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Comparing Honey bees and Stingless bee's pollination in greenhouse sweet melons

Ong'ute HW[1*], ED Kokwaro[2], M Kasina[3]
[1, 2] Kenyatta University, Department of Zoological Sciences, GPO, Nairobi, Kenya
[3] National Sericulture Research Center-KALRO, Thika, Kenya

Abstract
Sweet melon, *Cucumis melo* is a succulent, delicious and extra-sweet fruit that is grown in the warm areas. The fruit is of economic value and it is also a source of Vitamin C and A and antioxidants. Using a completely randomized design a study was conducted at KALRO Kabete, Kenya in three greenhouses where sweet melon plants were planted in plastic pots. Upon flowering colonies of honey bee, *Apis mellifera* and stingless bee, *Meliponula ferruginea* were placed in the first and second greenhouses for pollination. The third greenhouse was used a control. Observations on flower visits were made and time of visits on male and female flowers were recorded. Fruits were harvested on maturity and weight of fruits and number of developed and undeveloped seeds was counted. Collected data of number of visits, weight of fruits and developed seeds were subjected to ANOVA and the means were compared. Pollination by honey bees produced heavier fruits than pollination by stingless bees. Results also showed a significant difference in number of developed seeds between honey bee pollination and stingless bees pollination ($P<0.001$). Honey bees are therefore a more effective option in pollination of greenhouse sweet melons.

Keywords: honey bees, pollination, sweet melons

1. Introduction
Sweet melon (*Cucumis melo*) is an economic crop that belongs to the Cucurbitaceae family. The crop is grown in Kenya in the warm counties in Kenya such as Makueni, Machakos, Voi and Garissa as noted by Horticultural Crops Development Authority (2007) [2]. Globally, the crop is grown commercially in Turkey, China, Brazil and the United States. Cultivation of sweet melons provides a source of income, creates jobs and promotes collaboration between farmers, hence it is of great socio-economic importance. Sweetness, aroma, and health benefits make sweet melons a valuable fruit among consumers. The fruit is a good source of Vitamin C and Vitamin B complex, which are good for immunity. Like other crops, sweet melons depend on pollination for fruit set and seed production [9, 10, 11]. Without pollination, seed development in some crops fail and there is a risk of total yield loss [8]. Honey bees and stingless bees are both known pollinators of many crops as observed by Martins (2014) [3]. Despite the contribution of these bees in food production little is known about their effectiveness in pollinating sweet melons under greenhouse conditions. The aim of this study was to compare the pollination by honey bees and stingless bees on greenhouse sweet melons. The best pollinators of greenhouse sweet melons needs to be determined in order to develop ways of managing them and maximize on their services during crop production. Farmers interested in cultivating sweet melons can benefit from the new knowledge on the production of sweet melons under greenhouse conditions.

2. Materials and Methods
The study was conducted at KALRO Kabete, Kenya. Three greenhouses made of glass and cemented floors were used as enclosures for the experiment. Sweet melon establishment for greenhouse trials was done using certified Galia variety seeds. Plastic pots of 1foot were filled with sterilized soil obtained from Kenya Plant Health Inspectorate Service (KEPHIS). Seeds were sown 2cm deep in holes with a mixture of soil and one teaspoonful of NPK fertilizer. Watering was done regularly using watering cans. Thinning was done after establishment of sweet melon plants in the three greenhouses. Three greenhouses with three treatments of honey bees (*Apis mellifera*), stingless bees (*Meliponula ferruginea*), and a control with no bees were used for the greenhouse experiments. The bee colonies were introduced in the two greenhouses before anthesis of female flowers. Bee activity in the greenhouses was observed throughout the day during the flowering period. A stop watch was used to monitor the duration of visits on the sweet melon flowers in both greenhouses. On maturity the fruits from the greenhouses were harvested for yield data collection and analysis. Data on weight of fruits and the number of developed seeds was collected in the October to December season and March to May seasons. The developed seeds were further subjected to a germination test and the rate of germination was compared between seeds produced from honey pollination and those from stingless bees pollination. The data was analyzed using ANOVA for variance by comparing the means of the yields from the three greenhouses.

3. Results
Foraging behavior in greenhouses
Honey bees were observed making visits to the sweet melon flowers. The Honey bees spend time on the flowers foraging and they were observed leaving the flowers with pollon on their legs. The stingless bees did not show activity on the sweet melon flowers during the period of observation.

Fruiting percentage in three greenhouses
For pollination with *Apis mellifera* fruiting percentage was 80% and 70% for season 1 and season 2 respectively, while for pollination with *Meliponula ferruginea*, the fruiting percentage was lower with 20% and 30% recorded in season 1 and season 2 respectively as shown in table1.

Table 1: Fruiting percentage obtained from greenhouses

	Season 1		Season 2	
Treatments	**Total no. of fruits**	**% Fruiting**	**Total no. of fruits**	**% Fruiting**
Apis mellifera	16	80%	14	70%
Meliponula ferruginea	4	20%	6	30%
Control	0	0	0	0
p value	<.001		<.001	

Mean number of developed seeds

A significant difference was observed between pollination by honey bees and pollination by stingless bees on greenhouse sweet melons (P<0.001). Pollination through honey bees produced the highest average number of developed seeds as compared to pollination by stingless bees. The foraging behavior of honey bees on sweet melon flowers contributed to more pollination than the stingless bees that were hardly noticed on the sweet melon flowers as shown in figure 1.

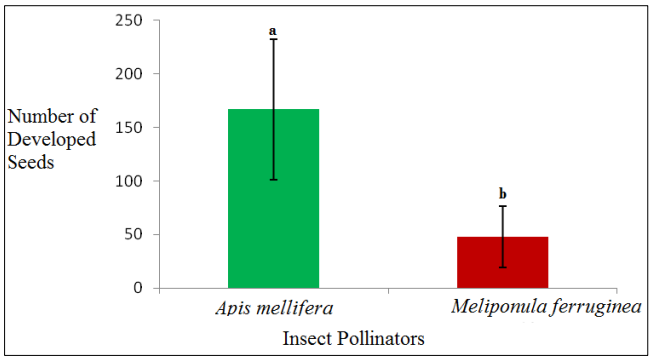

Fig 1: The mean number of developed seeds from greenhouses

4. Discussion

Honey bees were observed foraging on the sweet melon flowers and left the flowers with pollen on their tibia. Observation of this behavior confirms results of previous studies by Abou-Shaara (2014) in which honey bees have been observed visiting sweet melon flowers [1, 5, 7]. Their attraction to sweet melon flowers was because of the pollen reward that they gained as observed from their tibia. Stingless bees were rarely observed making visits to the sweet melon flowers. Their lack of activity on the sweet melon flowers was because they were not attracted to the sweet melon flowers. The stingless bees are also found in small colonies as compared to the big colonies of honey bees.

Fruiting percentage was high in the greenhouse with honey bees than in the greenhouse with stingless bees. This result came about because of the activity of the bees foraging pollen from the male flowers and transferring them to the female flowers. There was more successful pollination of female flowers in the process as compared to the flowers that were in the greenhouse with stingless bees. Some flowers in the greenhouse with stingless bees were aborting because of lack of pollination services. This result happened because there was no effective agent to transfer pollen from the male flowers to the female flowers. This results were in agreement with previous results of Ribeiro *et al.* (2015) [6]. In their study on yellow melon in Brazil their findings suggested that the presence of insect visitors increase the chances of pollination. Pollination by honey bees produced a significantly higher mean number of developed seeds as compared to pollination by stingless bees. This result is similar to previous findings by Munawar *et al*., (2009) [4] who mentioned that honey bee pollination of black seed has an effect on the number of seeds. The rapid movement of honey bees on flowers of many plants aids in the transfer of pollen to the stigmas and leads to successful development of fruits and seeds.

5. Conclusions

Honey bees play an important role in the pollination of sweet melons grown under greenhouse conditions. In the absence of pollination services during sweet melon production, there is a risk of total yield loss.

Honey bees are more effective pollinators of sweet melons as compared to the stingless bees. If managed properly and transferred in greenhouses during flowering, honey bees make a significant contribution in greenhouse farming.

6. Acknowledgment

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