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Diversity and Population Dynamics of Fruit Fly in Bottle Gourd and its Correlation with Abiotic Factors in Nagaland

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ABSTRACT: Fruit fly pose a significant growing threat to cucurbitaceous vegetables. An investigation was carried out to study the population dynamics of fruit fly in bottle gourd and its correlation with abiotic factors. Six species of fruit flies were identified *viz*., *Bactrocera dorsalis, B. verbasifoliae, B. tuberculata, B. rubigina, B. aethriobasis and B. zonata*. Among all the prevailing species, *B. dorsalis* was recorded as the most dominant and abundant species with relative abundance of 80.62% followed by *B. verbascifoliae* with 11.89%, *B. rubigina* with 3.16%, *B. tuberculata* with 2.64%, *B. aethriobasis with* 1.03% *and B. zonata* was the least abundant species representing 0.62%. The highest population of *B. dorsalis* was recorded during mid-July (31st SW) with a mean population of 60.66 flies/trap and was followed by another peak activity during 3rd July (29th SW) with 58.33 flies/trap. The lowest population count was recorded in *B. zonata* with a mean population of 2.33 flies/trap on 32th SW. Correlation analysis indicated that *B. dorsalis, B. aethriobasis, B. verbascifoliae* and *B. zonata* were found to be non-significant with all the abiotic factors. Whereas, *B. tuberculata* had negative significant correlation with maximum relative humidity (r = -0.898) and *B. rubigina* had shown significant negative correlation with maximum temperature (-0.868*) and minimum temperature (r = -0.758*) but non- significant with other weather parameters. Monitoring of fruit flies using methyl eugenol lure proved to be promising and potential management tool in order to bring out a sustainable pest management of fruit flies.**

Keywords: Fruit flies, *Bactrocera* spp, bottle gourd, abiotic factors, correlation.

INTRODUCTION

Cucurbits are the vegetable crops belonging to the family Cucurbitaceae that comprised of one of the most genetically diverse group of plants in the plant kingdom with their wide variation from arid to the humid tropic environments. They comprise of about 117 genera and 825 species and consisting principally of herbaceous plants with juicy stems. These include cucumber, muskmelon, watermelon, tinda, pumpkin, bitter gourd, bottle gourd, squash and snake gourd. Almost all the cucurbits have economic value and thus, this family is quite important (Chakravarty, 1982). India ranks second in fruits and vegetables production in the world, after China. As per National Horticulture Database (Second Advance Estimates) published by National Horticulture Board, during 2019-20, India produced 191.77 million metric tonnes of vegetables under a cultivation area of 10.35 million hectares. Bottle gourd is cultivated in approximately 181 thousand hectares in India with a total production of 3 million metric tonnes. In Nagaland, production of bottle gourd in 2020-21 is 833.10 metric tonnes with an area of 101.50 hectares as per the Directorate of Economics and Statistics.

Cucurbits are attacked by several pests which adversely affect the quality and quantity of produce. Most of the insect-pests cause damage at any stage of plant growth, but red pumpkin beetle, leaf miner, flea beetle are serious at seedling stage while fruit fly during fruiting stage (Ram *et al*., 2009).

The order Diptera (true flies) comprises morphologically and ecologically varied groups of taxa (Illango, 2012). Fruit flies (Tephritidae) are so called due to their close association with fruits and vegetables. Of the 4500 known species of fruit flies worldwide, nearly 200 are pests but about 70 species are regarded as agriculturally important throughout the world (Clarke *et al.,* 2005). About 5 per cent of all tephritid species are economically important (Freidberg, 2006). Fruit flies are the most damaging pest of cucurbitaceous crops. The management of fruit flies is challenging as the matured larvae drop to the ground for pupation in

soil (Heve *et al*., 2016). Fruit fly infestation reduce the yield and degrade the quality of cucurbit fruit (Sarkar *et al*., 2017). Larval stages feed on a broad range of fruit and vegetables causing direct damage, fruit drop and loss of export markets (Dominaik *et al*., 2015). Atwal and Dhaliwal (2005) reported that fruitfly caused 50 % damage on cucurbits in India, and depending on the environmental condition and susceptibility of crop species, extent of losses varied from 30% to 100% (Dhillon *et al.,* 2005). Population buildup of *Bactrocera* sp. in cucurbit through pheromone traps have been studied in Himachal Pradesh. (Devi and Mehta 2015). David and Ramani (2011) reported that 325 species of fruit flies are found in the Indian subcontinent and from India alone, there are 243 species in 79 genera. *Bactrocera dorsalis* (Hendel) is one of the most important among the five most damaging and aggressive fruit flies in the world (Leblanc and Putoa 2000). Oriental fruit fly or mango fruit fly, *Bactrocera dorsalis* (Hendel), guava fruit fly, *Bactrocera correcta* (Bezzi) and peach fruit fly, *Bactrocera zonata* (Saunders) are very important pests of fruit crops in India from economic point of view. They are commonly most important threat to horticulture (Verghese *et al*., 2004). There are approximately 700 known species of Dacine fruit flies endemic to Africa, Asia, Australia and South Pacific. Among the known Dacine species three of them namely *Dacus cucurbitae* (Coquillett), *Dacus dorsalis* (Hendel) and *Dacus zonatus* (Saunders) have high economic importance in India, due to their frugivorous, polyphagous and multivoltine habits. They have been found attacking a number of fruit and vegetable crops in India, including peach, plum, apricot, cucumber, bitter gourd, pumpkin, etc. (Butani and Verma 1977). Nair *et al.* (2017) studied the incidence of fruit flies in different cucurbitaceous crops and recorded nine species of Dacine fruit flies for the first time in Tripura. Kishor *et al.* (2018) conducted an extensive survey to determine the species diversity and relative abundance of fruit flies in gourds in Dharmapur and Coimbatore. Maharjan *et al.* (2015) conducted monitoring of cucurbit fruit fly in Bhaktapur district. Khan and Naveed (2017) observed the highest mean population of fruit fly in the month of August but the lowest population during winter months.

In order to control the damage, one should know about their importance of seasonal abundance and species diversity and no work was undertaken on species diversity of fruit fly in bottle gourd in Nagaland. So, the present study was conducted at Entomology Experimental Research Farm, School of Agricultural Sciences and Rural Development, NU, SASRD, Medziphema Campus during the cropping season from April to August, 2018 to find out diversity and population dynamics of fruit fly in bottle gourd in Nagaland.

MATERIALS AND METHODS

A. Location of the experiment:

The experiment site was located at Medziphema (25°45'43″ N and 93°33'04″ E) in the foothills of Pauna range, Dimapur district of Nagaland with an elevation of 310 m above sea level (MSL); subtropical climate condition with a predominantly high humidity (70-85%), moderate temperature and medium to high rainfall ranging from 2000-2500 m. Mean summer varies from 28-32°C and winter temperature varies from 10-15°C. Soil condition was sandy loam, well drained with mean pH of 4.4.

B. Experimental details

20 plots of size 5m × 3m each with 2m spacing between the blocks surrounded by 1m footpath around the border were subjected to Neighbour Balance Design (NBD) layout. VRBG-136 variety of bottle gourd seeds were procured from AICRP, Horticulture Dept. SASRD; NU. Seedlings of the plant were transplanted to the plots with a spacing of 2 m row to row and 80 cm plant to plant and replicated five times. Recommended agronomical practices were followed. Platform of split bamboos along with coconut ropes were established at 10-15 DAT in each plot for allowing the vine to creep on, and have a complete spread. The plants of 10 days were provided with support that was directed to the platform for proper spread of vines mat. Trap catches were taken at weekly intervals to study the population dynamics of the pest. Species diversity was estimated by taxonomic identification and was done by K. J. David Scientist, from ICAR- National Bureau of Agricultural Insect Resources. *Bactrocera dorsalis* and other fruit fly species were sorted out and counted. Fruit fly species collected were preserved as dry specimens.

The data on various abiotic factors such as temperature (maximum and minimum), relative humidity and rainfall were obtained from meteorological observatory Jhanapani. Weekly means for maximum and minimum temperature (ºC), relative humidity (%), total rainfall (mm) and sunshine (h/day) were worked out from 28th SW to 34th SW of 2018. Individual correlations between trap catches of *Bactrocera* species and mean maximum and minimum temperature, morning and evening humidity, total rainfall during the week and sunshine hours were worked out.

C. Preparation of traps

A 1 litre empty bottle was taken and three windows were cut with a knife at 3 inches away from the top with each window of 1 inch size. A small opening was made at centre in the cap using a nail. A 10 inches long wire was taken with a knot at the centre, then the wire was inserted from inside to the outside cap. A loop was made to hang the bottle and a hook to tie the lure inside the bottle was made at the other end. An inch thick cotton rope was cut at 2 inches length, and the end with thin wire was cut. Mixture of ethyl alcohol 60 ml + methyl eugenol 40 ml + malathion /DDVP (Pesticide) 20 ml (*i.e*. in the ratio of 6:4:2) was used as lures. The cut cotton pieces were dipped in methyl eugenol for 24 hours and lure was then covered with aluminium foil until use.120 ml mixture was used for preparing 30 lures i.e @ 4ml/lure. One third of aluminium foil was removed at the time of use and tied the lure to the thin wire in the lid. The trap counts of adult *Bactrocera* species was recorded at weekly interval by emptying

the traps and constituents were refilled. The number of species of fruit flies and number of fruit flies attracted per trap plot were counted and identified. The number of flies received from each trap determined the population build-up of the pest during the week.

D. Statistical analysis

The observation on study parameters taken for the NBD experiment were analysis through following matrix calculation

$R = C - N'\bar{K}N$

Where, C = Informative matrix of order 5 × 5
R = Replication matrix of order 5 × 5
N = Incidence matrix of order 10 × 5
N'= Transpose of N matrix of order 5 × 10
$\bar{K}$= Inverse of K matrix of order 10 × 10
K = Block size matrix of order 10 × 10

RESULTSAND DISCUSSION

Fruit fly species recorded during the present study are presented in Table 1 and shown in Fig. 1. Six species of fruit fly species *viz., Bactrocera dorsalis* (Hendel), *Bactrocera tuberculata* (Bezzi), *Bactrocera zonata* (Saunders), *Bactrocera verbascifoliae* (Drew *et al.* 2008), *Bactrocera rubigina* (Wang and Zhao) and *B. aethriobasis* (Hardy) have been recorded. Among these species, *B. dorsalis* (Hendel) was the most abundant species with total of 1554 individuals, followed by *B. verbascifoliae* (212), *B. rubigina* (64), *B. tuberculata* (54), *B. aethriobasis* (20) and lowest number were recorded in *B. zonata* (12). Similar identification was reported by Nair *et al.* (2017) who identified 20 species of Dacine fruit flies from Tripura.

Table 2 showed the relative abundance of fruit fly species collected during the period of study in bottle gourd. Out of six species of fruit flies, *viz*., *B. dorsalis, B. verbascifoliae, B. tuberculata, B. rubigina, B. aethriobasis* and *B. zonata* were recorded during the fruiting period *i.e.* June to August, 2018, *B. dorsalis* was recorded as the most dominant and abundant species with relative abundance of 80.62% followed by *B. verbascifoliae* with 11.89%, *B. rubigina* with 3.16%, *B. tuberculata* with 2.64%, *B. aethriobasis with 1.03% and B. zonata* was the least abundant species representing 0.62%.

Table 1: List of fruit fly species recorded in bottle gourd.

Sr. No.	Species	No. of individuals
1.	*Bactrocera dorsalis* (Hendel)	1554
2.	*Batrocera verbasifoliae*(Drew and Raghu)	212
3.	*Batrocera tuberculata*(Bezzi)	54
4.	*Bactrocera rubigina*(Wang and Zhao)	64
5.	*Bactrocera aethriobasis* (Hardy)	20
6.	*Bactrocera zonata* (Saunders)	12
Total number of individuals		**1916**

Fig. 1. [A] *Batrocera dorsalis;* [B] *Bactrocera aethriobasis;* [C] *Bactrocera tuberculata.*

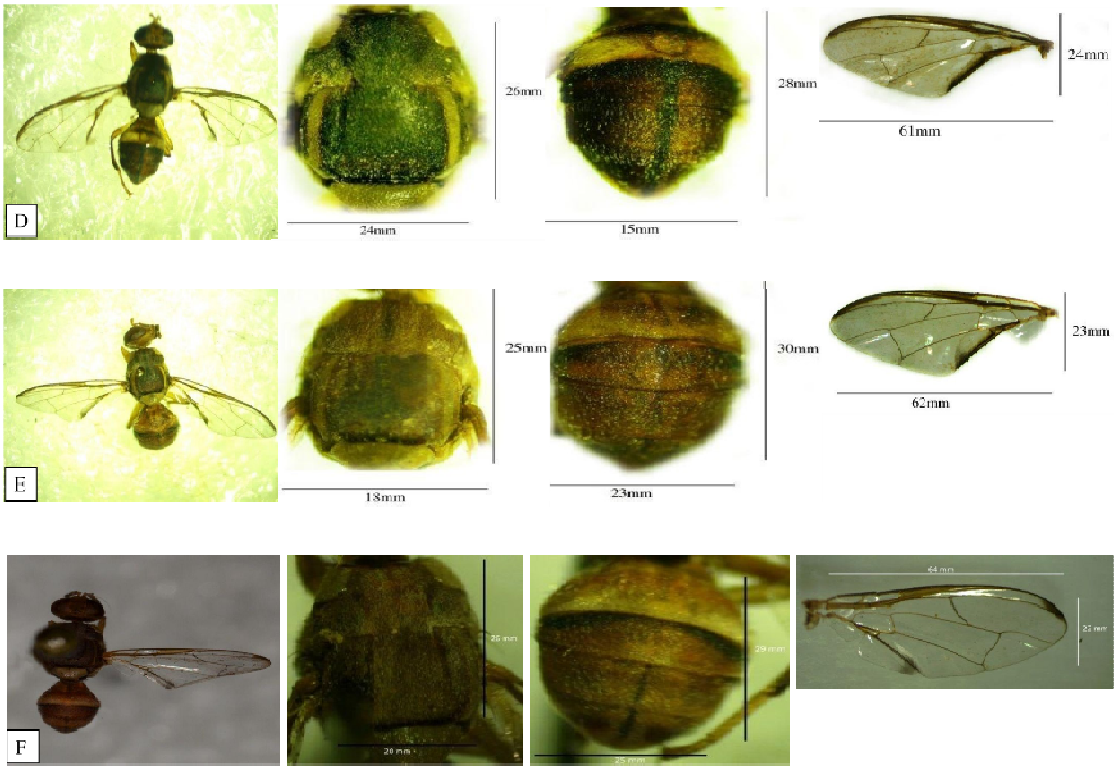

Fig. 1. [D] *Bactrocera verbascifoliae;* [E] *Bactrocera rubigina;* [F] *Bactrocera zonata.*

Table 2: Relative abundance (%) of fruit fly species in bottle gourd.

Sr. No.	Species Abundance	Percentage (%)
1.	*Bactrocera dorsalis* (Hendel)	80.62 %
2.	*Batrocera verbasifoliae* (Drew and Raghu)	11.89 %
3.	*Batrocera tuberculate* (Bezzi)	2.64 %
4.	*Bactrocera rubigina* (Wang and Zhao)	3.16 %
5.	*Bactrocera aethriobasis* (Hardy)	1.03 %
6.	*Bactrocera zonata* (Saunders)	0.62 %

The activity of *B. dorsalis*, *B. verbasifoliae*, *B. tuberculata*, *B. rubigina* and *B. zonata* were found to be prevalent throughout the fruiting period of the crop, i.e. from 28th SW to 34th SW whereas the activity of *Bactrocera zonata* initiated from the mid-July (31th SW). The details of the weekly observations of abundance of fruit fly species recorded are presented in Table 3. *B. dorsalis* was first recorded during last part of June *i.e.* 28th standard week (SW) with the catch of 47.33 flies/trap. However, the trap increased in subsequent weeks with the age of the crop and then reduced the population onwards the end of the cropping season. Significantly higher population of *B. dorsalis* was recorded during mid- July (31st SW) with the mean population of 60.66 flies/trap and was followed by another peak activity during 3rd July (29th SW) with 58.33 flies/trap. The lowest catch of *B. dorsalis* was during the end of the cropping season (34th SW) with a mean of 33.33 flies/trap followed by 33th SW (42.33flies/ trap) respectively. Similar findings were reported by Viraktamath and Ravikumar (2006) who observed the peak population of *B. dorsalis* during mid-July and Vayssieres *et al*. (2015) who observed that *B. dorsalis* was most abundant during the rainy season which was in conformity with the present study. On the contrary, Kumar *et al*. (2018) who reported that the maximum population of *B. dorsalis* caught through methyl eugenol traps was found in the month of August. Stanley *et al.* (2015) found the maximum population of *B. dorsalis* in the month of December which is contrary to the present study.

Weekly mean number of *B. verbasifoliae* indicated that the population fluctuated over the growing season and the first observation of *B. verbascifoliae* was during 26th June (39th SW) with the mean of 10.66 flies/trap. The population of *B. verbasifoliae* gradually increased towards the mid-season when there was maximum numbers of fruits in the field and the maximum population being recorded on 3rd July (29th SW) with mean of 26.00 flies/trap followed by 17th July (31st SW), 10 July (30th SW), 31st July (33rd SW) with mean population of 18.66, 17.66, 9.00 flies/ trap respectively. Whereas the lowest was found on first week of August (34th SW) with mean population of 3.00 flies/trap. This interpretation is sustained by the observations made by Patel *et al*. (2013) that the highest fruit fly infestation was found from April to July during 2009-2010 and 2010-2011. Ukey *et al.* (2014) found the peak population of *Bactrocera* spp. in the month of June and July which supports the present findings. The highest

population level of *B. rubigina* was recorded during 3rd July (29th SW) with mean of 17.33 flies/ trap followed by another peak activity during 26th June (28th SW) and 10th July (30th SW) with 13.66 flies/trap and 11.66 flies/trap respectively. The population started to decline from the mid-July and lowest was found during the harvesting period.

Table 3: Abundance of species and their correlation with abiotic factors.

Standard Week	Date of observation	Temperature (ºC)		Relative humidity (%)		Rainfall (mm)	Species abundance/Plot					
		Max.	Min.	Max.	Min.		Species 1	Species 2	Species 3	Species 4	Species 5	Species 6
28	26.06.18	33.8	25.3	91	69	29.2	47.33	0.00	13.66	7.33	10.66	5.00
29	03.07.18	33.5	24.9	90	73	30	58.33	0.00	17.33	20.00	26.00	8.00
30	10.07.18	32.6	24.6	93	78	67.8	54.66	0.00	11.66	12.00	17.66	11.33
31	17.07.18	32.2	24.4	94	74	90.1	60.66	6.33	6.00	12.66	18.66	6.33
32	24.07.18	34.2	25.2	93	68	69.7	53.33	17.33	4.66	4.66	6.66	2.33
33	31.07.18	33.6	25	95	70	55.2	42.33	13.00	4.33	3.33	9.00	4.00
34	07.08.18	34.5	24.9	96	72	65.3	33.33	4.66	4.00	3.00	3.00	5.66

Mean number of three replications
Species 1: *B. dorsalis;* Species 2: *B. aethriobasis;* Species 3: *B. rubigina*;
Species 4: *B. tuberculata*; Species 5: *B. verbascifoliae;* Species 6: *B. zonata*

Table 4: Correlation coefficient of species with abiotic factors.

Fruit flies spp.	Pearson's correlation coefficient				
	Temperature (ºC)		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
B. dorsalis	-0.710^{NS} (0.399)	-0.413^{NS} (0.366)	-0.606^{NS} (0.716)	0.342^{NS} (0.756)	-0.238^{NS} (0.288)
B. aethriobasis	0.305^{NS} (0.535)	0.254^{NS} (0.511)	0.460^{NS} (0.537)	-0.583^{NS} (0.800)	-0.115^{NS} (0.406)
B. tuberculata	-0.200^{NS} (0.515)	0.075NS (0.425)	-0.898** (0.537)	0.288^{NS} (0.728)	-0.274^{NS} (0.288)
B. rubigina	-0.868* (0.456)	-0.758* (0.414)	-0.324^{NS} (0.487)	0.611^{NS} (0.696)	0.055^{NS} (0.362)
B. verbasifoliae	-0.683^{NS} (0.659)	-0.492^{NS} (0.554)	-0.657^{NS} (0.705)	0.565^{NS} (0.756)	-0.014^{NS} (0.495)
B. zonata	-0.666^{NS} (0.445)	-0.446^{NS} (0.560)	-0.507^{NS} (0.560)	0.719^{NS} (0.619)	0.135^{NS} (0.330)

Note: df = (7-2) = 5 r (p = 0.05) = 0.755 r (p = 0.01) = 0.875 NS= Nonsignificant
* = Significant at 5% level of significance
** = Significant at 1% level of significance

In contrary to the present study, Devi and Mehta (2015) observed highest population of fruit fly in the first week of June. Kumar *et al*. (2006) also reported that maximum number of *Bacterocera* sp. was trapped during August in cucurbitaceous vegetables. The variation may be due to difference in climatic conditions. The weekly mean number of *B. aethriobasis* indicated that no population was observed during the beginning of fruiting period but started to appear from mid-July. Its peak population was observed during the last part of the month of July but lowest during the harvesting period. The highest population level of *B. tuberculata* was recorded during 3rd July (29th SW) with mean of 20.00 files/ trap followed by 31st SW (12.66 flies/trap). The population was somewhat constant from 32nd SW to 34th SW ranging from 3.00 flies to 4.66 flies/ trap. *B. zonata* was first started to appear from last part of June attaining its highest peak during 30th SW remain low throughout the growing period. Khan and Naveed (2017) reported highest mean populations (499) of *B. zonata* in the month of August which is in agreement with the present study. Agarwal *et al*. (1999) observed that population of *B. zonata* was higher than that of *B. dorsalis* with an average of 39.94 and 134.92 flies per trap per week, respectively which was at variation with the present study. The variation may be due to different in environmental condition.

Correlation studies between the fruit fly species and weather parameters (Table 4) revealed that *B. dorsalis, B. aethriobasis, B. verbascifoliae* and *B. zonata* were found to be non-significant. with maximum and minimum temperature, maximum and minimum RH and rainfall. A negative significant correlation was observed between *B. tuberculata* and maximum relative humidity (r = -0.898**) while non- significant with other weather parameters. The population of *B. rubigina* had shown significant negative correlation with maximum temperature (r = -0.868*) and minimum temperature (r = -0.758*) butnon- significant with maximum and minimum relative humidity and rainfall. Khan and Naveed (2017) found a positive correlation between the fruit fly and temperature which was in contrast with the present study. Boopathi *et al.* (2013) showed that rainy days and rainfall are negatively correlated with population of *Bactrocera dorsalis* which was in variation with the present finding. The variation may be due to different in environmental condition.

CONCLUSIONS

The study is an indicator that diverse species of fruit flies are abundantly attacking bottle gourd causing significant damage. *B. dorsalis* was recorded as the most dominant and abundant species followed by *B. verbascifoliae, B. rubigina*, *B. tuberculata*, *B. aethriobasis, and B. zonata. B. dorsalis, B. aethriobasis, B. verbascifoliae* and *B. zonata* were found to be non-significant with all the abiotic factors. Whereas, *B. tuberculata* had negative significant correlation with maximum relative humidity (r = -0.898**) and *B. rubigina* had shown significant negative correlation with maximum temperature (-0.868*) and minimum temperature (r = -0.758*). Monitoring of fruit flies using methyl eugenol lure proved to be promising and potential management tool in order to bring out a sustainable pest management of fruit flies.

FUTURE SCOPE

Application of insecticide is considered as a serious problem and threat to human and environmental health. Also, fruit fly being multivoltine, polyphagous and all its developmental stages in an unexposed form make it difficult to be controlled by chemical pesticides. Therefore, management of fruit flies using methyl eugenol lure proved to be promising and potential management tool as well as for timely monitoring of the pest population which is well depicted through the present investigation. So, it is imperative that future detail study is to be made on the above mentioned line of work in order to bring out a sustainable pest management of fruit flies to boost profitable crop production.

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Conflict of Interest. None.

REFERENCES

Agarwal**,** M. L., Kumar, P. and Kumar, V. (1999). Population suppression of *Bactrocera dorsalis* (Hendel) by *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) in North Bihar. *Shashpa, 6*(2), 189-191.

Atwal, A. S. and Dhaliwal, G. S. (2005). Agricultural pests of South Asia and their management. Kalyani Pub., New Delhi, India. pp. 189-190.

Boopathi, T., Singh, S. B., Ngachan, S. V., Manju, T., Ramakhrishna, Y. and Lalhruaipuii (2013). Influence of weather factors on the incidence of fruit flies in chilli (*Capsicum annuum* L.) and their prediction model. *Pest Management in Horticultural Ecosystems*, *19*(2), 194-198.

Butani, D. K. and Verma, S. (1977). Pests of vegetables and their control. *Pesticide,11*(3), 37-41.

Chakravarty, H. L. (1982). Fascicles of Flora of India. Botanical Survey of India, Calcutta.

Clarke, A. R., Armstrong, K. F., Carmichael, A.E., Milne, J. R., Raghu, S., Roderick, G. K. and Yeates, D. K. (2005). Invasive phytophagous pests arising through recent tropical evolutionary radiation: The *Bactrocera dorsalis* complex of fruit flies. *Annual Review of Entomology, 50*, 293-319.

David, K. J. and Ramani, S. (2011). An illustrated key to fruit flies (Diptera: Tephritidae) from peninsular India and Andaman and Nicobar Islands. *Zootaxa, 3021*, 1-31.

Devi, Y. K. and Mehta, P. K. (2015). Biodiversity and management of fruit flies infesting cucumber through pheromone trap in North-western Himalayas. *Journal of Insect Science*, *28*(1), 77-84.

Dhillon, M. K., Naresh, J. S., Singh, R. and Sharma, N. K. (2005). The melon fruit fly, *Bactocera cucubitae*: A review of its biology and management. *Journal of Insect Science*, *5*(40), 393-399.

Dominaik, B. C., Wiseman, B., Anderson, C., Walsh, B., McMahon, M. and Duthie R. (2015). Definition and management strategies for areas of low pest prevalence for Queensland fruit fly, *Bactrocera tryoni* Froggatt. *Crop Protection*, *72*, 41-46.

Drew, R.A.I., Raghu, S. and Halcoop, P. (2008). Bridging the morphological and biological species concepts: studies on the *Bactrocera dorsalis* Hendel complex (Diptera: Tephritidae): Dacinae in South-east Asia. *Biological Journal of Linnean Society, 93*, 217–226.

Freidberg, A. (2006). Preface-Biotaxonomy and Tephritoidea. In: Freidberg A (ed) Biotaxonomy of Tephritoidea. *Israel Journal of Environment, 35-36*, 1-7.

Heve, W. K., El-Borai, F. E., Carrillo, D. and Duncan, L. W. (2016). Biological control potential of entomopathogenic nematodes for management of Caribbean fruit fly, Anastrepha suspense Loew (Tephritidae). *Pest Management Science*.

Illango, K. (2012). Diversity and distribution of Indian Diptera (true flies). Abstracts. *International Conference on Entomology*, Punjabi University, Patiala, pp 61.

Khan, R. A. and Naveed, M. (2017). Occurrence and seasonal abundance of fruit fly, *Bactrocera zonata* (Saunders), (Diptera: Tephritiadae) in relation to meteorological factors. *Pakistan Journalof Zoology*, *49*(3), 999-1003.

Kishor, P., Kempraj, T., Elaiyabharathi, T. and Kavitha, C. (2018). Species Diversity and Relative Abundance of Fruit flies (Tephritidae: Diptera) in Cucurbitaceous Vegetables. *Madras Agricultural Journal*, *105*(4-5), 196.

Kumar, K. N. K., Verghese, A., Shivakumara, B., Krishnamoorthy, P. N. and Ranganath, R. (2006). Relative Incidence of *Bactrocera cucurbitae* (Coquillet) and *Dacusciliatus* Loew on Cucurbitaceous Vegetables. Fruit flies of Economic Importance: From Basic to Applied Knowledge Proceedings of the 7th International Symposium on Fruit flies of Economic Importance 10-15 September 2006, Salvador, Brazil. 249-253.

Kumar, U., Prasad, C. S., Vaibhav, V. and Saran, S. (2018). Population dynamics of mango fruit fly species caught through methyl eugenol traps at different locations of Western plain zone of Uttar Pradesh. *Pharmocognosy and Phytochemistry*, *7*(2), 2167-2168.

Leblanc, L. and Putoa, R. (2000). Fruit flies in French Polynesia and Pitcairn Islands. Secretariat of the Pacific Community Advisory Suva Fiji, Leaflet No. 29. pp 4.

Maharjan, R., Regma, R. and Paudel, K. (2015). Monitoring and Varietal Screening Cucurbit Fruit Fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) on Cucumber in Bhaktapur and Kathmandu, Nepal. *International Journal of Applied Sciences and Biotechnology*, *3*(4), 714.

Nair, N., Thangjam, B. C., Bhattacharjee, T. and Debnath, M. R. (2017). Species composition of Dacine fruit flies (Diptera: Tephritidae: Dacinae: Dacini) associated with Cucurbits in Tripura, a North Eastern state of

India. *Journal of Entomology and Zoology Studies*, *3*, 330-335.

Patel, R. K., Jhala, R. C., Joshi, B. K., Sisodiya, D. B., Verghese, A., Mumford, J. D. and Stonehouse J. M. (2013). Effectiveness of solvents for soaked–block annihilation of male fruit flies in Gujarat. *Pest management horticultural Ecosystem***,** *11*, 123-125.

Ram, H.H., Prasad, L., Singh, O. K., Yadav, R. S. and Singh, B. (2009). Screening of cucurbit germplasm against insect-pests and diseases under natural conditions. *Society for Recent Development of Agriculture, 9*(2), 229-234.

Sarkar, S., Das, S., Kamal, M. M., Islam K. S. and Jahan M. (2017). Efficiency of management approaches against cucurbit fruit fly (*B. cucurbita* Coquillett) of bittergourd. *Agricultural Research*, *42*(4), 757-766.

Stanley, J., Gupta, J. and Rai D. (2015). Population dynamics of fruit flies, *Bactrocera* spp. in North Western Himalaya. *Indian Journal of Entomology*, *77*(3), 214220.

Ukey, M. S., Chandele, A. G., Jadhav, R. S. and Wagh, S. S. (2014). Seasonal incidence of fruit flies, *Bactrocera* spp. (Diptera: Tephritidae) in relation to abioticfactors. *Ecology, Environment and Conservation, 20*(1), 365-368.

Vayssieres, J. F., De Meyer, M., Ouagoussounon, I., Sinzogan, A., Adandonon, A., Korie, S. and De Bon, H. (2015). Seasonal abundance of mango fruit flies (Diptera: Tephritidae) and ecological implications for their management in mango and cashew orchards in Benin (Centre & North). *Journal of Economic Entomology, 108*(5), 2213-2230.

Verghese, A., Tandon, P. L. and Stonehouse, J. M. (2004). Economic evaluation of the integrated management of the Oriental fruit fly *Bactrocera dorsalis*(Diptera: Tephritidae) in mango in India. *Crop Protection, 23*, 61-63.

Viraktamath, S. and Ravikumar, C. (2006). Management of fruit flies through mass trapping in guava at Dharwad. *Pest Management in Horticulture Ecosystem*, *12*, 137-42.

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