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Original Article

Species diversity of fruit flies (Diptera: Tepthritidae) and their damage on vegetables in Padang, West Sumatera, Indonesia

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Abstract

Vegetables in Padang are generally attacked by fruit flies. A study has been done to investigate the fruit flies' species diversity and measure the damage they have caused on these vegetables. Four kinds of vegetables viz. bitter gourd, cucumber, angled loofah, and chili pepper were sampled in the subdistricts of Pauh, Kuranji, Lubuk Kilangan, and Koto Tangah using purposive sampling. There were three species of fruit flies found in four vegetables in Padang, viz. *B. cucurbitae*, *B. dorsalis* and *Bactrocera* species. The highest percentage of plants infested was on angled loofah (20.34%). The highest diversity of fruit flies based on commodity was found on bitter gourd (0.010). Based on location, the highest species diversity was found in subdistrict of Lubuk Kilangan (0.240). The diversity and attack level of fruit flies in Padang City are relatively low, but the control of these pests is required to avoid the spread of them widely in West Sumatera.

Keywords: Diversity, fruit flies, *Bactrocera cucurbitae*, *B. dorsalis*, vegetables

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Introduction

Padang is a city situated on the lowland that has areas for vegetables farming. Four subdistricts in Padang viz. Pauh, Kuranji, Lubuk Kilangan, and Koto Tangah have certain areas planted with vegetables such as bitter gourd, angled loofah, cucumber and chili pepper. One of the big problem in vegetables farming especially in those areas is fruit fly infestation. The all year-round availability of host plants as food sources is considered as an important factor to influence the existence and the diversity of fruit flies in Indonesia (Nishida, 1980) and considered as an obstacle for agribusiness (Kartini et al., 2003) since the damage caused reduce fruits quality and quantity.

Fruit flies belong to Dacini tribe of Tephritidae family, consist of two genera, *Bactrocera* and *Dacus*. *Bactrocera* species are distributed in India, South East Asia to Pacific, while *Dacus* species are more common to Africa (Drew, 2004). Kaurow et al. (2015) found 10 species of *Bactrocera* on chili pepper, tomato and mango squash in Tomohon, North Sulawesi, viz. *B. cucurbitae*, *B. papayae* (=*syn. dorsalis*), *B. tau*, *Bactrocera* sp.1, *B. limbifera*, *B. carambolae*, *B. calumniata*, *B. umbrosa*, *B. facialis*, *B. unimacula*. Pramudi et al. (2013) found *B. cucurbitae* on angled loofah and cucumber in South Kalimantan. The intensity of fruit flies' infestation on chili pepper in West Java and Yogyakarta is between 10 to 35% from the total fruits observed (Hasyim et al., 2014).

Yield loss caused by the infestation of fruit flies on fruits or vegetables are ranged from 20 to 60% depending upon the host species, damage intensity and climate (Hasyim et al., 2014). However, species diversity of fruit flies and their damage on vegetables in Padang City has not been studied. Therefore, we conducted this study to gather the information about species diversity of fruit flies and their damage in Padang, West Sumatera, Indonesia. This information could be used by stakeholder to control fruit flies in the fields.

Material and Methods

Material

Four vegetables i.e. bitter gourd (*Momordica charantia*), cucumber (*Cucumis sativus*), angled loofah (*Luffa acutangula*), and chili pepper (*Capsicum annum*) were observed from monoculture plantation. The fruits were sampled from subdistricts of Pauh (64 m above sea level, S 00º52'46.3", E 100º25'31.8"), Kuranji (76 m above sea level, S 01º37'40.3", E 100º39'27.8"), Lubuk Kilangan (82 m above sea level, S 00º56'21.0", E 100º24'27.2"), and Koto Tangah (30 m above sea level, S 00º54'43.4", E 100º25'13.9") using purposive sampling method. One plot of 100 m^2 was created at each location and 10 subplots were formed in each plot with the size of 1 m^2.

Methods

The fruits that showed the symptoms such as discoloration to yellowish or brownish due to ovipositor penetration of fruit flies were collected from the subplots. Those fruits were kept into cage containing sterile wood fiber and covered with muslin until the adult of fruit flies emerged to identify further. The parameters observed were species diversity and abundance, infestation percentage and the indices of diversity, evenness, and dominance. The species were determined using binocular microscope in 40 times magnification, according to Drew (1989), Hancock et al. (2000), Plant Health Australia (2011) and Siwi et al. (2006).

Attack percentage by fruit flies was measured using formula:

$$A\ (\%) = \frac{n}{N} x\ 100\%$$

A = Attack level (%)
n = number of fruits attacked
N = Total of fruits observed

The diversity index of fruit flies was measured by using Shannon- Wienner formula (Magguran, 1988) as follows:

$$H' = -\sum Pi.\ln(Pi)$$

H' = Diversity index
Pi = Proportion between the number of individuals of one species and the total number of individuals found

The eveness of fruit flies was measured by using formula (Pielou 1975) as follows:

$$E = \frac{H\prime}{lnS}$$

E = Eveness index
H' = diversity index
S = number of species

The dominance of fruit flies was measured by using formula as follows:

$$D = \sum \left(\frac{ni}{N}\right)^2$$

D = Simpson dominance index
n = Individual number of species
N = Total of individual number from all species

Results

Species diversity and abundance

There were three species of *Bactrocera* found in our study, viz. *Bactrocera cucurbitae*, *Bactrocera dorsalis*, and *Bactrocera* species. The number of fruit flies collected in every location were varied. The species was dominated by *B. cucurbitae* (7,131 individuals), especially on angled loofah in Pauh and followed by *B. dorsalis* (246 individuals), and *Bactrocera* species (6 individuals). Furthermore, *B. cucurbitae* and *Bactrocera* species were found infesting all fruits except chili pepper, while only *B. dorsalis* that infested chili pepper (Table 1).

Bactrocera cucurbitae (Fig.1A-D) has a medium body size and brownish coloration (Fig.1A); Scutum is brownish red with four scutellar hairs, while the *lateral postsutural vittae* is narrow with *medial post sutural vittae. Post pronotal lobe* is pale yellow or orange, while *notopleuron* is yellow (Fig.1B);

Table-1: Species of fruit flies and their abundance in vegetables farming in Padang, West Sumatera, Indonesia

Location	Host plants	Number of fruit flies (individual)		
		B. cucurbitae	***B. dorsalis***	***Bactrocera sp.***
Pauh	Bitter gourd	541	-	1
	Cucumber	755	-	-
	Angled loofah	1,036	-	-
	Chili pepper	-	53	-
Kuranji	Bitter gourd	279	-	1
	Cucumber	786	-	-
	Angled loofah	1,227	-	-
	Chili pepper	-	63	-
Libuk Kilangan	Bitter gourd	433	-	-
	Cucumber	440	-	-
	Angled loofah	668	-	2
	Chili pepper	-	103	-
Koto Tangah	Bitter gourd	238	-	-
	Cucumber	419	-	1
	Angled loofah	309	-	-
	Chili pepper	-	27	-
Total		7,131	246	6
Average		594.25	61.5	1.5

The wings are transparent, with the *costal band* extended to the apex. There are additional costal band, cubital streak, and additional band on wings, basal costal and costal were plain and transparent (Fig. 1C); Abdomen is brownish orange with 'T' black pattern, while medial longitudinal has a dark band with medium size (Fig.1D).

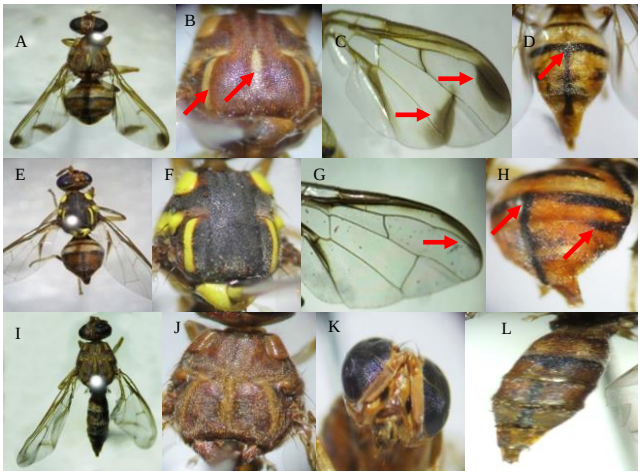

Figure-1: Morphological characters of *Bactrocera cucurbitae*

(A-D), *B. dorsalis* (E-H), and *Bactrocera* sp. (I-L). A, E, and L, dorsal view of adults; B) thorax, showing medial post sutural vittae (mid arrow) and lateral post sutural vittae (left arrow), C) wing, showing *costal band* extended to the apex, and D) abdomen, showing 'T' black pattern (arrow), G) wing, showing no cross band from costa to the distal part of the wing (arrow), H) abdomen showing T" pattern on abdominal terga, L) There is 'T' pattern on the abdomen.

Bactrocera dorsalis (Fig.1E-G) has a medium body size and black in coloration (Fig 1E); There is no *medial post sutural vittae* on the thorax, while the scutum is black, the *lateral postsutural vittae* has medium to larger size (Fig.1F); On wings there is no cross band from costa to the distal part of the wing. Costal band is congruent and overlap with R2+3, similar in width, but exceeded the edge of R2+3 (Fig. 1G); On tergum of abdomen there is "T" pattern. Abdominal terga III- IV have the dark parts which are narrow laterally. The edge of lateral band on abdomen is triangular (Fig.1H).

Bactrocera species (Fig.1I-L) has a medium size and slim abdomen with brownish coloration (Fig. 1I); The thorax was brownish red, with medial and lateral post sutural vittae (Fig. 1J); There was also an oval wide spot on the frons (Fig. 1K). The 'T' pattern on the abdomen was clear (Fig. 1L).

The infestation percentage

The infestation percentage of fruit flies were ranged from 2.83% to 20.34% and the highest was found on angled loofah (20.34%) especially in Kuranji, while the lowest was found on chili pepper (2.83%) especially in Koto Tangah (Table 2).

Table-2: Infestation percentage by fruit flies in vegetables farming in Padang, West Sumatera, Indonesia

Vegetables	Infestation percentage (%)				Average (%)
	Pauh	Kuranji	Koto Tangah	Lubuk Kilangan	
Bitter gourd	23.07	17.00	9.8	16.67	16.63
Cucumber	20.00	26.31	19.56	10.71	19.14
Angled loofah	14.28	44.44	11.76	10.90	20.34
Chili pepper	2.94	4.37	1.18	2.83	2.83

The fruits infested by fruit flies were generally showing similar symptoms, all rotted and softened due to the eating of the larvae from inside (Fig. 2). The infestation was marked by the presence of scars as the results of punctures by the ovipositor. The fruit changed color due to the infestation. On bitter gourd, the area surrounding the puncture of the ovipositor was then changed colour to yellowing (Fig. 2A); On cucumber, the fruit appeared abnormally, shorten, enlarges, redden (Fig. 2B); On angled loofah, the puncture and the surrounding area were brownish (Fig. 2C); While on chili pepper, the color changed to brownish back (Fig. 2D).

Figure-2: Fruit flies infestation on: A) bitter gourd, B) cucumber, C) angled loofah, and D) chili pepper.

The diversity index

The diversity of fruit flies was very low. The highest diversity index of fruit flies by commodity was observed on bitter gourd (H'= 0.010) and by location was in Lubuk Kilangan (H'=0.240). The fruit flies on angled loofah and cucumber was less diverse than on bitter gourd, with the biodiversity indexes (H') of 0.007 and 0.004 respectively. On chili pepper however, there was only one species found, therefore it was not possible to be counted. By locations, the fruit flies attacking the vegetables in Kuranji, Pauh and Koto Tangah were less diverse than that in Lubuk Kilangan with the biodiversity indexes (H') of 0.210, and 0.110 respectively where Koto Tangah and Pauh share the same index (Table 3).

Table-3: Indices of species diversity, evenness and dominance of fruit flies on vegetables in Padang City based on commodity and subdistrict

Category	Parameter					
	No. of individuals	No. of species	Density (species/m^2)	Diversity index (H')	Evenness index (E)	Dominance index (D)
Commodity						
Bitter gourd	1,493	2	49.77	0.010	0.001	0.137
Cucumber	2,401	2	80.03	0.004	0.006	0.129
Angled loofah	3,242	2	108.07	0.007	0.009	0.136
Chili pepper	246	1	8.20	0	0	0
Subdistrict						
Pauh	2,386	3	79.53	0.110	0.008	0.020
Kuranji	2,356	3	78.53	0.210	0.030	0.040
Koto Tangah	995	3	33.17	0.110	0.006	0.040
Lubuk Kilangan	1,646	3	54.87	0.240	0.030	0.050

Discussion

Three species of *Bactrocera* viz. *B. cucurbitae*, *B. dorsalis*, and *Bactrocera* species were found in four species of vegetables and subdistricts in Padang, West Sumatera, Indonesia. All of them were causing similar symptoms on their hosts viz. the punctures, the eating of the fruits from inside to leave the fruits rotten along with the changing of the fruits' coloration externally. Hasyim et al. (2014) explained that it is the female adult that puncture the healthy fruit and leave her eggs inside the fruits to hatch. The rotting of the fruits however, was also resulted by the development of bacteria that was brought in together with the eggs. As *B. cucurbitae* and *B. dorsalis* are known to be polyphagous in nature (Vargas et al., 2015), it was not surprising to find them in all studied vegetables. The unknown species of *Bactrocera* species was at least also not monophagous, since it was found on Cucurbitaceae and Solanaceae. Dhillon et al. (2005) and Vargas et al. (2015) stated that *B. cucurbitae* is the main pest on the family of cucurbitaceae. Astriyani et al. (2017), Kaurow et al. (2015), and Pramudi et al. (2013) are also found *B. cucurbitae* and *B. dorsalis (syn=papayae*) on vegetables.

Angled loofah was the most infested vegetable by fruit flies in all sampled areas, except in Koto Tangah. Cucumber followed angled loofah in every location as the second most attack vegetable, except in Koto Tangah, where it was the most infested. The highest infestation of fruit flies on angled loofah was assumed due to the absence of control by farmers, and the hosts were available continuously in the field. The farmers intentionally made the plants lived longer by pruning the old leaves therefore the plants could produce more flowers and fruits. The presence of fruit flies can cause the reduction of fruits quality to harvest failure. The amount of loss caused by *B. cucurbitae* might vary from 30 to 100% (Dhillon et al., 2005), while Kumar et al. (2006) reported that on cucumber, angled loofah, and bitter gourd in India, the loss could reach 75%. However, CABI (2005) reported that 100% loss could be observed on the neglected plants.

The size of population is related to the damage caused by the fruit flies. This could be seen from the result of this study where the population of fruit flies on angled loofah was the most abundance (Table 1) & the infestation was the highest (Table 2). Herlinda et al. (2007) stated that the high population of fruit flies in turn will increase the number of laid eggs and as a consequence the damage will be higher. *B. cucurbitae* was very abundant in the field due to the availability of the abundant hosts. Ginting (2009) stated that the factors affecting the abundance of species in a habitat are habitat condition, environment around them, species adaptation, and the availability of hosts in the habitat. According to Odum (1996) however, stated that the species that is found in abundance could be caused the abundance of species, biomass and important value, therefore the species dominated in the community. The dominance of *B. cucurbitae* on bitter gourd, angled loofah, and cucumber with dominance index 0.137, 0.136 and 0.129 (Table 3) was caused by the three host plants belong to the same family of cucurbitaceae.

One of important factors affecting diversity of a species is the availability of hosts as food sources (Nishida, 1980). Therefore, as *B. cucurbitae* is recorded as the main pest of Cucurbitae (Dhillon et al., 2005; Siwi et al., 2006; Vargas et al., 2015), Kaurow et al. (2015) found that chili pepper is the host of *B. dorsalis.* Arthur and Wilson (1967) described that a wide area supports the increase of a species population because of the availability of food sources and suitable habitat. According to Soegianto (1994), a community would have a high diversity index if the community is composed of many species with the same or almost similar abundance. On the other hand, if a community is composed of many species, but only few dominant species, thus the diversity is low.

Based on Shanon-Wiener index, the diversity of fruit flies' species in three species of vegetables is categorized as low because on these three vegetables there were only two species found, *B. cucurbitae* and *Bactrocera* sp. Species of fruit flies found in every location in Padang were the same, viz. *B. cucurbitae*, *B. dorsalis* and *Bactrocera* species. Insect species diversity is influenced by the dominance of one species over others in the area (Latip et al., 2015). Deguine et al. (2012) added that if number of species is more abundance but within one family, thus the diversity is lower compare to the condition where the number of species is less but belong to several families. The dominance of *B. dorsalis* on chili pepper is because the insect is the main pest on this host. Hancock et al. (2000) reported that *B. dorsalis* is the main pest on 51 plant families including chili pepper. The difference in dominance on a species is influenced by the different species of plants, and furthermore the chemical content in a plant influences the presence of insects in the plant (War et al., 2012).

Species diversity and dominance influence the

evenness of the species in an area. The highest index of species evenness of fruit flies on vegetables in Padang was found in cucumber plantation (E= 0.058) (Table 3). Based on location, the highest index of evenness was found in Kuranji (E = 0.03). These numbers are categorized as low (Odum, 1996). The low evenness is caused by the very significant different on number of individuals among *B. cucurbitae, B. dorsalis* and *Bactrocera* species. Odum (1996) also added that evenness index close to zero indicates that the distribution of a species in one area is not or less even.

Conclusion

There were three species of fruit flies found in four vegetables in Padang, viz. *B. cucurbitae, B. dorsalis* and *Bactrocera* species. The highest percentage of plants infested was on angled loofah (20.34%). The highest diversity of fruit flies based on commodity was found on bitter gourd (0.010). Based on location, the highest species diversity was found in subdistrict of Lubuk Kilangan (0.240).

Contribution of Authors

Budiyanti S: Conceived idea, conducted experiment, compilation of results and write up of article
Hidrayani: Supervised, helped in experiment and article write up in English
Hamid H: Supervised, compilation of results and article write up

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