evenness (0.160), and richness (0.291), were observed in mango orchard located in Dindigul District. The maximum number of fruit flies were trapped in 19th SMW in mango orchards in both Districts 134 and 145 flies/three traps, respectively. In Coimbatore District's guava orchard and Dindigul District's mango orchard, trap catches revealed a significant positive correlation with rainfall. The subsequent weather parameters like max. temperature, min. temperature, wind speed, and relative humidity, were either positively or negatively correlated with trap catches in mango and guava orchards. In multiple regression analysis, the maximum predictability was seen in mango orchard (75.54%) located in Coimbatore District and the minimum (66.68%) in mango orchard located in Dindigul District.

Keywords: Mango; guava; methyl eugenol; fruit fly; species diversity; weather factors.

1. INTRODUCTION

India is one of the leading producers of mango (*Mangifera indica*) and guava (*Psidium guajava*). Around 400 insect pests were infesting mango and guava, respectively [1] and [2]. Among them, fruit flies of the genus *Bactrocera* (Diptera: Tephritidae) is one of the major pests infesting mango and guava, causing yield loss between 40 to 70% in mango and 60 to 80% in guava [3] at field level and make it unconsumable and unmarketable. They are also a major constraint on the export of fresh mango fruits to foreign countries. It is a significant pest with great potential for invasion due to its vast host range, adaptability to a range of climates, and rapid reproduction rate. The family tephritidae includes more than 4000 species in 500 genera. Of the 4000 species known, 392 species have been recorded in India [4], among which six to seven species are found infesting mango and guava fruits in India. They include *Bactrocera dorsalis*, *B. zonata*, and *B. correcta*. Of them, *B. dorsalis*, commonly called the Oriental fruit fly, was earlier considered to be the most important and dominant species in Southern India, but now in recent times, *B. caryeae* has become widespread in southern India. Further, mango and guava are the common commercial hosts of *B. caryeae* [5].

Adult male flies of these species are attracted to the phenylpropanoid compound methyl eugenol (para-pheromone) and voraciously feed it [6], and it is converted into two main components, namely; (E)-coniferyl alcohol (E-CF) and 2-allyl-4,- 5-dimethoxyphenol (DMP), that are temporarily sequestered in the rectal gland of males that release them during courtship at dusk [7], which is present in over 450 species from 80 families spanning 38 plant orders that contain varying amounts of methyl eugenol in leaves, roots, stems, flowers, or whole plant extracts [8], and it plays an important role in monitoring and mass trapping of fruit flies. Seasonal fluctuations in abiotic factors, including temperature, relative humidity, rainfall, and wind speed are common and have a significant influence on the diversity of species and their occurrence. Understanding the relationship between the environment and fruit fly activity is therefore absolutely essential. The development and timely implementation of management technologies are made possible by sound knowledge based on the seasonal database of insect populations, species complex, seasonal abundance, dispersal patterns, and changes in population dynamics in relation to weather parameters. In light of this, the current investigation was made to comprehend the diversity of fruit fly species from the family Tephritidae, determine the species diversity, and determine the influence of weather parameters

on the total trap catches on methyl eugenol traps.

2. MATERIALS AND METHODS

2.1 Location of the Experiment

The present study was carried out at mango orchards located at Madampatti village, Coimbatore District, located between 10°96'N latitude and 76°86'E longitude, and Amarapoondi village, Dindigul District, located between 10°52'N latitude and 77°58'E longitude. Guava orchards located at Aalanthurai village, Coimbatore District, located between 10°93'N latitude and 76°79'E longitude, and Palaya Aayakudi, Dindigul District, located between 10°44'N latitude and 77°57'E longitude, from 16th to 25th SMW of 2023.

2.2 Trapping of Fruit Flies Using Methyl Eugenol Traps

The cylindrical jar-type trap of about 15cm height and 10cm diameter with four holes of about 20mm diameter in the sidewall, which act as entry points for fruit flies, was used to trap the male fruit flies in the mango and guava orchards. The plywood dispenser block with size of 4 x 2.5 x 1 cm was impregnated with methyl eugenol formulation for about 24 hours. The plywood dispenser was hanged at the top of the trap using an iron wire. Three traps were hanged in the mango and guava trees randomly at a height of 1.5m above ground level. The trapped male fruit flies were collected in the zip-lock cover at weekly intervals.

2.3 Identification and Accessing the Diversity Indices for Fruit Fly Mango and Guava Ecosystem

The trapped and collected fruit flies were observed under a stereo zoom light microscope for identification at species level using the dichotomous key developed by [9].

The diversity indices viz., relative Density (%) = (No. of individuals of one species / no. of individuals of all species) x 100; and alpha diversity quantified using Simpson's diversity index (*SDI*) [10], Shannon-Wiener Index (*H'*) [11], Pielou's Evenness Index (*E1*) [12], Margalef Richness Index (*Mg*) [13], and Dominance index were calculated by using the following formulae.

Simpson's diversity index

$$D = \sum n(n-1) / N(N-1)$$

Where, *n* = total number of organisms of a particular species and *N* = total number of organisms of all species.

Subtracting the value of Simpson's diversity index from 1, gives Simpson's Index of Diversity (*SID*). The value of the index ranges from 0 to 1, the greater the value the greater the sample diversity.

Shannon-Wiener index

$$H' = - \sum Pi \ln (Pi), \text{ where } Pi = S / N$$

Where, *S* = number of individuals of one species, *N* = total number of all individuals in the sample and *ln* = logarithm to base

Pielou's evenness index

$$E1 = H' / \ln(S)$$

Where, *H'* = Shannon-Wiener diversity index, *S* = total number of species in the sample.

Margalef Richness Index (*Mg*)

$$Mg = (S - 1) / \ln N$$

Where, *S* is the total number of species recorded and *N* is the total number of individuals summed overall *S* species.

Dominance index was calculated by using the formula)

$$D = \sum (n/N)^2 \text{ or } D = (\sum n(n-1)) / N(N-1)$$

Where, *n* = total number of organisms of a particular species and *N* = total number of organisms of all species.

2.4 Data Analysis

Abiotic factors such as maximum temperature, minimum temperature, relative humidity, rain fall and wind speed during the study period were obtained from the Agro Climate Research Centre (ACRC), Directorate of Crop Management (DCM), Tamil Nadu Agricultural University (TNAU), Coimbatore. The weather details collected were summarized into weekly average and correlated with the trap catches using

spearman rank correlation to assess the influence of varied weather factors on the diversity and spread of fruit flies.

The species diversity of the fruit flies, the correlation coefficient and the multiple regressions were analysed by using R software 4.2.3.

3. RESULTS AND DISCUSSION

3.1 Relative Abundance and Population Dynamics of Fruit Flies

The present study reveals that four fruit fly species viz., *B. dorsalis*, *B. correcta*, *B. caryeae* and *B. zonata* were attracted to the parapheromone methyl eugenol traps. All the species belong to the genus *Bactrocera* under the tribe Dacini of the subfamily Dacinae. The results revealed that among the species, *B. dorsalis* was found to be the dominant species,

followed by *B. correcta*, *B. caryeae*, and *B. zonata* in the mango and guava orchards of Coimbatore and Dindigul Districts. A total of 641 and 502 flies were trapped in the mango and guava orchards of Coimbatore District, respectively (Table 1). Out of 641 fruit fly trap catches in mango orchard of Coimbatore 85.65% flies were *B. dorsalis*, while the remaining 12.79%, 0.94%, and 0.62% were *B. correcta*, *B. caryeae*, and *B. zonata*, respectively (Fig 1). Similarly, in guava orchard at Coimbatore 72.51, 26.10, 1.00, 0.40 % of flies were identified as *B. dorsalis*, *B. correcta*, *B. caryeae* and *B. zonata*, respectively (Fig 1). The study also documented that the number of flies captured in the mango and guava orchards of Dindigul District were 950 and 179, respectively (Table 1). Among them 95.89, 4.00, 0.11 % were *B. dorsalis*, *B. correcta*, and *B. caryeae* in mango orchard (Fig 1). Further in the guava orchard of Dindigul District recorded 86.59, 12.85 and 0.56 % of trapped fruit flies were *B. dorsalis*, *B. correcta* and *B. zonata*, respectively (Fig 1).

Table 1. Abundance of fruit fly species collected from the mango and guava orchards

Different species of fruit flies trap catches for 10 weeks						
District	Orchard	* <i>B.dorsalis</i>	* <i>B. correcta</i>	* <i>B. zonata</i>	* <i>B. caryeae</i>	*Total trap catches
Coimbatore	Mango	549	82	4	6	641
	Guava	911	38	0	1	950
Dindigul	Mango	364	131	2	5	502
	Guava	155	23	0	1	179

*Cumulative mean of three traps

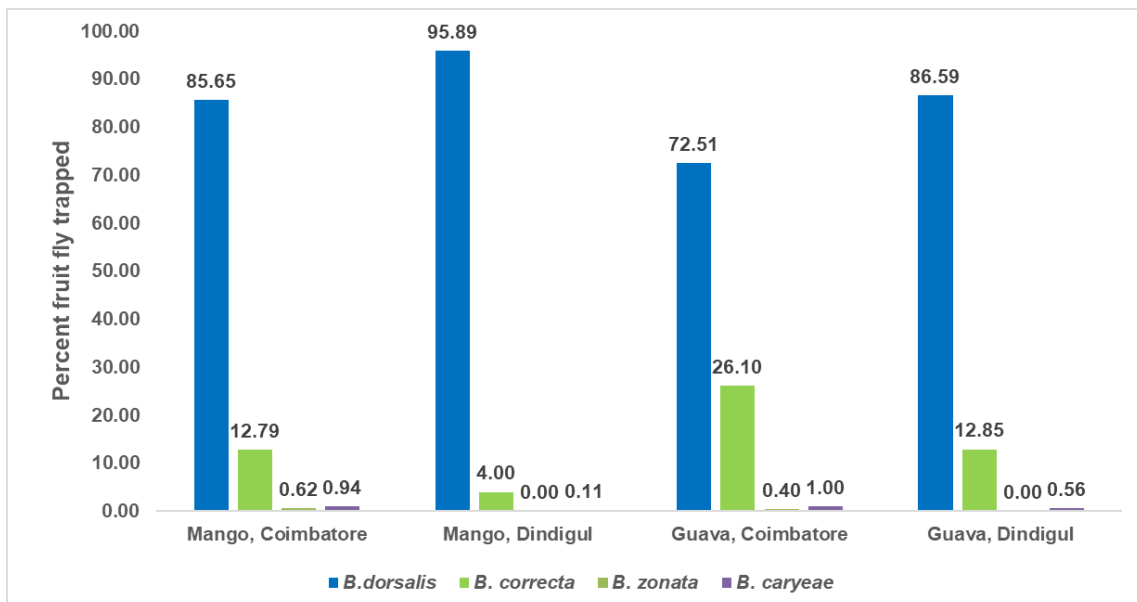


Fig. 1. Relative density of fruit fly species trapped in mango and guava orchards

The above results revealed that *B. zonata* was absent in both mango and guava orchards in Dindigul District. The *B. correcta* population was maximum in the guava orchards when compared to the mango orchards, and *B. dorsalis* was the dominant species in both the mango and guava orchards in Coimbatore and Dindigul Districts. The results are in agreement with the findings of [14], [15], [16], [17], and [18]. They have reported that *B. dorsalis* is the dominant species in the mango orchards in Tamil Nadu.

In the present study results also revealed that *B. dorsalis* is the dominant species in guava orchards, and the results are in concurrence with [19] and [20]. They have reported the same in Ranga Reddy District of Telangana and Ahmednagar District of Maharashtra, respectively, in guava orchard. On the contrary, [3] and [21] reported that *B. correcta* is the dominant species in the guava orchards of Tamil Nadu and Karnataka. [22] observed that *B. dorsalis* is the dominant species in the vegetable ecosystem in Uttar Pradesh.

The dynamics of fruit fly in methyl eugenol trap catches were observed between SMW (Standard Meteorological Week) 16 to SMW 25 during the fruiting season of mango and guava. In the mango orchard of Coimbatore District, the lowest fruit fly populations were captured during 16th SMW (27 flies), and the highest populations were captured during 19th SMW (134 flies) (Fig 2). In the mango orchard of Dindigul District the trapped fruit fly population was gradually increased from 16th SMW (72 flies) and reached a maximum of 145 flies during 19th SMW, there after the lowest flies trap catches were recorded

(39 flies) in 23rd SMW (Fig 2). In the guava orchard of Coimbatore District, the highest trap catches began to rise from 16th SMW (37 flies) and the maximum of 127 flies were trapped during 18th SMW, followed by 19th SMW (67 flies) onwards, and the least trap catches were observed during 23rd SMW (23 flies) (Fig 2). Similarly, in a guava orchard located in Dindigul District, the maximum number of fruit flies were trapped on 22nd SMW (29 flies) and the least population of 11 flies trapped in 24th SMW (Fig 2). The methyl eugenol trap catches were differed at the orchard level, which may be due to the difference in agro climatic factors, crop phenology, fruiting period, and fruit maturity. Similar findings were also reported by [16], [17], and [18]. There is a peak activity of fruit flies during the months of April – May, which coincides with the fruiting and ripening periods of the mango.

3.2 Species Diversity

Fruit fly diversity indices, richness, and evenness were computed. Guava orchard located in Coimbatore District had the highest Shannon index ($H' = 0.936$), followed by guava orchard in Dindigul District ($H' = 0.602$), and mango orchards in Coimbatore and Dindigul Districts had the lowest Shannon index (0.471 and 0.254, respectively) (Table 2). The same degree of order was also seen in the species evenness. A high Simpson's index of diversity (1-D) was found in the guava orchard of Coimbatore District (SID = 0.406), followed by mango orchard of Coimbatore District (SID = 0.250), guava (SID = 0.245), and mango (SID = 0.078) orchards of Dindigul District (Table 2).

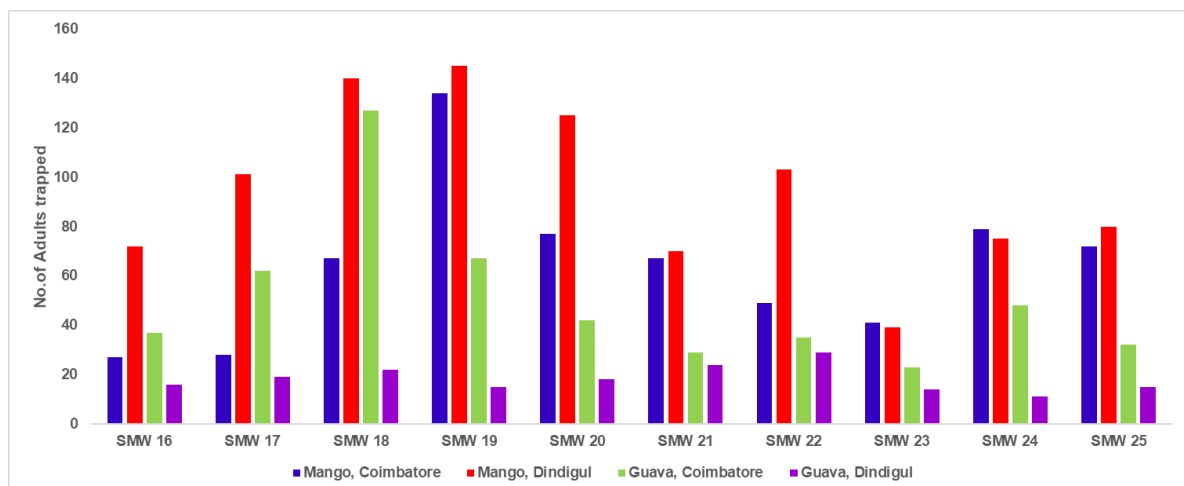


Fig. 2. Population trend of fruit flies in mango and guava orchards

The high Dominance index was found in mango orchards of both Districts (0.750 and 0.789), when compared to the guava orchards (0.406 and 0.235) in Coimbatore and Dindigul District (Table 2). The species richness was high in the mango and guava orchards of Coimbatore Districts (0.464 and 0.482), followed by the guava orchard of Dindigul District (0.385) and low species richness was observed in the mango orchard located in Dindigul District (0.291) (Table 2).

High species diversity and evenness were seen in the guava orchards in both Districts when compared to mango orchards.

3.3 Influence of Weather Parameters on Population Dynamics of Fruit Fly Species in Mango and Guava Orchards

Studies were conducted to determine the correlation between methyl eugenol fruit fly trap catches and weather factors such as maximum temperature, minimum temperature, wind speed, rain fall, and relative humidity.

3.3.1 Correlation coefficient

The correlation analysis between the weather parameters and fruit fly trap catches in mango orchard located in Coimbatore District revealed that trap catches were positively correlated with rain fall ($r=0.53$), relative humidity ($r=0.56$), and wind speed ($r=0.16$), negatively correlated with max. temperature ($r=-0.53$), and min. temperature ($r=-0.25$). In the guava orchard of Coimbatore District, the methyl eugenol trap catches have a positive correlation with rain fall ($r=0.73$), negatively correlated with the max. temperature ($r=-0.03$), min. temperature ($r=-0.31$), relative humidity ($r=-0.17$), and wind speed ($r=-0.20$). Further, in the mango orchard of Dindigul District the trap catches were positively correlated with min. temperature ($r=0.24$), rain fall ($r=0.67$), and relative humidity ($r=0.23$), negatively correlated with max. temperature ($r=-0.23$), and wind speed ($r=-0.57$). Similarly, in guava orchard, trap catches were positively correlated with min. temperature (0.28), rain fall ($r=0.33$) and relative humidity ($r=0.10$), negatively correlated with max. temperature ($r=-0.07$), and wind speed ($r=-0.61$).

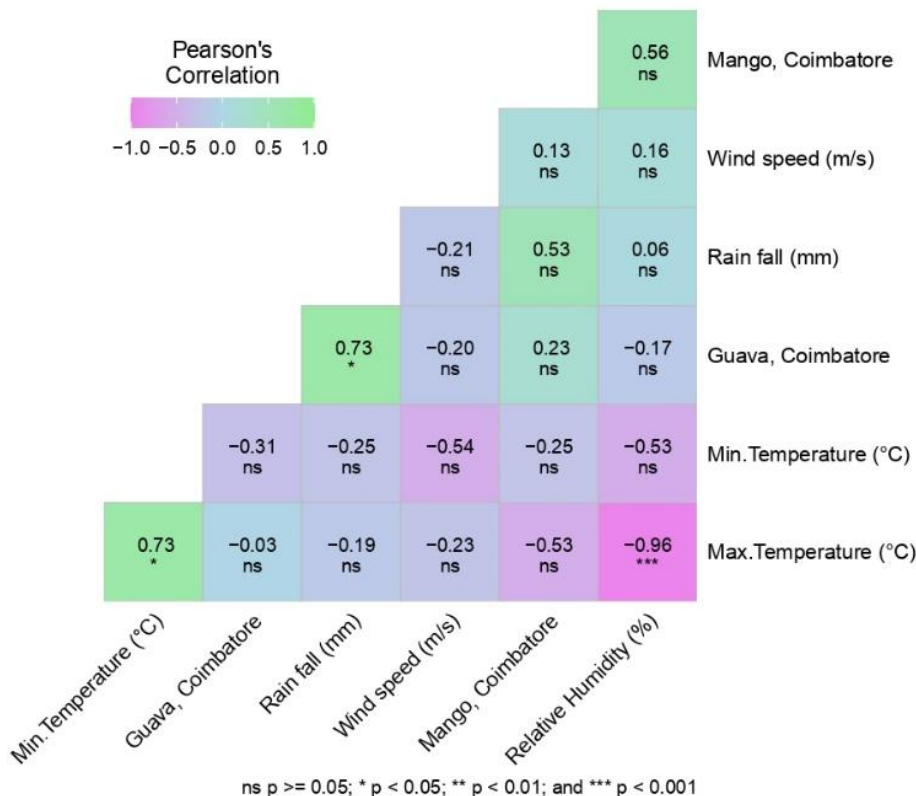


Fig. 3. Effect of weather parameters on methyl eugenol trap catches in mango and guava orchard of Coimbatore Districts

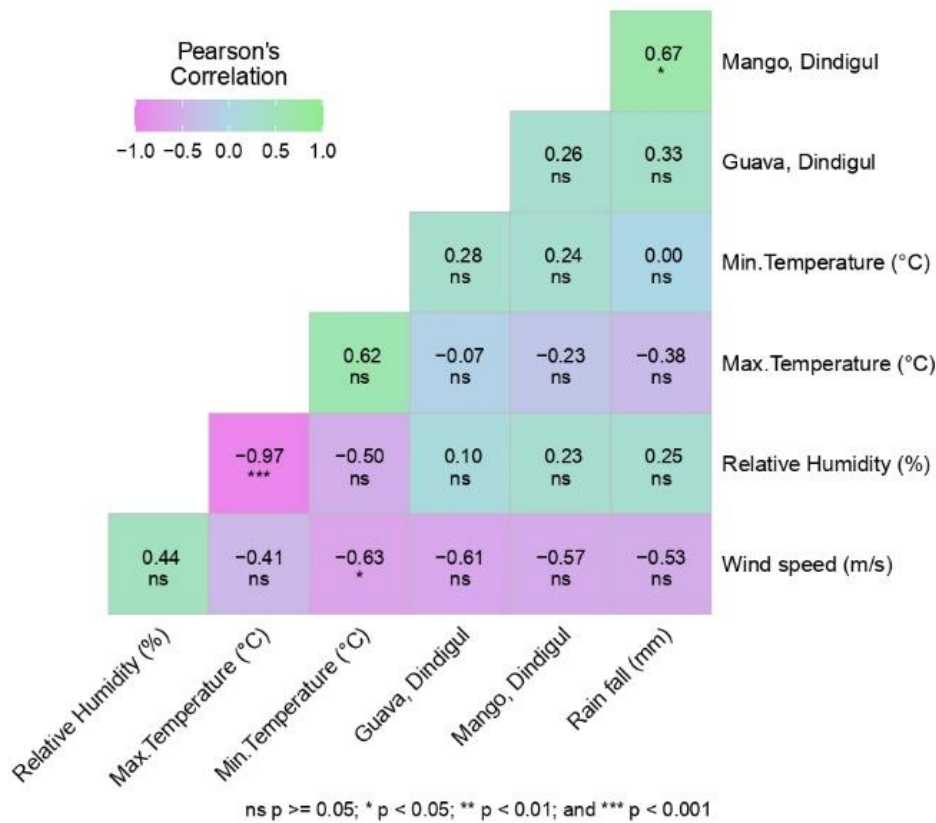


Fig. 4. Effect of weather parameters on methyl eugenol trap catches in mango and guava orchard located at Dindigul Districts

The result suggested that the number of fruit flies trapped in mango and guava orchards could rise when rain fall and relative humidity rises. In guava orchard of Coimbatore District, at the end of 10th week the relative humidity showed a negative correlation with methyl eugenol trap catches. In the same experiment, up to 5th week positive correlation was recorded between trap catches and relative humidity (r=0.34), after then from 6th to 10th week, negative correlation was recorded. This may be due to methyl eugenol content in the plywood dispenser was reduced after 5th week and influenced the reduction in the trap catches from 6th week onwards. The results are in agreement with [21], who stated that relative humidity and rainfall are positively correlated and maximum and minimum temperatures are negatively correlated during the study period 2016 – 2017 in guava orchards. Similarly, [23] stated that the temperature had a positive correlation with the fruit fly population at three of the five locations studied and the other two locations had a negative correlation with the temperature, and the rainfall had a positive correlation with the population in three locations. The fruit fly population has positive correlation

with rain fall, relative humidity and min. temperature and negative correlation with max. temperature [24]. According to [25] *B. dorsalis* in guava had a significant positive correlation with minimum temperature and morning and afternoon relative humidity but a significant negative correlation with maximum temperature. [26] reported that there is a positive correlation between population buildup and rainfall. There is a positive correlation between wind speed and trap catches [27].

3.3.2 Multiple regression

The effect of various meteorological parameters on fruit fly trap captures was studied using multiple regression analysis. The equation's prediction for mango and guava orchards located in Coimbatore and Dindigul Districts ranged from 75.54 percent to 66.88 percent. Mango orchard located in Coimbatore had the best predictability in the regression model (75.54%), followed by guava orchard located in Coimbatore (75.51), guava (68.02%) and mango (66.68%) orchards located in Dindigul, with the lowest predictability (Table 5).

Table 2. Species diversity indices for trapped fruit flies in mango and guava orchard

Orchard	Diversity of fruitfly Species					
	Shannon-Weiner index (H)	Simpson's index (D)	Simpson's index of diversity	Evenness (E)	Dominance Index (D)	Margalef Richness Index (Mg)
Mango, Coimbatore	0.471	0.749	0.25	0.339	0.75	0.464
Mango, Dindigul	0.254	0.921	0.078	0.16	0.789	0.291
Guava, Coimbatore	0.936	0.593	0.406	0.468	0.406	0.482
Guava, Dindigul	0.602	0.765	0.245	0.379	0.235	0.385

Table 3. Population dynamics of *Bactrocera* spp. in the mango and guava orchard located at Coimbatore (Dt.)

SMW	Date and month	Total number of fruit flies trapped/week		Meteorological parameters				
		*Mango	*Guava	Temperature (°C)		Wind speed (m/s)	Rain fall (mm)	Relative Humidity (%)
				Max.	Min.			
16	16 - 22 April	27	37	35.1	24.57	1.27	8.55	67.91
17	23 - 29 April	28	62	33.69	24.62	0.96	91.08	72.95
18	30 April - 6 May	67	127	29.2	23.41	1.11	130.09	81.24
19	7 - 13 May	134	67	29.75	24.13	1.17	158.69	84.46
20	14 - 20 May	77	42	30.7	24.68	1.04	26.48	84.12
21	21- 27 May	67	29	29.35	24.23	1.03	36.68	86.92
22	28 May - 3 June	49	35	29.56	24.19	0.99	45.45	85.01
23	4 - 10 June	41	23	28.78	23.79	1.31	57.7	86
24	11 - 17 June	79	48	28.65	23.71	1.42	42.69	87.48
25	18 - 24 June	72	32	28.83	23.46	1.31	31.92	86.18

*Cumulative mean of three traps

Table 4. Population dynamics of *Bactrocera* spp. in the mango and guava orchard located at Dindigul (Dt.)

SMW	Date and month	Total number of fruit flies trapped/week		Meteorological parameters				
		*Mango	*Guava	Temperature (°C)		Wind speed (m/s)	Rain fall (mm)	Relative Humidity (%)
				Max.	Min.			
16	16 - 22 April	72	16	37.34	23.23	1.63	2.11	48.21
17	23 - 29 April	101	19	32.51	23.33	1.67	95.85	69.66
18	30 April - 6 May	140	22	29.14	22.37	1.51	161.04	79.79
19	7 - 13 May	145	15	30.43	22.65	2.26	78.46	81.2
20	14 - 20 May	125	18	31.41	23.46	2.07	21.03	78.41
21	21- 27 May	70	24	31.42	22.69	2.19	24.08	77.73
22	28 May - 3 June	103	29	30.56	22.79	1.97	47.15	79.7
23	4 - 10 June	39	14	29.97	22.39	3.32	25.23	80.51
24	11 - 17 June	75	11	30.41	22.13	3.49	7.95	79.19
25	18 - 24 June	80	15	29.84	21.76	2.8	22.99	79.76

*Cumulative mean of three traps

Table 5. Multiple linear regression of methyl eugenol trap catches of fruit flies with weather parameters in mango and guava orchards

District	Orchard	Regression model	Regression coefficient (R ²)
Coimbatore	Mango	$Y = -1738.90 + 37.84 x_1 - 23.57 x_2 + 56.50 x_3 + 0.53 x_4 + 13.64 x_5$	0.7554
	Guava	$Y = 1567.28 - 25.38 x_1 + 0.96 x_2 - 45.53 x_3 + 0.28 x_4 - 8.96 x_5$	0.7551
Dindigul	Mango	$Y = -959.76 + 21.74 x_1 - 11.77 x_2 - 21.51 x_3 + 0.44 x_4 + 6.62 x_5$	0.6688
	Guava	$Y = 145.83 - 2.71 x_1 - 0.19 x_2 - 11.35 x_3 - 0.09 x_4 - 0.102 x_5$	0.6802

$x_1 = \text{maximum temperature}; x_2 = \text{minimum temperature}; x_3 = \text{wind speed}; x_4 = \text{rainfall}; x_5 = \text{relative humidity}; Y = \text{number of fruit flies}$

4. CONCLUSION

The present study revealed that, in mango and guava orchards located in Coimabtoe and Dindigul Districts, the prevalence of *Bactrocera* spp. was found in the order *B. dorsalis* > *B. correcta* > *B. Caryeae* > *B. zonata*. The highest number of fruit flies were trapped in 18th SMW and 19th SMW. A high level of species diversity and richness was present in the guava orchards of both Districts. The influence of weather parameters on the methyl eugenol trap catches shows that an increase in rainfall and relative humidity increased the trap catches.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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