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Species diversity and population dynamics of fruit flies in bitter gourd ecosystem

■ Mahesh Math*, Y. K. Kotikal[1] **and** Venkateshalu[1]

Agricultural and Horticultural Research Station, Kapikad, Ullal, Mangaluru (Karnataka) India
[1]Department of Entomology, College of Horticulture, University of Horticultural Sciences, **Bagalkot (Karnataka) India**

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***Corresponding author:**
Email : maheshento@gmail.com

ABSTRACT

Studies related to species diversity and seasonal incidence of fruit flies in drumstick ecosystems were conducted at University of Horticultural Sciences (UHS), Udyanagiri, Bagalkot, India during *Rabi* 2015-16 and *Kharif* 2016. During *Rabi* 2015 Shannon Wiener index (H') of diversity of the fruit fly population was maximum (H'=0.64) during 6th SMW of (February) 2016. The Pielou's evenness (J') value was maximum during 6th SMW of (February) 2016 and 52nd SMW of (December) 2015 (0.92 and 0.79, respectively). The maximum Simpson diversity index value (0.66) was recorded during 6th SMW of (February) 2016. During 2016 maximum H value (H'=0.61) was recorded during 38th followed by 36th SMW of (September) 2016 (0.79). The Pielou's evenness (J') ranged from 0.33 to 0.88. Maximum (J') value was recorded during 38th SMW of (September) 2016 (0.88) and 36th SMW of (September) 2016 (0.79).

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INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is one of the most popular vegetables in Southeast Asia and belongs to family Cucurbitaceae, which is also known as bitter melon, *Karella*, or balsam pear. The medicinal value of the bitter gourd, in the treatment of infectious diseases and diabetes, is attracting the attention of scientists worldwide. At present, in India, it is grown over an area of 93.00 thousand hectare with annual production of 1030 lakh tonnes. The area and production are fast increasing in the states like Telangana, Odisha, Bihar, Chhattisgarh and Madhya Pradesh (Anonymous, 2017). Increasing area and production, has resulted in increased intensity of pest infestation, particularly by the fruit fly. The fruits attacked in early stages fail to develop properly and drop or rot on the plant, whereas at later stage are prone to rot after harvest if stored. The aim of the study was to know the seasonal abundance, species diversity of the fruit flies in bitter gourd under the existing ecological conditions, particularly in Northern dry zone of Karnataka.

MATERIAL AND METHODS

Studies related to species diversity and seasonal incidence of fruit flies in bitter gourd ecosystem was conducted at University of Horticultural Sciences (UHS), Udyanagiri, Bagalkot, India during *Rabi* 2015-16 and *Kharif* 2016. The data on seasonal incidence of fruit flies were collected by installing barrix catch™ vegetable fly trap. Barrix catch™ vegetable fly traps were tied at canopy level @ 2 traps per treatment. Total Number and species of fruit flies trapped in each trap were counted at weekly interval. After each observation traps were emptied. Observations were recorded throughout the two cropping seasons. Cue lures were charged at monthly interval. Number of fruit flies trapped per trap per week for each species was averaged and correlated with weather parameters *viz.*, minimum and maximum temperature, minimum and maximum relative humidity, rainfall and wind speed.

Diversity index:

The species diversity was worked out by using the following Simpson's index (λ) (Simpson, 1949) and Shannon's Weiner index (H') (Shannon and Wiener, 1949) formulae to know the species richness in bitter gourd ecosystem and within the cropping season at different stages.

Simpson index = $\sum_{i=1}^{s} P_i^2$

where, Pi is the proportional abundance of the ith species given by

$$P_i = \frac{n_i}{N}, i = 1, 2, 3, \ldots\ldots\ldots S$$

where, ni number of individuals of the ith species and N is the total number of individuals for all S species in the population.

Simpson diversity= $1 - \sum p_i^2$

Shannon index (H^1) = $\sum_{i=1}^{s} [P_i \text{ in } P_i]$

where, H^1 is the average uncertainty per species in an infinite community made up of S species with known proportional abundance.

$P_i = P_1, P_2, P_3, \ldots\ldots\ldots\ldots PS$

where, P_i is the proportion of individuals found in ith species given by $\frac{n_i}{N}$ n_i and N are the number of individuals of ith species and total number of individuals, respectively.

Evenness indices:

Indices of evenness of Pielou's (J') (Pielous, 1969) were calculated using the following eq.

Pielou's evenness (J') :

$$J' = \frac{H'}{In\,(S)} = \frac{H'}{H\,max}$$

H' is Shannon's Weiner index

H max is the maximum diversity given by In (S).

where, S is the total number of species.

To know the diversity of the fruit flies occurring in the bitter gourd ecosystem, the collected specimens were mounted on paper point and were also preserved in 70 per cent alcohol with proper label and were sent for identification to Dr. K.J. David, Scientist **(**Agril. Entomology), Division of Insect Systematics, ICAR-National Bureau of Agricultural Insect Resources**,** Bengaluru. Species diversity was documented after getting identity of the fruit fly specimens.

RESULTS AND DISCUSSION

Total five fruit flies were observed in bitter gourd during *Rabi* 2015-16 and *Kharif* 2016. They were *Bactrocera cucurbitae* (Coquillet), *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Bactrocera gavisa* (Munro) and *Dacus ciliatus* Loew. The species diversity indices of fruit flies in bitter gourd during *Rabi* 2015 showed that Shannon Wiener index (H') of diversity of the fruit fly population ranged from 0.00 to 0.64, maximum (H'=0.64) during 6th SMW of (February) 2016 followed by 52nd SMW of (December) 2015 (H='0.55). A low H value in particular standard week indicated the low species diversity. The Pielou's evenness (J') ranged from 0.00 to 0.92. Maximum (J') value was recorded during 6th SMW of (February) 2016 and 52nd SMW of (December) 2015 (0.92 and 0.79, respectively). This indicated that species present in the community have almost equal number of individuals. Simpson diversity index ranged from 0.00 to 0.66. The maximum Simpson diversity index value (0.66) was recorded during 6th SMW of (February) 2016 followed by 52nd SMW of (December) 2015 (0.40) which indicated that the diversity of fruit fly species was maximum (Table 1). The species diversity indices of fruit flies during 2016 showed that Shannon Wiener index H of diversity of the fruit fly population ranged from 0.27 to 0.61. Maximum H value (H'=0.61) was recorded during 38th followed by 36th

SMW of (September) 2016 (0.79). The Pielou's evenness (J') ranged from 0.33 to 0.88. Maximum (J') value was recorded during 38th SMW of (September) 2016 (0.88) and 36th SMW of (September) 2016 (0.79). It indicated that species present in the community have equal members of individuals. Simpson diversity (D) index ranged from 0.11 to 0.43 (Table 2).

Agarwal and Kapoor (1988) reported seven species from Himachal Pradesh in cucurbit ecosystem *viz., B. tau, B. cucurbitae, B. dorsalis, B. zonata, B. scutellaris, B. diversa* and *Dioxyna sororcula* (Wiedemann). Prabhakar *et al.* (2009) also reported seven of fruit flies in cucumber field *viz.*, *Bactrocera (Bactrocera) latifrons* (Hendel), *B. (B.) nigrofemoralis* White and Tsuruta, *Dacus (Callantra) longicornis* Wiedemann, *Dacus (Callantra) sphaeroidalis* (Bezzi), *Cyrtostola limbata* (Hendel) and *Pliomelaena udhampurensis*. Similarly, Ganie *et al.* (2013) recorded four species of fruit flies on cucurbits namely, *B. cucurbitae, B. dorsalis, B. tau and B. scutellaris.* Nair *et al.* (2017) recorded nine species of *Dacine fruit flies viz., B. dorsalis, B. latifrons, B. (Hemigymnodacus) diversa* (Coquillett), *B. (Sinodacus) hochii* (Zia), *B. (Zeugodacus) caudata* (Fabricius), *B. (Zeugodacus) cucurbitae* (Coquillett), *B. (Zeugodacus) tau* (Walker), *B. (Parasinodacus) cilifera* (Hendel) and *Dacus (Callantra) longicornis* (Wiedemann) associated with cucurbit crops. *B. (Sinodacus) hochii* and *B. (Parasinodacus) cilifera* are the new records for India.

The first trap catches of *B. cucurbitae* catches noticed during the 51st SMW of (December) 2015, with an average of 2.00 flies per trap per week. The population remained lo w and reached to its maximum of 35.50 flies per trap per week during 2nd SMW of (January) 2016. Then onwards the trap catches declined and reached zero population during 7th and 8th SMW of (February) 2016. The first appearance of *Bactrocera* spp in the trap was observed during the 52nd SMW of December with mean number of 2.50 flies per trap per week. The population showed peak during 1st and 2nd SMW of (January) 2016 with mean catches of 3.00 flies per trap per week. Population decreased to 1.00 fly per trap per week during 6th SMW (Table 3). Irrespective of species of fruit flies maximum catches were noticed during 1st and 2nd SMW of (January) 2016 (31.00 and 38.50 flies/trap/week, respectively). Thereafter, population gradually declined to1.00 fly per trap per week during 7th SMW and no flies during 8th SMW (Table 3).

B. cucurbitae trap catches noticed during the 34th SMW of August 2016 with 16.00 flies per trap per week. The population reached to its maximum of 102.25 flies per trap per week during 36th SMW of 2016 and followed by 37th SMW recorded 96.00 flies per trap per week. The trap catches declined thereafter to 2.00 flies during 43rd SMW. The first appearance of *Bactrocera* spp in the trap was observed during 34th SMW of (August) 2016 with mean number of 1.00 fly per trap per week. The population reached to its maximum of 49.00 fly per trap per week during 38th SMW of (September) 2016. The trap catches declined thereafter recorded no flies during 40 to 43rd SMW. Irrespective of species of fruit flies, maximum catches were noticed during 36th and 37th SMW of (September) 2016 (135.00 and 108.00 flies/trap/week, respectively). Thereafter, population gradually declined and reached to 2.00 flies per trap per week during 7th SMW and no flies during

Table 1 : Species diversity indices for fruit flies in bitter gourd during *Rabi* 2015-16

SMW	Shannon's index (H')	Pielou's evenness (J')	Simpson index (D)	Simpson diversity index (1-D)
51	-	-	-	-
52	0.55	0.79	0.59	0.40
1	0.33	0.48	0.81	0.18
2	0.27	0.39	0.85	0.14
3	0.17	0.25	0.91	0.08
4	-	-	-	-
5	-	-	-	-
6	0.64	0.92	0.33	0.66
7	-	-	-	-
8	0.00	0.00	0.00	0.00

SMW- Standard meteorological weeks (- Species diversity was not noticed)

43rd SMW (Table 4).

Present results show slight variation in the peak activity when compared to the findings of Vargas *et al.* (1990) who noticed the highest number of *B. cucurbitae* in June and the lowest in April during first year whereas the highest captures occurred in October and the lowest in February during the second year. According to the findings of Anjum *et al.* (2000), peak population of fruit fly was recorded during the first week of July. Present results are in line with the findings of Banerji *et al.* (2005) who reported that infestation *B. cucurbitae* was highest during *Kharif* season followed by summer and *Rabi* seasons. The highest yield of 87.40 q per ha was recorded in the summer sown crop (March) with 27.6 per cent infestation followed by *Kharif* sown crop (June). According to Kakar *et al.* (2014), fruit flies infestations in bitter gourd reached the highest percentage in August and from there onwards the infestation drastically decreased and reached lowest infestation in November. But, in present study the highest infestation was recorded in September. This variation might be attributed to difference in geographical location and also variation in abiotic factors mainly cropping pattern. The results are broadly in agreement with Vignesh and Viraktamath (2015) who reported high incidence of *B. cucurbitae* during *Kharif* and low in *Rabi* season. However, there seems to be no definite trend in the population fluctuation of *B. cucurbitae* which might probably vary depending upon the crops cultivated and fruiting in a particular locality.

Influence of weather parameters on population dynamics of fruit fly species in bitter gourd during (*Rabi*) 2015-16 and (*Kharif*) 2016:

Studies were made to find out the relationship

Table 2: Species diversity indices for fruit flies in bitter gourd during *Kharif* 2016

SMW	Shannon's index (H')	Pielou's evenness (J')	Simpson index (D)	Simpson diversity index (1-D)
34	0.23	0.33	0.88	0.11
35	0.27	0.39	0.84	0.15
36	0.55	0.79	0.62	0.37
37	0.35	0.50	0.80	0.19
38	0.61	0.88	0.57	0.43
39	0.42	0.61	0.73	0.26
40	-	-	-	-
41	-	-	-	-
42	-	-	-	-
43	-	-	-	-

SMW- Standard meteorological weeks (- Species diversity was not noticed)

Table 3: Number of fruit flies trapped by barrix catch™ vegetable fly trap in bitter gourd during (*Rabi*) December 2015 to February 2016

SMW	*Trap catches per trap per week		Total flies No. of fruit flies
	B. cucurbitae	*Bactrocera* spp**	
51	2.00	0.00	2.00
52	8.00	2.50	10.50
1	28.00	3.00	31.00
2	35.50	3.00	38.50
3	21.50	1.00	22.50
4	4.00	0.00	4.00
5	1.00	0.00	1.00
6	2.00	1.00	3.00
7	0.00	1.00	1.00
8	0.00	0.00	0.00
Total flies caught	102.00	11.50	113.50

*Mean of 4 traps SMW- Standard meteorological weeks

** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

between trap catches of different species of fruit flies and weather parameters such as maximum and minimum temperature, morning and evening relative humidity and rainfall. Influence of weather parameters on *B. cucurbitae* and *Bactrocera* spp. population was worked out by calculating correlation coefficient of trap catches. The correlation analysis between the weather parameters and fruit fly trap catches revealed that *B. cucurbitae*

Table 4 : Number of fruit flies trapped by barrix catch™ vegetable fly trap in bitter gourd during (*Kharif*) August 2016 to October 2016

*SMW	*Trap catches per trap per week		Total fruit flies
	B. cucurbitae	*Bactrocera* spp**	
34	16.00	1.00	17.00
35	33.00	3.00	36.00
36	102.25	32.75	135.00
37	96.00	12.00	108.00
38	21.50	49.00	70.50
39	17.00	3.00	20.00
40	12.00	0.00	12.00
41	8.00	0.00	8.00
42	4.50	0.00	4.50
43	2.00	0.00	2.00
Total flies caught	312.25	100.75	413.00

*Mean of 4 traps SMW- Standard meteorological weeks
** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

Table 5 : Correlation co-efficients of trap catches of fruit flies with weather parameters in bitter gourd during 2015-16

Fruit fly species	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
B. cucurbitae	-0.429	0.281	0.284	0.666	0.000
Bactrocera spp.**	-0.161	-0.274	0.468	0.276	0.000

* Significant at 5% ** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

Table 6 : Correlation co-efficients of trap catches of fruit flies with weather parameters in bitter gourd during 2016

Fruit fly species	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
B. cucurbitae	-0.364	0.071	-0.569	0.318	0.121
Bactrocera spp.**	-0.609	-0.041	0.302	0.564	0.220

* indicate significance of value at P=0.05 ** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

Table 7: Multiple linear regression of trap catches of fruit flies with weather parameters in bitter gourd during 2015-16

Fruit fly species	Regression model	Regression co-efficient (R^2)
B. cucurbitae	$Y = 58.11 - 1.82x_1 - 0.79x_2 + 2.38x_3 - 2.55x_4 + 0.00x_5 + 14.64$	0.441
Bactrocera spp.**	$Y = 11.68 - 0.20x_1 - 0.46x_2 + 0.27x_3 - 0.28x_4 + 0.00x_5 + 1.09$	0.659

x_1 = Maximum temperature; x_2 = Minimum temperature; x_3 = Relative humidity in the morning; x_4 = Relative humidity in the evening; X_5 = Rain fall; Y = Number of fruit flies. ** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

Table 8 : Multiple linear regression of trap catches of fruit flies with weather parameters in bitter gourd during 2016

Fruit fly species	Regression model	Regression co-efficient (R^2)
B. cucurbitae	$Y = 1723.07 - 12.44x_1 + 4.05x_2 - 15.86x_3 - 0.37x_4 - 1.05x_5 + 29.17$	0.722
Bactrocera spp.**	$Y = -92.84 - 1.36x_1 - 0.28x_2 + 0.97x_3 + 0.83x_4 + 0.15x_5 + 18.80$	0.467

x_1 = Maximum temperature; x_2 = Minimum temperature; ; x_3 = Relative humidity in the morning; x_4 = Relative humidity in the evening; X_5 = Rain fall; Y = Number of fruit flies ** *Bactrocera zonata* (Saunders), *Bactrocera correcta* (Bezzi), *Dacus ciliatus* Loew

and *Bactrocera* spp. had no significant relationship with any of the weather parameters during 2015-16 and 2016 (Table 5). However, maximum temperature had negative relation with trap catches (r=-0.43) while, minimum temperature, morning and evening relative humidity, rainfall had positive relationship with trap catches of *B. cucurbitae* (r=0.28, 0.28, 0.67 and r= 0.00, respectively) during 2015-16. *Bactrocera* spp. had a negative relation with maximum and minimum temperature (r=-0.16 and -0.27) while, morning and evening relative humidity, rainfall had positive relationship with trap catches (r=0.46, 0.27 and r= 0.00, respectively) during 2015-16 (Table 5). During 2016, maximum temperature and morning relative humidity had negative relationship with trap catches (r=-0.36 and r=- 0.56, respectively) while, minimum temperature, evening relative humidity and rainfall had positive relationship with trap catches of *B. cucurbitae* (r=0.07, 0.31 and r= 0.12, respectively). *Bactrocera* spp. had a negative relation with maximum and minimum temperature (r=-0.60 and -0.04) while, morning and evening relative humidity, rainfall had positive relationship with trap catches (r=0.30, 0.27 and r= 0.56 and 0.22, respectively) during 2016 (Table 6).

Multiple regression analysis on the effect of different weather parameters together on the fruit fly trap catches showed the influence on fruit fly species during 2015-16. The influence of weather parameters on trap catches of *B. cucurbitae* was to the extent of 44 per cent. *Bactrocera* spp recorded 65.9 per cent (Table 7). During 2016, weather factors collectively influenced trap catches of *B. cucurbitae* to an extent of 72.2 per cent while only 46.7 per cent *Bactrocera* spp. (Table 8).

Present results also indicated varied responses by different species of fruit flies towards abiotic factors. The results of present correlation studies draw considerable support from the findings of Hasyim *et al.* (2008) who reported positive correlation of trap catches with mean temperature and rainfall. In the present study, there was a negative correlation between maximum temperature and weekly trap catches of fruit flies. The present findings are in conformity with Laskar and Chatterjee (2010) who found that the mean maximum, minimum temperature had positive and significant correlation, whereas relative humidity had negative correlation with melon fruit fly incidence. The results were also more or less in conformity with Barma *et al.* (2013) and Barma and Jha (2011) who observed significant positive correlation with maximum and minimum temperature, significant negative relation with relative humidity. According to Sunil *et al.* (2016), fruit fly infestation was at peak during last week of September (52%) and last week of February (33%). Fruit fly, in *Kharif* had significant positive correlation with rainfall (r = 0.71) and positive correlation with maximum temperature (r = 0.35) and maximum RH (r = 0.59). During *Rabi*, there was significant positive correlation with maximum temperature (r = 0.76). Multiple linear regression suggested that incidence of fruit fly on bitter gourd was influenced by rainfall to an extent of 51 per cent during *Kharif* and 59 per cent by maximum temperature during *Rabi*. None of the abiotic factors exhibited significant correlation with the weekly trap catches of *B. cucurbitae* and other fruit fly species. The present findings indicted that diversity of fruit flies, *Bactrocera* spp. in bitter gourd ecosystem is very low. The dominant species found in bitter gourd ecosystem was *B. cucurbitae*. Irrespective of species of fruit flies maximum catches were noticed during 1st and 2nd SMW of (January) 2016 (31.00 and 38.50 flies/trap/week, respectively) while during 36th and 37th SMW of (September) 2016 (135.00 and 108.00 flies/trap/week, respectively).

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