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): 2059-2063

Received: 25-11-2020
Accepted: 27-12-2020

Navendu Nair
Department of Agriculture Entomology, College of Agriculture, Tripura, India

Moulita Chatterjee
Department of Agriculture Entomology, Uttar Banga Krishi Vishwavidyalaya, West Bengal, India

Prasenjit Pal
Department of Extension and Social Sciences, College of Fisheries, CAU, Tripura, India

Kalpana Das
Department of Zoology, Rabindranath Thakur Mahavidyalaya, Tripura, India

Corresponding Author:
Navendu Nair
Department of Agriculture Entomology, College of Agriculture, Tripura, India

Seasonal incidence of fruit flies (*Zeugodacus caudatus* and *Bactrocera rubigina*) in Tripura, N.E. India

Navendu Nair, Moulita Chatterjee, Prasenjit Pal and Kalpana Das

Abstract
The present study of two years duration was carried out in Tripura to investigate the seasonal incidence of *Zeugodacus caudatus* and *Bactrocera rubigina* in relation to abiotic factors using Para- pheromone lure (cue-lure) baited traps. Variations in seasonality among these two species have been found. The adult population of *Z. caudatus* remained consistently moderate to high during July to October while that of *B. rubigina* remained moderate to high during March to October. Activity of *Z. caudatus* remained very low during a prolonged span of time (November to May) as compared to *B. rubigina* (November to February). *Z. caudatus* was totally absent in the field from 3rd week of November to middle of February. However, during some other times of the year i.e. from last week of July to end of October *Z. caudatus* outnumbered *B. rubigina*. *Z. caudatus* has significant positive correlation with maximum temperature (r= 0.410), minimum temperature (r= 0.622) and relative humidity (r= 0.548) whereas *B. rubigina* has significant positive correlation with maximum temperature (r= 0.731), minimum temperature (r= 0.757), rainfall (r= 0.436) and relative humidity (r= 0.359) at 1% level of significance.

Keywords: *Zeugodacus caudatus*, *Bactrocera rubigina*, fruit fly, seasonal incidence, Tripura

Introduction
The tribe Dacini is an interesting group of Tephritid fruit flies for Entomological studies. All Dacini members are associated with fruits or flowers of plants as per their choices for hosts but only about 10% of the 932 currently recognized species are pests of commercial fruits and vegetables [5, 18, 16, 3]. Among these, some of the species are economically very important crop pests but other species are also important in bio diversity point of view. In this respect, *Bactrocera rubigina* and *Zeugodacus caudatus* are not economically important pests but are present in large number in the nature and also are captured in large number in cue-lure baited traps in Tripura, India [14].

Bactrocera rubigina, a dacini fruit fly is not a pest species [4]. It is distributed in China, Bhutan, Thailand, Vietnam, Bangladesh, India, Taiwan [4, 8, 14, 3]. From India it has been recently reported from Tripura where large number of male flies is attracted to cue-lure traps [14]. Males are also attracted to zingerone-baited traps [2]. Only one host plant, *Litsea verticillata* has been recorded so far and that too from China [9].

Zeugodacus caudatus (Fabricius), presently renamed from *Bactrocera caudata* (Fabricius), is widespread from India to China, and south to Indonesia. Larvae have been bred from male flowers of squash (*Cucurbita moschata* Duchesne) [1]. However, from available literatures it appears that further studies are required to ascertain its host plants.

The population build up of any phytophagous insect is dependent on prevailing weather condition and changes accordingly based on abiotic factors like temperature, humidity, rainfall, etc. Information on seasonal population fluctuation and peak activity of Dacini fruit fly in relation to weather factors are essential, which may also be correlated with flowering or fruiting seasons of its host plants. Keeping in view the apparent importance of these two species of fruit flies, the present investigation was carried out since not much information is available pertaining to population dynamics of these two species of fruit flies.

Materials and Methods
The present study was carried out in farm area of College of Agriculture, Tripura from July, 2015 to June, 2017. Para- pheromone lures (cue-lure) baited traps were installed at ten sites.

The traps were prepared with plastic mineral water bottles of one litre capacity. Cotton rope of ½ inch's thickness and 2 inch's length soaked in a solution of Ethyl Alcohol, Cue lure and DDVP (6:4:2) was suspended from the top of the bottle with the help of a thin iron wire. The traps were hung at about 1.5 meters height from the ground maintaining a distance of at least 300 m^2 between the traps. At every 21 days intervals the old lures were replaced. Trapped *B. rubigina* and *Z. caudatus* males were separated from each other as well as from other species by observing key taxonomic characters. Trap records were taken at every seven days interval and mean trap catches were calculated for every week throughout the experiment.

Meteorological data used in the present study were collected from ICAR, Lembucherra, Tripura. Correlation and Regression study was made between weekly trap catches and mean weather parameters *viz*., maximum temperature, minimum temperature, relative humidity and rainfall for every standard week.

Results and Discussion

It is evident from the present study of two years duration that the population of *Z. caudatus* fluctuates dramatically trough out the year (Table-1). Three distinct stages of population dynamics have been noticed. The adult population remained consistently moderate to high during 27th - 44th standard weeks of 2015 when 21-48 flies per trap were captured and during 24th – 44th standard weeks of 2016 when 21-49 flies per trap were captured. All of a sudden the fly population declined drastically from 45th standard week of 2015 and 2016. The adult flies were totally absent in the field from 47th standard week of 2015 to 7th standard week of 2016 and from 47th standard week of 2016 to 7th standard week of 2017 i.e. from middle of November to middle of February not a single representative if *Z. caudatus* was trapped. Fly population was very low during 8th to 22nd standard week of 2016 and 8th to 23rd standard week of 2017 when less than 10 flies were captured per trap per week i.e. from late February to early June the fly activity was very less.

Study on correlation between weather parameters and incidence of *Z. caudatus* has revealed that there is significant positive correlation with maximum temperature (r= 0.410), minimum temperature (r= 0.622) and relative humidity (r= 0. 548) at 1% level of significance and impact of rainfall was found to be non-significant (r= 0. 149) (Table 2).

It is evident from the multiple linear regression analysis between *Z. caudatus* and the weather parameters that minimum temperature has significant influence and maximum temperature, rainfall and relative humidity have non-significant influence on seasonal incidence of *Z. caudata* population. All the weather factors together influenced the fruit fly trap catches to the extent of 53 percent. The multiple linear regression model fitted was $Y= 4.78-3.16\ x_1+3.50\ x_2-0.07\ x_3-0.57\ x_4$. Where, x_1 = Maximum temperature, x_2 = Minimum temperature, x_3 = Rainfall, x_4 = relative humidity (Table 3).

Many works have been done to gather genetic information of *Z. caudatus* [10, 19, 20, 15] but the information on seasonal incidence of this fruit fly species is meagre.

In case of *B. rubigina* (Table-4) the adult population was moderate to high during 27th–44th standard week of 2015 when 13-38 flies per trap were captured. Fly population suddenly declined from 45th standard week of 2015 and remained very low up to 6th standard week of 2016 with less than 10 fly/trap/ week. Not a single fly was trapped on 3rd and 4th standard week of 2016. From 7th standard week of 2016 the fly population gradually increased and remained moderate to high up to 44th standard week of 2016. During this period 11-43 flies/ trap/ week were recorded. Then again from 45th standard week the fly population remained very low up to 8th standard week of 2017 when 1-7 nos. of flies/ trap/ week were recorded. Then from 9th standard week of 2017 the fly population remained moderate to high up to the end of the present study i.e. 26th standard week of 2017 with 14-48 nos. of flies/ trap/ week. So, it is evident from the present study that adults of *B. rubigina* remain least active during cooler months i.e. from November to February and their activity remain moderate to high during the remaining period of the year (Table-4). From the available literatures it appears that seasonal incidence of *B. rubigina* as recorded during the present study is almost similar with that of *Z. cucurbitae* and *Z. tau* [7, 17, 11, 12] but *Z. caudatus* has shown quite different pattern of population fluctuation during the present study.

Studies on the relationship between trap catches of *B rubigina* and weather parameters have revealed that there is significant positive correlation with maximum temperature (r= 0.731), minimum temperature (r= 0.757), rainfall (r= 0.436) and relative humidity (r= 0.359) at 1% level of significance (Table 5). From the multiple linear regression analysis between *B rubigina* and the weather parameters it is evident that maximum temperature, minimum temperature and rainfall have significant influence while relative humidity has non-significant influence on seasonal incidence of *B rubigina* population. The weather factors under study togetherly influenced the fruit fly population to the extent of 61 percent. The multiple linear regression model was $Y=-31.28+1.36\ x_1+1.11\ x_2+0.03\ x_3-0.213\ x_4$. Where, x_1 = Maximum temperature, x_2 = Minimum temperature, x_3 = Rainfall, x_4 = relative humidity (Table 6).

According to Hossain *et al.* (2019) [6] seasonal peaks in abundance were positively correlated with rainfall and temperature for *B. rubigina.*

The present authors are in agreement with the opinion of Hossain *et al.* (2019) [6] who mentioned that its host plants, likely different from the less widespread *Litsea verticillata* host recorded in China [9], has yet to be determined since it is widespread and common in Bangladesh and throughout tropical Asia. Since adults of both, *B. rubigina and Z. caudatus* are commonly encountered in large number in cue-lure traps in present time in north-east India [13,14], further works need to be carried out to ascertain the host plants of these two species of fruit fly in this region of India as well.

Table 1: Seasonal incidence of fruit fly (*Zeugodacus caudatus*)

standard week	Per Week catches of *Z. caudatus*	standard week	Per Week catches of *Z. caudatus*	standard week	Per Week catches of *Z. caudatus*	standard week	Per Week catches of *Z. caudatus*
2015		2016		2016		2017	
27	28	1	0	27	21	1	0
28	37	2	0	28	25	2	0
29	30	3	0	29	27	3	0
30	36	4	0	30	41	4	0
31	37	5	0	31	49	5	0
32	35	6	0	32	36	6	0
33	32	7	0	33	33	7	0
34	40	8	1	34	35	8	1
35	44	9	3	35	36	9	2
36	36	10	4	36	39	10	4
37	30	11	5	37	34	11	5
38	48	12	7	38	35	12	4
39	45	13	5	39	47	13	7
40	42	14	1	40	42	14	8
41	36	15	1	41	36	15	3
42	44	16	1	42	44	16	2
43	40	17	1	43	40	17	1
44	21	18	2	44	28	18	2
45	2	19	2	45	1	19	2
46	1	20	1	46	1	20	1
47	0	21	3	47	0	21	1
48	0	22	1	48	0	22	2
49	0	23	11	49	0	23	9
50	0	24	21	50	0	24	10
51	0	25	25	51	0	25	11
52	0	26	26	52	0	26	12

Table 2: Correlation co-efficient between weather parameters and incidence of *Z. caudatus*

Weather Parameters	Correlation value with Mean weekly trap catches
Maximum Temperature	0.410**
Minimum Temperature	0.622**
Rainfall	0.149 NS
Relative Humidity	0.548**

(* = significant at 5%, **= significant at 1%, NS = Non-significant)

Table 3: Multiple regression equation between weather parameters and incidence of *Z. caudatus*

Weather Parameters	Regression model	Standard Error	P-value
Maximum Temperature (x_1)	$Y=4.78-3.16\ x_1+3.50\ x_2-0.07\ x_3-0.57\ x_4$ $R^2=0.535$	0.877	0.000
Minimum Temperature (x_2)		0.567	0.000
Rainfall (x_3)		0.021	0.000
Relative Humidity (x_4)		0.252	0.024

Table 4: Seasonal incidence of fruit fly (*Bactrocera rubigina*)

standard week	Per Week catches of *B. rubigina*	standard week	Per Week catches of *B. rubigina*	standard week	Per Week catches of *B.rubigina*	standard week	Per Week catches of *B. rubigina*
2015		**2016**		**2016**		**2017**	
27	34	1	6	27	30	1	2
28	38	2	1	28	31	2	1
29	36	3	0	29	34	3	1
30	35	4	0	30	36	4	2
31	23	5	3	31	22	5	5
32	22	6	5	32	21	6	7
33	27	7	13	33	25	7	5
34	24	8	16	34	28	8	7
35	23	9	11	35	19	9	14
36	25	10	15	36	23	10	22
37	21	11	23	37	15	11	28
38	18	12	35	38	18	12	28
39	25	13	33	39	21	13	34
40	24	14	43	40	14	14	48
41	19	15	40	41	18	15	43
42	21	16	37	42	15	16	35

43	20	17	35	43	16	17	30
44	13	18	28	44	12	18	27
45	4	19	25	45	2	19	28
46	3	20	22	46	1	20	21
47	5	21	24	47	1	21	24
48	2	22	21	48	2	22	25
49	1	23	22	49	1	23	24
50	2	24	32	50	2	24	23
51	2	25	36	51	2	25	26
52	2	26	31	52	6	26	30

Table 5: Correlation co-efficient between weather parameters and incidence of *B. rubigina*

Weather Parameters	Correlation value with Mean weekly trap catches
Maximum Temperature	0.731**
Minimum Temperature	0.757**
Rainfall	0.436**
Relative Humidity	0.359**

(* = significant at 5%, **= significant at 1%, NS = Non-significant)

Table 6: Multiple regression equation between weather parameters and incidence of *B. rubigina*

Weather Parameters	Regression model	Standard Error	P-value
Maximum Temperature (x_1)	$Y=-31.28+1.36\ x_1+1.11\ x_2+0.03\ x_3-0.213\ x_4$ $R^2=0.618$	0.589	0.023
Minimum Temperature (x_2)		0.381	0.004
Rainfall (x_3)		0.014	0.033
Relative Humidity (x_4)		0.169	0.212

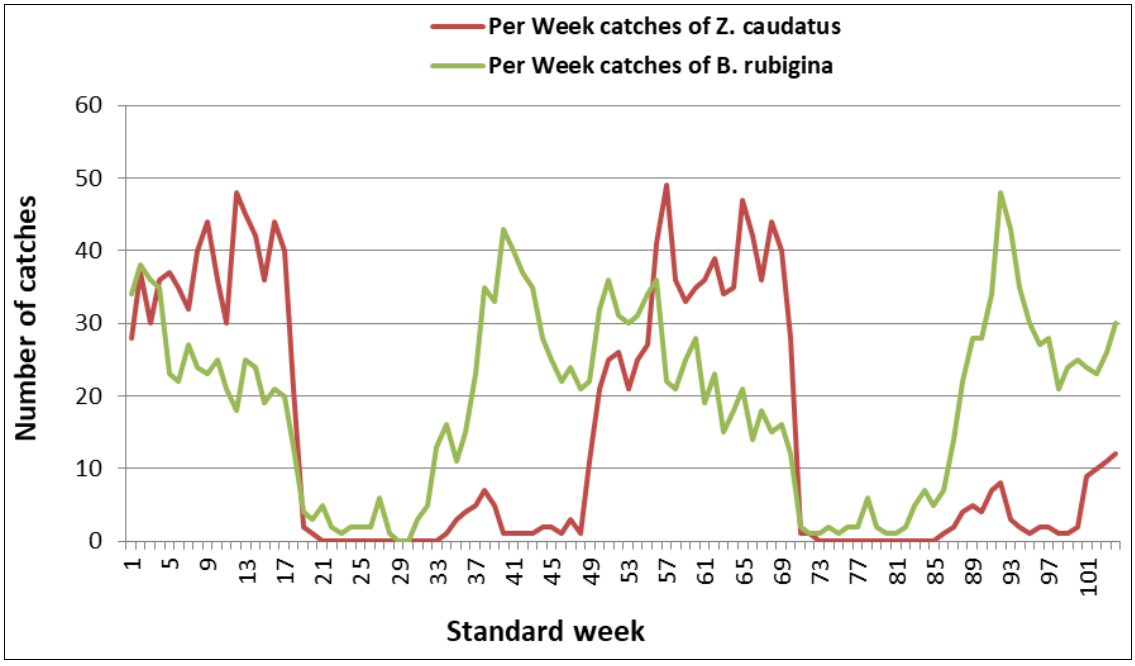

Fig 1: Seasonal incidence of fruit fly (Per Week catches of *Z. caudatus* and *B. rubigina*)

Conclusion

It is evident from the present investigation that variations in seasonality among *B. rubigina* and *Z. caudatus* are there. During certain period of the year one species remains more prevalent than the other and vice versa. Activity of *Z. caudatus* remains very low during a prolonged span of time as compared to *B. rubigina*. However, during some other times of the year *Z. caudatus* out numbers *B. rubigina*. The adult population of *Z. caudatus* remained consistently moderate to high during July to October while that of *B. rubigina* remained moderate to high during March to October. Both *Z. caudatus* and *B. rubigina* have significant positive correlation with maximum temperature, minimum temperature and relative humidity. Moreover, *B. rubigina* has significant positive correlation with rainfall also.

Acknowledgement

The authors are grateful to the Principal, College of Agriculture, Tripura for the liberal facilities provided for this study. The authors are also grateful to the ICAR, Lembucherra, Tripura for providing the meteorological data required for this study.

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