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# SURVEY OF CROP- PLANTS AND HONEY BEE POLLINATION: A STIMULUS TO FOOD SECURITY IN KWARA STATE NIGERIA

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## ABSTRACT

The relevance of honey bees and their role in pollination and consequently in food production can not be over overemphasized. This present study was planned to observe, document bee's pollinators' activities, identify common bee forage plants, as well as investigate bee/plant interaction. The study was conducted at five research bee farms (apiaries) which were purposefully selected due to their locations and standard. These include Afon, Amberi, Buari, Kwara State University Malete and University of Ilorin apiaries located within guinea and derived ecological zones of Kwara State, Nigeria. The study involves a survey of types of plants visited by worker honey bees for nectar and/or pollen in and around the apiaries, collection and identification of plant species types. The result of the study on the frequency of bee visitation among foraging plants revealed *Parkia biglobosa* (18.71%); *Azadiracta indica* (17.14%); *Anarcadium occidentale* (14.93%) at the Guinea savanna, while *Moringa oleifera* (17.97%); *Pisdium guajava* (17.12%) and *Butyrospermum parkii* (12.88%) were recorded at derived savannah areas. On food crops visited by bees *Arachis hypogea* (24.06%); *Phaseolus vulgaris* (22.29%); *Abelmoschus esculentus* (21.59%) and *Citrullus colocynthis* (16.35%) are most important food crops while cereal crops include *Zea mays* (0.21%) and *Sorghum bicolor* (0.14%) were less visited by honey bee. Cultivation of a wide variety of bee plants to provide adequate incentive for the bee colony and avoid *Apis mellifera* swarming occasioned by inadequate nectar and pollen is among the suggestions proffered.

**Keywords:** Honey bee; pollination; crop- plants inventory; food security

## INTRODUCTION

Honey bee is a social insect known as the most economically valuable insect because of its honey production and pollination activities (Ajao *et al*., 2014). In most ecosystems, bees (Hymenoptera: Apidae) are the primary pollinators of flowering plants. The process by which pollen is transferred to the female reproductive organs of a plant (from the anthers to the stigma), thereby enabling fertilization to take place is known as pollination. Plants rely on wind, water, or animals to move pollen between the different flowers. Many agricultural crops and natural plant populations are dependent on pollination

and often on the services provided by wild and managed pollinator communities with potential effects on plant reproduction, food supply and security (Free, 1993; Ajao and Oladimeji, 2017a).

About 90% of flowering plant species, including many important crop species (Klein *et al.*, 2007) rely on animal pollinators (Ollerton *et al.*, 2011; Laura *et al.*, 2013). According to Klein *et al.* (2007), an estimated 35% of crop production is as a result of insect pollination all over the world. Apart from the honey bee, there are over 4,000 species of other native pollinators engaged in crop pollination service capable of providing pollination services to a wide variety of crop species with an estimated annual contribution valued at $3.1 billion (Michener, 2007). Estimates also place the annual global value of pollination services, including those of wild and managed bees, at $216 billion or about ₦64 trillion per year, or 9.5% of the worldwide annual crop value (Gallai *et al.*, 2009; Nkonya *et al.*, 2009 and Munyuli, 2010). The relationship between pollinators and flowering plants is one of the mutually beneficial relationships under the natural ecosystem. Bees benefit humans in numerous ways such as providing agricultural services like pollination of agricultural crops thereby increasing crop yield, diversity and crop availability at all times thus sustaining food security. The bees are essential to the production of many fruits, vegetables, food crops, the life of pastures, forests, landscapes, and the diet of humans, domesticated and wild animals.

Bees benefit a host of other animals apart from man for food in form of honey. Some of these animals present and pose themselves as pests, pathogens and predators of bees. Bears are the most notorious bee hive raiders, birds, raccoons, skunks, squirrels, bats, opossums and countless insects among many others (Buczkowska *et al.*, 2000; Canto–Aguilar and Parra-Tabla, 2000; Carrek and Williams, 2002; Klein *et al.*, 2003; Cerana, 2004; Michener, 2007; Shivaramu *et al.*, 2012 and Manuel *et al.*, 2015). Biodiversity is measured as the number of different plant and animal species found in a certain unit area. High biodiversity correlates with the high age of the ecosystem and the stability of an environment. A stable environment creates development, specialization and best use of ecological niches. The high biodiversity in tropical savannah and forest can be as a result of the species' efforts to avoid disastrous effect of diseases and pests. It is an important aspect of plant science particularly due to the global drive towards the documentation of customary use and knowledge of plants.

Several authors (Robertension, 1929; Bascompte *et al.*, 2003; Ollerton *et al.*, 2011) have collected and categorized insect visitors to plants, as well as plant and insect phenologies, in natural habitats speculated how changes in biodiversity (Biesmeijer *et al.*, 2006 in Laura *et al.*, 2013) and phenology (Fitter and Fitter 2002) might translate into changes in the structure (Hegland *et al.*, 2009, Memmott *et al.*, 2007) and stability (Thebault and Fontaine, 2010) of complex interaction networks. However, there has been a lack of documentation of plants visited by bee in the study area and this study was designed to document such information.

## MATERIALS AND METHODS

### The Study Area

The study was conducted in Kwara State which lies between latitudes 8° 10' and 19° 50'N and longitudes 3° 10'N and 6° 05'E. The State falls within the southern savanna zone.

Kwara State partly belongs to one of the four major zones into which Keay (1953) divided the savanna regions of Nigeria. The derived savanna zone extends southwards from the southern guinea zone to the forest zone (Adegbola and Onayinka 1976; Ajao, 2012). The State covers a total land area of about 32,500 square kilometres. It falls within the southern limits of the tropical Savannah zone of Nigeria with mean annual rainfall ranging from 800 mm to 1500 mm, concentrated between the months of April and October with two peaks in July and September (Keay, 1953; Ibiremo *et al*., 2010). The mean annual temperature is between 31.5 °C and 35 °C. February to April are the hottest months while June to September has the lowest maximum temperature which coincides with the peak of the dry and wet seasons respectively.

Kwara State lies in two geo-ecological zones; the derived savanna which is characterized by woodland and the Guinea savanna which is characterized by tall grasses growing intermixed with deciduous trees (Adegbola and Onayinka, 1976; Ajao, 2012). The vegetation consists largely of a great expanse of arable land and rich fertile soil. The savannah is characterized by tall grasses intermixed with scattered trees. Economic trees found in the area include *Citrus sinensis, Parkia biglobosa, Butyrospermum parkii, Azadirachta indica, Mangifera indica, Acacia species, Delonix regia,* and *Anacardium occidentale*. These species of trees provide forage for the honey bees (Ajao e*t al.*, 2014).

**Sampling Procedure and Data Collection**

Primary data subjected to a pre-survey test were used for this study. The study was conducted at five research bee farms (apiaries) which were purposefully selected due to their locations, standard and institutionalization. These include Afon apiary, Beekeeping Training and Research Centre (BTRC), with apiaries situated at Amberi and Buari, Kwara State University Malete and University of Ilorin apiaries which are located within guinea and derived ecological zones of Kwara State, Nigeria. Visual observations of types of plants visited by worker honey bees in and around the apiaries was also carried out. These observations were made during field trips of the bee in apiaries in the two ecological zones. Only plants on which honey bee sustained foraging for nectar and/or pollen were recorded. Some parts (leaves, stems and flowers) of bee visited plants were collected to identify species types, common and scientific names. Unfamiliar plants were identified using botanical field guides (Keay *et al.*, 1964; Hopkins and Stanfield, 1966; Ghazanfar, 1989). The honey bees foraging activity was observed and the number of bee visiting trees, food crops and weeds in the vicinity of the farms were recorded between periods 6 am-10 am, 12 noon to 4 pm and 5 pm-7 pm weekly from July, 2013 to March, 2014.

**Data Analysis**

Descriptive statistics such as tables, frequency counts, percentage, mean and standard deviation were used to document bee pollinators' activities and common bee forage plants. The double - difference analytical tool was employed to measure the difference in output (Naira/ha) of a soybean (*Glycine max*) and watermelon (*Citrullus lanatus*) farms with or without pollination activities (Oladimeji *et al.*, 2017a & b). Therefore, to evaluate the effect of bee pollination on two selected crops (Soybean and watermelon), Verners in their double difference estimator model version gave the model as:

$$DD = \left(Y_{P_1} - Y_{P_0}\right) - \left(Y_{nP_1} - Y_{nP_0}\right) \quad \text{..... (1)}$$

Where: $Y_{P_1}$ = Yield of crops after Bee Pollination Service (BPS); $Y_{P_0}$ = Yield of crops before BPS: $Y_{nP_1}$ = Output of non-benefited crop after BPS and $Y_{nP_0}$ = Output of non-benefitted crop before BPS.

## RESULTS

Results in Table 1 showed the list of crop plants and weeds visited by the honey bee. During the study period, both the crops cultivated (trees and arable crops) and weeds in the two ecological zones showed slight deviation from each other. The most prominent arable and tree crops visited by bees include: Cashew, Mango, Moringa, Mahogany, Melon, Groundnut, soya bean, watermelon, Okra and Cereals. In addition, bees also visited a myriad of weeds such as: sida acuta, hog weed, tridax, jatropha and sunflower.

Table 1: The common, scientific and local names of trees, food crops and weeds visited by bees

| Common/English name | Scientific name | Local name (Yoruba) | Family |
|---|---|---|---|
| Tree crops | | | |
| Cashew | *Anacardium occidentale* | Kasu | Anarcadiaceae |
| Mango | *Mangifera indica* | Mongoro | Supotaceae |
| Neem | *Azadrachta indica* | Dongoyaro | Meliaceae |
| Moringa | *Moringa oleifera* | Ewe-Igbale | Moringaceae |
| Mahogany | *Khaya senegalensis* | Aidan | Meliaceae |
| Coconut | *Cocos nucifera* | Igi-ogbon | Arecaceae |
| Shea butter tree | *Butyrospermum parkii* | Igi-shia | Sapotaceae |
| Cheery fruit | *Chrysoplyllum albidum* | Agbalumo | Sapotaceae |
| Orange | *Citrus sinensis* | Osan-minmu | Rutaceae |
| Acacia | *Acacia spp* | Kasia | Fabaceae |
| Locust bean tree | *Parkia biglobosa* | Igi iru/Igi Igba | Fabaceae |
| Flamboyant tree | *Delonix regia* | Igi olododo pupa | Fabaceae |
| Guava | *Pisdium guajava* | Girofa | Myrtaceae |
| Food crops | | | |
| Melon | *Citrullus colocynthis* | Egusi-bara | Cucurbitaceae |
| Groundnut | *Arachis hypogeal* | Epa | Leguminosae |
| Lagos spinach | *Celosia argentea* | Efo shoko | Amaranthaceae |
| Okra | *Abelmosehus esculentis* | Ila | Malvaceae |
| Maize | *Zea mays* | Agbado | Poaceae |
| Guinea corn | *Sorghum bicolor* | Oka-baba | Poaceae |
| Soya beans | *Glycine max* | Ewa | Leguminosae |
| Cassava | *Manihot esculenta* | Ege | Euphorbiaceae |
| Weeds | | | |
| Hog weed | *Boerhavia diffusa* | Etiponla, Etipon-ola | Nyctagainaeae |
| Bitter leaf | *Vernonia amygdalina* | Ewuro | Asteraceae |
| Tridax | *Tridax procumbens* | Igbalode/kodele | Asteraceae |
| Devil's bean | *Mucuna sloanei* | Werepe | Leguminosae |
| Sida acuta | *Sida acuta* | Osepotu/Esopotu | Malvaceae |
| Jatropha | *Jatropha gossypifola* | Botuje pupa/lapalapa | Euphorbiaceae |
| Sunflower | *Elianthus annuus* | Iyeye-Ododo Europu | Asteraceae |
| Pig weed | *Amarauthus viridis* | Tete-elegun | Amaranthaceae |
| Haemorrahage plant | *Aspilia Africana* | Yunyun | Asteraceae |

Source: Survey 2014

Table 2 presents the frequency of bee visitation among foraging plants in Guinea and Derived savannah. The honey bee most frequently visited three tree crops in guinea savannah which accounted for about 50% level of visitation: *Parkia biglobosa* (18.71%); *Azadiracta indica* (17.14%); *Anarcadium occidentale* (14.93%). However, *Moringa olifera* (17.97%); *Pisdium guajava* (17.12%) and *Butyrospermum parkii* (12.88%) are the three most common tree crops in the derived savannah areas. It suffices to note that *Magnifera indica* and *Pisdium guajava* also recorded 14.13% and 11.05% visitation in the guinea savannah area.

Table 2: Foraging sources and frequency of bee/tree visit in Guinea and Derived savannah

| Plant species | Guinea savannah | | Derived savannah | | Total |
|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | |
| *Azadiracta indica* | 707 | 17.14 | 78 | 2.68 | 785 |
| *Anacardium occidentale* | 616 | 14.93 | 206 | 7.08 | 822 |
| *Mangifera indica* | 583 | 14.13 | 165 | 5.67 | 748 |
| *Parkia biglobosa* | 772 | 18.71 | 182 | 6.25 | 954 |
| *Khaya senegalensis* | 148 | 3.59 | 70 | 2.40 | 218 |
| *Cocos nucifera* | 36 | 0.87 | 259 | 8.89 | 295 |
| *Delonix regia* | 39 | 0.95 | 145 | 4.98 | 184 |
| *Acacia spp* | 18 | 0.44 | 115 | 3.95 | 133 |
| *Citrus sinensis* | 148 | 3.59 | 240 | 8.24 | 388 |
| *Butyrospermum parkii* | 308 | 7.45 | 375 | 12.88 | 683 |
| *Moringa oleifera* | 248 | 6.01 | 523 | 17.97 | 771 |
| *Chrysoplyllum albidum* | 47 | 1.14 | 55 | 1.89 | 102 |
| *Pisdium guajava* | 456 | 11.05 | 498 | 17.12 | 954 |
| Total | 4126 | 100.0 | 2911 | 100 | 7037 |

Source: Survey Data (2014)

Table 3 also present food crops visited by bees in both guinea and derived savannah areas studied. *Arachis hypogea* (24.06%); *Phaseolus vulgaris* (22.29%); *Abelmoschus esculentus* (21.59%) and *Citrullus colocynthis* (16.35%) are most important food crops that received bee visit totaled about 85%.

Table 3: Foraging sources and frequency of bee/food crop visited in Guinea and Derived savannah

| Zones | Guinea savannah | Derived savannah | |
|---|---|---|---|
| Food crops | Frequency (%) | Frequency (%) | Total |
| *Citrullus colocynthis* | 2384(16.35) | 1973(13.42) | 4357 |
| *Arachis hypogeal* | 3508(24.06) | 3416(23.24) | 6924 |
| *Celosia argentea* | 1120(7.67) | 1068(7.26) | 2188 |
| *Abelmosehus esculentis* | 3150(21.59) | 4172(28.38) | 7322 |
| *Zea mays* | 30(0.21) | 70(0.48) | 100 |
| *Sorghum bicolor* | 20(0.14) | 39(0.27) | 59 |
| *Phaseolus vulgaris* | 3250(22.29) | 2845(19.36) | 6095 |
| *Manihot esculenta* | 1123(7.69) | 1115(7.59) | 2238 |
| Total | 14585 (100) | 14698(100) | 29283 |

Source: Survey Data 2014

It is important to stress that *Celosia argentea* (7.67%) and *Manihot esculenta* (7.69%) were also visited by bee for foraging. However, Cereals crops such as *Zea mays* (0.21%) and *Sorghum bicolor* (0.14%) were less visited by bees in the studied area. The patterns of bee visitation to food crops in derived savannah study area are closely similar to that of guinea savannah. For example, *Abelmoschus esculentus* (28.38%); *Arachis hypogea* (23.24%); *Phaseolus vulgaris* (19.36%) and *Citrullus colocynthis* (13.42) also accounted for about 85% bee visitation in the study areas while cereals crops were also less frequently visited by bee.

Table 4 also showed the distribution of bee visitation to weeds in both guinea and derived savannah. *Helianthus annuus* (33.03%); *Tridax procumbens* (26.66%) and *Jatropha gossypifola* (13.67 %) were the commonest weed visited by bees and accounted for about three-fourth (74%) of total weed visitation in the study areas. *Vernonia amygdalina* (8.54%); *Amarathus viridis* (7.98%) and *Boerhavia diffusa* (6.99%) were also visited by bees.

Table 4: Foraging sources and frequency of bee/weeds visit in Guinea and Derived savannah

| Zones | Guinea savannah | Derived savannah | |
|---|---|---|---|
| Common weeds | Frequency (%) | Frequency (%) | Total |
| *Boerhavia diffusa* | 1102(6.99) | 1218(8.91) | 2320 |
| *Vernonia amygdalina* | 1345(8.54) | 1226(8.97) | 2571 |
| *Tridax procumbens* | 4202(26.66) | 3165(23.16) | 7367 |
| *Mucuna sloanei* | 105(0.67) | 182(1.33) | 287 |
| *Sida acuta* | 32(0.21) | 47(0.34) | 79 |
| *Jatropha gossypifola* | 2155(13.67) | 2259(16.53) | 4414 |
| *Helianthus annuus* | 5205(33.03) | 4145(30.34) | 9350 |
| *Amarauthus viridis* | 1258(7.98) | 1175(8.60) | 2433 |
| *Aspilia Africana* | 355(2.25) | 248(1.82) | 603 |
| Total | 15759(100) | 13665(100) | 29424 |

Source: Survey Data (2014)

**Effect of Bee Pollination Services (BPS) on Food Security Status of Bee Farmers**

The mean difference between Gross Margin of watermelon and soybean farms situated in and around apiaries where pollination activities were taken place and farms that were distance away from apiaries where there was virtually no pollination activities is depicted in Table 5. The result of DD revealed that watermelon and soybean output (Naira) had a positive mean difference of ₦23870.04.0 and ₦2907.52 respectively.

Table 5: Double difference result of BPS practice on users and non-users

| Crops | Variable | Mean | Std. Dev. | t-value | SE | p-value |
|---|---|---|---|---|---|---|
| Watermelon | DD | 23870.04 | 110.13 | 4.06 | 10.4 | 0.0002*** |
| Soybean | DD | 2907.52 | 46.87 | 13.92 | 6.6 | 0.0006*** |

Source: Oladimeji *et al.* (2017), DD denote Double Difference, SE = Standard Error

It is evidence that the difference in gross margin could be attributed to bee pollination activities as observed in the double difference evaluation method used. The difference in Gross Margin was statistically significant at 1% level for both farms. The implication is that engagement in honey bee farming equally provides additional output in soybean and watermelon farms. For example, the additional output may be reserved for home consumption and income from sale of output of soybean and watermelon could be spent on purchasing more food items for consumption or assets to cater for general welfare.

## DISCUSSION

It is expedient to recall that bee visited myriads of crop plants and weeds in the study area in line with studies of Laura *et al.* (2013); McNally, (2015) and Showket *et al*. (2017) who observed that the bees usually found their food in form of nectar or pollen from flowering plants mainly from cultivated crop plants, wild economic trees and weeds. It is pertinent to note that the efficiency of honeybees emanated from their great numbers, their physique and their behaviour of foraging on only one plant species at one time. Flowers exploit insects to achieve pollination; at the same time insects exploit flowers for food and the diversity of both required understanding of the plants visited by the bees.

Sharma (2004); Kasina *et al. (*2009); Oladimeji *et al.* (2017) observed a positive significant difference in yield between bee pollinated and non-pollinated crops in Kullu valley (India), Western Kenya and Kwara State, Nigeria. The study by Oladimeji *et al.* (2017) also revealed that bee pollination had a significant impact on the arable farms that had interaction with bee farms based on the improvement in the net farm income which resulted from increased yield. This implies that diverse insect communities occur where pollen and nectar resource diversity is high (Potts *et al.*, 2003 in McNally, 2015). However, both pollen and nectar have their complexity in plant reproduction to produce and ensure the next generation of plants. According to (Ashton *et al.*, 1988; Klein *et al.*, 2017), bee pollinated flowers have evolved in such a way that a visiting bee has to brush against the flower's anthers bearing pollen, or there may be a special mechanism to release the anthers to spring up or down to cover the bee with pollen.

Figure 1 present common tree plants based on random counting and permutation available for honey bee foraging activity in both guinea and derived savannah of studied areas. The honey bees relied mostly on this tree crops when cultivated arable crops are either not available due to season or not cultivated at all. This support Food and Agriculture Organization (FAO) assertion that more than 100 crop species provide 90% of food world-wide, 71 are pollinated by bees.

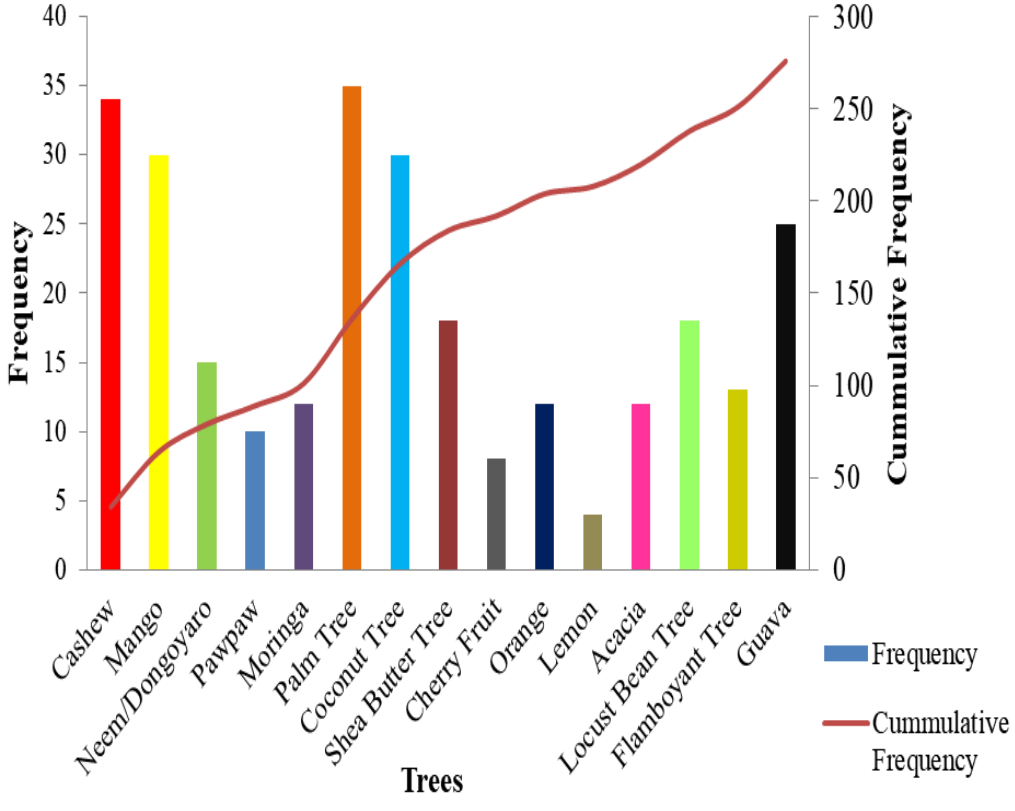


Figure 1: Common bee trees and their frequency in both guinea and derived savannah ecozones

A critical look at figure 2 which depicts dominance weed plants visited by bees in both guinea and derived savannah of the studied areas. This implied that weed plants, including ornamentals, sedges and flowers for landscaping activity served as alternative to both tree and food crops as a source of food to the bees in the absence of either or both. Kevan, (1991); Ajao *et al.* (2014a & b) opined that compared with other insects, bees are extremely hairy. Each hair has a branched structure that makes it highly effective at catching pollen. Bees have to learn where in a flower the nectar is to be found. To guide the bees, many plants have *bee-tracks*, which are lines of colour leading the bee towards the nectar. These can sometimes be seen by humans, but some are in the ultra-violet part of the spectrum and visible to bees, but not humans. In this way, the plant also guides the visiting bee to pass the anthers or stigma in the right way. Bees have no problems in finding the nectar in flat, open flowers, but in flowers that are more complex, they have to learn it by trial and error (Carrek and Williams, 2002).

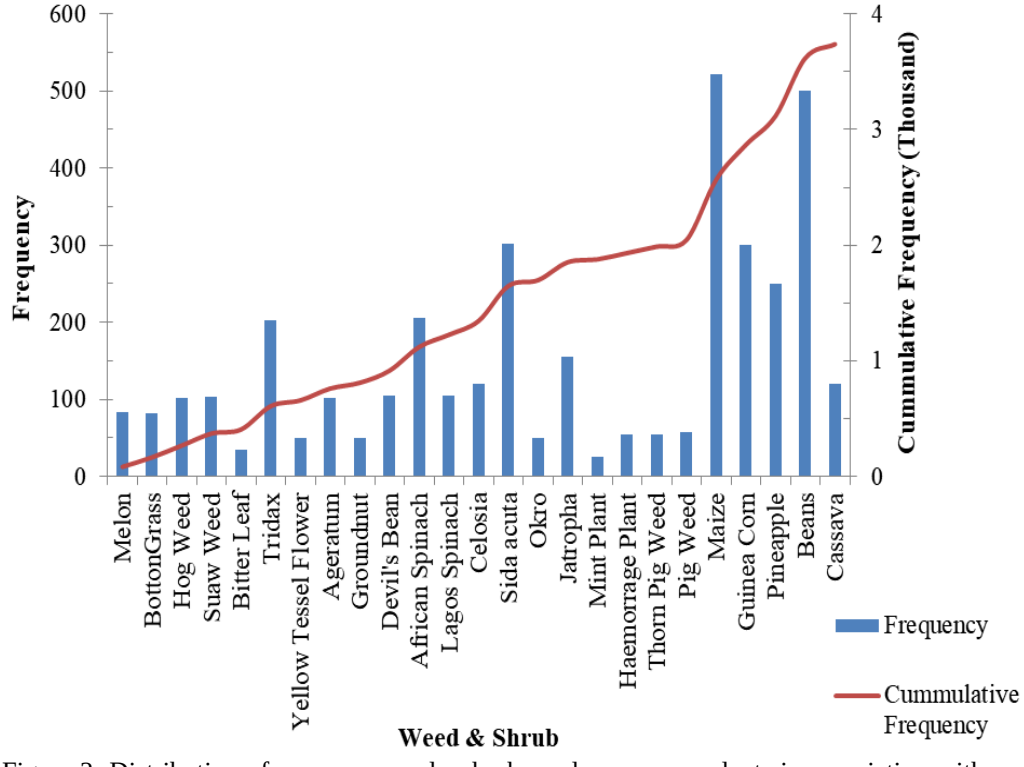


Figure 2: Distribution of common weeds, shrubs and some crop plants in association with honey bees

After some visits in the same type of flower, the bee has learned where the nectar is, and learns this for the next visit. Pollen is the protein food for bees. Without pollen, the young nurse bees cannot produce bee milk or royal jelly to feed the queen and brood. If no pollen is available to the colony, egg laying by the queen will stop. Therefore, pollinators are key to global sustainable terrestrial productivity (Augspurger, 1983).

The bee pollination activities and interaction has positive influence on food security status of bee farming households. Result indicated that there was statistically significant difference in output between crops cultivated in and around the apiaries and farms that were hardly patronized by bee pollination activities. This indicates higher output and invariably higher income for bee farming households, hence the greater the probability of being food secure. This could be expected because, increased in farm output, all things being equal, means increased access to food.

## CONCLUSION

The study concluded that bees forage on myriads species of trees, shrubs and weeds of different families at different periods of the day. Therefore, a wide variety of bee plants should be cultivated to be able to provide adequate incentive for the bee colony to avoid *Apis mellifera* swarming occasioned by inadequate nectar and pollen around apiaries. This

will enable the bees to consolidate its energy on productive activity such as pollination service which could lead to biodiversity of economic, medicinal and ornamental plants for sustainable ecosystem and food security for man.

Both honey bee and plants are enhancing national economy and improve standard of living of people since they are sources of food security. Plant needs bee for maintenance and regenerating of the system within which bee exist. The better the species of fruits and seed generated within an ecosystem the greater and richer its diversity and its life carrying capacity.

## REFERENCES

Abbot, R. J. and Irwin, J. A. (1988). Pollinator movements and the polymorphism for out crossing rate at the ray locus in common groundsel Senecio vulgaris. *Heredity*, 60:295– 298.

Abrol, D. P. (1987). Interrelation and path coefficient analysis of environmental factors influencing pollination activity of Apis dorsata on Prunus persica. *Tropical Ecology*, 28:147–154

Adegbola, A. A. Onayinka, E. A. O. (1976). A review of range management problems in the southern guinea and derived savanna zones of Nigeria. *Tropical grasslands*, 10(1):22-29.

Ajao, A. M. (2012). Comparative Studies on Ecology and Morphometrics of Reared and Feral Honeybees in Geological Zones of Kwara State, Nigeria. Phd Thesis, Federal University of Agriculture, Abeokuta.

Ajao, A. M., Oladimeji, Y. U., Idowu, A. B., Babatunde, S. K. and Obembe, A. (2014a). Morphological characteristics of *Apis mellifera* L. (Hymenoptera: Apidae) in Kwara State, Nigeria. *International Journal of Agricultural Sciences*, 4(4):171-175.

Ajao, A. M., Oladimeji, Y. U., Babatunde, S. K. and Obembe, A. (2014b). Differential morphometric patterns of apis mellifera and adaptation to climatic variations in Kwara State, Nigeria. Gobal Journal of Bioscience and Biotechnology, 3(1): 34-40.

Ajao, A. M. and Oladimeji, Y. U. (2017). Farmers' Knowledge, Attitude and Perception of Bee Pollination of Watermelon and Soybean in North-Central, Nigeria. *Journal of Advances in Biology & Biotechnology*, 12(1): 1-9.

Ashton, P. S., Givnish, T. J. and Appanah, S. (1988). Staggered flowering in the Dipterocapaceae: New insights into floral induction and the evolution of mast fruiting in the a seasonal tropics. *Am. Nat.* 132: 44–66.

Augspurger, C. K. (1983). Phenology, flowering synchrony, and fruit set of six neo-tropical shrubs, *iotropica* 15: 257–267.

Bascompte, J., Jordano, P. Melián, C. J. and Olesen, J. M. (2003). The nested assembly of plant- animal mutualistic networks. *Proc. Natl. Acad. Sci.,* 100: 9383-9389.

.Buczkowska, H., Kowalska G.and Cane, J. H. (2000). Effect of pollination by bumble bee (Bombus terrestries) on yield of aubergine grown in a plastic tunnel. *Annales Universitatis Marial Curie Sklodowska*, 8: 383–389.

Canto-Aguilar, A. and Parra-Tabla, V. (2000). Importance of conserving alternative pollinators assessing the pollination efficiency of the squash– bee, Peponapis limitaris in Cucurbita moschata (Cucurbitaceae). *J. Ins. Conserv.*, 4: 203 –210.

Carrek, N. L. and Williams, H. (2002). The economic value of bees in the UK. *Bee World*, 79:115–123.

Cerana, M. M. (2004). Flower morphology and pollination in Mikania (Asteraceae). *Flora–Morphology, Distribution, Functional Ecology of Plants*, 199(2): 168–177.

Fitter, A. H. and Fitter, R. S. (2002). Rapid changes in flowering time in British plants. *Science*, 296: 1689-1695.

Free, J. B. (1993). Insect pollination of crops. Academic Press, Sam Diego, CA; 1993.

Gallai, N., Salles, J. M., Settele, J and Vaissière, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics*, 68: 810-821.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L. and Totland, O. (2009). How does climate warming affect plant-pollinator interactions? *Ecol. Lett.* 12: 184-191.

Ibiremo, O. S., Ipinmoroti, R. R., Ogunlade, M. O., Daniel, M. A. and Iremiren, G. O. (2010). Assessment of soil fertility for cocoa production in Kwara State: Southern Guinea Savanna Zone of Nigeria. *Journal Agric. Sci.*, 1(1): 11-18.

Kasina M, Kraemer M, Martius C. Wittmann D (2009). Diversity and activity density of bees visiting crop flowers in Kakamega, Western Kenya. *J. Apicul. Res*. 48(2):134-139.

Keay R. W. J. (1953). An outline of Nigerian vegetation. Federal department of forest research. Federal government printer.

Klein, A. M., Steffan-Dewenter I. and Tscharntke, T. (2003). Bee pollination and fruit set of *Coffea arabica* and *C. canephora* (Rubiaceae). *Am. J. Bot.* 90: 153–157.

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan, D. I., Cunnigham, S. A., Kremen,C, and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proc. *Royal Soc*., 274:303-313.

Kwara Agricultural Development Project' (2008) *House Journal and Bulletin*, July, 2008.

Laura, A. B., John, C. M. and Tiffany M. K. (20113). Plant-pollinator interactions over 120 years: loss of species, co-occurrence and function. Scienceexpress Report, Pp 1-6.

Manuel. R., David, W. R., Miguel, A. (2015). High yields and bee pollination of hermaphroditic rambutan (*Nephelium lappaceum* L.) in Chiapas, Mexico. *Fruits* 70:23–27.

McNally, M. (2015). Plant-pollinator interactions characterized by diversity and abundance in grassland communities on the National Bison Range and the Flathead Reservation. UNDERC West Publication, 29pp.

Memmott, J., Craze, P. G., Waser, N. M. and Price, M. V. (2007). Global warming and the disruption of plant-pollinator interactions. *Ecol. Lett.* 10: 710-719.

Michener C. D. (2007). The bees of the world, Johns Hopkins Univ. Press, Baltimore, 2nd ed.. Miller-Rushing, A. J. and Primack, R. B. (2008). Global warming and flowering times in Thoreau's Concord: A community perspective. *Ecology* 89: 332-340.

Munyuli, T. M. B. (2010). Pollinator biodiversity and economics of pollination services in Uganda. PhD dissertation, Makerere University, Kampala, Uganda. 451Pp.

Nkonya, E., Philip, D., Mogues, T., Pender, J, and Kato, E. (2009). Inputs of community driven development programmes on income and asset acquisition in Africa: The case of Nigeria. Paper presented at the Int. Assoc. of Agric. Economics Conference, Beijing, China.

Oladimeji, Y. U., Ajao, A. M., Abdulrahman, S., Suleiman, R. and Bolaji, A. M. (2016). Estimation of efficiency differentials in honey bee enterprises: implications for higher productivity in Kebbi and Kwara States of Nigeria. *Gashua Journal of Irrigation and Desertification Studies*, 2(2): 38-49.

Oladimeji1, Y. U., Ajao, A. M. and Abdulsalam, Z. (2017a). Arable crop farming and adoption of bee pollination services among farming households in Kwara State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, 15(2): 1-10.

Oladimeji, Y.U., Ajao, A. M.,Abdullahi, A. N. , Abdulsalam, Z. and Damisa, M. A. (2017b). Adoption of Improved Technologies and Management Practices Among Bee Farmers in North Central and North Western Nigeria towards Sustainable Development Goals. *Ethiopia Journal of Applied Science and Technology*, 8 (1): 1-13.

Ollerton, J., Winfree, R. and Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120: 321-328.

Robertson, C. (1929). Flowers and Insects: Lists of Visitors to Four Hundred and Fifty-Three Flowers. Science Press Printing Company, Lancaster, Pennsylvania.

Sharma, H. K. (2004). Report on cash crops farming in the Himalayas: The importance of Pollinators and pollination in vegetable seed production in Kullu Valley of Himachal Pradesh. India Final Report Submitted to FAO and International Centre for Integrated Mountain Development-Kathmandu, Nepal; 2004.

Shivaramu, K., Sakthivel, T. and Rami-Reddy P.V. (2012). Diversity and foraging dynamics of insect pollinators on rambutan (*Nephelium lappaceum* L.), (18): 158–160.

Showket, A. D., Gh, I. H., Bilal, A. P., Ab, R. W. and Sajad, H. P. (2017). Pollination and evolution of plant and insect interaction. *Journal of Pharmacognosy and Phytochemistry*, 6(3): 304-311

Thébault, E. and Fontaine, C. (2010). Stability of ecological communities and the architecture of mutualistic and trophic networks. *Science*, 329: 853-859.