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Insect diversity visitors to gadung 21 variety of Mango flower on off Season and on Season

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Abstract

Mango plantations (*Mangifera indica* Linn.) are generally flowering once a year. By technological innovation, the mango inflorescences period can be carried out over the flower season (Off Season). The purpose of this study is to examine the insect diversity of visitors to mango flowers in spring (on-season and off-season). Research was carried out in March-May and July - September 2017. The study was conducted in Rembang District, Pasuruan Regency, East Java with the topography of 60 meters above sea level with an average temperature of 26°C - 32°C and a minimum humidity of 80% - 88%. The insect diversity of visitors to mango flowers is observed by purposive sampling method, and periodic direct observation (scan sampling) is carried out. Data were analyzed with the help of the R statistic application version 3.4.1 and vegan package version 2.4-4. The results of the study were 17 species, 12 families, and 5 orders. The percentage of insects is dominated by 51% order Hymenoptera, 46% Diptera, Lepidoptera, Homoptera, and Hemiptera 1% each. The results of the analysis of the diversity of insect communities of visitors to manga flowers show that overall they are still classified as moderate with index values (1≤ H'≤ 3). Evenness of insects in the moderate category with an index value of E = 0.6, and species richness in the low category with an index value of R = 1.4. Domonation index D = 0.5 and close to value 1, which means that there is a dominant of species. Insect species of visitors to the mango flower Gadung clone 21, are dominated by *Chysomya* sp., *Apis* sp. *Eristalis* sp., *Trigona* sp. and *Crematogaster* spp.

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Introduction

National mango production in Indonesia in 2014 amounted to 2,431,330 tons, and in 2015 amounted to 2,178,826 tons, a decrease of 252,504 tons (10.39%). The decrease in production also occurred at the regional level, namely East Java province with 116,083 tons (12.58%) (Promosiana and Atmojo, 2015).

Generally, mango (*Mangifera indica* L.) plantations in East Java can only harvest fruit once a year with a short harvest period, which is between October and December. This has resulted in the continuous supply of mangoes that have not been able to meet market demand, both in the domestic market and the export market (Yuniastuti, 2012).

The technological engineering of flowering fruit trees economically is very important to get fruit out of season. Technological innovation is a success that has been achieved in stimulating mango trees to flower off-season by using Agrochemical technology (Maloba *et al.*, 2017). Flowering technology innovations outside the season (off-season) provide the successful harvest of mangoes from May to June (Husen *et al.*, 2017).

Gadung 21 mango is the latest superior variety that has been registered based on the Minister of Agriculture Decree No.121 / Kpts / SR.120 / D.2.7 / 12/2016. Gadung 21 mango production can reach 108 -136kg/ tree/year (Ministry of Agriculture, 2016). The reality of the productivity of Gadung 21 mangoes is still very low at 60-65kg/tree in production center area (Diperta Pasuruan Regency, 2013). One indicator of an increase in Gadung 21 mango production is the successful pollination of mango flowers. Mango flowers are monoecious (Mukherjee, 1948), it takes the help of pollinating insects to do cross-pollination (Singh, 1990). 75% pollination of vegetables, fruits, and food is helped by insects (Klein *et al.*, 2007).

Research of Insect diversity in horticultural plants in Asia has been widely reported, among others, the results of research on insect diversity in intercropping of chili and onion plants obtained by 24 different species. 15 species of Pests, 6 species of Predators, and 3 species of insect pollinators (Ellahi *et al.*, 2017).

The results of research on the diversity of grape ecosystems found 2983 individuals, with details of 12 Orders, 44 families, 68 species. Of the total individuals were dominated by 2650 individuals of insect class and 333 Arachnida individuals (Pillai *et al.*, 2017). According to Kumar *et al.* (2016) reported the composition of the ordered diversity of pollinating insects visiting mango flowers in Indian plantation areas as follows, order Hymenoptera, Diptera, Lepidoptera, and Coleoptera. In southern Taiwan, it was reported that pollinators of mango flower visitors were mostly Diptera orders 42 percent (15 species) and ordered Hymenoptera 30.7 percent (14 species) (Sung *et al.*, 2006). Because of the limited information on insect diversity of visitors to mango flowers in Indonesia, therefore further research is needed.

Information on research on visitor insect diversity in horticultural plants, especially mangoes in East Java, Indonesia is still minimal. The latest information obtained from the composition of insect diversity in five fruits (mangoes, oranges, apples, star fruit, and noni) was 90 species of insects from the five Diptera orders, Coleoptera, Heteroptera, Lepidoptera, and Hymenoptera (Ernawati and Kahono, 2010).

The purpose of this study was to study the insect diversity of visitors to mango flowers in two different seasons (Off season and On season). It is expected that some insect species have a role as ecosystem services in mango plant agroecosystems. The results of this study are expected to contribute to the optimization of flowers pollination to increase the production of mango plants.

Materials and methods

Study site

This research was conducted at the farmer's Mango Garden located in Watu Lunyu Village, Oro Oro Ombo Kulon, Rembang District, Pasuruan Regency, East Java. Coordinate of research location 70 38' 44.92" LS; 1120 45'49.51 BT with topography 60 meters above sea level and the total area of Gadung 21 mango Garden is seven Hectares. Gromosol soil type, the average temperature is 26°C - 32°C with a minimum humidity of 80% - 88%. (Drawing plan in Appendix).

Oro oro village Ombo Kulon and Oro oro Ombo Wetan, Rembang Subdistrict, Pasuruan Regency is a special area of Gadung 21 variety of mango plant.

This research was carried out twice, on off-season flowering (off season) of mango plants in March - May 2017 by providing a growth regulator Paklobutrazol in December 2016 and on flowering season (on season) of mango plants in July - September 2017.

Sampling Method

Sampling of mango trees for the observation of insect visitors diversity as many as 20 trees by Purposive sampling. The age of the mango plant used is 12-15 years. Each mango tree is taken 5 flower panicles with a length of ± 40 - 60 centimeters as high as 1.5 meters above the ground.

Observation of flower visitor insects on the mango plant area was carried out by Scan Sampling. Observations are carried out every 15 minutes periodically from 6:30a.m. to 5:00p.m., specifically at 06.30a.m., 07.30a.m., 08.30a.m., 09.30a.m., 10.30a.m., 11.30a.m., 12.30p.m., 13.30p.m., 14.30p.m., 15.30p.m., dan 16.30p.m.

Taking insect species diversity of mango flowers visitors is carried out using insect nets 20cm in diameter, and periodically observed directly. Some samples of insect species of mango flower visitors are then collected with insect net and preserved in 70% ethanol or dry. The preservation of insect species used standard methods (Upton, 1991). Insect identification is carried out up to the level of family, genus or morpho species, based on Borror *et al.*, (1989); Goulet and Huber (1993). Guelph Pollination, Pollinator Identification (www.pollination guelph.ca), Naumann, (1991), The Asian Honey Bee (2007).

Data Analysis

The analysis of the diversity of mango pollinator insects was calculated using analysis of variance (Anova) to determine the diversity and abundance of species in different flowering seasons. Analysis of similarity (Anosim) to find out the comparison of species composition in different flower seasons.

Non-Multidimensional Scaling (MNDS) was used to show differences in species composition based on the Bray-Curtis similarity index. To find out the difference between the time and the day of observation in different flower seasons, population data per species was then converted to the dominance index of Simpson (D), diversity index (H') of Shannon-Wienner, and level of similarity (E) of Pielou and species richness (R) from Margalef (Ludwig & Reynold, 1988). All data were analyzed with the help of the R statistic application version 3.4.1. (R Core Team, 2016) and vegan package version 2.4-4. (Oksanen *et al.*).

Result and discussion

Based on two observations carried out in March-May 2017 (Off Season) and July - September 2017 (On Season), four insect orders 17 species 72620 individuals visiting mango plants was found. The five orders are Hemiptera families: Cicadellidae (990 individuals, 1.4%), Hemiptera family: Alydidae, Pentatomidae (706 individuals, 0.94%), Lepidoptera family: Nymphalidae, Papilionidae, Pieridae, Hesperidae (864 individuals, 1.16%), Diptera family : Calliphoridae, Syrphidae (33366 individuals, 45.9%), and Hymenoptera families: Formicidae, Apidae and Vespidae (36694 individuals, 50.6%) were orders with abundance of dominant individuals (Fig. 1).

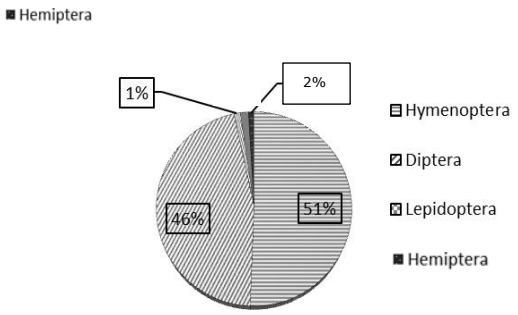

Fig. 1. Percentage of individuals for each insect order mango flower visitors.

Species richness Index (R) is the simplest measure of biodiversity, because it only takes into account differences in the number of species in a habitat. The results of the analysis show that species richness is in the low category and the existence of these types of

insects is evenly distributed or stable in every gadung 21 mango flower season. According to the analysis results, it is found that evenness of insects in each season is stable. From the results of the observations, it is seen that the species richness is almost evenly found in each observation season both off season and on season. The insect diversity index of mango flower visitors in each season is in the moderate category, namely the diversity index at intervals 1 ≤ H '≤ 3. Diversity is a combination of the number of species in a community (species richness) and evenness of each species (Evenness) (Magurran, 2004). Evenness index value (E) is a measure of species scatter patterns in a habitat. Evenness index values vary from 0 to 1. The closer to 1, all species have almost the same level of evenness. If the value approaches 0 it is estimated that a species becomes more dominant (Magurran, 2004). The results of the t-test analysis showed that the E value in the on season was greater than the off season, there was a significant difference (P = 0.02943). The E value in the off season tends to be close to zero, which means in that season there is one type of insect that dominates.

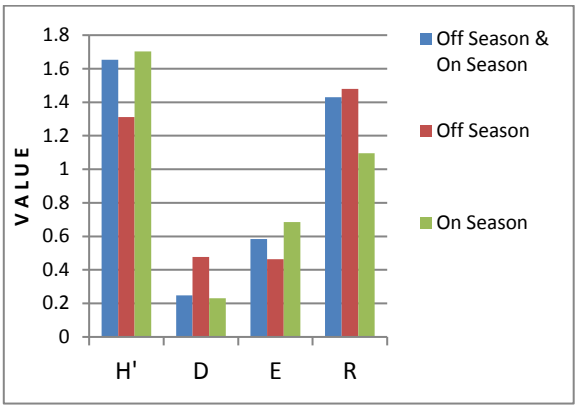

Fig. 2. Comparison of Insect Diversity Index Value. H': Diversity; D': Domination; E': evenness; R': Species richnes.

Table 1. Insect Diversity Index in Mango Flowers in the Off Season and On Season in each Observation Time.

Index	Off Sn & On Sn	Category	Off Season	Category	On Season	Category
H'	1.65377	Moderate	1.312016	Moderate	1.703897	Moderate
D	0.248411	non dominant	0.477297	Dominant	0.230471	non dominant
E	0.583708	Stable	0.463084	Stable	0.685699	Stable
R	1.429465	Low	1.479954	low	1.095026	low

Table 2. T-test results Components of insect diversity.

Index's	Off Season	On Season	P
H'	1,31201	1,70389	0,09686
D	0,47729*	0,23047	0,04429
E	0,46308	0,68569*	0,02943
R	1,47995***	1,09502	3,02 x $^{10-5}$

Table 2 shows the value of the dominance index in the off season looks larger than the season dominance index value on season, there is a significant difference (P = 0.04429). The results of the observation showed that during the off season the insects of the type of Green Flies (*Chrysomya* sp.) were not found in the on season. The dominance index value ranges from 0-1. If the value approaches 0 then no individual dominates, and if the value approaches 1 means there is one type that dominates (Odum, 1998).

Species richness index (R) is determined by two variables, namely the number of species and abundance. The higher the two variables in a habitat, the higher the richness index. The species richness index value does not take into account the proportion of a species to total abundance. The results of the analysis in Table 2 show a very significant difference (P = 3.02 x 10-5). The observation number of insects species found in the off season as a whole amounted to 17 species with an average abundance of 4506. In the on season there were 12 species with an average abundance of 2096 (Table 3). The abundance of individual types of insects decreases to 100%. Margalef conveys a species richness index that is combined with an individual abundance value in each sample unit of the same size placed in the same community. The calculation method is called the Margalef (R) Richness Index (Magurran, 2004).

The results of chart visualization show that at each observation time there are a number of different

species (Table 3 and Fig. 3). The time outside of the observation flower season at 07.30 is the time that has the highest number of the highest species which then decreases until the observation time at 14.30 and increases again at the next observation. Whereas in the flower season at 08:30 is the average number of the highest species, then the same as when outside the flower season the number of species decreased until the time of observation at 14.30 and rose again at the time of the next observation.

Table 3. Diversity of Insect Abundance in Mango Flowers in the Off Season and On Season in each Observation Time.

Time	Ordo		Famili		Species		abundance per observation		Abundance	
	A	B	A	B	A	B	A	B	A	B
6:30	5	4	11	9	16	11	139	69	3339	1660
7:30	5	4	12	9	17	12	233	110	5597	2638
8:30	5	4	12	9	17	12	303	140	7275	3370
9:30	5	4	12	9	16	12	315	134	7547	3220
10:30	5	4	10	8	12	11	325	122	7801	2920
11:30	5	3	8	7	9	10	232	100	5559	2387
12:30	3	3	5	7	5	9	150	77	3592	1855
13:30	3	3	5	7	5	9	75	38	1788	918
14:30	3	3	5	6	6	6	47	10	1126	232
15:30	3	3	6	7	7	9	95	76	2280	1824
16:30	3	3	6	7	9	9	153	84	3666	2026
Average	4	4	8	8	11	10	188	93	4506	2096

Description: A: Off season B: On season.

Insect activity generally follows the rhythm of the biological clock that allows when the insects do an activity or rest. The research results conducted by Danks (2003), that various life activities of insects have a temporal (temporary) response, Ecological complexity in all ecosystem components requires daily and seasonal time intervals. The results of the study show that the time of behavior activities sought and visited flowers from several orders of Hymenoptera, Lepidoptera and Diptera insects carried out in the morning. The activity of collecting pollen and sucking on nectar is carried out around 08.00-10.00 in the morning (Upadhyay, 2014). Insect visits will decrease at 12.00-14.00, but part of the order of Hymenoptera insects, Diptera conducts activities again to visit flowers at 15.00 - 17.00 in the afternoon and specifically from the Stratiomyidae family the highest abundance at 17.00 (Willmer, 1983).

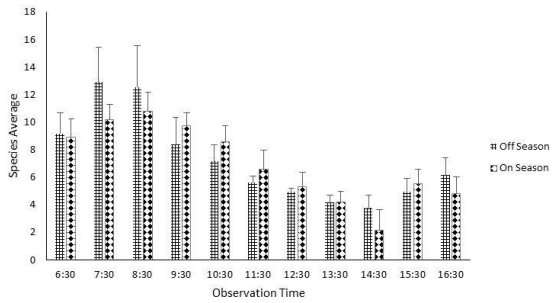

Fig. 3. Average Insect Species Diversity at Time of observation in different flower seasons.

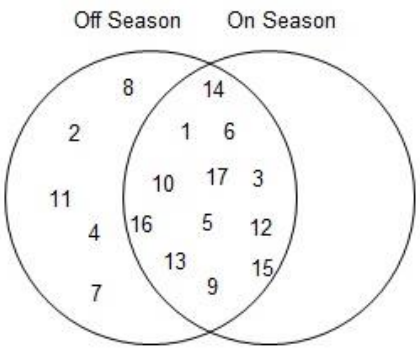

Fig. 4. Comparison of Complementary Composition of Insect Species Visitors to Mango Flowers in two different seasons.

The results of Bray Curtis's analysis revealed that the diversity of insect species in mango plants carried out in two seasons, Off Season and On Season, showed that the similarity of species on Off Season and On Season was above 63%. The number of insect species found in the Off Season and On Season has a different composition. The Off Season found 17 species of insects and On Season found 12 species (Table 4 & Figure 4). The similarity of the number of insect species that can be found on Off Season and On Season is 12 species. The 12 species of insect visitors to the mango flower function are Pollinators, Predators and Pests.

There are 5 species of insects in the Off Season which are not found in the On Season. The values in the Bray-Curtis index formula in two habitats tend to be identical if the index value is close to 1, which means that more and more of the same species are found in both fields with relatively the same population abundance (Magurran, 2004).

Table 4. Diversity of Insect Species in Off Season and On Season.

No	Species	Season		Total
		Off Season	On Season	
1	Alydidae sp.1	56	304	360
2	Alydidae sp.2	38	0	38
3	*Apis* sp.	5990	7199	13189
4	*Chrysomya* sp.	27744	0	27744
5	*Eristalis* sp.	2332	3290	5622
6	Formicidae	10632	6932	17564
7	*Graphium* sp.	20	0	20
8	Hesperiidae sp.	57	0	57
9	*Hypolimnas* sp.	139	223	362
10	*Idiocerus* sp.	154	836	990
11	*Melanitis* sp.	36	0	36
12	*Pentatomidae* sp.	44	264	308
13	Pieridae sp.	324	65	389
14	*Polistes* sp.1	121	201	322
15	*Polistes* sp.2	126	195	321
16	*Trigona* sp.	1675	3268	4943
17	*Xylocopa* sp.	82	273	355
		17	12	72620

Table 5. Bray-Curtis Similarity Index in different flower seasons.

	Off Season	On Season
Off Season	1	
On Season	0,635	1

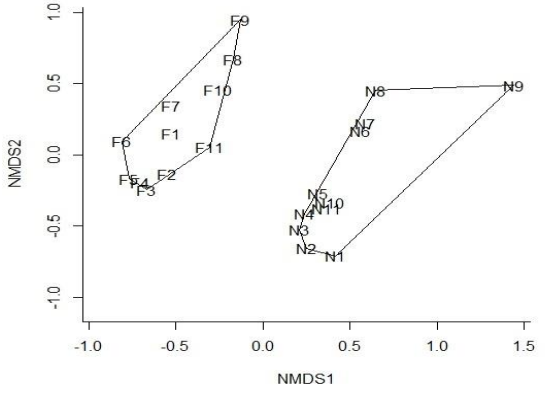

Fig. 5. Non-Multidimensional Scaling from Insect Abundance of Mango Flower Visitors in Off Season (F) and On Season (N) (R = 0.6652; P = 0.001).

The composition of insect species based on their abundance in different flowering seasons is indicated by a dot on the NMDS scheme that describes the time in each season. Based on each time of observation of insects, the highest similarity is found at points F4 and F5, which are at 09.30 and 10.30 outside the flower season. While the lowest insect similarity is found at points F9 and N9, which is at 14.30 in the spring and outside the flower season. The visualization of the Bray Curtis index with NMDS shows that there are similarities between the highest and lowest insect species between the two seasons resulting in an analysis of similarities which can be stated that the similarities of 2 seasons at the time of observation based on insect abundance were significantly different (R = 0.6652; P = 0.001).

Conclusion

Insects of gadung 21 mango flower consist of 17 species, 12 families, and 4 orders. The percentage of insects is dominated by 51% order Hymenoptera, 46% Diptera, Lepidoptera and Hemiptera 2%. Insect Diversity Index (H') in the Off Season and On Season is in the moderate category. The dominance (D) of insect types occurs in the Off Season, and the evenness index value (E) approaches the value of 1 in the On season. The off season type Richness (R) index is higher than On season. The insect species of visitors to Gadung 21 mango are dominated by *Chysomya* sp., *Apis* sp. *Eristalis* sp., *Trigona* sp., and *Crematogaster* spp.

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