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Species Diversity and Relative Abundance of Fruit Flies in Three Important Cucurbit Crops in Medziphema, Nagaland

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ABSTRACT: Fruit flies are among the most common insects that eat vegetables (Diptera: Tephritidae). To finish their development, their larvae consume the pulp or seeds of fruits, which encourages the entry of infections and an early fall of the fruits, harming fruit yield. The purpose of this study was to identify the diversity of fruit fly species associated with cucurbit crops in Medziphema, Nagaland. To study theirdiversity, three different cucurbitaceous crops *viz*., cucumber, pumpkin and ash gourd were grown in three different isolated farms. Methyl eugenol, cue lure and banana poison bait were used in different plastic bottle traps to attract and catch different species fruit flies to determine diversity and relative abundance. The fruit flies species recorded from different cucurbitaceous crops were *Bactrocera dorsalis, Zeugodacus tau*, *Bactrocera tuberculata*, *Zeugodacus cucurbitae* and *Bactrocera ruiliensis* (Diptera: Tephritidae). *B. dorsalis* was the most abundant species in all the cucurbit crops. The Shannon-Weiner diversity index (H'), Simpson diversity index (SDI) and evenness of species (E_H) computed for fruit flies in three different cucurbit fields revealed that the H' value was highest in ash gourd (1.29), while SDI value was recorded highest in cucumber (0.397) andE_H value was in the range of 0.736 to 0.799 in the three cucurbits.

Keywords: Cucurbits, Fruit flies, Diversity, Methyl eugenol, Cue lure.

INTRODUCTION

Cucurbits are vegetable crops from the Cucurbitaceae family, which principally includes species that are eaten as food all over the world. 825 species and 118 genera make up the family. Cucurbits are eaten in a variety of ways, such as salad ingredients (cucumber, gherkins, long melon), dessert ingredients (melons), sweet treats (ash gourd, pointed gourd), pickled gherkins and for culinary purposes. Some of them, such as the bitter gourd, are well renowned for their special therapeutic qualities. Cucumber and melon are two of the 20 most significant vegetable crops in the world now among the cucurbits. According to an FAO estimate, cucurbits account for 5.6% of India's total vegetable production and are grown on 4,290,000 ha with a productivity of 10.52 t/ha. Fruit flies have been considered one of the most dangerous cucurbit pests due to their polyphagous behaviour and significant economic losses to vegetables that can range from 30 to 100% depending on the crop and season (Dhillon *et al*., 2005). Cucurbit fruit suffers from fruit fly infection, which lowers yield and lowers quality (Sarkar *et al*., 2017). Fruit flies are considered as one of the most damaging pest of cucurbitaceous crops as their management is difficult because the grown larvae drop to the ground to pupate in soil (Heve *et al*., 2016). Dominaik *et al*. (2015) reported that larval stages feed on a wide range of fruit and vegetables causing direct damage, fruit drop and loss of export qualities.

Due to their tendency for strutting and vibrating their wings, fruit flies (Diptera: Tephritidae) are one of the most diversified groups of insects. They are also among the most dangerous pests of horticultural crops in the world (White and Elson-Harris 1992; Agarwal and Sueyoshi 2005). Over 4448 fruit fly species or subspecies belong to the family Tephritidae, which is divided into 481 genera (Thompson1998; Agarwal and Sueyoshi 2005). There are 79 genera and 243 species of fruit flies in India (Agarwal and Sueyoshi 2005). According to David and Ramani (2011), there are 325 species of fruit flies on the Indian subcontinent, with 243 species in 79 genera being found in India alone. One of the five most destructive and aggressive fruit flies in the world is *Bactrocera dorsalis* (Hendel) (Leblanc and Putoa 2000). From an economic standpoint, the fruit flies *Bactrocera dorsalis* (Hendel),

Bactrocera correcta (Bezzi) and *Bactrocera zonata* (Saunders), sometimes known as the Oriental fruit fly or mango fruit fly, are major pests of fruit crops in India. They are frequently the biggest threat to horticulture (Verghese *et al*., 2004). Fruit flies of the genus Dacine are indigenous to Africa, Asia, Australia, and the South Pacific, with about 700 species currently recognised. The three most prevalent pest species among the Dacine are *Bactrocera cucurbitae*, *B. dorsalis* and *B. zonata*, but *B. correcta*, *B. diversa* and *B. latifrons* still have a limited geographic distribution (Kapoor,2005). While *Dacus cucurbitae* attacks 150 host plants, *Dacus dorsalis* infests about 70 different host plants (Dhamdhere and Odak1975). According to Bharathi *et al*. (2004), fruit flies are an important pest of ornamental plants, fruits and vegetables. Nair *et al*. (2017) studied on the species composition of Dacine fruit flies associated with cucurbit crops and reported nine species viz., *Bactrocera dorsalis*, *Bctrocera latifrons*, *B. diversa*, *B. hochii*, *B. caudata*, *B. cucurbitae*, *B. tau*, *B. cilifera* and *Dacus longicornis* from Tripura. Twenty different species of Dacine fruit flies known to exist in this Indian state's northeast. Of these, 6 species (*Bactrocera nigrifacia*, *B. rubigina*, *B. tuberculata*, *B. bogorensis*, *B. vulta* and *B. apicalis*) are new records for India and 11 species are new records for the state (Nair *et al*., 2018).

Medziphema, Nagaland is situated between 25°45′53″N latitude and 93°53′04″E longitudes at an elevation of 310 meters above mean sea level. Despite the fact that there are a number of cucurbit insect pests in the area, fruit flies cause up to 80% of the crop's overall damage (Gupta *et al*., 1992; Sood *et al*., 2010). A number of fruit fly species from the area have been identified. Unfortunately, due to the invasion of numerous new species brought on by the recent change in temperature, clear and specific information on fruit flies infesting cucurbits is still scarce. So, the objective of the present research was to determine the diversity of fruit flies that are common in the region's cucurbit ecosystem as well as the patterns of distribution of key species.

MATERIAL AND METHODS

Three different cucurbit crops *viz*., cucumber, pumpkin and ash gourd were grown following recommended agronomic practices in three different experimental farms of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during summer season of 2020-21. The experiment was laid in Randomized Block Design (RBD) with four treatments replicated five times. The treatments were T_1: Methyl eugenol 40 ml + ethyl alcohol 60 ml + malathion 20g, T_2: Cue-lure 40 ml + ethyl alcohol 60 ml + malathion 20g, T_3: Banana poison bait @ 1 kg rotten banana + 10 g carbofuran + 5 g yeast + 5 g citric acid and T_0: Control (water).

Four different fruit fly bottle traps were set up in different plots of three different cucurbits fields at initiation of flowering. This trap was made up of transparent mineral water bottle of 1L capacity with four holes of 20 mm size on four sides. A cotton wad impregnated with the treatment was placed inside the trap in a loop made of iron wire. Impregnation of these chemicals was carried out at weekly intervals. Preparation procedure was followed from the booklet by Latha and Sathyanarayana, National institute of plant health management, Hyderabad (2015).

The fruit fly adults attracted in different traps were collected at weekly interval and brought to the laboratory where their numbers were counted, identified species wise and the individual specimens were preserved in different glass vial (8 × 0.75 cm^2) containing 95 per cent alcohol.

The relative abundance and diversity indices of fruit fly in three different cucurbit crops were worked out by using the following formula.

A. Relative abundance

$$\text{Relative abundance} = \frac{\text{No. of individual of one species}}{\text{No. of individuals of all species}} \times 100$$

B. Diversity indices

(i) Shannon-Weiner Index (H'). Shannon-Weiner Index is a very widely used diversity index for comparing diversity between various habitats (Clarke and Warwick 2001). Shannon- Weiner Index assumes that individuals are randomly sampled from an independently large population and all the species are represented in the sample.

A value near 4.6 would indicate that the numbers of individuals are evenly distributed between all the species. Mathematically, Shannon-Weiner Index is:

$$H' = \frac{s}{i=1} - \sum Pi \log 2\ pi$$

Where,

Pi = The proportion of individuals of i^{th} species in a whole community (n_i/N)

s = The number of species

(ii) Simpson Diversity Index (SDI). Simpson Diversity Index measures the probability that two individuals randomly selected from a sample will belong to the same species (Simpson 1949). The value of this index ranges between 0 and 1 which indicates greater the value, greater the sample diversity.

$$SDI = \sum[n_i\ (n_i\text{-}1)]/N(N\text{-}1)$$

Where,

n_i = The total number of individuals of a particular species

N = The total number of individuals of all species

(iii) Species Evenness (E_H). Evenness is a measure of the relative abundance of different species making up the richness of an area. This evenness is an important component of diversity indices (Leinster and Cobbold 2012) and expresses evenly distribution of the individuals among different species.

The value of E_H ranges from 0 to 1 with 1 indicating maximum evenness. Mathematically,

$E_H = H'/H'_{max} = H'/\ln S$

Where,

H' = The number derived from the Shannon diversity Index

H'_{max} = The maximum possible value of H'

S = The total number of species

RESULTS AND DISCUSSIONS

A. Species Identification

Fruit fly species recorded during the present study are presented in Table 1 and Plate 1. The five fruit fly species that have been identified during the year 2020 and 2021 are *Bactrocera dorsalis*, *Zeugodacus tau*, *Bactrocera tuberculata*, *Zeugodacus cucurbitae* and *Bactrocera ruiliensis*. *Bactrocera ruiliensis* was reported for the first time from Nagaland.

B. Diversity indices of fruit flies on important cucurbits of Nagaland

The Simpson's diversity index (SDI) estimated for fruit flies in the year 2020 was highest in cucumber with 0.415 followed by pumpkin with 0.390 and was least in ash gourd with 0.330, according to the diversity indices data taken from two years of experimental trials (Table 1). Whereas the ash gourd field had the greatest Shannon-Weiner Index (H') (1.30), pumpkin was second (1.19) and cucumber had the lowest score (1.14). Species evenness, which showed that all the species were distributed equally in all the cucurbit fields as all the values obtained from different fields were close to 1 with 0.711 in cucumber, 0.742 in pumpkin and 0.807 in ash gourd, was a sign of the even distribution of species in three different cucurbit fields. Similarly, in 2021, the Simpson's diversity index (SDI) value was highest in cucumber (0.379) followed by pumpkin (0.374) and lowest in ash gourd (0.341). However, Shannon-Weiner Index (H') was highest in ash gourd (1.27) followed by cucumber (1.23) and was least in pumpkin (1.21). The maximum species evenness pattern was showed in ash gourd with 0.791 which was followed by cucumber with 0.762 and lowest in pumpkin with 0.755.

Pooled data (Table 1) showed that highest Simpson diversity index (SDI) was in cucumber (0.397) followed by pumpkin (0.381) and least in ash gourd (0.336). However, Shannon- Weiner diversity index (H') was highest in ash gourd (1.29) followed by pumpkin (1.21) and cucumber (1.18). The value of species evenness was maximum in ash gourd (0.799) followed by pumpkin with 0.749 and cucumber with 0.736.

C. Relative abundance of fruit flies species in different cucurbits

(i) Cucumber. The data (Table 2 and Fig. 1) from two years experimental trials revealed that in the year 2020 the relative abundance of different fruit flies species was recorded highest for *B. dorsalis* (59.94%) followed by *Z. tau* (19.71%), *B. tuberculata* (11.24%), *Z. cucurbitae* (6.84%) and *B. ruiliensis* (2.35%). Similar result was obtained in 2021, with highest relative abundance percentage obtained for *B. dorsalis* (56.64) which was followed by *Z. tau* with 18.97, *B. tuberculata* with 12.49, *Z. cucurbitae* with 8.31 and *B. ruiliensis* with 3.69.

Pooled data (Table 2 and Fig. 1) reveals that *B. dorsalis* have the highest relative abundance percentage with 58.29which was followed by *Z. tau* with 19.35, *B. tuberculata* with 11.83, *Z. cucurbitae* with 7.53 and *B. ruiliensis* with 2.99.

(ii) Pumpkin. The data (Table 2 and Fig. 1) from two years experimental trials revealed that *B. dorsalis* was the most abundant species as compared to the other four species of fruit flies. The relative abundance percentage of *B. dorsalis* in the year 2020 was observed to be 57.39 followed by *Z. tau* with 19.66, *B. tuberculata* with 12.56, *Z. cucurbitae* with 7.59 and *B. ruiliensis* with 2.79. In the year 2021, the relative abundance of *B. dorsalis* was 55.28% which were followed by *Z. tau* with 19.84%, *B. tuberculata* with 15.05%, *Z. cucurbitae* with 7.56% and *B. ruiliensis* with 2.27%.

Pooled data (Table 2 and Fig. 1) reveals that *B. dorsalis* have the highest relative abundance with 56.36% which was followed by *Z. tau* with 19.74%, *B. tuberculata* with 13.78%, *Z. cucurbitae* with 7.58% and *B. ruiliensis* with 2.54%.

(iii) Ash gourd. The data from two years experimental trials (Table 2 and Fig. 1) revealed that *B. dorsalis* was the most abundant species as compared to the other four species of fruit flies. The relative abundance percentage of *B. dorsalis* in the year 2020 was observed to be 49.56 followed by *Z. tau* with 22.84, *B. tuberculata* with 15.47, *Z. cucurbitae* with 9.08 and *B. ruiliensis* with 3.05. In the year 2021, the relative abundance of *B. dorsalis* was 50.84% which was followed by *Z. tau* with 22.99%, *B. tuberculata* with 14.97%, *Z. cucurbitae* with 8.45% and *B. ruiliensis* with 2.75%.

Pooled data (Table 2 and Fig. 1) revealed that *B. dorsalis* have the highest relative abundance percentage with 50.19 which was followed by *Z. tau* with 22.90, *B. tuberculata* with 15.23, *Z. cucurbitae* with 8.78 and *B. ruiliensis* with 2.90.

From the present findings it can be illustrated that based on pooled data of Shanon-Weiner index (H'), the diversity of fruit flie's species in three species of cucurbits is categorized as low, it was in the range of 1.18 to 1.29 which is less than 4.6. The value obtained for Simpson diversity index (SDI) was also low under different cucurbit crops because the value of the index ranges from 0.336 to 0.397 which is not near to1. The low value of H' and SDI is because on these three cucurbits only five species of fruit flies were observed *viz*., *B.dorsalis*, *Z. tau*, *B. tuberculata*, Z. *cucurbitae* and *B. ruiliensis* resulting in low diversity index value. These findings correspond with those of Kishor *et al.* (2018), who found that only two species (*B. cucurbitae* and *Dacus ciliates*) of cucurbits attacked the Coimbatore and Dharmapuri districts of Tamil Nadu, resulting in a low diversity of fruit flies (H'=0.04 to 0.06) under gourds. Across all of the different cucurbit fields, the species evenness value ranged from 0.736 to 0.799, indicating that the individuals are more evenly distributed within the population. Similar findings came from the trials conducted by Ganie *et al.* (2013). They found that cucurbits had low fruit fly diversity, with H' values ranging from 0.255 to 0.511 and evenness index values between 0.846 and 0.977. The index value of species evenness of fruit flies on vegetables in Padang, according to Budiyanti *et al.* (2019), was E_H= 0.058 in a cucumber plantation, which is inconsistent with the current data.

According to the pooled relative abundance data, *B. dorsalis* dominated all other species in cucurbit crops, with relative abundance values ranging from 50.19 to 58.29%. This finding are in line with Hancock *et al*. (2000) who reported that *B. dorsalis* is the main pest on 51 plant families including cucumber, pumpkin and ash gourd. Similarly, the present findings are in conformity with Apriyadi *et al*. (2021) who reported eight species of fruit fly *viz., B. dorsalis, B. carambolae, B. occipitalis, Z. caudata, B. umbrosa, B. neocognata, Z. cucurbitae* and *B. albistrigata* from cucumber field and out of the eight species, *B. dorsalis* was the most dominant species. Varun *et al*. (2022) also observed six species of fruit flies being associating with the cucurbit ecosystem, *viz., Zeugodacus cucurbitae, Z. tau, Bactrocera dorsalis, B. zonata, B. digressa and B. correcta.* Konyak *et al*. (2023) during their study also identified six species of fruit flies *viz*., *Bactrocera dorsalis, B. verbasifoliae, B. tuberculata, B. rubigina, B. aethriobasis and B. zonata. B. dorsalis* was identified as the most prevalent and abundant species overall, with a relative abundance of 80.62%.*B. cucurbitae and B. dorsalis* have been identified on vegetables by Astriyani *et al.* (2017); Kaurow *et al.* (2015); Pramudi *et al.* (2013). Pramanik *et al*. (2021) reported that *Bactrocera dorsalis*, *Zeugodacus cucurbitae* and *Zeugodacus tau* were the predominant fruit fly species during the fruiting season in snake gourd field. Whereas, Kishor *et al*. (2018) reported two species of fruit flies from three different gourd i.e., *B. cucurbitae and Dacus ciliates* and *B. cucurbitae* was the dominant species in all the three gourds.

Table 1: Diversity of fruit flies species recorded in different cucurbit crops during 2020 and 2021.

Species	First year (2020)			Second year (2021)			Pooled		
	Cucumber field	Pumpkin field	Ash gourd field	Cucumber field	Pumpkin field	Ash gourd field	Cucumber field	Pumpkin field	Ash gourd field
Bactrocera dorsalis	1604.00	1375.00	1233.00	1362.00	1271.00	1185.00	1483.00	1323.00	1209.00
Zeugodacus tau	528.00	471.00	568.00	457.00	456.00	536.00	492.50	463.50	552.00
Bactrocera tuberculata	301.00	301.00	385.00	301.00	346.00	349.00	301.00	323.50	367.00
Zeugodacus cucurbitae	183.00	182.00	226.00	200.00	174.00	197.00	191.50	178.00	211.50
Bactrocera ruiliensis	63.00	67.00	76.00	89.00	52.00	64.00	76.00	59.50	70.00
Total number of species	2679.00	2396.00	2488.00	2409.00	2299.00	2331.00	2544.00	2347.50	2409.50
Shannon-weiner diversity index (H')	1.14	1.19	1.30	1.23	1.21	1.27	1.18	1.21	1.29
Simpson diversity index (SDI)	0.415	0.390	0.330	0.379	0.374	0.341	0.397	0.381	0.336
Evenness of species (E_H)	0.711	0.742	0.807	0.762	0.755	0.791	0.736	0.749	0.799

*Population based on 20 traps

Table 2: Relative abundance (%) of fruit flies species recorded during 2020 and 2021.

Species	Relative abundance (%)								
	2020			2021			Pooled		
	Cucumber field	Pumpkin field	Ash gourd field	Cucumber field	Pumpkin field	Ash gourd field	Cucumber field	Pumpkin field	Ash gourd field
B. dorsalis	59.87	57.39	49.56	56.54	55.28	50.84	58.29	56.36	50.19
Z. tau	19.71	19.66	22.84	18.97	19.84	22.99	19.35	19.74	22.90
B. tuberculata	11.24	12.56	15.47	12.49	15.05	14.97	11.83	13.78	15.23
Z. cucurbitae	6.84	7.59	9.08	8.31	7.56	8.45	7.53	7.58	8.78
B. ruiliensis	2.35	2.79	3.05	3.69	2.27	2.75	2.99	2.54	2.90

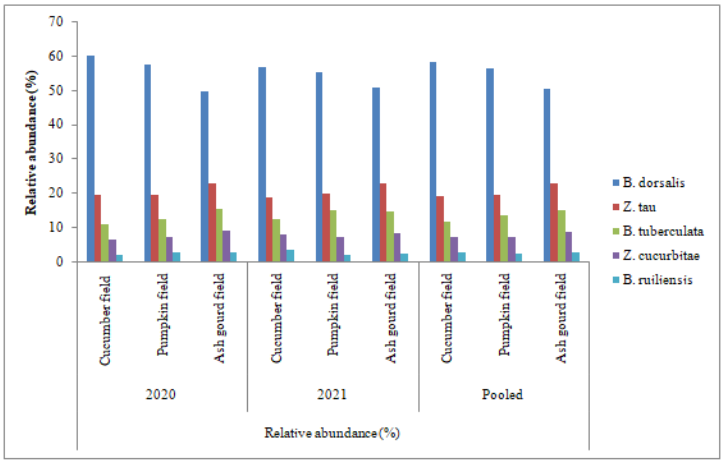

Fig. 1. Relative abundance (%) of fruit flies species recorded during 2020 and 2021.

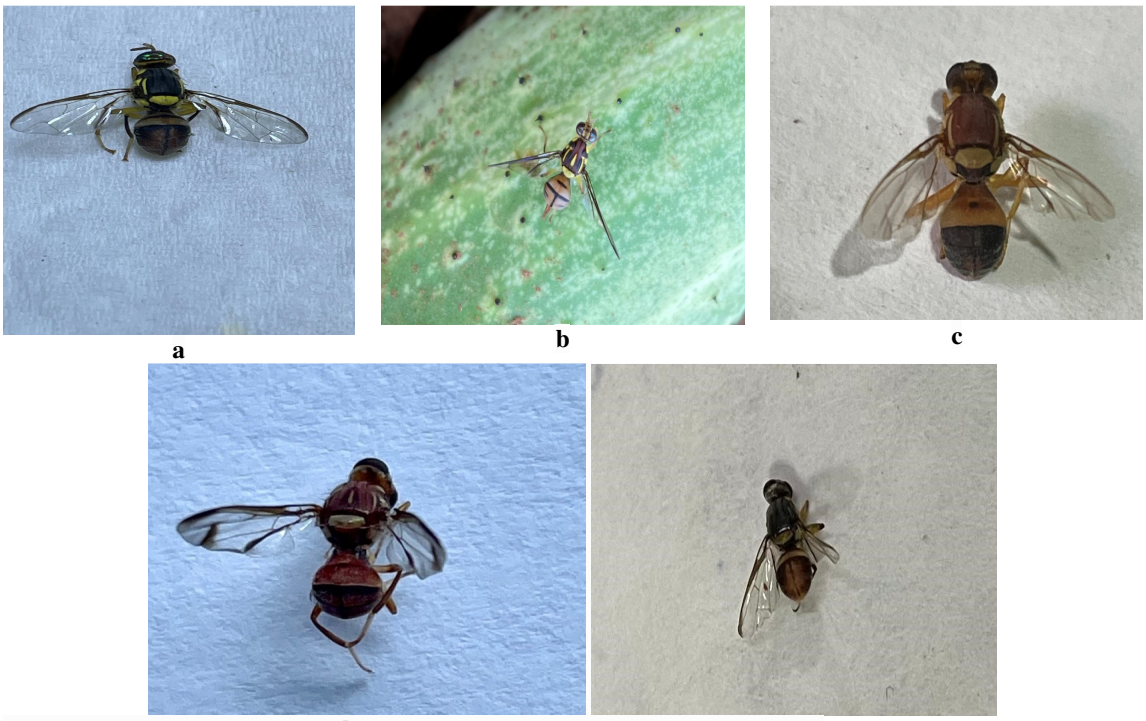

Plate 1. a- *Bactrocera dorsalis*, **b-** *Zeugodacus tau*, **c-** *Bactrocera tuberculata*, **d-** *Zeugodacus cucurbitae* and **e-** *Bactrocera ruiliensis*

CONCLUSIONS

B. dorsalis was the most dominant fruit fly species among the different species of fruit flies, with the highest relative abundance percentage in all the three cucurbit crops of Medziphema area of Nagaland. The diversity of fruit flies was relatively low in all the cucurbit fields. However, they were distributed evenly as the value of evenness of species (E_H) was found high in all the cucurbit fields.

FUTURE SCOPE

Detailed study on diversity of fruit flies can also be conducted in different districts of Nagaland as in the present study it was only conducted in three different locations of Medziphema area under Chumukidema district of Nagaland.

Conflict of Interest. None.

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