



Research Article

Insect visitors of rambutan (*Nephelium lappaceum*), Black plum (*Syzygium cumini*) and cashew (*Anacardium occidentale*)

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ABSTRACT

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The honeybees are labelled as the champion pollinators. Through their pollination services, the quality of seed set, forage crops, and fruit yield improves. Field experiments were conducted to determine the effect of introduced honeybees (*Apis mellifera* L.) in the number and weight of harvested fruits of the three (3) tropical fruit-bearing trees (rambutan, black plum, cashew). Three (3) fully grown rambutan, black plum, and cashew trees approximately 10 years old were selected. The t-Test was employed using 20 samples per treatment (open pollinated flowers, T1 in three (3) replications wherein twenty (20) panicle samples were selected) to gather the needed data. During the onset of blooming, one (1) standard bee colonies major pollinator aside from the other insects in the area was placed within the vicinity of the plantation crops. Results of the study on the pollination of insect visitors on the experimental fruit trees showed significant differences between the open pollinated flowers (T1) and enclosed treatments (T2). In terms of harvested, percentage and weight of developed fruits of rambutan, black plum and cashew, results revealed that trees introduced with honeybee as pollinators significantly produced more fruits and heavier developed fruits than those in enclosed flowers (T2).

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Introduction

The honeybees are labeled as the champion pollinators. More than 75% of the world's food crops depend, to some extent, on bee pollination which does not only result in a higher number of fruits, berries or seeds, it also gives a better quality of produce with less malformations resulting in higher commercial value (USDA, n.d.; UN-FAO, 2018; Klatt, et.al., 2014). Some reasons to "BEE grateful for our pollinators" are as follows: (1) they improve our diets by providing micronutrient-rich-foods; (2) they give us honey; (3) they have a great work ethic visiting four million flowers to produce a kilogram of honey; (4) they make our foods taste better; (5) they increase food production and food security; and (6) they maintain biodiversity (UN-FAO, 2018). Bees are known for their key roles in ecological balance as well as in natural and agricultural ecosystems. According to (UN-FAO, 2016), "pollinators are economically, socially and culturally important to world food production and nutritional security." Moreover, through honeybee pollination, quality of seed set, forage, crops, and fruit yield also improves.

In another study conducted by Bareke and Addi (2019), they mentioned that pollination is a critical link in the functioning ecosystem as it improves yield of crops. Of the approximately 300 commercial crops, about 84% are insect-pollinated and honeybees are responsible for 70-80%. McGregor (2009) recognized Baker and Hurd's (1968) claim on the important ecological relationship for they stated that "insect pollination is still extremely important among the fortes of the grassland, in the shrub and herb layer of the temperate forest and in the desert. It remains undiminished in the tropics." *Apis mellifera* L. bees are highly generalist and able to interact with hundreds of native plant species (Aslan, et.al., 2016). The United States Department of Agriculture (USDA) released the work of Martin, Campbell, and Ruberte (1987) titled "Perennial Edible Fruits of the Tropics: An Inventory." The fruit trees in this study were described as follows:

Rambutan (*Nephelium lappaceum* L.) originated in Southeast Asia, native in Malaysia, and was introduced into tropics but rare outside Asia. It belongs to the family Sapindaceae and it grows well in hot, wet tropical lowlands and is not frost-tolerant. It is propagated by seed, layering, or grafting and fruit ovoid about 5-6 centimeters long becomes fruits in 10-12 clusters with a greenish, yellowish, or reddish external color, and a translucent, whitish internal color. The flower clusters consist of terminal or axillary panicles. Normally, only one carpel of its fruit develops from but sometimes, bicarpellate are also seen. Its fruit is 3-8 centimeters long and is ovate or ellipsoidal with a short, thick pedicel about 2-4 centimeters wide. Usually, there is one to a fruit rambutan seed which is 2-3 centimeters long. This fruit is sweet and is typically grown in hot tropics with good commercial value. Rambutan is dependent upon insects for pollination. Its aromatic flowers are highly attractive to many insects, especially bees. Those commonly found visiting rambutan flowers include bees, butterflies, and flies. Placing honeybee colonies in rambutan plantations is an important and practical recommendation for assuring adequate pollination and fruiting (Tropical Fruit Global Information System, nd).

Black Plum (*Syzygium cumini* S.) originated in Southeast Asia particularly the Philippines and with pantropic distribution. It thrives well in areas under adverse conditions and tropical lowland or hot subtropical climates which sometimes, becomes a weed. The tree grows up to 16 meters high which can be propagated by seeds, grafting, and layering. If from seeds, the tree bears fruit within five (5) to six (6) years. Blooming season varies per geographical location and fruit matures in 90 days. Fruit ellipsoid is 1.5 to 2.5 centimeters in diameter with five (5) to 20 per cluster. Purple is the color of the fruit's external color while its inside is lavender.

This sweet fruit despite its astringent and low appeal is usually eaten fresh but it can also be made as jellies or wine.

Cashew (*Anacardium occidentale* L.) is native to South America and it best thrives in hot tropical areas with elevation below 1,000 meters. It can be propagated by seed, layering, or cutting. It flowers from February to March and fruit matures in 60-90 days. Cashew has one 2.5 to 3 centimeters-long seed (cashew nut) that hangs below the peduncle or the cashew's apple which comes either in clusters or solitary. Cashews are highly commercialized because of their quality and nutrition-rich nuts. The fruit's outside color is red or yellow while its inside is pale-yellow. Freitas and Paxton (2009) shared the result of their study citing that insects appear to be the major pollinators of cashew and based from their direct observations of insects visiting the flowers and counts of pollen grains adhering to such insects suggests that the honeybee (*Apis mellifera* L.) although a non-native insect, is the major pollinator of commercially grown cashew in Brazil. The Philippine Statistics Authority (2018) reported that in 2016, the volume of rambutan and cashew production in the country was 7,668 metric tons and 216,298 metric tons, respectively. In the Ilocos Region alone, 101 metric tons of rambutan was produced out of the 2,994 number of bearing trees planted. Meanwhile, 464 metric tons of cashew was produced in the same region out of the 65,417 bearing trees. Although pummelo and black plum were not included in the PSA list, it is known that our country produces and exports pummelo because of good quality and high demand. On the other hand, black plum which is not as popular as the other fruits, is still always being sold out in local markets when supply is available.

The conduct of this study is important to determine the effect of introduced honeybees (*Apis mellifera* L.) in the number and weight of harvested fruits of the four tropical fruit-bearing trees (rambutan, black plum, and cashew) through their pollination services. Considering that the trees are easily grown in the Philippines, have good market potentials, and excellent nutritional value for human benefit, essential information derived from its results will profit the tree growers and farmers while contributing to improved management practices of forest trees and farming systems; hence, protecting the best pollinators and ensuring food security and biodiversity.

Materials and Methods

Description of study site

The existing matured fruit trees (rambutan, hybrid black plum, and cashew) approximately ten (10) years old planted at the NARTDI bee pasture area within the DMMMSU-NLUC Compound, served as experimental trees. The researchers randomly assigned fruit trees (3 plants per species). The following were the areas of the experimental trees: (rambutan) 121.8 square meters; (black plum) 180 square meters; and (cashew) 171 square meters. While waiting for the fruit trees to bear flowers, proper cultural and management practices were applied in the study sites through irrigation and under brushing. The location of the fruit trees was adjacent to each other; hence, only one (1) standard or 10-framer strong honeybee colony from the NARTDI demonstration apiary was placed in the study site, and served as major pollinators. Two hundred forty (240) bamboo enclosures with nets (mesh cloth) were assembled for all the experimental fruit trees (3 per species) subjected in this study. Data were gathered from the pair of 20 open pollinated flower (OFP) panicles and 20 enclosed flower (EF) panicles from each experimental tree.

Experimental design and treatments

From the selected experimental fruit trees, three (3) fully grown and fruit-bearing trees were identified. The t-Test was employed using 20 samples per treatment with three (3) replications. Treatment 1 (T1) was the open pollinated flowers (OPF) and treatment 2 (T2) was the enclosed flower (EF) with net.

Statistical analysis

To determine the significant difference, treatment means were subjected to t-Test.

Results and Discussion

Yield parameters of rambutan (*Nephelium lappaceum* L.)

Significant effect of honeybee pollination was obtained on the harvested fruits and weight of fruits of rambutan as presented on table 1. Open pollinated flowers (T1) significantly more harvested fruits with a mean of (5.80) than the enclosed flowers with net T2 with 0.88 fruits. With respect to the weight of fruits of rambutan pollinated with honeybee the open pollinated flowers obtained the highest weight of fruits (0.18kg) than the enclosed flowers with net (0.02kg). As regards to the number of flowers, Number of develop fruits and percentage of develop fruits per panicle did not differ significantly in those open pollinated flowers and enclosed flowers.

Table 1. Yield parameters of rambutan (*Nephelium lappaceum* L.) pollinated by honeybees (*Apis mellifera* L.)

Treatment	Mean				
	No. of Flowers/ Panicle	No. of Developed Fruits/Panicle	% Developed Fruits/Panicle	Harvested Fruits*	Weight of Fruits (kg)
T1 (OPF)	330.20	19.80	6.15	5.80 a	0.18 a
T2 (EF)	286.77	8.62	3.06	0.88 b	0.02 b
Significance	ns	ns	ns	*	*
tStat	1.34	2.61	1.82	4.12	4.01

Yield parameters of black plum (*Syzygium cumini* S.)

As reflected in table 2, a significant difference was noted on the number of percent develop fruit per panicle, harvested fruits per panicle, and weight of fruits per panicle.

Table 2. Yield parameters of black plum (*Syzygium cumini* S.) pollinated by honeybees (*Apis mellifera* L.)

	Mean				
	No. of Flowers/ Panicle	No. of Developed Fruits/Panicle	% Developed Fruits/Panicle	Harvested Fruits*	Weight of Fruits (kg)
T1 (OPF)	223.85	105.33	46.77a	7.95a	0.083a
T2 (EF)	260.12	86.25	34.68b	2.10b	0.023b
Significance	ns	ns	*	*	*
c.v. (%)	1243.95	134.65	17.37	2.71	0.01

No significant difference was noted on the developed fruit per panicle with a mean of 105.33(open-pollinated) and 86.25 (closed-pollinated), and number of flowers per panicle with means ranged from 223.85 to 260.12 flowers per panicle, respectively. On the number of developed fruits per panicle, open-pollinated flowers (T1) significantly produced more developed fruits (4,677) than the flowers enclosed with net (T2) with only 34.68 fruits. Result revealed that open-pollinated flowers (T1) had significantly higher percentage of developed fruits (46.77%) than the enclosed flowers with net(T2) with only 34.66%.

Yield parameters of cashew (*Anacardium occidentale* L.)

Table 3 shows a significant difference on the number of flowers per panicle, number of developed fruits per panicle, percent developed fruits per panicle, number of harvested fruits, and weight of fruits of cashew in open-pollinated (T1). On the number of flowers per panicle, the T1significantly produced more flowers. With respect to number of developed fruits per panicle, similarly, T1 significantly produced more developed fruits with a mean of 2.65 fruits than those in the enclosed treatment (T2).

Table 3. Yield parameters of cashew (*Anacardium occidentale* L.) pollinated with honeybees (*Apis mellifera* L.)

Treatment	Mean				
	No. of Flowers/ Panicle	No. of Developed Fruits/Panicle	% Developed Fruits/Panicle	Harvested Fruits*	Weight of Fruits (kg)
T1 (OPF)	17.86a	2.65a	15.39a	2.65a	0.16a
T2 (EF)	11.83b	0.75b	6.80b	0.75b	0.04b
Significance	*	*	*	*	*
c.v. (%)	2.64	0.08	2.89	0.08	0.00

Table 4. List of other insect pollinators/visitors of black plum and cashew

No.	Name of Insects	Family
1	<i>Apis mellifera</i>	Apidae
2	<i>Apis cerana</i>	Apidae
3	Stingless bees	Apidae
4	<i>Apis dorsata</i>	Apidae
5	Butterfly	Papilionidae
6	Bumble bee	Apidae
7	Wasps	Vespidae
8	Ants	Formicidae
9	Bugs	Lygaeidae
10	Hornets	Vespidae

Our study was small-scale (3 fruit-bearing trees). Nevertheless, we found positive influence of honeybees (*Apis mellifera* L.) in the weight and quantity of developed and harvested fruits of rambutan, black plum, and cashew. Globally, *Apis mellifera* L. is regarded as a universal, adaptable, and commonly used managed pollinator and has become the standard management for a small number of crops, to improve practice as well as increase and stabilize yield (Rader, et.al., 2016; Cunningham and Le Fuevre, 2013). We have also observed that aside from honeybees as major pollinator, there were other generalist flower visitors (other species of bees, butterfly, wasps, etc.) that visited the experimental trees. Awareness of insects' pollination benefits is critical to food security, and the interdependence of farmers, consumers, and pollinators is similarly essential (Hall and Martins, 2020). Although we have not measured the nutrient availability of the harvested rambutan, black plum, and cashew fruits, during the conduct of our experiment, we did not introduce fertilizer or any soil organic matter which could have affected plant growth and productivity (Chen, et.al. 2020) yet, number of developed fruit panicles (black plum) as well as the weight of developed and harvested fruits have significant differences in open-pollinated black plum and cashew trees than those in excluded flowers. Most observations were conducted during the trees' blooming seasons (rambutan-May, 2020; black plum- march, 2020; and cashew-February, 2020).

Conclusion

Based on the results of the study, pollination of the insect visitors on the experimental fruit trees revealed significant differences between open-pollinated flowers (T1) and enclosed flowers (T2) in rambutan number of harvested and weight of fruits, black plum in terms of number and percentage of developed fruits per panicle as well as in number of harvested and weight of developed fruits. On the other hand, it has been noted that there are significant differences in all the yield parameters of cashew. It is therefore concluded that for rambutan, there is a significant difference of T1 and T2 in the number and weight of fruits and black Plum, in the percentage of developed fruits, and number of harvested and weight of developed fruits, respectively. For cashew, T1 has a significant difference from T2 in all parameters. Based on the present study's significant breakthroughs, the following are the recommendations: (1) Introduction of honeybees (*Apis mellifera* L.) as additional pollinator of black plum and cashew is highly recommended to obtain higher number/percentage of heavier developed fruits. (2) Open-pollination by honeybees (*Apis mellifera* L.) of rambutan, black plum, and cashew's flowers is recommended to obtain higher fruit yield and efficient pollination.

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