Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(1): 1838-1842

Received: 19-10-2020
Accepted: 21-12-2020

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Impact of weather parameters on the population dynamics of fruit flies (Tephritidae: Diptera) in mango orchard of Krishnagiri district, Tamil Nadu, India

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Abstract
Population dynamics of the Tephritid fruit flies-*Bactrocera dorsalis* Hendel and *Bactrocera correcta* Bezzi were studied in mango ecosystem at Gangaleri location in Krishnagiri district of Tamil Nadu during January to December 2018. The relationship of weather factors to population fluctuation of adult fruit flies in mango orchard was assessed in trap catches at fortnight intervals in fixed locations. The populations of *B. dorsalis* started increasing from first fortnight of April (12.5 flies/ trap/ fortnight) and reached the first peak (96.0 flies/ trap/ fortnight) in the second fortnight of June. Thereafter *B. dorsalis* catches gradually declined (with 77.5 flies/ trap/ fortnight) from first fortnight of July and reaching the lowest level (of 3.00 flies/ trap/ fortnight) during second fortnight of December. While the relative population of *B. correcta* was lower, it started increasing from first fortnight of April (from 3.0 flies/ trap/ fortnight) to also reach the first peak in second fortnight of June (13.5 flies/ trap/ fortnight),whereafter the catches declined from first fortnight of July (7.0 flies/ trap/ fortnight) with the catches reaching the lowest level (0.5 fruit flies/ trap/ fortnight) during second fortnight of December. Correlation studies with weather parameters showed that they together tended to influence the trap catches of *B. dorsalis* to an extent of 46 per cent, whereas catches of *B. correcta* were apparently not correlated with weather factors. The potential utility of these results in local fruit fly management is indicated.

Keywords: mango, population dynamics, *Bactrocera dorsalis* Hendel, *B. correcta* Bezzi

Introduction
Mango (*Mangifera indica* L.), is a widely consumed and delicious tropical fruit, and India is the global leader in mango production. Off season cropping of mango is unique to certain tracts of Tamil Nadu state in the country. While most mango cultivars tend to fruit during from April to August, certain varieties like Bangalora could also be made to mature on off- season from September to December.

Aluja (1994) [6] reported that Tephritid fruit flies are major pests of mango in most parts of the world, especially subtropical and tropical countries. Fruit fly infestation is a major constraint to mango fruit industry (Ooi, 1991) [23]. The Oriental fruit fly *Bactrocera dorsalis* (Hendel) is the most widespread pest of mango in the world (Butani, 1979) [8]. In India, the other two species of fruit fly which occur in mango and guava ecosystems include *Bactrocera correcta* Bezzi. (Nath and Bhushan, 2006) [22]. In Tamil Nadu, these three species are known to be wide spread and can cause considerable fruit yield losses in the major mango growing areas which include Krishnagiri District.

Abraham Verghese *et al*. (2002) [2] reported that fruit flies can cause yield loss ranging from 2.5 to 59.0 per cent and the loss due to *B. dorsalis* varied also with season and region. They observed higher fruit infestation on varieties Banganapalli and Totapuri with mean infested fruits being 46.0% and 59.0%, respectively. The seasonal abundance of larval hosts could also be major factors regulating the fruit fly populations (Kapatos and Fletcher, 1984) [19]. The extent of fruit damage may go upto 80 per cent when the pest incidence occurs in an epidemic form (Abdullah *et al*., 2002) [1]. The Male Annihilation Technique (MAT) using the Para pheromone- methyl eugenol- along with insecticides (like malathion) has been used to suppress the populations of fruit fly males (Singh *et al*., 2013) [27] and is considered as an

eco-friendly and consumer-safe management measure for fruit flies (Sumathi *et al*., 2019) [28]. In this context, the present field studies were conducted in Gangaleri village of Krishnagiri district in Tamil Nadu to monitor the population dynamics of the two species of fruit flies and also assess their relationship with local weather parameters and the results are discussed herein.

Materials and Methods

The present study was taken up on Bangalora variety in a mango orchard at Gangaleri village of Krishnagiri District from first fortnight of January 2018 to second fortnight of December 2018. The population dynamics of fruit flies was estimated with Methyl eugenol traps (standard white jar traps (15 cm high×10 cm dia) supplied by Sun Agro Biotech Research Centre, Chennai). This para-pheromone lure is known to attract the two species of fruit fly *viz*., *B. dorsalis and B. correcta* which were monitored in the trap catches. The traps were hung in outer and lower branches of the selected mango trees, with distance between each trap being about 50 meters. Two traps were hanged at about 2 m height above the ground in the mango trees. The fruiting period of mango in Gangaleri village f was found to occur from April to August. The fruit fly species collected from each trap were identified as per the taxonomic key provided by David and Ramani (2011) [11] and counted for each fortnight interval throughout the study period. The weather parameters *viz*., Maximum and Minimum Temperatures (ºC), Rain fall (mm) were also recorded for this location to work out the correlation between weather parameters and population dynamics of the fruit flies as per statistical methodology detailed in Gomez and Gomez (1983) [13].

Results and Discussion

The population dynamics of the two species of fruit flies- *B. dorsalis* and *B. correcta* – which was assessed by catches in using the methyl eugenol traps kept in Gangaleri location showed considerable variation among the fortnightly catches during 2018. The initial fortnightly *B. dorsalis* catch was very low (0.50 flies/ trap) during first fortnight of January. The adult catches showed significant increase from first fortnight of April (12.5 flies/ trap) and reached a first peak (96.0 flies/ trap) in second fortnight of June. The adult population tended to decline gradually (77.5 flies/ trap) from first fortnight of July and reached the lowest level (3.0 flies/ trap) during second fortnight of December (Table 1).

The results revealed considerable variation in trap catches of *B. dorsalis* between first fortnight of January to second fortnight of December 2018, with one major peak observed during second fortnight of June. There was also considerable variation among the three weather factors, apparently related to the local *B. dorsalis* population (Figure 1). These results are in conformity with the findings Gajalakshmi *et al*. (2011) [12] who had found that peak of *B. dorsalis* population in mango crop in Tamil Nadu was observed during June. Further, Bansode and Patel (2018) [7] also reported similarly from South Gujarat that the maximum numbers of B/dorsalis adults were trapped in June, which indicated the local peak in the fly population. However, our results are also in over all agreement with the other finding elsewhere in India by Nair (1995) [21] who reported that the peak population of. *B. dorsalis* was during June to July, which may be attributed to local crop phenology/variety differences. The same results are inconformity with the findings of Ravikumar and Viraktamath (2006) [25] and Ranjitha and Viraktamath (2006) [24] who reported on the population fluctuation of fruit flies that occurs in mango orchard at Dharwad, wherein *B. dorsalis* catch was 8.33 flies /trap during 27th standard week (late July).

In comparison, the overall smaller numbers of *B. correcta* in trap catches showed initially higher catches (19.0 flies/ trap/ fortnight) during first fortnight of January. The catches of *B. correcta* started increasing again from first fortnight of April 2018 (3.0 flies/ trap/ fortnight) to second fortnight of June (13.5 flies/ trap/ fortnight), reaching its first peak. The catches of fruit flies gradually declined from first fortnight of July (7.0 flies/ trap/ fortnight) and reaching the lowest level of 0.5 fruit flies/ trap/ fortnight during second fortnight of December (Table 1).

These fluctuations in populations could also be explained as noted by Suresh Babu and Viraktamath (2003) [30] that the fluctuation of fruit flies may be also dependent on the availability of the host crops. Further, Sarada *et al*., (2001) [26] had also mentioned that the peak fly population in the mango orchard was observed from May to July, which coincided with local fruit maturity period in Tirupati, Andhra Pradesh. Our results, however, are not in agreement with the findings of Suresh Babu (2002) [29] who found peak population of *B. correcta* in later months (during 46th standard week) besides by Ranjitha and Viraktamath (2006) [24] reporting the peak catches of *B. correcta* during August to November.

In our target location, trap catches of *B. dorsalis* population showed significant positive correlation with minimum temperature (r = 0.663) and not correlated with maximum temperature and rainfall. (Table 2). Such positive relationship with minimum temperatures is in conformity with was earlier report in India by Kannan and Venugopala Rao (2006) [18] and. Agarwal *et al*. (1995) [4]. Among the weather parameters such significant positive correlation with minimum temperature on mango crop has also been reported by Agarwal and Kumar (1999) [3], besides by Verghese and Sudhadevi (1998) [31] and Gupta and Bhatia (2000) [14] who found that trap catches of *B. dorsalis* have a significant positive correlation with minimum temperature. The current result also reconfirms the findings by Sarada *et al*. (2001) [26] that fruit fly population of *Bactrocera* sp. had positive correlation with minimum temperature and positive non-significant correlation with maximum temperature. The present findings are also coinciding with the results of Gajalakshmi *et al*., (2011) [12] that relationship between the *B. dorsalis* population and weather factors, showed a significant positive association with minimum temperature (r=0.552), besides non-significant relationship with maximum temperature and rainfall as also found by Mahmood et al. (2002) [20]

The seasonal trap catches of *B. correcta* in our target location had non significant correlation with maximum, minimum temperature and rainfall, with the weather parameters together influencing the trap catches only to the extent of 4 per cent (Table 2)..The present study results are at variance with the observations of Agarwal and Deepa (2013) [5] who conducted such study at five locations of Kanpur district, (U.P) and found that population of *B. correcta* was influenced by temperature, which had a positive correlation at three places, negative correlation two other places (r = -0.034 and 0.2811). The finding of the present investigation is in agreement with the reports of Rainfall had a positive correlation with catches of *B. correcta* at three locations while it showed negative correlation at two places.

The present finding, however, is in overall agreement with the results of Gajalakshmi *et al*. (2011) [12] who had reported that *B. correcta* showed a significant positive correlation with minimum temperature (r=0.548). Minimum temperature and population of guava fruit fly *B. correcta* had the same positive correlation (Hendrichs *et al*., 2002) [16]. Sarada *et al*. (2001) [26] observed that fruit fly population of *Bactrocera* sp. had positive correlation with rainfall. The present study corroborates with Hasyim *et al*. (2008) [15] who reported that rainfall had positive and highly significant correlation with fruit flies caught per trap, besides with the report of Jalaluddin *et al*. (2001) [17] that weekly catch of *B. correcta* had significant positive correlation with rainfall (r = 0.2364) in guava orchard.

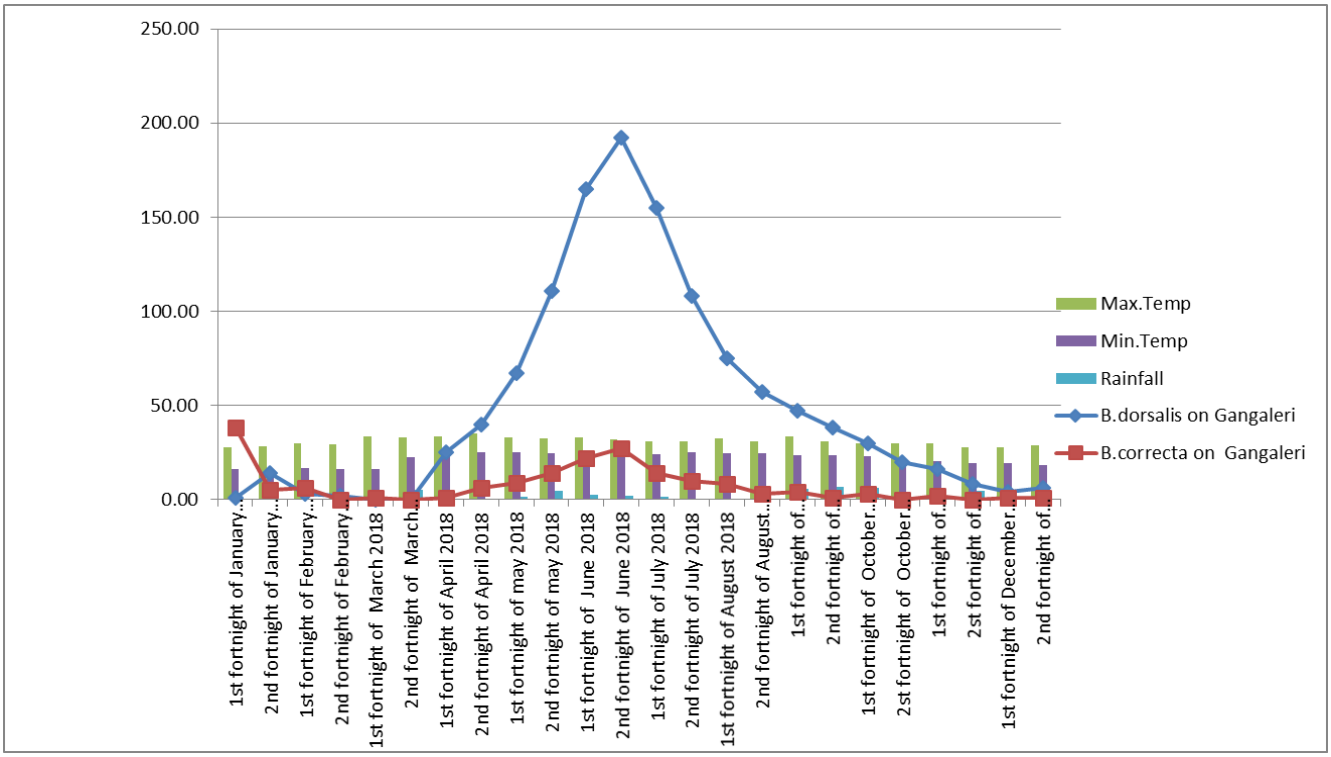

Fig 1: Population dynamics of *Bactrocera dorsalis* and *B. correcta* in the mango orchard in relation with weather parameters during January-December, 2018.

Table 1: Population dynamics of *Bactrocera dorsalis* and *B. correcta* in the mango ecosystem of Gangaleri village in Krishnagiri District (during January to December 2018)

Fortnight intervals	Number of fruit flies trapped/ fortnight			
	B. dorsalis	**Mean±S.D**	***B. correcta***	**Mean±S.D**
1st fortnight of January	1.00 (1.22)^{f}	0.50±0.71	38.00 (6.20)^{a}	19.00±15.56
2nd fortnight of January	14.00 (3.81)^{ef}	7.00±2.83	5.00 (2.35)^{bd}	2.50±0.71
1st fortnight of February	3.00 (1.87)^{f}	1.50±0.71	6.00 (2.55)^{bd}	3.00±0.00
2nd fortnight of February	2.00 (1.58)^{f}	1.00±1.41	0.00 (0.71)^{d}	0.00±0.00
1st fortnight of March	0.00 (0.71)^{f}	0.00±0.00	1.00 (1.22)^{d}	0.50±0.71
2nd fortnight of March	0.00 (0.71)^{f}	0.00±0.00	0.00 (0.71)^{d}	0.00±0.00
1st fortnight of April	25.00 (25.05)^{def}	12.50±10.61	1.00 (1.22)^{d}	0.50±0.71
2nd fortnight of April	40.00 (6.36)^{def}	20.00±18.38	6.00 (2.55)^{cd}	3.00±1.41
1st fortnight of May	67.00 (8.22)^{cde}	33.50±17.68	9.00 (3.08)^{bcd}	4.50±6.36
2nd fortnight of May	111.00 (10.56)^{bc}	55.50±34.65	14.00 (3.81)^{bcd}	7.00±5.66
1st fortnight of June	165.00 (12.86)^{ab}	82.50±38.89	22.00 (4.74)^{abc}	11.00±4.24
2nd fortnight of June	192.00 (13.87)^{a}	96.00±39.60	27.00 (5.24)^{ab}	13.50±10.61
1st fortnight of July	155.00 (12.47)^{ab}	77.50±31.82	14.00 (3.81)^{bcd}	7.00±1.41
2nd fortnight of July	108.00 (10.42)^{bc}	54.00±35.36	10.00 (3.24)^{cd}	5.00±5.66
1st fortnight of August	75.00 (8.69)^{cd}	37.50±28.99	8.00 (2.92)^{cd}	4.00±0.00
2nd fortnight of August	57.00 (7.58)^{cdef}	28.50±10.61	3.00 (1.87)^{cd}	1.50±2.12
1st fortnight of September	47.00 (6.89)^{def}	23.50±9.19	4.00 (2.12)^{d}	2.00±2.83
2nd fortnight of September	38.00 (6.20)^{def}	19.00±2.83	1.00 (1.22)^{d}	0.50±0.71
1st fortnight of October	30.00 (5.52)^{def}	15.00±5.66	3.00 (1.87)^{d}	1.50±2.12
2st fortnight of October	20.00 (4.53)^{def}	10.00±2.83	0.00 (0.71)^{d}	0.00±0.00
1st fortnight of November	16.00 (4.06)^{def}	8.00±2.83	2.00 (1.58)^{d}	1.00±0.00
2st fortnight of November	8.00 (2.92)^{ef}	4.00±2.83	0.00 (0.71)^{d}	0.00±0.00
1st fortnight of December	4.00 (2.12)^{f}	2.00±1.41	1.00 (1.22)^{d}	0.50±0.71
2nd fortnight of December	6.00 (2.55)^{f}	3.00±1.41	1.00 (1.22)^{d}	0.50±0.71

Figures in parentheses are square root transformed values

Mean in a column followed by same letters are not significantly different (P = 0.05) by LSD

Table 2: Correlation and multiple linear regression model for weather parameters on trap catches of *B. dorsalis and B. correcta* in mango ecosystem (during January - December 2018)

Fruit fly species	Correlation Coefficient value			Multiple linear regression equation	Coefficient of determination
	Max. Temperature (^{0}C) (X1)	Min. Temperature (^{0}C) (X2)	Rainfall (mm) (X3)	(Y)	(R^2)
B. dorsalis	0.394 ^{NS}	0.663**	0.120 ^{NS}	$Y= -135.56-2.90X_1+13.07X_2-3.79X_3$	0.462
B. correcta	0.019 ^{NS}	0.108 ^{NS}	-0.092 ^{NS}	$Y= 11.58-0.59X_1+0.71X_2-0.70X_3$	0.040

X_1 = maximum temperature; X_2 = minimum temperature; X_3= rain fall; Y = number of fruit flies.
Significant at 0.01% NS = Non significant

Conclusion

The adult population of *B. dorsalis* in the study location (Gangaleri of Krishnagiri district) reached its first peak (96.00 flies/ trap/ fortnight) in the second fortnight of June 2018, while *B. correcta* also recorded the peak (13.50 flies/ trap/ fortnight) in the same fortnight. In terms of correlation with weather factors, *B. dorsalis* population had significant positive correlation with minimum temperature (r = 0.663) and but not correlated with maximum temperature and rainfall. In case of *B. correcta* there was non significant but positive correlation with maximum and minimum temperature and negative correlation with rainfall. Apparently the mainabiotic factors did not seem to play an important role in regulating *B. correcta* population.

The present studies reconfirm that minimum temperature could be used for short term forecast of *B. dorsalis* populations which are predominant in the chosen location. Further studies in additional locations among mango farms across Krishnagiri district are recommended towards developing a more robust baseline and prediction tool for managing these two important fruit fly species in this mango growing tract in Tamil Nadu.

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