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Pollinator Diversity and Floral Calendar of Forage Resources for Pumpkin, Machakos County, Kenya

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ABSTRACT

The abundance and diversity of bees correlate with the abundance and diversity of forage resources. Pollinator reservoirs in croplands can augment pollination of flowering crops by increasing pollinator diversity and abundance. Therefore, this study provides empirical evidence on the diversity and abundance of alternative forage resources in two landscape classes with pumpkin fields. The study was undertaken in 32 pumpkin farms; 16 for each natural difference vegetation index (NDVI classes). Flowering plants were identified and counted within and around farms at 2 m × 2 m quadrat and 4 m × 50 m belt transect from the middle of the farm towards the exit. Approximately 142 plant species were recorded and their abundance varied between NDVI classes and across months. In the 2 m × 2 m quadrat 6,765 plants were observed in May in low NDVI and 4,399 in medium NDVI were recorded in May. Abundance, diversity and annual floral resource structure for honeybees in low and medium Normalized difference vegetation index (NDVI) classes in Machakos County were determined: The 4 m × 50 m belt transect had the highest numbers of plants (1,434-20,825) and plant species across the months and between NDVI classes. At least 35% of plants remained actively flowering during the sampling period, therefore, can serve as alternative forage sources for pollinators. Our inventory of plants can be used to develop a floral calendar for adoption by farmers for on-farm management of pollinators. The floral calendars will be predictive tools used to detect a correlation between flowering plants, seasons and pollinators.

Keywords: Pollinators, Normalized difference vegetation index, biodiversity, floral calendar.

INTRODUCTION

Globally, insect pollinators are undergoing unprecedented declines which have been aggravated by habitat loss due to the destruction of habitats through intensification in land use, land fragmentation, urbanization, and deforestation in addition to climate changes and the introduction of an invasive plant (Prakash and Verma, 2022; Dicks *et al.*, 2011; Wilson and Fox, 2021). Habitat fragmentation and isolation due to land use may reduce bee species' richness and abundance and change their foraging behavior (Pardee *et al.,* 2023). Therefore, there is a need of deliberate effort to protect pollinators through understanding their floral resources and conserving them (Potts et al., 2003). Several reports have indicated that floral abundance and bee abundance, as well as floral diversity and bee diversity, have positive relationships (Kratschmer *et al.*, 2018; Theodorou *et al.*, 2020). Bees (both managed and feral) comprise the majority of insect pollinators of wild and cultivated flowering plants in many ecosystems (Osterman *et al.*, 2021).

Cucurbitaceae (Pumpkin family) are crops with high pollination dependency (Klein *et al.*, 2007). In the context of Africa, there has been an increase in pumpkin production which can be used to feed the growing population in a sustainable manner. For instance, the production of pumpkins in Kenya has increased from 888 hectares with a revenue of USD 410 thousand in 2009 to 1,342 hectares in 2013 with a revenue of USD 7400 thousand (Ndegwa, 2016). For successful pumpkin production, the presence of sufficient honey bees in its flowers is important (Hanif et al., 2022; Njoroge, 2005). However, these bees require alternative forage resources when pumpkins are not flowering, to sustain their population. Previous studies indicate that the presence of diverse flowering plants across seasons improves the conditions for bees hence increasing their abundance and diversity (Martins, 2015). According to Gikungu *et al*. (2011) in Kakamega forest, the overall bee abundance was high in fallow farmland. Apart from a high richness of floral resources, fallow farmland was constantly very heterogeneous, consisting of woody and herbaceous plants offering nesting and feeding requirements for a large diversity of bee species. It is important to have a diversity of wild flowering plants close to bee nesting sites for pollination efficiency. Previous work in Kenya indicated that availability of floral resources promotes year-round bee presence in the farmlands hence increased pollination (Guantai *et al*., 2019).

There are several factors that are likely to cause a decline of natural habitats that subsequently affect the availability floral of resources and consequently flower visiting insects hence their decline. Evidently, pumpkin production in Kenya remains low due to, amongst other factors, insufficient pollination caused by a decline in the abundance and diversity of bee species available for pollination as well as floral resources for bees (Guantai *et al*., 2019). Unfortunately, there is a paucity of information in Yatta and Masinga Sub-Counties of Machakos County on the source of floral resources for pumpkin pollinators when the pumpkin plants are not in bloom or when they close their flowers in the afternoon periods. It is also not clear whether they can provide floral resources for the bees throughout the year.

The study of floral resources (pollen) in the pumpkin production area is an essential component of managing pumpkin productivity. Therefore, this study's aim was to investigate abundance, diversity, and availability of alternative floral resources for pumpkin pollinators and their documented phenology. Data obtained from this research will be used to determine alternative floral resources for pumpkin pollinators throughout the year. Documentation of flowering plants that offer floral resources for honeybees in and around farms will provide insights into their management and conservation preventing their declines. This will contribute to the improvement of the yield of pumpkins.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Machakos County which lies between latitudes 0º45' to 1º31' S and longitudes 36°45' to 37°45' E. The county covers 6,208 km^2 with a population of 1,098,584 (KNBS, 2014). The area is semi-arid with hilly terrain divided into low and medium Normalized Difference Vegetation Index (NDVI) classes and has an altitude of 1,000 m to 2,100 m above sea level. Machakos has eight sub-counties but the ecological research study was carried out in Yatta and Masinga Sub-Counties which are the major pumpkin-growing regions in the County. They have arid and semi-arid lands (ASAL) characteristics that are suitable for pumpkin farming. Yatta Sub-County lies between 700-800 m above sea level and latitude 0°03′ and 1°12′ South and longitude of 37°47′ and 38°57′ East (Jaetzold and Schmidt, 2006); with a total land area of 1,059 km^2. Masinga Sub-County is located at 1,183 m above sea level and latitude 0.9757° South and a longitude of 37.6037° East with a total area of 1,402.8 km^2 (GOK, 2008) (Figure 1). Most farmers in the two Sub-Counties are smallholder farmers that practice mixed farming (crops and livestock) with low investment for agricultural production. The most common crops planted by farmers include; pumpkin, maize, beans, and cowpeas intercrop (Liavoga *et al*., 2014). However, natural plant biodiversity over time has faced increasing climate change, threats from human over-exploitation, and the destruction of plant resources at an alarming rate thus call for proper research, documentation, and management of these natural resources (Nzizi, 2016). Ethical considerations were maintained during the study including voluntary participation, informed consent, anonymity, confidentiality, and farmers being debriefed at the end of the study. These considerations were taken into account in order to prevent as much harm as possible to the farmers (Follan and Minis,2010).

Landscape Classification and NDVI Computation

Normalized Difference Vegetation Index (NDVI) was used to quantify vegetation by determining the density of green on a patch of land (Fig.1). NDVI in essence is the vegetation cover of natural forest and perennial crops such as tea, coffee, and avocado that are not much affected by seasons (Guerschman *et al*., 2003). Only a few sites on land are covered with grasslands, shrublands, and annual crops maize and beans which constantly change depending on the season and farmers' decisions (Adan *et al*., 2021). Rainfall data from the Climate Hazard Group Infrared Precipitation with Station (CHIRPS, University of California, Santa Barbara, USA) was used at a 5 × 5 km spatial resolution to determine the exact dry and wet seasons in 2019 for the study area. Sentinel-2 (S2) satellite images were then utilized to compute the NDVI in the cloud-based Google Earth Engine platform (GEE, Alphabet, Mountain View, USA) according to Gorelick *et al.* (2017). One hundred and ninety-five S2 images were acquired for both the wet (February to May, 99 images) and dry (June to August, 96 images) seasons. We created a composite image for each season using the multi-date S2 median reflectance pixel values at 10 m spatial resolution. A detailed description of the S2 image processing steps is found in Adan *et al.* (2021). Using Equation (1), we calculated the NDVI for both dry and wet composite images based on red and near-infrared bands: (Equation 1)

$$NDVI = \frac{(NIR-red)}{(NIR+red)}$$

where NIR and red are reflectance values at near-infrared and red bands 8 and 4 of S2, respectively. The wet and dry season NDVI values were reclassified into three vegetation classes (low, medium and high) using the unsupervised K-means clustering method (Adan *et al.* 2021). The ranges of NDVI values for each class for the dry season were -0.320- 0.077 (low), 0.077 - 0.133 (medium), and 0.133 - 0.619 (high), while the NDVI ranges for the wet season were -0.373 -0.158 (low), 0.158–0.249 (medium) and 0.249–0.730 (high). Subsequently, a multi-season composite classified map was created by combining the outputs of the wet and dry season classifications based on the cluster values for both seasons (Adan *et al.* 2021). Machakos County is located in one of the dry areas of Kenya and it mainly has medium and low NDVI. Vegetation such as shrubs and grasslands displays moderate NDVI, while high NDVI indicates dense vegetation cover (Boitt and Odima, 2017).

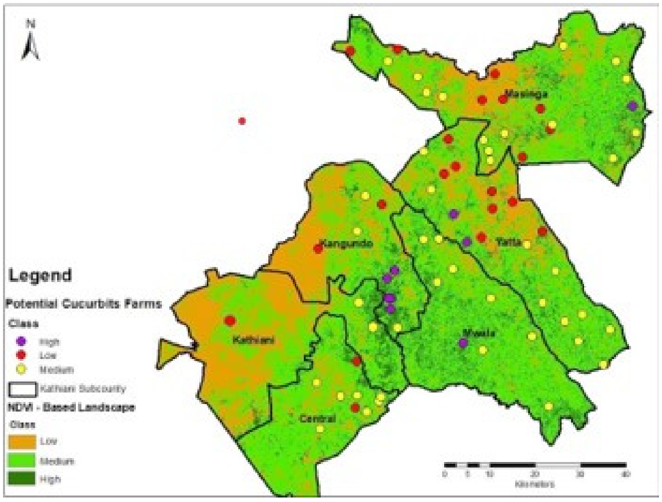

Figure 1. Distribution of pumpkin farms in Machakos County. Landscape cover classes were produced by the authors using Planet Scope satellite imageries.

Data collection

Purposive sampling technique was used to target farmers and snow balling technique was used to identify the specific pumpkin farmers and their locations in the low and medium NDVI. The study was conducted in two cropping seasons of pumpkins (November 2019-April 2020 and May 2020- August 2020). Each farmer was provided with 2kg of fertilizer and 60 - 70 Dora F1 hybrid pumpkin seeds depending on the farmers' crop size area. Data on flowering plants were collected twice per month in 32 farms that were selected based on the NDVI classes; 16 in low and 16 in medium 3 kilometres away from each other. The farms were equally distributed in Yatta and Masinga Sub-Counties.

Data on floral pattern within and around the pumpkin farms were collected once a week in two dry seasons; January 2020-February 2020 and June 2020-August 2020 and wet season of March 2020-May 2020. Two square meter (2m × 2m) quadrat were established in the middle of the pumpkin farm for sampling of flowering plants. A belt transect was also established using a tape measure measuring 4 m × 50 m moved from the middle of the farm at a slow steady pace while data being collected from the middle of the farm to the edge of the farm. Plant taxonomic data (the flowering plants, number of flowers on the plants, type of flowers), and data on pollinators (the names of flower visitors and the time taken by the visitors in the flowers within a period of 5 minutes was recorded in seconds) were collected. Samples of flowering plants that were not identified in the field were transferred in herbarium sheets in specimen box for expert identification to the National Museums of Kenya (NMK) herbarium.

Data analysis

The datasets were analyzed with R software version 4.0.1 (R Core Team, 2020). The variations of plant species in terms of abundance and effect of months and NDVI on the number of plant species was assessed using a generalized linear mixed effect model (GLMM) with Poisson error distribution in 2 m × 2 m quadrat and 4 m × 50m belt transect. In this model farms were used as random variables.

Relative abundance was determined as follows:

$$Relative\ abundance = \frac{n}{N}$$

where n was the frequency of a particular plant species and N was total number of all sampled plant species.

The species richness, evenness and diversity of plants were determined by Shannon-Waiver diversity index to compare different months and NDVI using the following formula (Al-Fedaghi, 2012):

$$H' = -[EPi \; x \; ln(Pi)]$$

where *H'* is the Diversity Index, *Pi* is the proportion of each species in the sample, and *LN (Pi)* is the natural logarithm of this proportion.

Evenness of plant species compares the similarity of the population size of each species. Evenness Index (*J'*) (Kiros et al., 2018) was calculated using the ratio of observed diversity to maximum diversity using the equation:

$$J' = \frac{H'}{Hmax}$$

where *H'* is the Shannon Wiener Diversity index and H_{max} is the natural log of total number of species.

RESULTS

Abundance and diversity of plants in and around pumpkin farms

The total number of flowering plant species recorded were 142 within and around the pumpkin farmlands both in the 2 m × 2 m quadrat and in the 4 m × 50m belt transect (Supplementary information S1).The frequency of plants observed differed significantly among the plant species (χ^2 = 451.72, df = 141, P < 0.001), between the NDVI classes (χ^2 = 44.79, df = 1, P < 0.001) and across the months (χ^2 = 353.06, df = 7, P < 0.001) in 2 m × 2 m quadrat. Likewise, the frequency of plants observed differed significantly among the plant species (χ^2 = 439.98, df = 131, P < 0.001), between the NDVI classes (χ^2 = 4.87, df = 1, P =v0.027) and across the months (χ^2 = 321.45, df = 7, P < 0.001) in 4 m × 50 m belt transect.

Generally, 2m × 2m quadrat and 4m × 50m belt transect had more diverse plants in May (6765) and March (13,903), respectively. In the 50 m quadrat, the diversity in the low NDVI and medium NDVI was 2.73-3.59 and 2.45-3.43, respectively, while in 2 m quadrat diversity in low NDVI and medium NDVI was 0.00-3.09 and 0.63-3.05, respectively. In 2 m × 2 m quadrat the highest number of plants (6,765) was observed in the month of May in low NDVI while in medium NDVI, 4,399 plants were recorded (Table 1).

Table 1. Species abundance and diversity in 2 m × 2 m quadrat in low and medium Normalized Difference Vegetation Index (NDVI

Parameters	Month							
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Low NDVI								
Abundance	278	138	1,261	118	6,765	629	12	314
Species richness	4	1	18	6	34	10	6	6
Shannon-Weiner diversity index (H')	0.88	0.00	2.62	1.58	3.09	2.01	1.20	0.17
H' Max	1.39	0.00	2.89	1.79	3.53	2.30	1.79	1.79
Species evenness (J)	0.64	0.00	0.91	0.88	0.88	0.87	0.67	0.10
Medium NDVI								
Abundance	45	1,586	1,806	3,58	4,399	375	94	121
Species richness	2	11	22	9	29	6	6	11
Shannon-Weiner diversity index (H')	0.63	2.25	2.77	1.99	3.05	1.62	1.57	1.73
H' Max	0.69	2.40	3.09	2.20	3.37	1.79	1.79	2.40
Species evenness (J)	0.11	0.94	0.90	0.90	0.91	0.91	0.88	0.72

Generally, 4 m × 50 m transect belt had the highest total numbers of plants that ranged between 1,434-20,825 across the months in both NDVI classes with the highest number observed in February (20,825) in medium NDVI (Table 2). The diversity in the low NDVI and medium NDVI was 2.73-3.59 and 2.45-3.43, respectively. Species richness was highest in 4 m × 50 m transect belt (r-70) in the month of July in low NDVI and r-57 in medium NDVI. Low species richness was recorded in January in both NDVI; medium (r-29) low (r-19). The 4 m × 50 m transect belt had the highest species diversity recorded in the month of July (4.25).

Table 2. Species abundance and diversity in 4m × 50m transect belt in low and medium Normalized Difference Vegetation Index (NDVI)

Parameters	Month							
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Low NDVI								
Abundance	1,434	12,617	13,903	11,947	6,907	10,813	2,317	1,464
Species richness	29	37	45	50	40	41	70	40
Shannon-Weiner diversity index (H')	2.73	2.80	3.09	3.41	3.14	3.20	3.59	2.72
H' Max	3.37	3.61	3.81	3.91	3.69	3.71	4.25	3.69
Species evenness (J)	0.81	0.78	0.81	0.87	0.85	0.86	0.85	0.74
Medium NDVI								
Abundance	2,449	20,825	10,718	10,563	8,489	12,878	2,283	2,325
Species richness	19	39	44	57	38	40	42	39
Shannon-Weiner diversity index (H')	2.45	2.93	2.97	3.43	2.86	3.03	2.81	2.89
H' Max	2.94	3.66	3.78	4.04	3.64	3.69	3.74	3.66
Species evenness (J)	0.83	0.80	0.78	0.85	0.79	0.82	0.75	0.79

A high percentage of flowering plant species was recorded in low NDVI compared to medium NDVI. Popcorn cassia (*Senna didyomobotria*) had the highest percentage (55.8%) followed by wild basil (*Ocimum suave*) (20.2%), white eye (*Richardia brasiliensis*), common bean (*Phaseolus vulgaris*) both had low percentage of 1% (Figure 2). In medium NDVI passion fruit (*Passioflora edulis*) had the highest percentage 33.6%, followed by wild basil (*Ocimum suave*) (30.2%). Mexican marigold (*Tagetes minuta*) (0.7%) andwhite wort (*Leucas martiniciensis*) (0.7%) had the lowest numbers (Figure 2).

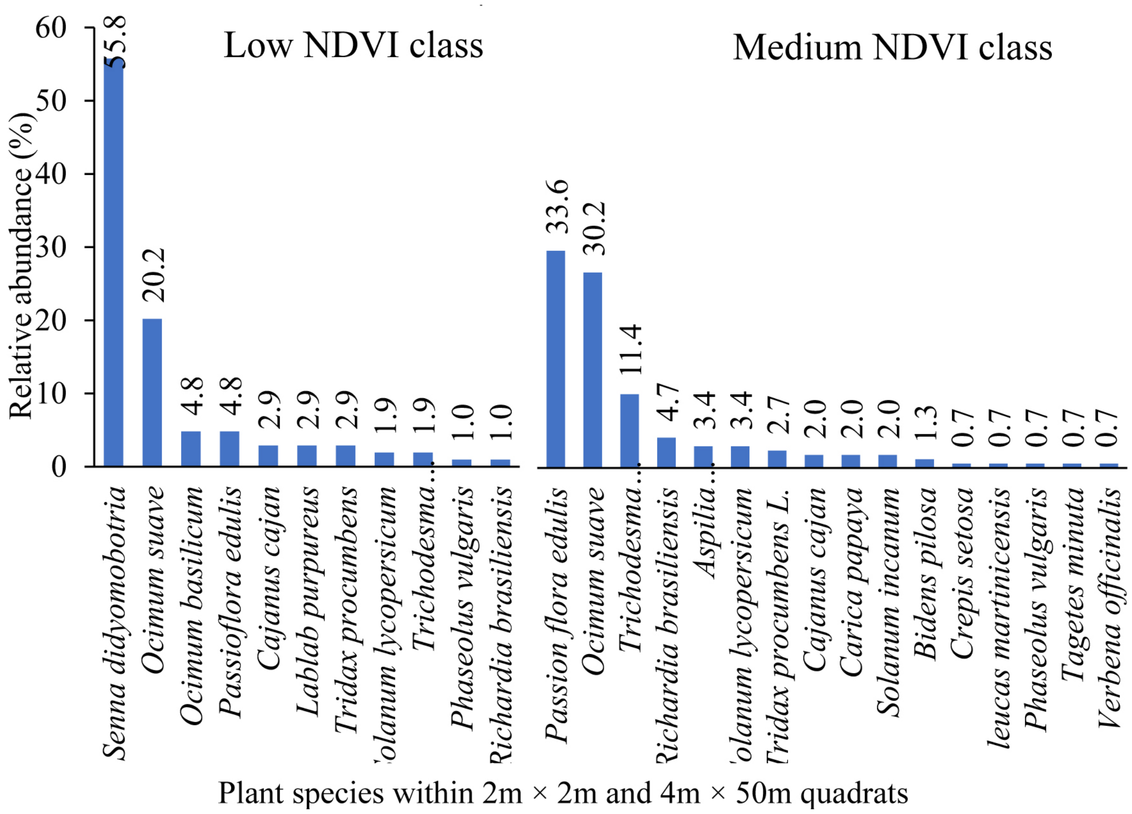

Figure 2. Percentage of plant species in low and medium NDVI classes in pumpkin farms of Machakos County

Floral calendar of honey bee resources

The floral calendar of plants species indicated that there were variations in total number of plants, total number of flowering plants and number of flowers produced across the months and NDVI classes. In both low NDVI and medium NDVI, the highest numbers of total plants, flowering plants and number of flowers were recorded in February, March, April, May and June while the lowest numbers of total plants, flowering plants and number of flowers were recorded in July, August and January (Figure 3).

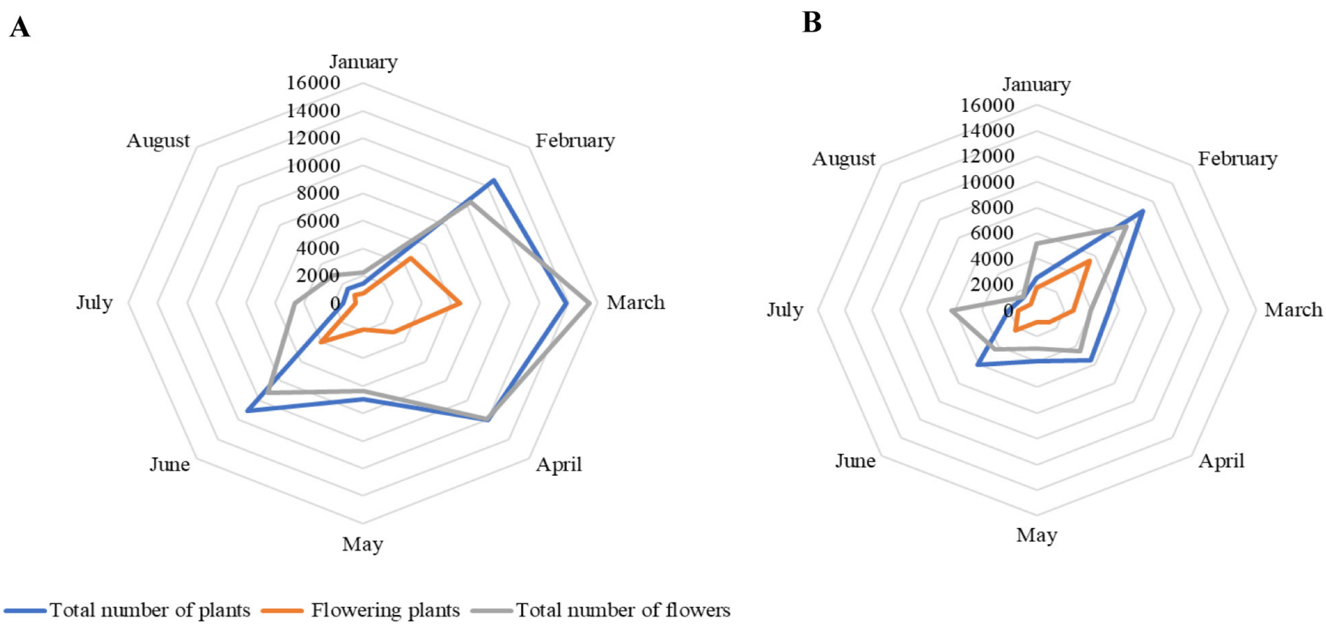

Figure 3. Number of total plants, flowering plants and number of flowers across the months of January to August in low (**a**) and medium (**b**) Natural Difference Vegetation Index (NDVI) in Machakos County.

Foraging calendar of flower visitors

About six flower visitors were observed on the flowers in both low and medium NDVI. The flower visitors with their relative abundance were recorded as follows: honeybees (52.98%), butterflies (37.01), stingless bees (9.33%), carpenter bees (0.38), wasps (0.13), beetles (0.10%), and hover flies (0.07%). Generally, the abundance of flower visitors varied between NDVI classes and across months. In low NDVI, the abundance of honeybees was generally higher (400 to 854) between March and June, compared (49 to 135) to the months of January, February, July and August (Figure 5). In Medium NDVI, the abundance of honeybees was higher (313 to 847) in January, February, March, April, May and June than (31 to 140) in July and August.

The abundance of butterflies was higher in low NDVI between the months of April and June (509 to 734) compared to the months of January, February, July and August (14 to 46) (Figure 5). In Medium NDVI, the abundance of butterflies was higher (265 to 544) in April to June, February and July had the least (14 to 36). Except for March (740) in low NDVI, stingless bees had the lowest abundance during entire study period (0 to 66). Carpenter bees were seldomly observed in March (20), and August (5) in low NDVI and in February (13), March (2), April (1) and December (1).. Hoverflies and beetles had the least abundance in both low and medium NDVI (0 to 3) (Figure 4).

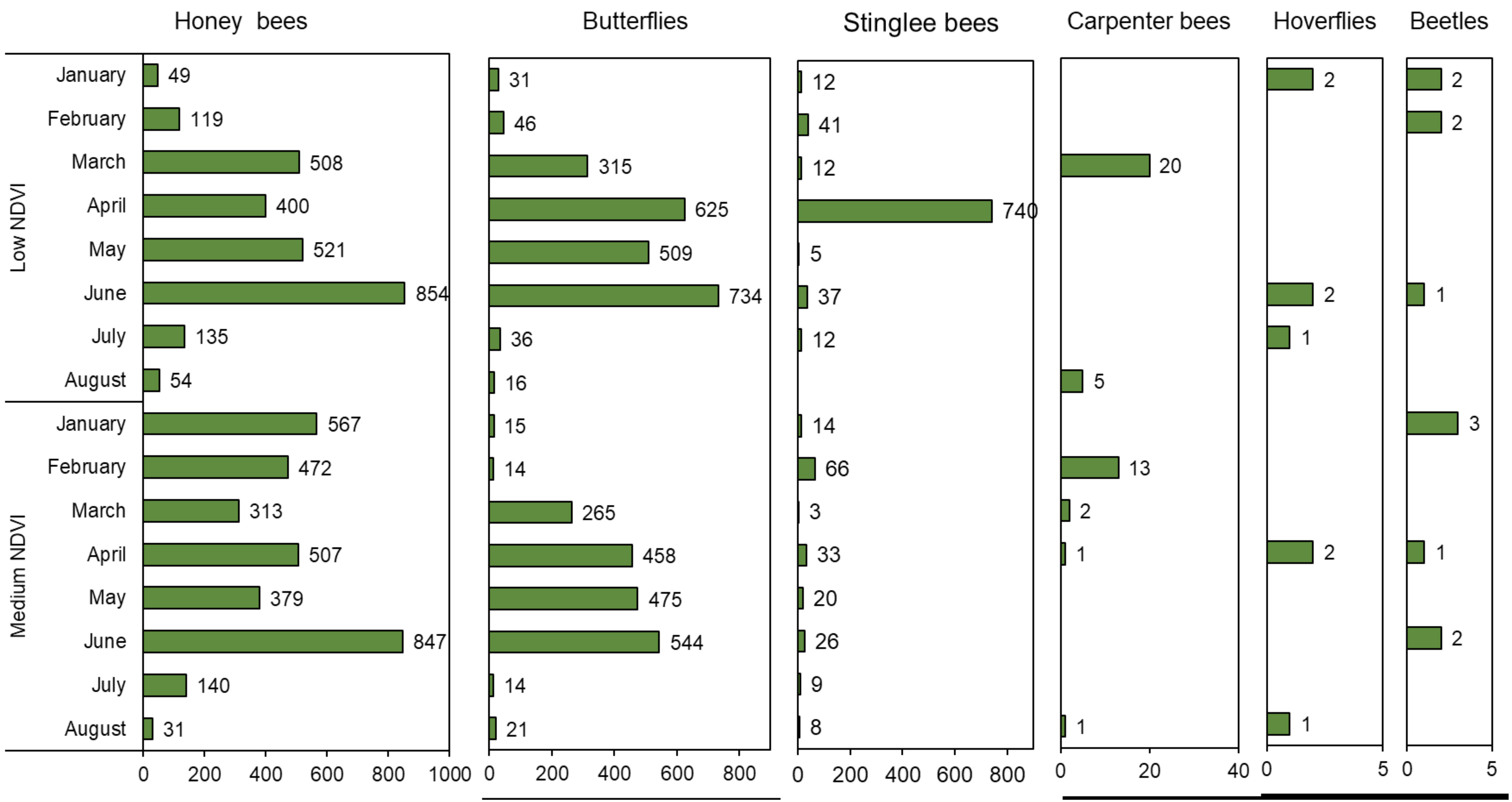

Figure 4. Abundance of pollinators in low and medium Natural Difference Vegetation Index (NDVI) in Machakos County.

DISCUSSION

Enhancing abundance and diversity of flowering plants by planting or conserving these plants in and around farms acts as excellent reservoirs of pollinators and generally improves crop pollination. Various studies have been done to support addition of floral resources to natural landscape to increases wild bee abundance, diversity and richness (M'Gonigle et al., 2015; Xerces 2011) and consequently increase pollination services provided by wild bees in adjacent crop lands (Leong et al., 2016). Pollination reservoir directly affects crop production in the farmlands (Ventrurini et al., 2017). Carvalheiro et al. (2012) reported that pollination reservoirs in South African mango orchards increased flower visitors and yields significantly in adjacent mango fields. This study findings show that at least 30% of plant species in and around pumpkin farms remained actively flowering during January to August sampling period indicating year-round availability pollinators' forage rewards. These findings are in agreement with study by Robinson (2014) reporting that most plant species are biennial and perennial providing pollen and nectar year round while annual plant species present pollen and nectar within a relatively short temporal window each year.

Increase in abundance and diversity of flowering plants increases the availability of the resources to the pollinators especially honeybees. This study recorded a high diversity of flowering plants in medium NDVI. This is in agreement with the study done by Hoehn et al., 2008, species-rich bee community appeared to enhance pollination efficiency through spatial and temporal complementarity in its pollination behavior, suggesting that a single or a few plant species may not provide the same benefits as a rich community of functionally distinct species. Most studies have associated the increases in bee richness and abundance to the presence of plant species in areas surrounding farmlands (Haaland *et al.,* 2011). Swiss Ecological Compensation Areas, constitutes one of the agri-environmental schemes that promote the availability of bee forage resources in the landscape. Through such scheme, the species richness and abundance of both large and small-bodied bees have been substantially increased (Albrecht *et al*. 2007). Similarly, studies done in German, Switzerland and Finland (Korpela et al., 2013) found farm fields incorporating agri-environmental niches supported a greater abundance and diversity of bees than unimproved fields. Use of hedgerows correlates positively with abundant and diverse pollinator communities (Kleijn et al., 2015).

Insects like honeybees, hoverflies, wasps, ants, halictus bees, stingless bees, beetles and butterflies. were found visiting flowering plants in the study sites in Yatta and Masinga within and around the pumpkin farms. The results obtained are similar to studies done by Korpela et al. (2013) whereby flowering plants were mostly observed in the medium NDVI compared to low NDVI. and the same plants had more flower visitors that spend more time in their flowers.

CONCLUSION

This study reveals that non crop flowering plants like weeds play a key role in providing floral resources (pollen, nectar) to the flower visiting insects when crops like pumpkins are not flowering. The farmers should be encouraged to practice agro-ecological practices that will increase the abundance and diversity of flowering plants within and around the cropping area hence pollinators. This can be done by the farmers in Kenya to be educated to keep the areas around the farms lands to be left with hedgerow plants. These helps in the management of the pollinators especially honey bees within the farms preventing there migration hence high crop yield.

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Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author upon reasonable request

Conflict of interest

The authors declare no potential conflict of interest.

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Supplementary information S1

Flowering plants species recorded from January 2020 to August 2020 in the Yatta and Masinga sub-counties of Machakos County, Kenya.

Common name	**Scientific name**	**Common name**	**Scientific name**
Acacia albida	*Acacia xanthophloe*	Mexican merigold	*Tagetes minuta*
African spider flower	*Cleome gynandra*	Mexican prickly poppy	*Argemone mexicana*
Alfalfa	*Medicago arborea* L.	Milk weed	*Launaea hafunensis*
Bad smell melon	*Momordica foetida*	Morning glory	*Ipomea convolvulaceae*
Bananas	*Musa ocuminata*	Morning glory	*Ipomea abscure*
Billy goat weed	*Ageratum conyzoides*	Nandi flame	*Spathodea campanulata*
Bitter lettuce	*Launaea cornuta*	Oliender	*Nerium oleander*
Black beans	*Lablab purpureus*	Orange	*Citrus sinensis*
Black eye susan	*Thunbergia alata*	Pale toadflax	*Linaria repens*
Blackjack	*Bidens pilosa*	Passion fruit	*Passioflora edulis*
Black night shade	*Solanum nigrum*	Paw paw	*Carica papaya*
Blue woodruff	*Asperula arvensis* L.	Pepper	*Capsicum annuum*
Bottle guard	*Lagenaria siceraria*	Pig weed	*Amaranthus retroflexus*
Bougainvillea	*Bougainvillea spectabilis*	Pigeon peas	*Cajanus cajan*
Bristly hawks' beard	*Crepis setosa*	Popcorn cassai	*Senna didyomobotria*
Bristly starbur	*Acanthospermum hispidum*	Pricky hibiscus creeper	*Hibiscus surattensis*
Camel bush	*Trichodesma zeylanicum*	Rattle pod	*Crotalaria marginella*
Carrot grass	*Parthenium hysterophorus*	Rattle pod	*Parentucellia viscosa*
Castor	*Ricinus communis*	Red-fruited nightshade	*Solanum villosum*
Coat buttons	*Tridax procumbens*	Rose mallow	*Hibiscus vitifolius*
Coffee senna	*Senna occidentalis*	Sesame	*Sesamum calycinum*
Common bean	*Phaseolus vulgaris*	Sodom apple	*Solanum incanum*
Common holy hock	*Alcea rosea*	Speedy weed	*Flaveria bidentis*
Common laburnum	*Laburnum anagyroides*	Spreading day flower	*Commelina diffusa*
Cow peas	*Vigna unguiculata*	Strings of stars	*Heliotropium steudneri*
Devils horsewhip	*Achyranthes aspera*	Sweet alice	*Lobularia maritima*
Double thorn	*Oxygonum sinuatum*	Sweet potato	*Ipomea batatas*
Drumstick tree	Moringa oleifera	Tamarind	*Tamarindus indica*
Dyer's madder	*Rubia tinctarum*	Thorn apple	*Datura stronium*
Egg plant	*Solanum melongera*	Thumbai	*Leucas aspera*
Flower-of-an-hour	*Hibiscus trionum*	Tobacco weed	*Solanum mauritanium*
Gallant soldier	*Galinsoga pasiflora*	Tomato	*Solanum lycopersicum*
Goose berry	*Physalis peruviana*	Verbena	*Verbena officinalis*
Green grams	*Vigna radiata*	White eye	*Richardia brasiliensis*
Gum arabica tree	*Acacia nilotica*	White thyme	*Satureja montana*
Hedgehog cucumber	*Cucumis dipsaceus*	Whitewort	*Leucas martinicensis*
Indian mallow	*Abutilon hirtum*	Wild basil	*Ocimum basilicum*
Ipomea	*Ipomea* spp.	Wild basil	*Ocimum gratisenum*
Iron weed	*Vernonia noveboracensis*	Wild basil	*Ocimum suave*
Iron weed	*Vernonia noveboracensis*	Wild sage	*Lantana camara*
Kiss me on the mountain	*Impatiens glandulifera*	Wild sunflower	*Aspilia mossambicensis*
Lablab bean	*Dolichos luticola*	Wire weed	*Sida acuta*
Locust bean	*Ceratonia siliqua* L.	Yellow Oliander	*Cascabela therelia*
Maize	*Zea mays*	Yellow trumphet	*Tecoma stans*
Mango	*Mangifera indicum*		