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# Research Article
# Comparative Study of Forage Plants by *Apis mellifera adansonii* (Hymenoptera: Apidae) in Osun State, Nigeria

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## Abstract

**Background and Objective:** The quality of beehive products by *Apis mellifera adansonii* in different ecological zones is dependent on the quality and quantity of rich flora sources available within their explorative environment. The study investigated and compared forage plant species patronized by *A. mellifera adansonii* at Ejigbo and Osogbo districts. **Materials and Methods:** Plant species visited by honeybees which exhibited explorative behavior for at least 5-15 min with pollen loads were identified. Visit frequencies of honeybees on identified plant species were recorded using Capture-Mark-Recapture method. **Results:** Twenty-one plant species belonging to 15 families were identified being visited by *A. mellifera adansonii* as nectar and pollen sources at both districts. *Chromolaena odorata* (Asteraceae), *Melanthera rhombifolia* (Asteraceae), *Tridax procumbens* (Asteraceae), *Stachytarpheta cayennensis* (Verbenaceae), *Stachytarpheta indica* (Verbenaceae), *Azadirachta indica* (Meliaceae), *Carica papaya* (Caricaceae), *Cola nitida* (Sterculiaceae), *Clerodendrum dusenii* (Lamiaceae), *Mangifera indica* (Anacardiaceae), *Manihot esculenta* (Euphorbiaceae), *Scoparia dulcis* (Plantaginaceae), *Sida scabrida* (Malvaceae), *Solanum gilo* (Solanaceae), *Talium triangulare* (Portulacaceae), *Vernonia amygdalina* (Compositae), *Zea mays* (Poaceae) were identified honeybees' foraged plants at Ejigbo. *Carica papaya*, *C. odorata*, *M. rhombifolia*, *S. scabrida*, *S. indica*, *T. triangulare*, *T. procumbens* and *Z. mays* were common at both districts. Results showed no significant differences ($p>0.05$) in the visitation intensity on identified honeybees' foraged plant species across both districts. This implies that honeybees probably patronize plant species with preferred rewarding food sources despite ecological differences and distance. **Conclusion:** It is recommended that rewarding plant species should be identified and cultivated in different ecological zones to boost production of beehives' products.

Key words: Foraging time, visitation intensity, honeybees, foraged plants, asteraceae, beekeeping

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Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Honeybees, *A. mellifera*, depend solely on nectar and pollens of plants for food. Worker bees make thousands of visits to flowers to collect nectar and pollen. While doing this, they pollinate indirectly the flowers, thereby helping to increase fruit and seed yield both in wild and cultivated plants. They generally gather nectar and pollen beyond their immediate needs thereby constantly exuding and preserving the surplus as honey within the honeycombs during nectar and pollens flow period[1]. Honeybees visit diverse flowers of variety of plant species to gather nectar and pollen, making plant fertilization possible which translates to conservation of biodiversity in the wild[2]. Honeybees contribute immensely to the maintenance of ecosystems and Agricultural production while they produce important products such as honey, bees wax, royal jelly and propolis[1]. In 2000, the estimated value of increased yield and quality of crops, due to pollination by honeybees, in the United States of America was $14.6 billion[2]. Nectar secretion within flowers usually starts about the time flowers open and cease soon after fertilization[2]. Beekeepers refer to the heaviest nectar production as honey-flow and most regions have predictable blooming seasons of best nectar-producing flowers[1]. Plants visited by honeybees can be identified through direct observation of foraging bees, palynological analysis of honey, analysis of pollen loads removed from returning foragers and analysis of pollen stores in nests or hives[3,4].

Studies in various ecological zones of Nigeria revealed large diversity of honeybee flora in the country. Ayansola and Davies[3] reported 49 plant species from the Tropical Rain Forest and Derived Savanna zones of southwestern Nigeria, while Nnamani and Uguru[5] identified 56 plant species in south eastern, Nigeria. On the other hand, Mbah and Amao[6] and Ebenezer and Olugbenga[7] identified 28 and 26 plant species, respectively from Guinea Savanna zone in north central part of the country while Abdullahi *et al*.[8] identified 103 plant species from Sudan Savanna zone in the north-eastern part. Gezahegn[9] noted that not all plant species are important to honeybees. Those plants that supply both nectar and pollen abundantly when in bloom are often called honeybee plants[10]. The honeybee plants are best suited for honey production as well as colony maintenance, in that honeybees obtain protein from pollen source plants and carbohydrate from nectar source plants[11]. Nectar producing plant species are of utmost interest to beekeepers except few plants. Most reliable nectar producers in Florida are *Avicennia germinans*, *Schinus terebinthifoliusas*, *Sabal palmetto*, *Ilex glabra*, *Melaleuca quinquenervia*, *Serenoa repens* and *Nyssa ogeche* as identified by Sanford[12]. Delaphane *et al*.[13] revealed that in planting bee pastures, it is important to choose a collection of plants that will produce unbroken succession of bloom throughout the season. Also, planting or encouraging permanent bee pasture near apiary improves bee nutrition[13]. The distribution and type of honeybee plants as well as their flowering duration vary from region to region due to variations in topography, climate and farming practices. Hence, every region has its own honey flow and floral dearth periods of short or long duration and the knowledge on bee flora helps in the effective management of bee colony during such period [11]. Generally, flowering calendars make it easier to plan various beekeeping management operations such as the citing of hives near some selected crops and deciding the best time for honey harvest and/or colony swarming. Hence, adequate knowledge about bee flora species within the ecological zones including the floral calendar is a prerequisite to the successful establishment of Apiary[11].

In the rain forest of south western Nigeria, the following plants were reported to be visited by honeybees. These include *Cocos nucifera* (Palmae), *Acacia ataxacantha* (Fabaceae), *Abelmoschus esculentus* (Malvaceae), *Coffea Arabica* (Rubiaceae), *Hoslundia opposite* (Labiatae), *Aspilia Africana* (Compositae), *Capsicum annum* (Solanaceae), *Solanum melongena* (Solanaceae), *Theobroma cacao* (Sterculiaceae) and *Cucurbita maxima* (Cucurbitaceae). In Nigeria, there are several reports on foraged plants of melliferous and nectivorous sources across the country. Omoloye and Akinsola[14] reported on suitable and preferred honeybees plant species in south west. Also, Ayansola and Davie[3] studied the food-plants of honeybees (*A. mellifera andasonni* ) in the rain forest and derived Savanna zones of south western Nigeria. Larinde *et al*.[15] studied bee foraging plants and its implication on Apiary management in southern Nigeria. While Mbah and Amao[6] reported 28 plant species visited by honeybees, (*A. mellifera adansonii* ) in Zaria (Northern Nigeria). Dukku[16] identified 61 plant species visited by honeybees, *Apis mellifera* L. in Sudan Savanna zone of north eastern Nigeria. Beekeepers at Ejigbo and Osogbo districts lack adequate knowledge of forage plant species by honeybees in the districts which negates expected yield in relation to apiary management and flowering seasons of for age plants. Hence, the main goal of this study is to contribute to the knowledge of honeybee forage plant species of pollen and nectar sources with the aim to provides additional data on plants visited by honeybees within the identified beekeeping zones at Ejigbo and Osogbo, south western Nigeria. Thus, the objectives of this study are (i) To identify the honeybee flora in the study areas (ii) To note the flowering time of the bee flora

(iii) To record visit frequencies of honeybees and compare the visitation intensity on identified plant species in both districts. The results of the study will be used to guide and make adequate recommendations on possible and preferred honeybee forage plants species to improve honey and pure beeswax production as one of the empowerments programme in the study areas.

## MATERIALS AND METHODS

**Study sites:** The study sites include Ejigbo district (7°54′ N, 4°18′54′′ E, 300 m above sea level) and Osogbo district (7°76′ N, 4°60′64′′ E, 336 m above sea level). Each study site was randomly sectioned into quadrats for quantitative sampling study of the forage plant communities.

**Identification and monitoring of foraging activities of *A. mellifera adansonii* on plant species at each study sites:** The identification of forage plants visited by honeybees was done through direct observations of foraging honeybee workers, with pollen loads, on flowers of identified plants. Each study site was monitored twice a week, in the morning between 8:00 am and 6:00 pm per day during the study period between, September, 2016-August, 2017.

**Collections, preservation and taxonomical identification of foraged plants at each study sites:** Before foraged plant collection, some plants with foraging honeybees were photographed with cybershot DSC-W220 12. The IMP digital camera and saved for presentation. Thereafter, foraged plant samples were collected on the field using sharp penknife. Each sample include a branch of the plant with the full complement of its leaves, buds and flowers. Each was placed in-between the pages of old newspaper within wooden plant press and sun and oven dried alternatively for 4-7 days for post-harvest preservation. Thereafter, at intervals of 4 weeks, all the preserved foraged plant samples were packed in labelled brown envelopes separately and forwarded for taxonomical identification by accredited and recognized herbarium of Department of Botany, Obafemi Awolowo University, Ile-Ife, Osun state, Nigeria. This process was repeated for other samples collected throughout the study duration on both study sites. Only plants with foraging honeybees on their blossom flowers and nectar zones were collected and prepared for taxonomical identification.

**Visitation intensity of *A. mellifera adansonii* on foraged plants:** The intensity visit by *A. mellifera adansonii* was evaluated using Capture-Mark-Recapture method[17] using insect sweep-net trap. The criteria of honeybees' visit were restricted to (i) Pollen basket load of the hind tibia of worker honeybees (ii) Collection of nectar from flower base of observed foraged plants. Data on visit frequencies of honeybees on foraged plants were recorded.

**Statistical analysis:** Collected data on visitation frequencies of *A. mellifera adansonii* on identified foraged plants at both study sites were analyzed using students t-test with Microsoft Excel 2016 at 5% level of significance.

## RESULTS AND DISCUSSION

At Ejigbo, a total of 17 plant species belonging to 14 families which comprised of tree crops, forest trees, root/tuber crops, herbs and shrubs were observed while 12 plant species belonging to 8 families comprising of herbs, climbers and tree were identified as bee forage plants at Osogbo (Fig. 1). The family: Asteraceae was most visited by honeybees at both study sites. The common foraged plant species across the two study sites include 8 plant species belonging to 6 families (Table 1). These include *C. papaya*, *C. odorata*, *M. rhombifolia*, *S. scabrida*, *S. indica*, *T. triangulare*, *T. procumbens* and *Z. mays*. The study observed that different plant species flowered at different period of the year across the study sites, although this was not correlated to specific yield of any beehives within the study sites. There were variations in the honeybees' visitation rates to each

Table 1: Common foraged plant species at Ejigbo and Osogbo districts

| Plant species | Common names | Family | Plant types |
|---|---|---|---|
| *Carica papaya* | Pawpaw | Caricaceae | Tree crop |
| *Chromolaenaodorata* | Siam weed | Asteraceae | Herb |
| *Melantherarhombifolia* | Broom weed | Asteraceae | Herb |
| *Sidascabrida* | Wire weed | Malvaceae | Herb |
| *Stachytarphetaindica* | Blue snake weed | Verbenaceae | Herb |
| *Taliumtriangulare* | Waterleaf | Portulacaceae | Herb |
| *Tridaxprocumbens* | Tridax | Asteraceae | Herb |
| *Zea mays* | Maize | Poaceae | Tree crop |

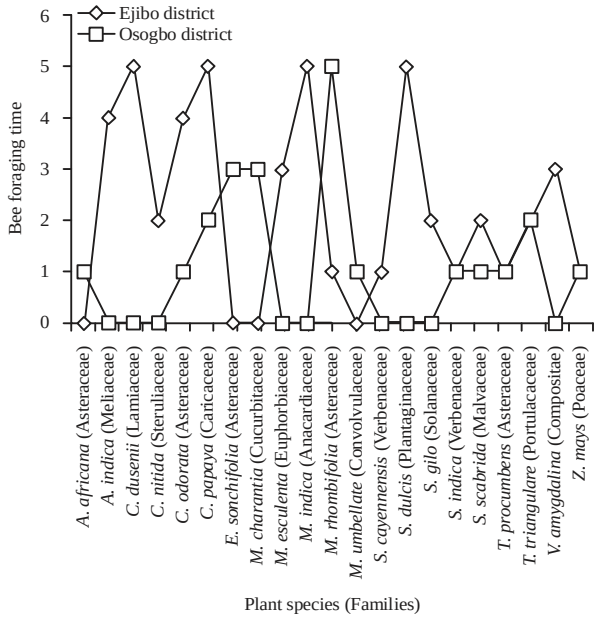


Fig. 1: Comparative bee foraging time on plant species at both district of Osun state, Nigeria. (Time range: Not Applicable = 0, 8.00-10.00 am = 1, 10.01-12.00 noon = 2, 12.01-2.00 pm = 3, 2.01- 4.00 pm = 4, 4.01-6.00 pm = 5)

Table 2: Visitation intensity of honeybees on plant species at Ejigbo district

| Plant species | Flowering season | Average visit frequency of *A. mellifera adansonii* | Categorized visitation intensity |
|---|---|---|---|
| *Azadirachta indica* | Dry/rainy season | 256 | ++ |
| *Carica papaya* | Rain season | 486 | +++ |
| *Chromolaene odorata* | Rain season | 373 | +++ |
| *Clerodendrum dusenii* | Rain season | 284 | ++ |
| *Cola nitida* | Dry/rain season | 487 | +++ |
| *Mangifera indica* | Dry season | 508 | +++ |
| *Manihot esculenta* | Rain season | 294 | ++ |
| *Melanthera rhonibifolia* | Rain season | 446 | +++ |
| *Scoparia dulcis* | Rain season | 88 | + |
| *Sidascabrida* | Dry season | 346 | +++ |
| *Solanum gilo* | Rain season | 328 | +++ |
| *Stachytarpheta cayennensis* | Dry season | 489 | +++ |
| *Stachytarpheta indica* | Dry season | 424 | +++ |
| *Talinum triangulare* | Rain season | 364 | +++ |
| *Tridax procumbens* | Rain season | 310 | +++ |
| *Vernonia amygdalina* | Dry/rain season | 268 | ++ |
| *Zea mays* | Rain season | 422 | +++ |

+: (1-100) Occasionally visited, ++: (101–300) often visited, +++: (301-600) abundantly visited, Dry season: October-April, Rain season: May-September

plant species across study sites. Hence, some plants were occasionally visited, some were often visited while others were abundantly visited (Table 2, 3). But, there was no significant difference ($t\text{-}_{value}$) (1.99) < $t\text{-table}_{(40df.0.025)}$ (2.02), ($p>0.05$) in the visitation intensity (rate of visit) on different identified foraged plant species by *A. mellifera adansonii* across the study sites. Plates 1-4 showed the pictures of some identified foraged plant species.

From this study, a total of 21 plant species were identified as honeybees foraged plants with nectar and pollen sources within the study duration at both districts. The categorization of these plants species into 15 families indicated the diverse nature of the natural food sources of honeybees which probably dictate the flora richness of honey produced within the study sites (Districts). *Chromolaena odorate* (Asteraceae), *M. rhombifolia* (Asteraceae), *T. procumbens* (Asteraceae), *S. indica* (Verbenaceae), *S. cayennensis* (Verbenaceae), *A. indica* (Meliaceae), *C. papaya* (Caricaceae), *C. nitida* (Sterculiaceae), *C. dusenii* (Lamiaceae), *M. indica* (Anacardiaceae), *M. esculenta* (Euphorbiaceae), *S. dulcis,* (Plantaginaceae), *S. scabrida* (Malvaceae), *S. gilo* (Solanaceae), *T. triangulare* (Portulacaceae), *V. amygdalina*

Table 3: Visitation intensity of honeybees on plant species at Osogbo district

| Plant species | Flowering season | Average visit frequency of *A. mellifera adansonii* | Categorized visitation intensity |
|---|---|---|---|
| *Aspilia Africana* | Dry/rain season | 574 | +++ |
| *Carica papaya* | Rain season | 488 | +++ |
| *Chromolaena odorata* | Dry/rain season | 294 | ++ |
| *Emilia sonchifolia* | Dry season | 242 | ++ |
| *Melanthera rhombifolia* | Dry/rain season | 492 | +++ |
| *Merremiaum bellate* | Rain season | 68 | + |
| *Momordica charantia* | Dry/rain season | 310 | +++ |
| *Sidas cabrida* | Rain season | 224 | ++ |
| *Stachytarphe taindica* | Dry season | 268 | ++ |
| *Talium triangulare* | Rain season | 82 | + |
| *Tridax procumbens* | Rain season | 520 | +++ |
| *Zea mays* | Rain season | 216 | ++ |

+: (1-100) Occasionally visited, ++: (101-300) often visited, +++: (301-600) abundantly visited, Dry season: October-April, Rain season: May-September

Plate 1: Honeybee on flower of *A. africana*

Plate 3: Honeybee on flower of *S. indica*

Plate 2: Honeybee on flower of *T. procumbens*

Plate 4: Honeybee on flower of *C. dusenii*

(Compositae) and *Z. mays* (Poaceae) were identified honeybees foraged plant species at Ejigbo. Members of the family: Asteraceae were more abundant and frequently visited by honeybees followed by the family: Verbenaceae. While, *A. africana* (Asteraceae) *C. papaya* (Caricaceae), *M. rhombifolia* (Asteraceae), *M. charantia* (Cucurbitaceae) and *T. procumbens* (Asteraceae) were abundantly visited by honeybees at Osogbo. Other plant species are either often or occasionally visited. Akunne *et al*.[18] reported that 31 families were identified attractive to honeybees in Awka (Akwa Ibom state, Nigeria) and Agulu (Anambra state, Nigeria) environs with Asteraceae (31, 25%) being the highly visited botanical family, followed by Euphorbiaceae and Verbenaceae, respectively. From literature searches and the results of this study, members of the family: Asteraceae are well patronized by honeybees than other botanical families in Nigeria. However, from this study, there was no significant difference in the visitation intensity on different identified foraged plant species by *A. mellifera adansonii* at both study sites. *Tridax procumbens* (Asteraceae) was one of the 28 forage species listed by Mbah and Amao[6] in northern Nigeria and one of the 40 foraged plant species listed by Omoloye and Akinsola[14]. Also, in this study, *T. procumbens* had abundant patronage across Ejigbo and Osogbo districts, Osun state. From the results of this study and the reports of Mbah and Amao[6] and Omoloye and Akinsola[14], it showed that some plant species were more visited by honeybees across different ecological zones. This may probably because honeybees select and preferred to visit rewarding forage food sources within neighboring vegetative zones. In Zaria, *Vernonia kotschyana* (Asteraceae) was identified to be visited by honeybees as reported by Mbah and Amao[6] but in this study *Vernonia amygdalina* was identified at Ejigbo but often visited by honeybees. *Chromolaena odorata*, *M. indica*, *M. esculenta*, *V. amygdalina*, *Z. mays*, *A. africana*, *C. papaya*, *T. triangulare* and *T. procumbens* were foraged by honey bees at both study sites which were also identified by Ayansola and Davies[3]. It is recommended that (i) Cultivation of honeybees' preferred plant species should be encouraged around apiaries to improve annual yield of honey and other beehives' products (ii) Further researches should be conducted to examine the possibilities of using honeybees and alternative pollinators as efficient pollinators to improve and increase crop and fruit production (iii) Creating awareness and training of beekeepers and prospective beekeepers on how to identify local suitable and preferred plant species commonly visited by honeybees to boost production of beehives' products, hence empowering the citizenry.

## CONCLUSION

The study provides additional information on foraged plants visited by honeybees both at Ejigbo and Osogbo districts, Osun state, Nigeria. Members of botanical family: Asteraceae were identified as major sources of nectars and pollens identified in Osun state, Nigeria. Visitation intensity rate of honeybees depends on quantum of pollen or nectar reward from individual plants visited.

## SIGNIFICANCE STATEMENT

Honeys are nutritious products, mainly composed of carbohydrates, from honeybees, *Apis mellifera adansonii*, which are widely consumed as food globally and are also major ingredients in preparation of many Pharmaceutical products such as cough syrup. This study on bees foraged plants provide some lists of plant species and their botanical families within Osun state, Nigeria. These identified foraged plant species are sources of food for honeybees from which honey are produced and stored in honeycombs within beehives in the region. The richness of honey produced in specific regions is dictated by botanical and vegetational foraging sources which could be exploited for Apitherapy and health medication.

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