

## Research Article

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# Population dynamics and diversity of *Bactocera* species and *Dichasmimorpha longicaudata*, its parasitoid in correlation with abiotic factors

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### Abstract

Fruit flies are destructive pests and caused heavy losses in agricultural products by reducing crop production. The reported study was planned to evaluate the relationship between population dynamic of fruit flies and its parasitoid in guava orchards in relation to prevailing ecological condition. For this purpose, baited pheromone traps containing methyl eugenol with contact action Insecticides were installed in guava orchards in Faisalabad district during 2016-18. Trapped fruit flies were collected after every fortnightly interval and brought in the laboratory for identification of species. The infested guava fruits were also collected from fruit trees during the fruiting season and kept under laboratory conditions to identify and record parasitoids species as well as emerging Fruit flies. Results revealed that *B. zonata*, *B. correcta* and *B. dorsata* prevail around the year. However population of *B. dorsata* was more than *B. zonata* followed by *B. correcta*. Peak infestation of fruit fly was has been observed in October 2016-17 while in 2018 highest population was recorded in September. However, low population of fruit flies species had been recorded when temperature dropped < 05 °C. Emergence from infested fruit predicts that 60% emergence was solely by the population of *B. dorsata* followed by *B. zonata* and *B. correcta* throughout the year. The highest number of *D. longicaudata* was recorded in July and August and also directly influenced by pupae emergence from the larvae. Highest and lowest temperature exerted more effect on population fluctuation of pest as well as its parasitoid as compared to other factors.

**Keywords:** Abiotic factor; Diversity; Fruit fly species; Parasitoid; Population dynamics

## Introduction

Guava (*Psidium guajava*) is most favorite and nutritional fruit in Asia as well as all over the world belongs to family *Myrtaceae* [1]. Fruit flies are most destructive pests of fruits, causing decrease in yield and deteriorating the market value. In 1907, it was first observed in Taiwan [2] but now it has been spread to Asia Pacific regions [3, 4]. It inserts the ovipositor in the fruits and lays egg inside, near fruit skin. Maggots develops inside the fruit. Latterly, maggots drill its way out after completing its period to pupate in soil and emerge as winged adult to continue the life cycle [5]. There is great taxonomic diversity in fruits fly with more than 5000 species present all over the world [6] which not only infest the fruit but also affect the vegetables. Among all the fruit fly species *Bactrocera zonata*, *B. correcta* and *B. dorsata* are commonly found in guava orchards. Peak population of different species of fruits flies was recorded from April to August on guava and mango orchards [7] and caused 30 to 100% losses in these fruits. Fruit flies quarantine pest and caused hindrances in international trade [8].

Farmers use different techniques to control fruit fly attack. Chemicals used to control fruit fly are not encouraged due to residual effects [9]. Different environmental friendly techniques like Sterile Insect Technique (SIT) [10] pheromone traps [11] and sanitation (disposal of damage fruits) [12, 13] are well adopted approaches for the management of fruit flies. The scientist observed population dynamics of this pest by using different traps like McPhail traps and correlated it with environmental conditions [14].

In recent decades, increasing interest in parasitoids into integrated pest management programs has been replaced by classical biological control. This is often likely to reflect not only an increased awareness of the non-target action of

insecticides on beneficial insects and human beings but also significant advancements in rearing techniques and artificial diets for rearing hosts for augmentative biological control programs [15, 16]. *Diachasmimorpha longicaudata* Ashmead (Hymenoptera: Braconidae) is naturally available parasitoid in Pakistan and South East countries [17]. It parasitoid the larval and prepupal stages of fruit fly of genera *Anastrepha*, *Ceratitis* and *Bactrocera*. In Pakistan, Its parasitism rate exceeds 36% on *B. Dorsalis* and 44% in *B. Zonata* [18]. The objective of this study is to evaluate the diversity and population dynamics of fruit fly species and its parasitoid *D. longicaudata* and its relation to environmental factors in Faisalabad during years 2016-18.

## Materials and methods

Studies on population dynamics of fruit flies was conducted in different places of guava orchards in district Faisalabad during 2016-18. The fruit fly species mainly (*B. zonata*, *B. correcta* and *B. dorsata*) were recorded by installation traps in guava orchards. In the selected orchards, five fruit fly traps with methyl-eugenol and contact action insecticide (Malathion @ 1ml/trap) (as bait) was installed at 6 feet height from the ground and 12 m apart from each other. The baits in traps was replaced every 24 hours. The data regarding number of fruit flies were recorded fortnightly. Collected individuals were identified up to species level. The population fluctuation of three fruit fly species (*B. zonata*, *B. correcta* and *B. dorsata*) were kept in consideration in this study. Infested guava fruits were collected and kept in laboratory under favorable conditions to identify the fruit fly species and their parasitoids. The obtaining pupae from larvae were kept in Petri dishes and emerging fruit fly species and parasitoids from pupae were recorded and identified. The meteorological data was also

obtained from crop physiology section, Ayub Agriculture Research Institute Faisalabad.

#### **Data analysis**

The mean values of pest and parasitoid population along with standard error was calculated by using statistical software (Statistix 8.1). The impact of environmental factors on the fluctuation of three species of fruit fly on individual and combined level by using Hierarchical Regression Model.

#### **Results**

##### **Population fluctuations of fruit fly species (*B. zonata*, *B. correcta* and *B. dorsata*) during 2016-18**

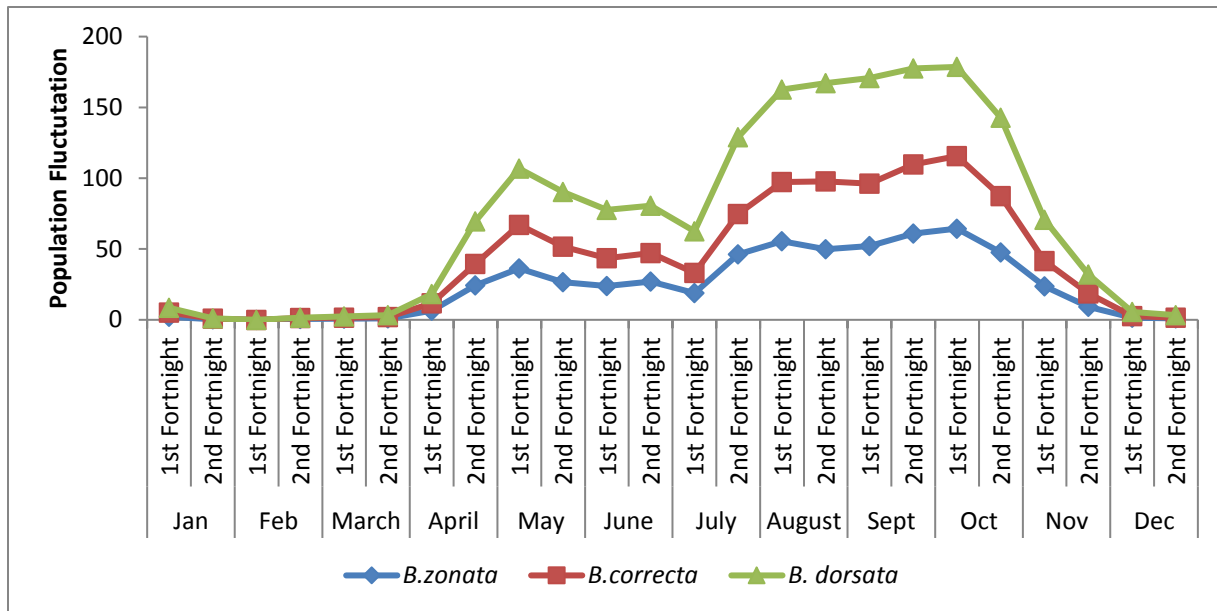
##### **Population fluctuations of fruitflyspecies (*B. zonata*, *B. correcta* and *B. dorsata*) during 2016**

Population of *B. zonata*, *B. correcta* and *B. dosata* from the orchards of Guava in District Faisalabad during 2016-2018. After experiments it is obvious that population of fruit fly correlates with the ripening of guava fruits and weather conditions. The minimum mean population (0.4/trap) of *B. zonata*, was observed in the February 2016. *B. correcta* was not observed during first fortnight of February during 2016. *B. dorsata* lowest peak was recorded in last weeks of January 2016 with mean population of 0.2/trap. The population of all three species start to increase in the last week of March during 2016 with mean population of *B. zonata*, *B. correcta* and *B. dosata* was 1.00, 1.00 and 2.00 per trap, respectively. However average population of *B. zonata* was 36.2/trap, *B. correcta* was 30.8/trap and *B. dorsata* was 39.8/trap in May. In June 2016, *B. zonata* and *B. Correcta* population increased and it reached to 36.2/trap, 20.2/trap, respectively. for but *B. dorsata* population declines to 33.4/trap. for July 2016 *B. zonata* counts about 25.2 however species *B. correcta* number population reduces to 28.4 and *B. dorsata* increases to almost

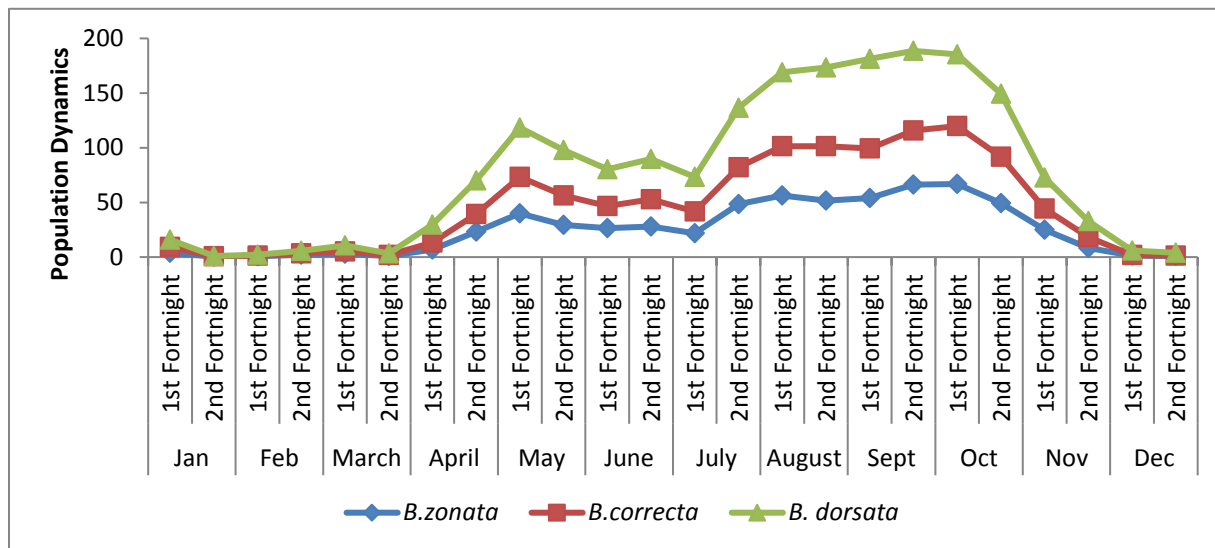
55.4/trap. The maximum population of *B. zonata* was in August and September 56.4/trap, 55.4/trap, respectively after that its population decreased and reached to 1.00/trap in December 2016. However, *B. correcta* highest population was observed in first week of October 51.2 and it decreased in December to 0.6. *B. dorsata* population was highest in September 74.6/trap and lowest in mid of December 1.8/trap (Graph 1).

##### **Population Fluctuations of Fruit fly species (*B. zonata*, *B. correcta* and *B. dorsata*) during 2017**

The population of fruit flies in the year 2017 shows a slight different trend as compared to 2016. Minimum population 0.2/trap of *B. correcta* was observed in last week of January in 2017 and an increases rate was recorded in October that was 53/trap. Population level start to declines afterward reaches to 1.6/trap in November and 1.00/trap in the month of December during the present year. However, *B. correcta* population was minimum 0.2/trap in the last week of January. The gradual increase in population of *B. correcta* was observed in March and April that was 2.3/trap, 15/trap, respectively and finally population was maximum in first week of October. Afterward, population start to decline with decrease in temperature and population was 0.4/trap in December. *B. dorsata* population was higher than *B. correcta* and *B. zonata*. The least population of *B. dorsata* was recorded in February and March that was 1.00/trap and 5.6/trap. The *B. dorsata* population gradual increase was observed in the months of April 30.8/trap and May 45.2/trap. Maximum population of *B. dorsata* was recorded the month of September 81.8/trap in 2017. After that gradual decrease in population was recorded in October 57.8 and finally lowest population was in December 2.4/trap (Graph 2)



Graph 1. Population dynamic of three fruit flies species during year 2016



Graph 2. Population dynamic of three fruit flies species during year 2017

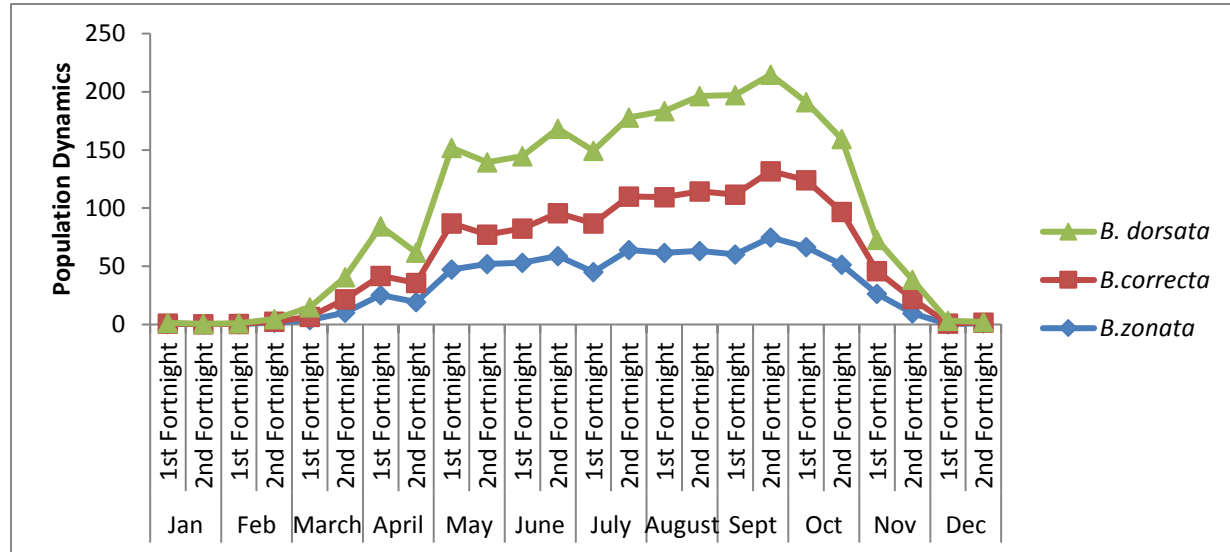
**Population fluctuations of fruit fly species (*B. zonata*, *B. correcta* and *B. dorsata*) during 2018**

During 2018, there was zero population of *B. zonata* in February. After February, Population level gradually start to increase and there was 2.00/trap in March and 47.2/trap in May, highest population was recorded in August and September that was 55.4/trap and 74.8/trap, respectively. After September, population level start to

decline and finally, population of *B. correcta* was highly reduced in last week of January 2018. The population rises as the temperature enhance. The tremendously enhanced population was recorded in August 51/trap and September 57/trap and highest peak population was observed in first week of October 57.4/trap. Lowest level of population was recorded in December that was 0.6/trap. *B. dorsata* population was lowest in February 0.6/trap and March 8.2/trap. Gradual increase

in *B. dorsata* population was recorded in April 26.2/trap, May 65/trap, June 72.4/trap and peak level of population was recorded in September 85.4/trap. After that population

gradually start to decrease from October and attained its lowest population level in December 0.6/trap (Graph 3).



Graph 3. Population dynamic of three fruitflies species during year 2018

### Impact of weather parameters on population fluctuation of fruit fly species

Weather factors significantly affect the fluctuation of all species of fruit fly in this experiment. The impact of weather conditions during 2016 revealed that maximum temperature was exerted 46.53% role in *B. zonata* population fluctuation which highest as compared to other climatic factors. High temperature showed highly significant positive impact on population while minimum relative humidity, temperature and rain fall during 2016 played 11.16%, 6.79 and 0.01% role respectively. High temperature impacted 64.44% role for the population variation of *B. zonata* during 2017 and similarly it played 64.44% role during 2018. Low temperature exerted more role (10.78%) than relative humidity (5.00%) during 2018. Low temperature and humidity positively significantly affect the variation of *B. zonata* population (Table 1).

The *B. correcta* showed almost similar relation with climatic conditions. High

temperature had participated highest 45.1% role and showed highly significant impact on population fluctuation on *B. correcta* during 2016 (Table 2). The relative humidity had more role (10.57%) as compared to low temperature (5.66% and 7.49%) during 2016-17 while low temperature participated (11.73%) more than relative humidity (9.37%) during 2018 (Table 2). High temperature exerted positive significant impact (54.4%) on the population of *B. correcta* in 2018 (Table 2).

In the case of *B. dorsata*, more population fluctuation was observed as compared to *B. zonata* and *B. correcta*. Similarly, high temperature showed highest role (51.37%) during 2016 on the pest population fluctuation as compared to other weather factors (Table 3). The impact of maximum temperature was significant positive. The minimum temperature had 9.11% and 12.67% during 2017 and 2018 which higher than relative humidity (8.11% and 3.52%) whereas relative humidity participated more

(10.87%) than minimum temperature (8.34%) during 2016. Maximums temperature had positive significant impact 46.6% and 64.4% roles during 2017 and 2018 respectively (Table 3).

**Table 1. Regression analysis (Hierarchical regression model) of population fluctuation of *Bactrocera zonata* with weather factor along with coefficient of determination for 2016-2018**

Year	Regression equation	Impact
2016	$Y^{**} = -43.09^{*} + 2.087X_1^{**}$	46.53
	$Y^{**} = -11.11 - 0.12X_1 + 2.12X_2$	6.79
	$Y^{*} = -152.348^{**} + 3.29878X_1 + 3.29878X_2 + 1.11428X_3^{*}$	11.16
	$Y^{**} = -152.553^{*} + 3.28627X_1 + 0.12103X_2 + 1.11879X_3^{*} - 0.02998X_4$	0.01
2017	$Y^{**} = -41.57^{*} + 2.108X_1^{**}$	46.68
	$Y^{**} = -12.61 + 0.119X_1 + 1.93X_2^{*}$	7.12
	$Y^{**} = -123.56^{*} + 2.67X_1 + 0.51X_2 + 0.90X_3^{*}$	9.53
	$Y^{**} = -120.51^{*} + 2.18X_1 + 1.34X_2 + 0.93X_3^{*} - 0.81X_4$	5.5
2018	$Y^{**} = -58.76^{**} + 3.92X_1^{**}$	64.44
	$Y^{**} = -29.34 + 0.74X_1 + 2.16X_2^{**}$	10.78
	$Y^{**} = -91.02^{*} + 1.51X_1 + 1.92X_2^{**} + 0.69X_3^{*}$	5.00
	$Y^{**} = -78.97^{*} + 1.37X_1 + 1.81X_2^{*} + 0.57X_3 + 0.20X_4$	1.44

Where, Y=Fruitfly (*Bactrocera zonata*) Population; X1= Fortnightly Maximum temperature; X2= Fortnightly Minimum temperature; X3= Average Fortnightly relative humidity; X4= Average Fortnightly rainfall (mm); \* = Significant at  $P \leq 0.05$ ; \*\*= Highly Significant at  $P \leq 0.01$

**Table 2. Regression analysis (Hierarchical regression model) of population fluctuation of *Bactrocera correcta* with weather factor along with coefficient of determination for 2016-2018**

Year	Regression Equation	Impact
2016	$Y^{**} = -34.32^{**} + 1.67X_1^{**}$	45.1
	$Y^{**} = -10.61 + 0.025X_1 + 1.57X_2$	5.66
	$Y^{**} = -122.258^{*} + 2.73X_1 - 0.030X_2 + 0.881X_3^{*}$	10.57
	$Y^{**} = -123.35^{*} + 2.67X_1 + 0.123X_2 + 0.91X_3^{*} - 0.67X_4$	0.43
2017	$Y^{**} = -33.10^{*} + 1.70X_1^{**}$	46.26
	$Y^{**} = -9.06 + 0.048X_1 + 1.60X_2$	7.49
	$Y^{**} = -96.40^{*} + 2.051X_1 + 0.48X_2 + 0.71X_3^{*}$	8.99
	$Y^{**} = -93.88^{*} + 1.66X_1 + 1.75X_2 + 0.74X_3^{*} - 0.677X_4$	5.73
2018	$Y^{**} = -39.78^{**} + 2.07X_1^{***}$	54.4
	$Y^{**} = -16.06 + 0.31X_1 + 1.74X_2^{*}$	11.73
	$Y^{**} = -81.32^{**} + 1.13X_1 + 1.48X_2^{*} + 0.73X_3^{*}$	9.37
	$Y^{**} = -74.90^{*} + 1.06X_1 + 1.43X_2^{*} + 0.66X_3^{*} + 0.11X_4$	0.68

Where, Y=Fruitfly Population; X1= Fortnightly Maximum temperature; X2= Fortnightly Minimum temperature; X3= Average Fortnightly relative humidity; X4= Average Fortnightly rainfall (mm); \* = Significant at  $P \leq 0.05$ ; \*\*\*= Highly Significant at  $P \leq 0.01$

**Table 3. Regression analysis (Hierarchical regression model) of population fluctuation of *Bactrocera dorsata* with weather factor along with coefficient of determination for 2016-2018**

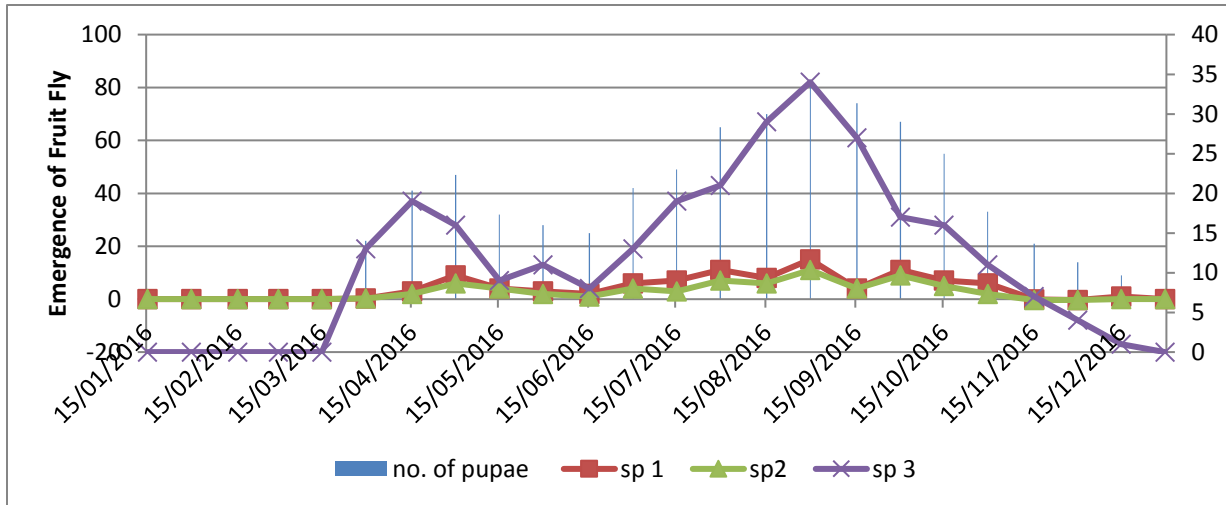
Year	Regression equation	Impact
2016	$Y^{**} = -54.01^{**} + 2.60X_1^{**}$	51.37
	$Y^{**} = -11.97 - 0.31X_1 + 2.79X_2^*$	8.34
	$Y^{**} = -177.31^* + 3.70X_1 + 0.41X_2 + 1.30X_3^*$	10.87
	$Y^{**} = -179.448^* + 3.57X_1 + 0.71X_2 + 1.35X_3^* - 0.311X_4$	0.75
2017	$Y^{**} = -49.66^* + 2.57X_1^{**}$	50.49
	$Y^{**} = -11.28 - 0.064X_1 + 2.56X_2^*$	9.11
	$Y^{**} = -136.44^* + 2.80X_1 + 0.95X_3 + 1.02X_4^*$	8.81
	$Y^{**} = -133.19^* + 2.29X_1 + 1.84X_2 + 1.05X_3^* - 0.87X_4$	4.52
2018	$Y^{**} = -71.14^{**} + 3.56X_1^{**}$	69.68
	$Y^{**} = -33.60^* + 0.79X_1 + 2.76X_2^{**}$	12.67
	$Y^{**} = -94.47^{**} + 1.55X_1 + 2.522X_2^* + 0.68X_3^*$	3.52
	$Y^{**} = -85.99^* + 1.45X_1 + 2.44X_2^* + 0.59X_3 + 0.144X_4$	0.51

Where, Y= Fruitfly Population;  $X_1$ = Fortnightly Maximum Temperature;  $X_2$ = Fortnightly Minimum Temperature;  $X_3$ = Average Fortnightly Relative Humidity;  $X_4$ = Average Fortnightly Rainfall (Mm); \* = Significant At  $P \leq 0.05$ ; \*\*= Highly Significant At  $P \leq 0.01$

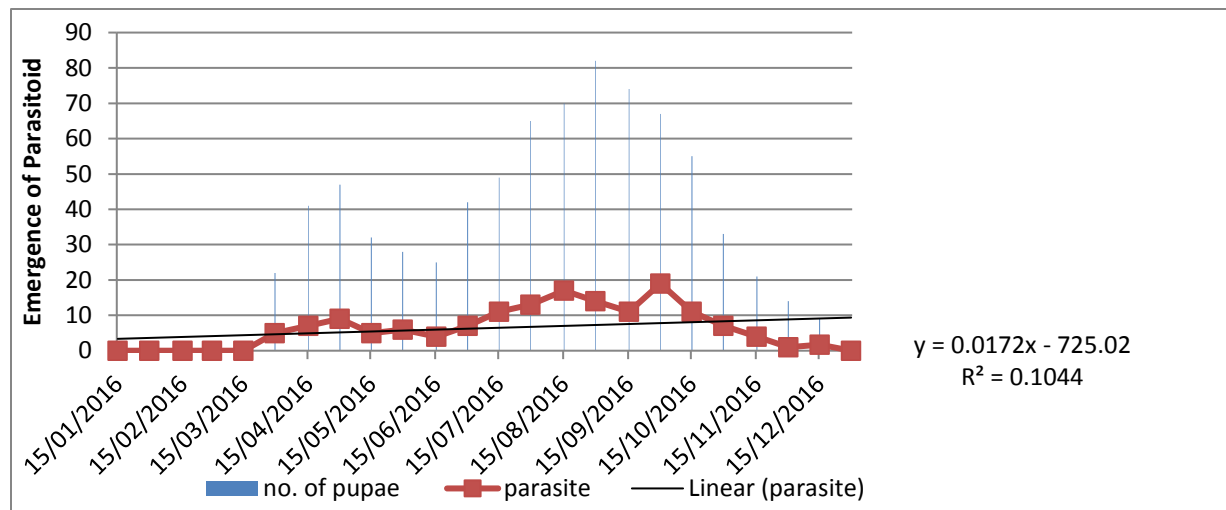
**Emergence of different fruitfly species and its parasitoid under laboratory conditions**

Results showed that there is no pupation until middle of March for all species of fruit flies during 2016 (Graph 4). However, The number pupae increased till October after which pupation decrease and becomes zero in the month of December. Relationship between parasitoid emergence and number of pupae showed that they have positive relationship with each other (Graph 5). Number of pupae increased as the number of parasitoid emerged until October. Highest number of parasitoid emergences were recorded in July and August during 2016. Results showed that there a positive relationship between parasitoid emergence with number of pupae in 2017 (Graph 6) of pupae. Highest number of emerged parasitoids was recorded in July

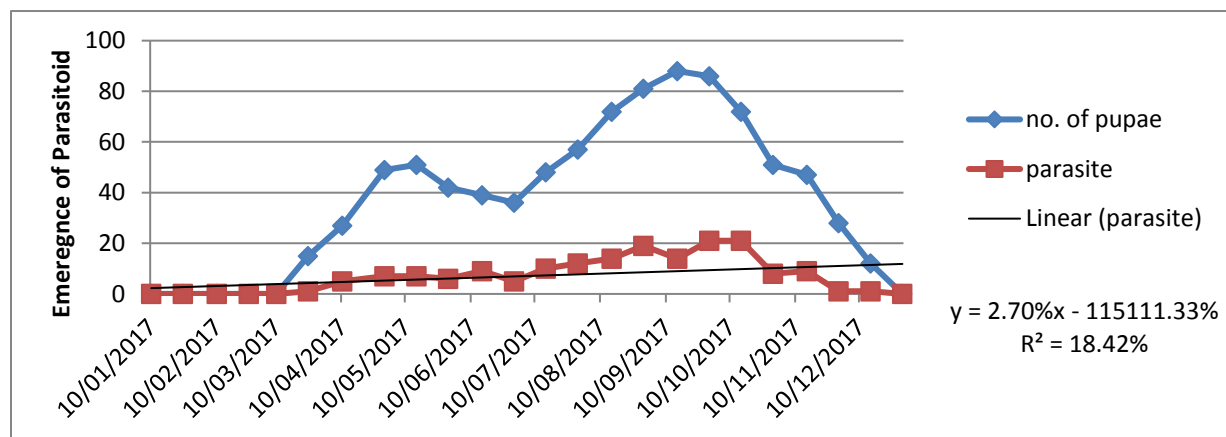
and August during 2017. Comparative analysis of population dynamic of three fruitflies species are depicted in (Graph 7), it showed that the population of all fruit fly species was higher in 2017 than from the previous year and same pattern was also recorded for number of pupae. Population dynamic of all three fruit flies species and number of pupae in 2018 is almost similar as that of during 2017 and positive linear relationship was recorded (Graph 8). Results (Graph 9) showed a positive relationship between parasitoid emergence and number of pupae. As the number of pupae increases up to October the no of parasitoid emergence also increases. Maximum no of parasitoid emerged were observed in July and August during 2018.



Graph 4. Emergence of fruit fly species under laboratory conditions during 2016

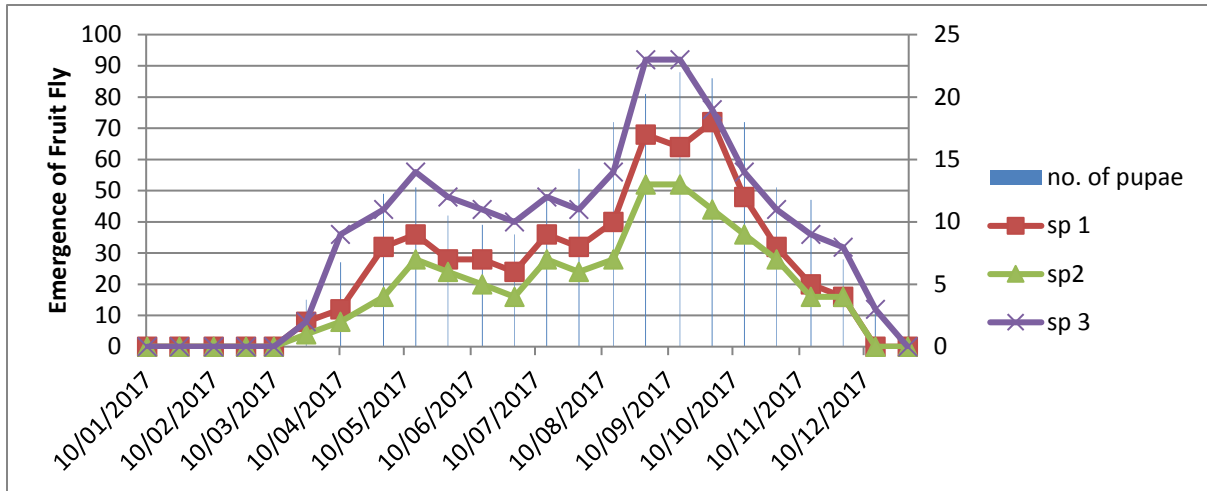


Graph 5. Emergence of parasitoids (*D. longicaudata*) under Laboratory conditions during 2016

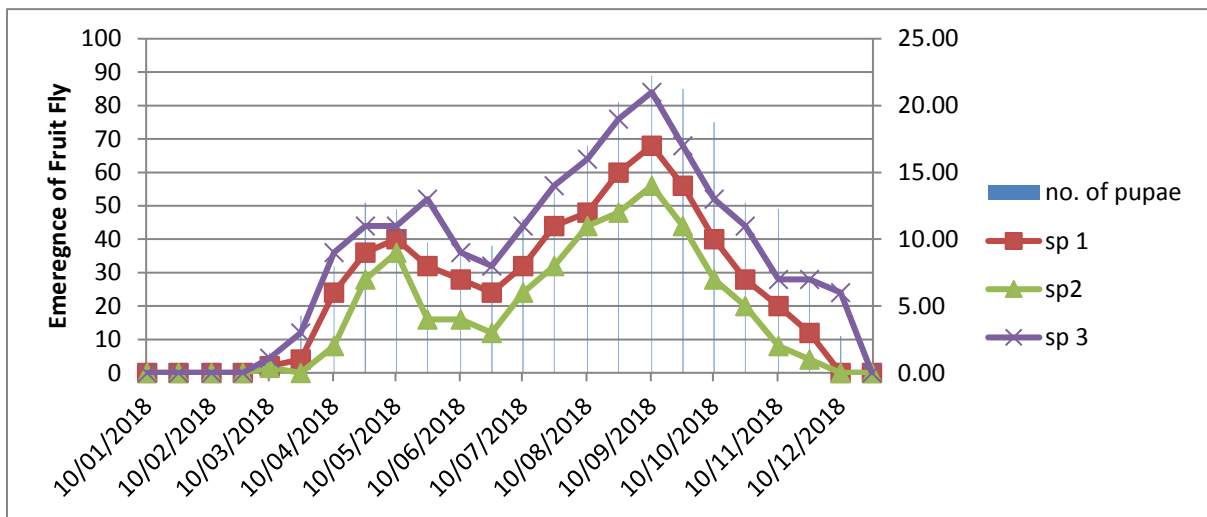


Graph 6. Emergence of Parasitoids (*Dichasmimorpha Longicaudata*) Under Laboratory Conditions during 2017

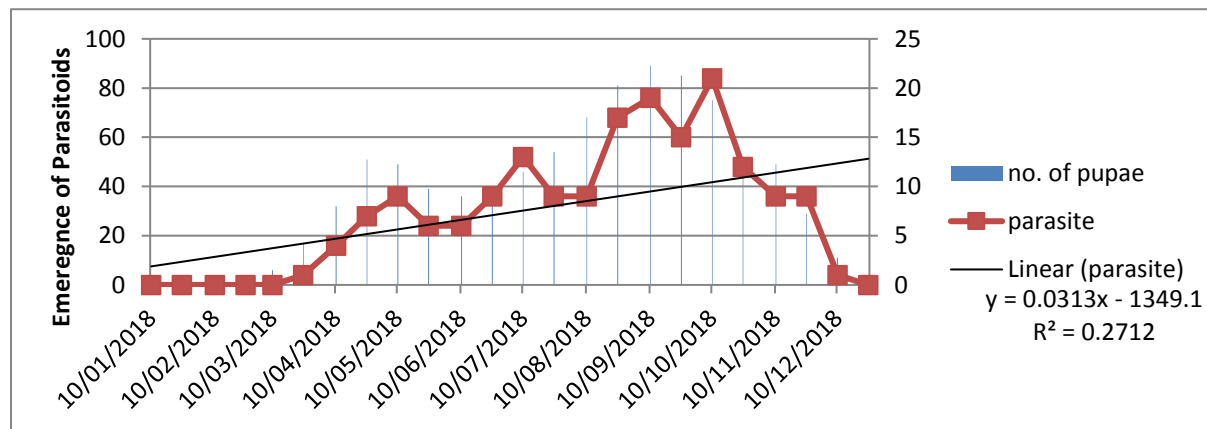




Graph 7. Emergence of different fruitfly species under Laboratory conditions during 2017



Graph 8. Emergence of different fruitfly species under Laboratory conditions during 2018



Graph 9. Emergence of parasitoids (*Dichasmimorpha longicaudata*) under laboratory conditions during 2018

## Discussion

The Studies on population dynamics of different species of fruit flies (*B. zonata*, *B. correcta* and *B. dorsata*) and its parasitoid (*D. longicaudata*) was conducted in district Faisalabad by installing pheromone traps in guava orchards for the period of three years (2016-18). The results of our research indicated that the fruit fly population appeared in March and increased with passage of time and attained highest population peak in October while negligible fruitfly population was observed in December, January and February on guava plants. Our results are similar to researcher who showed that the population of two specie of fruitfly (*B. correcta* and *B. dosata*) appeared in pheromone traps before April [31, 34] and the population gradually increased until end of May but again uplifted to its peak population in August [32, 33]. It is also concluded that the fruitfly species (*B. zonata*, *B. correcta* and *B. dosata*) on guava fruit orchards prevailed throughout the study year. These findings are in accordance with the research who observed fruit fly population throughout the year except in the month of January [19-21]. The variation in Fruit fly species (*B. zonata*, *B. correcta* and *B. dorsata*) were also considered in this research. Highest population of *B. dorsata* was observed during three years of study followed by *B. zonata* and *B. correcta*. The infested guava fruits were collected from the canopy of fruit trees and kept them under laboratory conditions to identify the fruit fly species and its parasitoid. The pupae of fruit fly emerged from larvae was recorded in April and attained its highest number in October while declined gradually in November and no pupae was observed in December, January and February. From emerging fruit fly, highest number of adults of the *B. dorsata* was recorded followed by adults of *B. zonata* and *B. correcta*. So it is concluded that *Bactorcera dosrsata* was

found more prominent than other two species. The results are similar to the researchers who revealed the abundance of *B. dorsalis* and *B. correcta* in many important vegetable crops and different fruits [22, 23, 30]. The results showed that the population of fruit fly was higher in 2017 then from the previous year but similar population was recorded in 2018 and same pattern was also recorded for number of pupae. The highest parasitoid (*D. longicaudata*) were observed in July and August. The number of parasitoids directly influenced by the number of pupae emerged from the larvae. The parasitoid was positively affected by the temperature and relative humidity. The results are similar to scientist who indicated that the population of parasitoid and fruit fly population directly influence by relative humidity and temperature [35]. The correlation and regression among the fruit fly population, Parasitoids, Temperature, relative humidity, and rain fall were also worked out. The pest population of all three fruit fly population fluctuation of fruit fly species was significantly positive affected by maximum temperature and relative humidity but the pest population negatively inflicted by low temperature. The results indicated that fruits were more infested by fruit fly in July august and October during 2016-18. These months have high temperature and relative humidity as compared to other months. The researchers also concluded fluctuation in pest population due to maximum and minimum temperatures [3, 24, 25]. The scientist in Lucknow described the similar correlation between pest population and temperature in orchards [37] and the researcher in Karnataka indicated that the fruit fly positively influenced by wind speed in mango orchards [36]. Results indicated that relative humidity played negligible role in fluctuating the pest population. Similar the researcher also concluded that negative correlation of relative humidity with fruit fly population

[25-27]. In the present study rain fall also slightly affected the pest population adversely. The scientist showed the significant positive correlation between fruitfly and maximum temperature while relatively negative relationship with rainfall and relative humidity [38].

### Conclusion

It is concluded that *Bactrocera dorsata* remained more abundant than *B. zonata* and *B. correcta* in guava orchard in Faisalabad district during 2016-2018. Pest population varied during whole year. Maximum pest was observed from 2<sup>nd</sup> fortnight of April to October. Among weather factors, temperature played key role in variation the pest population. The inferred results could predict the maximum infestation periods of fruit flies in guava orchards and help to adopt management practices accordingly.

### Authors' Contributions

Conceived and designed the experiments: KJ Ahmad, Q Ali & F Hafeez, Performed the experiments: A Aslam, MF Akhtar & MU Qasim, Analyzed the data: Q Ali, D Hussain & MJ Saleem, Contributed reagents/materials/analysis tools: MA Ayub & M Zubair, Wrote the paper: A Aslam, MF Akhtar & M Shehzad.

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