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Short Communication

Population dynamics and diversity of tephritid fruit flies (Diptera: Tephritidae) under mid hill conditions of Himachal Pradesh

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Abstract

Studies on population dynamics and diversity of tephritid fruit flies (Diptera: Tephritidae) under mid hill conditions of Himachal Pradesh using Palam fruit fly traps revealed the prevalence of fruit flies species *Bactrocera* (*Zeugodacus*) *tau* (Walker), *Bactrocera* (*Zeugodacus*) *cucurbitae* (Coquillett), *Bactrocera* (*Zeugodacus*) *scutellaris* (Bezzi), *Bactrocera zonata* (Saunders), *Bactrocera dorsalis* (Hendel), *Bactrocera divenderi* (Maneesh, Hancock and Prabhakar), *Dacus longicornis* (Wiedemann) and *Dacus sphaeroidalis* (Bezzi). Among different fruit fly species trapped, *Bactrocera divenderi* was the most dominant species followed by *B. dorsalis* and *B.tau.* Among abiotic factors, temperature showed positive correlation with trap catches.

Key words: Fruit flies, *Bactrocera, Dacus sphaeroidalis, Dacus longicornis*

Cucurbits are infested by a variety of insect-pests from germination to harvesting although a few of them such as hadda beetle, red pumpkin beetle and fruit flies are particularly problematic. Depending on the season and the cucurbit species, losses due to fruit fly might range from 30 to 100 per cent (Dhillon *et al*. 2005). Family Tephritidae (true fruit flies) consists of more than 5000 species scattered globally in 500 genera (Scolaris *et al*. 2021). Fruit flies are also termed as ''ornamental flies'' due to their strutting and vibrating wings (Kapoor 1993). Tephritid fruit flies belonging to subfamily Dacinae have worldwide spread, covering tropical and subtropical regions making it troublesome to raise cucurbitaceous vegetables (Allwood *et al*. 2001). So far, eighteen fruit fly species have been found associated with sixteen different cucurbits in India (Pramanik *et al*. 2021). With the arrival of monsoon, fruit flies reach their peak activity, and as a result, any residual insecticides used to control them are washed away. Fruit fly eggs are inserted inside the fruits making the maggots inaccessible to contact insecticides. After the eggs are laid, there is no way to manage the infestation except to remove and destroy infested fruits. Moreover, injudicious use of insecticides may leave residues harmful to consumers.

Fruit fly control frequently necessitates the use of multiple strategies. Each of these strategies has its own set of benefits and drawbacks, and its use may or may not be appropriate in every situation (Suckling *et al*. 2014). Protein baits, fruit bagging, field sanitation, fruit fly-resistant genotypes, parapheromone traps, augmentation of bio control agents, and soft pesticides can all be used to successfully manage fruit fly in a local area. The sterile insect approach has also been effectively employed in the control of fruit flies as part of the area wide management program (Dhillon *et al*. 2005). Male annihilation technique (MAT) has been used with methyl eugenols and cuelure in attractant traps for mass trapping of adult male fruit flies apart from food baits mixed with a toxicant as bait application technique to attract female flies (Devi *et al*. 2020). Population dynamics and knowledge about the species prevalent in a particular area is of utmost importance and could play a decisive role in the

success of a management programme. The present studies were therefore, carried out in mid hill conditions of the state to study the population dynamics and diversity of tephritid fruit flies for effective implementation of management strategies.

Population dynamics of fruit flies at Palampur

The studies on population dynamics of fruit flies were carried out in the experimental farm of Department of Entomology, College of Agriculture, CSKHPKV, Palampur situated at an elevation of 1290 m above mean sea level in North Western Himalayas. Geographically, the experimental site is situated at 32.10^0 N latitude and 76.91^0 E longitude. The region falls in the mid-hill sub-humid zone (zone II) of Himachal Pradesh. The studies were conducted during *kharif*, 2022 using Palam fruit fly traps obtained from Department of Entomology, College of Agriculture, CSKHPKV, Palampur to record the prevalence and abundance of fruit flies. Palam fruit fly traps were installed in the cucurbit ecosystem at five locations to know about the economically significant fruit fly species associated with cucurbits. Palam trap consisted of empty mineral water bottle with central 10 cm section covered with yellow adhesive tape and has 15 holes in the middle of the bottle. The lure was loaded inside the bottle impregnated in a wooden block (4×3×12cm) containing mixture of parapheromone and insecticides. The wooden blocks were changed after every four weeks. The trapped fruit flies were counted weekly and brought to laboratory for identification following White and Elson-Harris (1992) to determine population dynamics and relative abundance of fruit fly species at Palampur. The data obtained was analyzed statistically to draw conclusions.

Relation of fruit fly species with abiotic factors

The weather data were collected from the meteorological observatory of the Department of Agronomy, CSKHPKV Palampur. Mean trap catches was correlated with ecological parameters to establish relationship with abiotic factors (maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, rainfall and sunshine hours) using step wise and multiple correlation analysis.

The results presented in Table 1 showed that eight species of fruit flies i.e. *Bactrocera (Zeugodacus) tau* (Walker), *Bactrocera (Zeugodacus) cucurbitae* (Coquillett), *Bactrocera (Zeugodacus) scutellaris* (Bezzi), *Bactrocera zonata* (Saunders), *Bactrocera dorsalis* (Hendel), *Bactrocera divenderi* (Maneesh, Hancock and Prabhakar), *Dacus longicornis* (Wiedemann) and *Dacus sphaeroidalis* (Bezzi) *Zeugodacus tau* (Walker), *Zeugodacus cucurbitae* (Coquillett). *Zeugodacus scutellaris* (Bezzi), *Bactrocera zonata* (Saunders), *Bactrocera dorsalis* (Hendel), *Dacus longicornis* (Wiedemann) and *Dacus sphaeroidalis* (Bezzi) were prevalent in parapheromone traps (Palam fruit fly trap) at Palampur.

Bactrocera divenderi (earlier misidentified as *B. nigrofemoralis*) was the most predominant species recorded in the fruit fly traps at Palampur which was first observed during 1st week of April (14th SW) with mean initial population of 93.0 flies per trap per week. Thereafter, the population showed high fluctuation, as 116.0 flies/trap/week were recorded during 15th SW which decreased in next week (16th SW) to 103.0 flies/trap/week. However, trap catches increased again during 2nd fortnight of April (17th SW) to 177.0 flies/trap/week and reached to its 1st peak (444.0 flies/trap/week) during first week of May. The population of *B. divenderi* was observed to decrease gradually thereafter, recording 274.0 flies/trap/week (19th SW) to 221.5 flies/trap/week (21st SW). Trap catches slightly increased again to 226.0 and 284.5 flies/trap/week during 22nd and 23rd SW and reached to its 2nd peak of 525.5 flies/trap/week during 24th SW. Thereafter, the population of *B. divenderi* was observed to decrease gradually from 389.5 flies/ trap/week (25th SW) to 15.0 flies/ trap/week (39th SW). *Bactrocera tau*, the most dominant species recorded in infested cucurbit fruits was the third dominant species trapped in the fruit fly traps. It was first observed during 1st week of April (14th SW) with mean initial population of 61.5 flies/ trap/week which decreased to 47.5 flies/ trap/week during the 15th SW and again increased during the next week to 64.0 flies/ trap/week (16th SW). The trap catch fluctuated during the entire trapping period. The highest trap catch of 107.0 flies/ trap/week was observed during 2nd fortnight of May (21st SW). Thereafter, the population decreased to 88.0 flies/ trap/week (22nd SW) and kept on fluctuating and decreasing with minimum trap catch of 11.5 flies/

Table 1. Weekly parapheromone trap (Palam trap) catches of adult male fruit flies during 2022 at Palampur

Sampling date	Weekly fruit fly catch/ trap #									Total fruit
	SW	*B. divenderi*	*Z.tau*	*B. dorsalis*	*Z. cucurbitae*	*Z. scutellaris*	*B. zonata*	*D. sphaeroidalis*	*D. longicornis*	fly trap/week
April- 04	14	93.0	61.5	12.0	3.0	0.0	0.5	0.5	0.0	170.5
11	15	116.0	47.5	33.5	1.5	0.0	0.5	0.5	0.0	199.5
18	16	103.0	64.0	45.5	3.0	0.0	1.5	0.0	0.0	217.0
25*	17	177.0	31.0	26.5	1.0	3.0	1.5	0.0	0.0	240.0
May - 02	18	444.0	18.0	12.0	1.0	4.0	1.5	0.0	0.0	480.5
9	19	274.0	19.0	30.0	0.5	10.5	7.0	0.0	0.0	341.0
16	20	227.0	83.0	90.5	0.5	13.5	9.5	0.0	0.0	424.0
23*	21	221.5	107.0	99.5	0.0	3.0	4.0	0.0	0.0	435.0
30	22	226.0	88.0	29.0	1.0	12.0	1.0	0.0	0.0	357.0
June -06	23	284.5	69.5	220.5	0.0	3.5	11.5	0.0	0.5	590.0
13	24	525.5	64.0	229.5	0.0	3.5	0.0	0.0	0.0	822.5
20*	25	389.5	73.5	156.5	0.5	5.0	0.0	0.0	0.5	625.5
27	26	247.5	57.5	115.0	0.0	3.0	0.0	0.0	0.0	423.0
July – 04	27	29.5	22.5	40.0	0.5	5.5	3.0	0.0	1.5	102.5
11	28	24.5	25.5	29.5	0.5	18.5	1.0	0.5	0.5	100.5
18*	29	20.0	37.5	88.5	0.0	15.5	1.0	0.0	0.0	162.5
25	30	25.5	36.5	106.5	0.0	13.5	0.5	0.0	0.0	182.5
Aug-01	31	20.0	27.5	24.0	2.5	19.0	2.0	0.0	0.0	95.0
8	32	29.5	71.5	40.0	1.0	9.0	0.0	0.0	0.0	151.0
15*	33	29.5	24.5	39.0	0.5	24.0	9.0	0.0	0.0	126.5
22	34	15.0	24.0	35.0	0.5	19.5	2.5	0.0	0.0	96.5
29	35	42.5	38.0	52.5	0.0	6.0	1.0	0.0	0.0	140.0
Sep-05	36	47.5	39.0	70.5	0.0	3.0	0.5	0.0	0.0	160.5
12*	37	33.0	30.0	39.0	2.0	3.0	0.0	0.0	0.0	107.0
19	38	20.0	11.5	20.0	1.0	1.5	0.5	0.0	0.0	54.5

*New recharged wooden blocks; # Mean of five replication; SW = Standard Week

trap/week during 38th SW but never reached to zero (Table 1).

Bactrocera dorsalis, the second dominant species in trap catches was first observed during 1st week of April (14th SW) with mean initial population 12.0 flies/ trap/week. The population increased for next two weeks to 33.5 flies/ trap/week (15th SW) and 45.5 flies/ trap/week (16th SW) and then decreased for next two weeks i.e. 26.5 and 12.0 flies/ trap/week during 17th and 18th SW, respectively (Table 1). It showed increasing trend from 19th SW with 30.0 flies/trap/week to 26th SW with 115.0 flies/trap/week. However, population decreased thereafter for next two weeks i.e. 40.0 and 29.5 flies/ trap/week on 27th and 28th SW, respectively. The population of *B. dorsalis* increased again for next two weeks to 88.5 and 106.5 flies/trap/week during 29th and 30th SW, but decreased gradually thereafter to 24.0 flies/ trap/week (31st SW) and 19.0 flies/trap/week (39th SW).

Bactrocera cucurbitae earlier a dominant species in the cucurbit ecosystem in the state (Gupta *et al*. 1992) was observed to be the less dominant as evident from less trap catches compared to *B. divenderi, B. dorsalis, B. tau and B. scutellaris*. It appeared during the 1st week of April (14th SW) with mean initial population of 3.0 flies/trap/week and in next week decreased to 1.5 flies/trap/week (15th SW). The population remained low and ceased to zero during 4th week of May (21st SW), 1st, 2nd and 4th week of June (23rd, 24th and 26th SW), 3rd and 4th week of July (29th and 30th SW), 4th week of August (35th SW), 1st and 4th week of September (36th and 39th SW) (Table 1). The highest population of 3.0 flies/ trap/week was recorded during 1st and 3rd week of April (14th and 16th SW). The population of *B. cucurbitae* remained low throughout the trapping period. *Bactrocera scutellaris* was first observed during 4th week of April (17th SW) with mean initial population 3.0 flies/trap/week. Thereafter, its population showed increasing trend till 3rd week of May (20th SW) and decreased in next week to 3.0 flies/ trap/week in 21st SW. The population showed high fluctuation, as 12.0 flies/trap/week were recorded during 22nd SW which decreased during next weeks (23rd and 24th SW) to 3.5 flies/trap/week. Throughout the trapping period, a similar pattern in trap catches was observed and highest population of 24.0 flies/trap/week was observed during 33rd SW followed by 19.5, 19.0, 18.5, 15.5 and 13.5 flies/trap/week during 34th, 31st, 28th, 29th and 30th SW, respectively (Table 1). The population decreased gradually to 6.0 flies/ trap/week (35th SW) to 1.0 flies/trap/week during 39th SW.

The perusal of data presented in Table 1 reveal that *Bactrocera zonata* was first recorded during 1st week of April (14th SW) with mean initial population 0.5 flies/ trap/week which increased in the following weeks till it attained its first peak during 3rd week of May (20th SW) with mean population catch of 9.5 flies/ trap/week. Trap catches of *B. zonata* was observed to decrease for next two weeks from 4.0 flies/trap/week (21st SW) to 1.0 flies/ trap/week (22nd SW). *B. zonata* attained three population peaks during 20th SW (9.5 flies/ trap/week), 23rd SW (11.5 flies/trap/week) and 33rd SW (9.0 flies/trap/week). The population remained low and reached to zero during 24th, 25th, 26th, 32nd, 37th and 39th SW.

Dacus sphaeroidalis and *Dacus longicornis* population remained low and appeared only thrice and four times throughout the trapping period. The first trap catch of *D. sphaeroidalis* was recorded during 1st week of April (14th SW) with mean population of 0.5 flies/ trap/week; second during 2nd week of April (15th SW) with 0.5 flies/ trap/week and third during 2nd week of July (28th SW) with 0.5 flies/trap/week which implies that the species is a minor species in the state. Similarly, *D. longicornis* appeared only four times throughout the trapping period i.e during 23rd SW (0.50 flies/trap/week), 25th SW (0.50 flies/ trap/week), 27th SW (first week of July) with highest catch of 1.50 flies/ trap/week and 28th SW (2nd week of July) with 0.50 flies/ trap/week.

Fruit flies were active all year round, although their peak activity was observed from April to July at Palampur. The result of trap catches are in agreement to earlier reports of Hussain *et al*. (2022) who have also observed peak activity of fruit flies in April to July at Punjab, Pakistan in guava orchard. Pujar *et al*. (2018) had reported that fruit fly *B. cucurbitae* incidence was high in gourds from June to October. Vignesh *et al.* (2020) observed the prevalence of *B. dorsalis* and *B. correcta* in the guava orchards where peak activity was observed during August while low population was observed during February. Sheikh (2011), Devi and Mehta (2015) also observed peak

population of *B. dorsalis* in June - August at Palampur. *Dacus longicornis* and *D. sphaeroidalis* only appeared 3-4 times in entire trap catch from April to September which are in agreement with Prabhakar *et al*. (2012) and Devi and Mehta (2015). *Bactrocera divenderi* which was earlier misidentified as *Bactrocera nigrofemoralis* (Singh *et al*. 2022) was recorded as the dominant species followed by *Bactrocera dorsalis* in trap catches but the significance of former species as a pest is still not well recognized and established.

All prevalent species viz., *B. divenderi, B.dorsalis, B.zonata* showed highly significant correlation with maximum temperature but negative relation with rainfall, RH (M) and RH (E) and positive correlation with sunshine (Table 2). There was however, a strong negative association between *B. cucurbitae* and relative humidity (morning & evening) and rainfall. The findings are in agreement to those of Halder *et al*. (2022), who also reported negative correlation between fruit fly population and rainfall. The results of present studies concluded that temperature played a key role in the fruit flies population growth while, other elements like rainfall and relative humidity had a minimal impact on abundance of population of fruit flies which are in accordance with the results of Khan *et al*. (2021). Nair *et al*. (2020) also reported that the trap catches of *B. tau* had significant positive correlation with maximum temperature and minimum temperature. Bal *et al*. (2022) concluded that the population density of *Bactrocera dorsalis* is much higher than that of *Bactrocera correcta* and *Bactrocera cucurbitae* at Kanke, Ranchi (Jharkhand). *Bactrocera dorsalis* in particular was more prevalent during the hot summer than during the monsoon which eventually decreased in abundance with the altered climate. The findings of Vignesh *et al*. (2020) further support the present findings which reported that the incidence of *Bactrocera* spp. is negatively correlated with morning and evening relative humidity (RH) and rainfall, and positively correlated with maximum and minimum temperature.

Conclusion

It is concluded from the present studies that among all the prevailing species, *Bactrocera divenderi* was found to be the most predominant species trapped in Palam fruit fly traps followed by *Bactrocera dorsalis*. Among different weather factors, temperature was observed to play a significant role in regulating population dynamics of most of prevailing species as indicated by a positive correlation.

Conflict of interest: There is no conflict of interest among the authors of the present study.

Table 2. Relationship of fruit flies activity with abiotic factors

Species	Correlation coefficient value					
	Maximum Temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	RH (Morning) (%)	RH (Evening) (%)	Sunshine (hr)
B. divenderi	+0.783**	+0.057	-0.584**	-0.632**	-0.598**	+0.396*
Z.tau	+0.538**	-0.034	-0.308	-0.505**	-0.479*	+0.388
B. dorsalis	+0.587**	+0.516**	-0.275	-0.201	-0.146	+0.119
Z. cucurbitae	-0.069	-0.594**	-0.035	-0.241	-0.319	+0.304
Z. scutellaris	-0.320	+0.533**	+0.680**	+0.380	+0.479*	-0.451*
B. zonata	+0.325	+0.315	-0.054	-0.373	-0.287	+0.280
D. sphaeroidalis	+0.080	-0.316	-0.151	-0.150	-0.202	+0.272
D. longicornis	-0.014	+0.282	+0.116	+0.138	+0.055	-0.171
Total fruit fly/trap/week	+0.815**	+0.212	-0.529**	-0.584**	-0.536**	+0.367

* 5% level of significance ** 1% level of significance

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