FORAGING SOURCES AND EFFECTS OF SELECTED PLANT CHARACTERS AND WEATHER VARIABLES ON THE VISITATION INTENSITY OF HONEYBEE, *Apis mellifera adansonii* (Hymenoptera: Apidae) IN THE SOUTHWEST NIGERIA

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Running Head: Foraging intensity of honeybee in Nigeria.

Received 17 February 2006; accepted 15 May 2006

Summary

This study identified field foraging sources and the effects of selected plant characters and weather variables on the visitation intensities of the honeybee, *Apis mellifera adansonii* in selected sites in Ibadan and Ogbomosho, Southwest Nigeria. Results indicated a total of 41 foraging sources of which 36 were common to the two sites while two other species were found to be exclusive to each of the studied locations. The activities of this bee species varied on the identified foraging sources for pollen or for nectar collection. Even when a plant; *Helianthus annuus* produced both pollen and nectar at the same time, visitation was for one and never for both pollen and nectar by a particular bee. The intensity of visitation was significantly higher ($p<0.05$) on *Cochlospermum tinctorium* (2732 times) than on other foraging sources being lowest on *Helianthus annuus* (184). Tall plants with comparatively larger size petals were preferred. No significant relationship was established between flower colour and visitation by the bees. Wind speed significantly ($p<0.05$) affected the intensity of visitation but the correlation between bee visitation and other weather parameters of solar radiation, temperature and humidity was negative. The peak of foraging activities of the bees was between 9 a.m. and 1 p.m. local time depending on the daily weather condition.

Keywords: Foraging sources, visitation intensity, *Apis mellifera adansonii*, plant characters, weather variables

INTRODUCTION

The species diversity of the honeybee, *Apis mellifera* L. in the parkland of Nigeria humid savannah and elsewhere in Africa is complex forming an integral component of the natural ecosystem (Culliney 1983, Adjare 1984, Ikediobi et al. 1985, Mutsaers 1991). *Apis mellifera adansonii* is about the most common that has been given due attention in Nigeria probably because of its beneficial attributes as a natural agent of pollination and as the most important of all insect pollinators (Melnickenko and Khalifman 1977, Jay 1986, Mutsaers 1991, Kumar et al. 1994). This species is the source of good quality honey that is commonly harvested in the wild in Nigeria until recent time (Ikediobi et al. 1985, Mutsaers 1991). Bee domestication in artificial nest is becoming very popular due to encouragement from the Nigerian government through the activities of National Directorate of Employment (NDE) and the National Poverty Eradication Project on self employment.

The overt role of honeybees in the Nigerian agro-ecosystem is evident with great potential at enhancing increased crop yields

but this potential is yet to be tapped (Melnickenko and Khalifman 1977, Jay 1986, Kumar et al. 1994). It is known that the quality and quantity of crop yield could be enhanced by up to 20 – 30% due to visitation by honeybees (Melnickenko and Khalifman 1977, Kumar et al. 1994). It is also known that honeybees could remain faithful to a food source as long as the foraging activities remain rewarding and not disrupted (Free 1970, Fletcher 1978, Dutton et al. 1981). They monitor sample and pool information about the most rewarding food sources available with highly developed system of recruiting nest mates to these sites (Jay 1986). This indicates that with good management, bee farming could develop in Nigeria and elsewhere in Africa beyond honey production to utilization for the purpose of artificial pollination of crops as it is done in the more developed economies of the world. To achieve this however, one of the major factors to consider is to identify the foraging sources within the ecosystem that the native honeybees prefer and visit as well as the factors that would affect their visitation activities and intensity (Esch and Burns 1996, Benedek et al. 1997). Preference of a food host by a bee may vary with host species, cultivars; periods as well as climatic factors especially wind (Benedek et al. 1997). Effective and efficient management which this study attempts to project would also improve quality of honey since honeybees in the wild could forage for several kilometres away from their hives thus expending most of the energy needed to produce good quality honey.

This study therefore sought to identify the important foraging sources and the effects of selected plant characters and weather variables on the visitation intensities of the honeybee, *Apis mellifera adansonii* in the parkland of Nigeria humid savannah.

MATERIAL AND METHODS

The study was carried out between October and March 2003 and 2004 in two locations: The Botanical Garden, University of Ibadan (7.23°N; 3.54°E at an altitude of 234 m above sea level) and the Bee Keepers Association Apiary, Ladoke Akintola University of Technology, Ogbomosho (8.08°N; 4.14°E at an altitude of 300 m above sea level) in the southwest Nigeria. Average annual rainfall at the two sites is between 1300 – 2000 mm with bimodal pattern. The mean relative humidity ranges between 60 and 80% while the mean solar radiation between 15 and 18 Mj/m^2/day. The ecological characteristics of these sites favour active foraging activities of honeybees (Mutsaers 1991).

Identification of the Foraging Sources

A census of plants at the study sites was carried out to identify common food hosts by observing at close range the activities of the honeybees. A preliminary checklist of all potential food hosts visited by the bees was compiled. The identity of these food hosts were confirmed at the Department of Botany (Herbarium Section), University of Ibadan, Nigeria. The family, common (local) names and the blooming period (seasonality) were identified for each of the plants.

Determination of the intensity of visitation of bees on selected foraging sources

Five foraging sources; *Oncoba spinosa*, *Cochlospermum tinctorium*, *Gliricidia sepium*, *Tridax procumbens* and *Helianthus annuus* were selected and used for this study based on: blooming period which coincided with the period of this study, moderate height which gives reasonable clear vision; ease of establishment and adaptation to local weather condition and relative abundance within the study area. The five

species were encountered in Ibadan whereas only three species; *Gliricidia sepium*, *Tridax procumbens* and *Helianthus annuus* were found and studied at the Ogbomosho site. The intensity of visitation by the foraging honeybee was visually monitored by recording the number of times a particular foraging source was visited by the bee, *Apis mellifera adansonii*. The record was taken on each plant per day for each hour between 8 a.m. and 6 p.m. (local time) using a hand-operated tally counter for a total of nine observations/plant species. The behaviour patterns of the bees were also observed along with the count data.

Plant characteristics and intensity of visitation

The characters of the selected five plants used in this study were measured on the field at the two sites. Height was physically taken using a tape measure. For the taller species, a pole was placed at a pre-set distance between observer and the tree and using the known height of the pole, the preset distance and the total distance from the observer to the tree, the actual tree height was estimated by mathematical formula: Tangent ⊘ = opposite / adjacent. Flower petal size was estimated using the graph sheet method. The petals were placed on the graph sheet, traced out with a pencil and the area calculated. The petal colour was superficially classified into white, yellow or purple and for emphasis, 'light' or 'deep' were used to qualify the flower colour. Weather data in the form of day temperature, day relative humidity, rainfall, day wind speed and solar radiation were taken daily electronically using standard equipment and measurements.

Data Analysis

All count data were pooled for each plant species and subjected to one way ANOVA where necessary and the means thereafter separated using the Tukey Honestly Significant test (HSD; p=0.05).

RESULTS

Foraging sources and activities of the honeybee in the southwest Nigeria

The foraging sources of the honeybee, *A. mellifera adansonii* found both at the Botanical Garden, University of Ibadan and the Bee Keepers Association Apiary at the Ladoke Akintola University of Technology, Ogbomosho are presented in Table 1. A total of 40 plant species were encountered as foraging hosts to *A. mellifera adansonii*. Of these 36 were found at both sites while two species were found to be exclusive to each location. *Blighia unijugata* and *Dialum guineense* were found only at the Bee Keepers Association Apiary in Ogbomosho while *Oncoba spinosa* and *Cochlospermum tinctorium* were found only at the Botanical Garden, University of Ibadan. It was also found that of the selected five plants species studied (Table 2), the flowers of *Oncoba spinosa* were visited exclusively for pollen whereas; the flowers of *Cochlospermum tinctorium* and *Gliricidia sepium* were visited for nectar only. The activities of the bees during nectar collections with their proboscis in order to suck nectar were obvious during each visit causing some distortions which did not form a definite pattern on the surface of the petals. *Helianthus annuus* produced both pollen and nectar simultaneously at the time of this study but each visit by a bee was for either pollen or nectar but never both per visit.

Relationship between selected plant characters and visitation intensity by honeybee

The relationship between the selected plant characters and visitation intensity by *A. mellifera adansonii* is presented in Ta-

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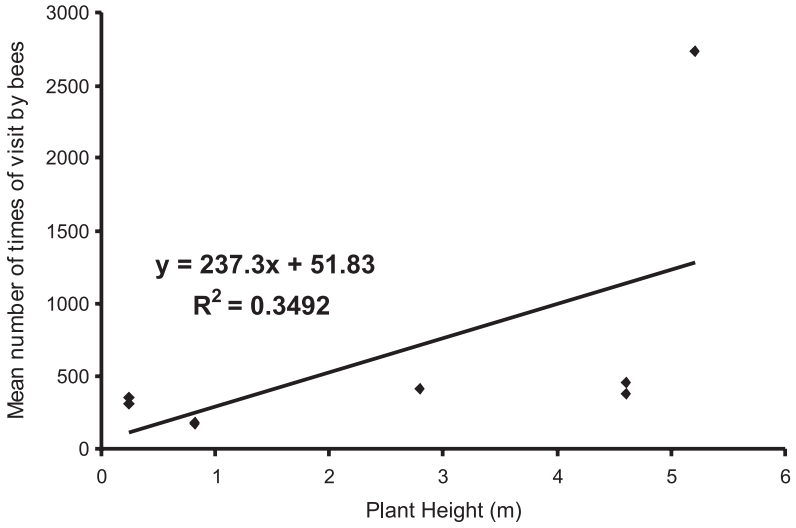

Fig. 1. Relationship between plant height and visitation intensity of the honeybee, *Apis mellifera adansonii* in Ibadan and Ogbomosho, Southwest Nigeria (n=9).

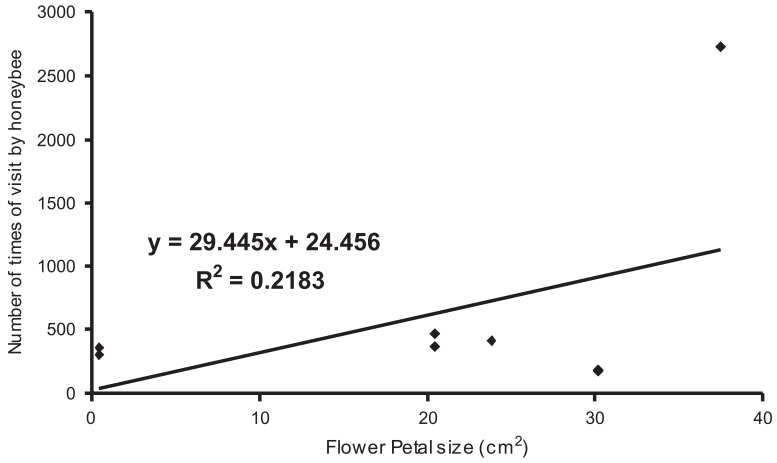

Fig. 2. Relationship between Flower petal size and visitation intensity of the honeybee, *Apis mellifera adansonii* in Ibadan and Ogbomosho, Southwest Nigeria.

ble 2 and Fig. 1 and Fig. 2. At the Ibadan study site, mean number times of visitation on *Cochlospermum tinctorium* (2732) was significantly higher ($p<0.05$) than on each of *Oncoba spinosa* (417), *Gliricidia sepium* (373), *Tridax procumbens* (357) and *Helianthus annuus* (184). The result also followed the same pattern at the Ogbomosho study site, being highest on *Gliricidia sepium* (462), followed by *Tridax procumbens* (311) and lowest on *Helianthus annuus* (168). The bees showed preference for taller plants than shorter plants. There was a positive linear correlation (defined by the equation $y = 237.3x + + 51.83$ and $r = 0.59$) between plant height and intensity of visitation by *A. mellifera*. Similarly there was comparatively weaker but positive correlation ($y = 29.445x + + 24.456$; $r = 0.47$) between flower petal size of the plants and intensity of visitation by *A. mellifera* indicating preference for

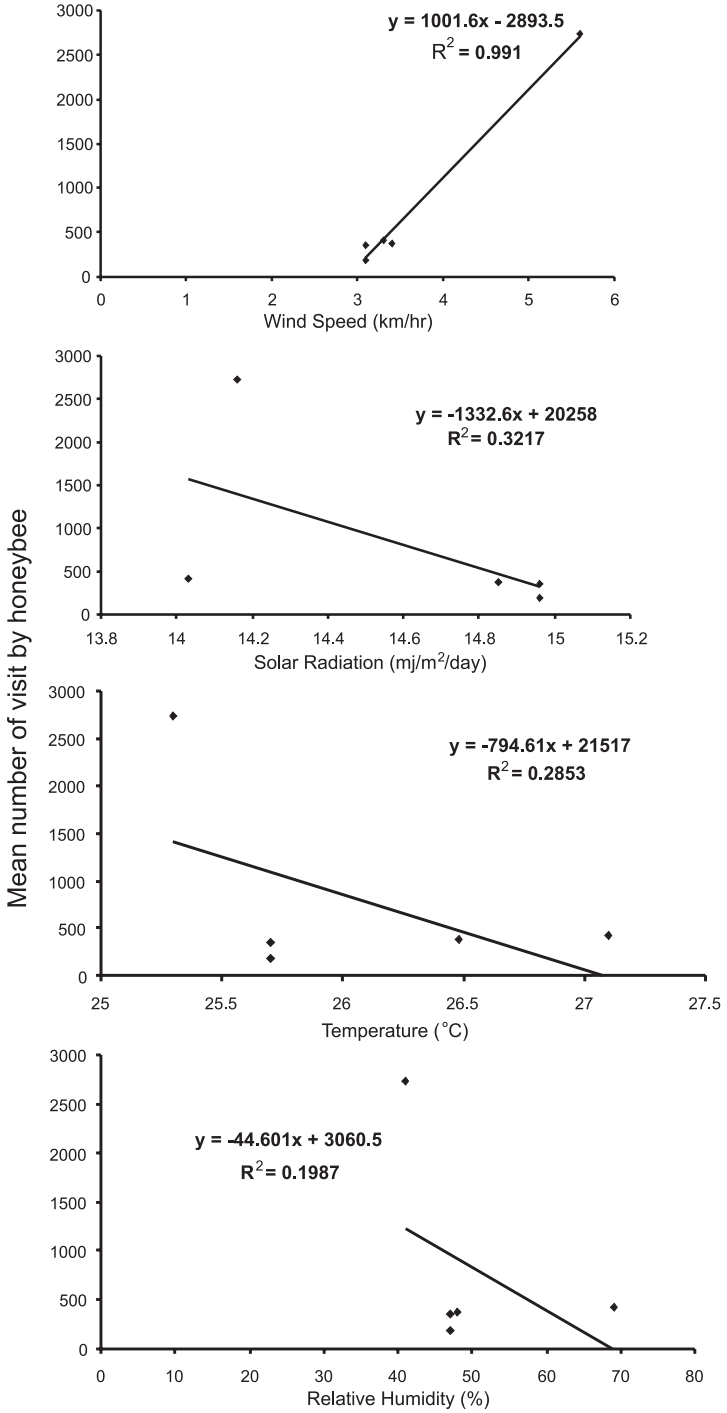

Fig. 3. Relationship between weather parameters (wind speed, solar radiation, temperature and relative humidity) and visitation intensity of the honeybee, *Apis mellifera adansonii* in Ibadan and Ogbomosho, Southwest Nigeria.

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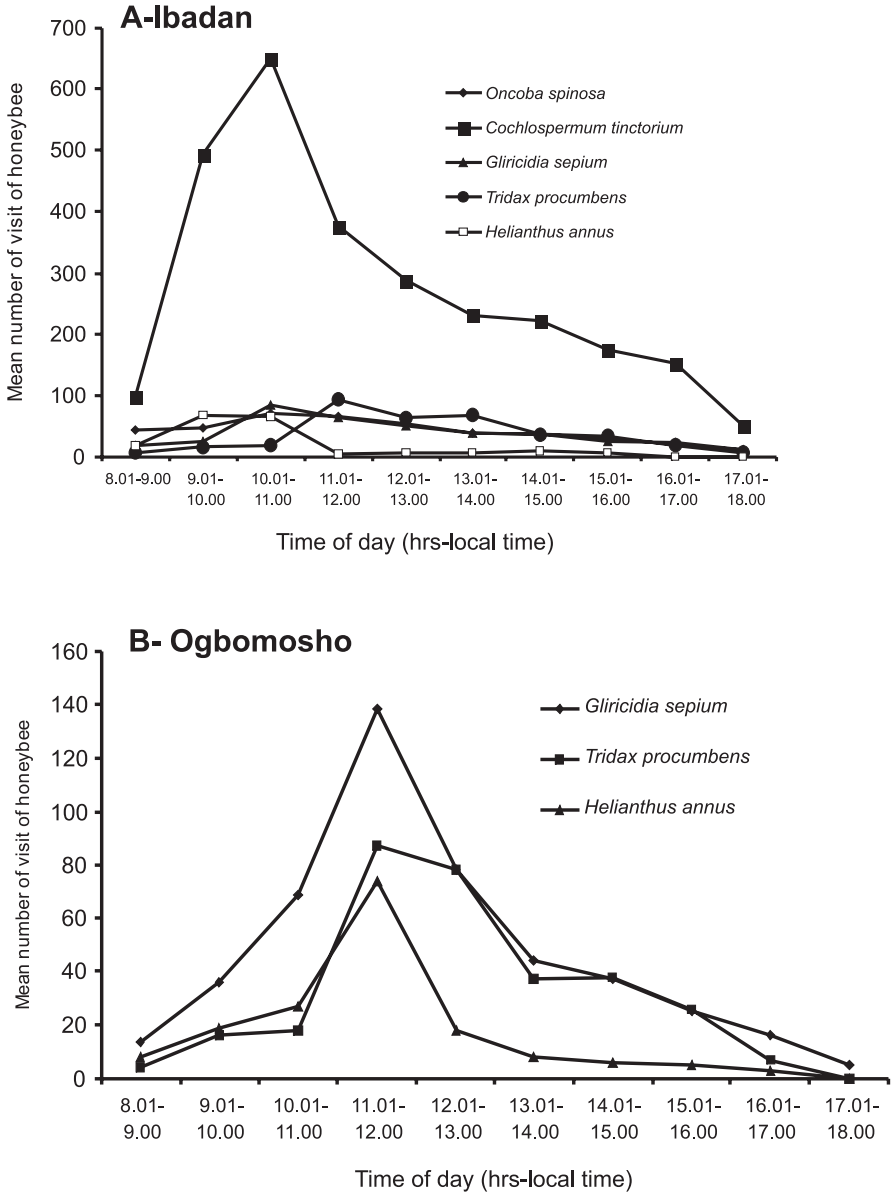

Fig. 4. Pattern of visitation of the honeybee, *Apis mellifera adansonii* in relation to actual time of day on five forging sources in Ibadan (A.) and tree foraging sources in Ogbomosho (B.) Southwest Nigeria.

larger flower sized plants. However no relationship could be established between flower colour and visitation intensity by the honeybees. For example, there was a significant difference ($p<0.05$) between visitation intensity by the bees on *Cochlospermum tinctorium* with highest visitation record and *Helianthus annuus* which recorded the lowest visitation record yet, both have similar yellow colours (Table 2).

Table 1.

Diversity of foraging sources of the honeybee,
Apis mellifera adansonii in Ibadan and Ogbomosho, Southwest Nigeria.

Forage species	Family	Seasonal Blooming period	Occurrence of species
Acacia albida	Fabaceae	Oct – Jan.	Encountered at all sites studied
Acacia nilitica	Fabaceae	Nov. – March	
Acacia goumansi	Fabaceae	July – Sept.	
Acacia polyacantha	Fabaceae	March – July	
Albizia glaberrima	Mimosaceae	Dec. – March	
Albizia lebbek	Mimosaceae	Nov. – March	
Alloyphilus africanus	Sapindaceae	May – Aug.	
Anacardium occidntalis	Anacardiaceae	Nov. – March	
Anogeissus eiocarpus	Fabaceae	Aug. – Sept.	
Azadirachta indica	Meliaceae	Dec. – May	
Berlima grandiflora	Fabaceae	Nov. – March	
Blighia unijugata	Sapindaceae	Dec. – March	Encountered at Ogbomosho only
Bombax bounpozense	Bombacaceae	Dec. – Feb.	Encountered at all sites studied
Burkea Africana	Fabaceae	Dec. – June	
Ceiba petandara	Bombacaceae	Dec. – Jan	
Chromolaena odorata	Asteraceae	Nov. – April	
Citrus sp.	Rutaceae	April – Sept.	
Combretum paniculatum	Combretaceae	Dec. – Feb.	
Combretum smeathmanni	Combretaceae	Jan. – Dec.	
Cochlospermum tinctorium	Cochlospermaceae	Nov. – March	Encountered at Ibadan only
Cocos nucifera	Palmae	All year round	
Dialium guinense	Fabaceae	May – Sept.	Encountered at Ogbomosho only
Elaeis guineensis	Combretaceae	All year round	Encountered at all sites studied
Erythrina senegalensis	Papilionaceae	Oct. – Jan.	
Gliricidia sepium	Fabaceae	Dec. – Feb.	
Helianthus annuus	Asteraceae	Nov. – Feb.	
Hevea brasiliensis	Anacardiaceae	Most seasons	
Luffa aegyptica	Cucurbitaceae	Sept. – Nov.	
Mangifera indica	Anacardiaceae	Nov. – Feb.	
Manihot esculenta	Euphorbiaceae	Sept. – Nov	
Naudea latifolia	Rubiaceae	April - May	
Oncoba spinosa	Flacourtaceae	Nov. – Jan.	Encountered at Ibadan only
Psidium guajava	Myrtaceae	April – May	Encountered at all sites studied
Royostonea regia	Palmae	Sept. – Jan.	
Solenostenon monostachyus	Lamiaceae	June – Sept.	
Spondias mombin	Asteraceae	March - April	
Taninum triangulare	Portulacaceae	April – Sept.	
Tetracera affin	Combretaceae	All year round	
Tetracera potatoria	Combretaceae	All year round	
Tithonia diversifolia	Asteraceae	Oct. – Dec	
Tridax procumbens	Asteraceae	April – Oct.	

Table 2.

Botanical characteristics of selected foraging sources in relation to visitation intensity of the honeybee, *Apis mellifera adansonii* in Ibadan and Ogbomosho, Southwest Nigeria.

Foraging sources	Plant type	Flower colour	Petal size ($cm^{2)}$	Plant height	Mean no. of visit by honeybee
Oncoba spinosa	Woody shrub	White	23.8 c	2.8 c	417 b
Cochlospermum tinctorium	Tree	Yellow	37.5 a	5.2 a	2732a
Gliricidia sepium	Woody shrub	Light purple	20.4 c	4.6 a	373 b
Tridax procumbens	Herb	Cream white	0.4 d	0.25 d	357 b
Helianthus annuus	Herb	Deep yellow	30.2 b	0.82 d	184 c

Means followed by same letter within the same column are not significantly different at p=0.01 (Tukey HSD).

Relationship between selected environmental variables and visitation intensity by honeybee

The relationship between weather parameters in terms of mean day temperature, day relative humidity, day wind speed and solar radiation and visitation intensity by *A. mellifera adansonii* is presented in Fig. 3. From this study, only wind speed affected the intensity of visitation of the honeybee to the foraging sources; thus there was a significantly positive correlation between the day wind speed and the number of visit to the foraging sources as defined by the equation $y = 1001.6x - 2893.5$; $r^2 = 0.995$. A negative correlation was established between the intensity of visitation by the honeybee and other weather parameters like solar radiation, temperature and humidity. This relationship was however not significant (Fig. 3).

Pattern of foraging activities in relation to time of day by honey bee

The pattern of visitation of the honeybee, *Apis mellifera adansonii* in relation to actual time of day on the forging sources at the two study sites is presented in Fig. 4. Generally foraging by the bees starts from day break and lasted till 18.00 hours (h) daily. The period of high foraging activities of the honeybees was between 9.00 hours and 13.00h (local time) depending on the type of the foraging resource visited. Whereas the peak of foraging activities was between 10 a.m. and 11 a.m. on *Cochlospermum tinctorium* at Ibadan, the peak of foraging by the bees was between 11 a.m. and 12 at noon on all the foraging resources at the Ogbomosho site.

DISCUSSION

The local foraging sources of the honeybee in the Southwest Nigeria are diverse probably due to the beautiful tropical environment that favours survival of many plants and insect species (Culliney 1983, Adjare 1984, Ikediobi et al. 1985, Mutsaers 1991). The ample diversity of foraging sources as recorded at the two sites covered in this study provide the necessary field environment for the bees to select and adopt a particularly rewarding foraging source. It is accepted in this report that there could be other plant species of importance to the forager bee within the geographical region covered in this study, therefore the list presented herein provides a guide to the local beekeeper in identifying the rich foraging resource for his bees in order to determine their abundance, time and duration of blooming and the attractiveness to bees for pollen or nectar. It has been well established for a long time that

one of the most difficult but very important problem faced by the local beekeeper is the determination of the foraging sources for which his bees collect nectar and pollen as well as an understanding of the blooming patter of these plant species (Lovell 1926). A well known characteristic of insect pollinated flowers is possession of pollen grains or nectar or both. The species sampled in this study were petaloid with bright colours. However it was found in this study that larger size of flowers rather than the colours was a major factor in the attraction of honeybees to the foraging sources. Pierre et al. (1996) reported that the efficient response of honeybees in cross pollination between apetalous and petalous lines and found a very low correlation between flower colour and visitation by bees. Therefore, attraction of honeybees to the foraging sources was due to interplay of several factors of which olfactory rather visual cues generated by nectar and pollen grains are key factors (Kaur and Sihag 1994, Sharma and Bichoo 1996, Omoloye et al. 2002a, b). Similarly in this study, *A. mellifera adansonii* responded positively to taller trees rather shorter shrubs or herbs. This is an altitudinal behaviour that is characteristic of good fliers. Esch (1996) had reported that flight altitude is important to honeybees for distance estimation by the retinal flow in the foraging bee probably because objects move faster and further across the retina when the bee flies close to the ground. It is also shown in this study that wind speed among other weather variables is directly related to high visitation intensity by the bees. Reason could be that olfactory cues are distributed and spread faster under windy conditions than in other weather factors. This finding agreed with Benedek et al. (1997) who reported that the most important environmental factor determining honeybee visitation is the wind speed. Temperature as well as solar radiation and relative humidity were negatively correlated to visitation by honeybees indicating that *A. mellifera adansonii* would not tolerate extremes of these weather factors. It is known that at higher temperature, bees compensated better for variations in the hive air temperature by dancing around the hives which follows the principle of selective heterothermy, thereby turning their thermal behaviour to the requirements of the daily activity at the time (Sharma and Bichoo 1996).

In conclusion, this study has shown the vast array of foraging sources available in selected sites in Southwest Nigeria. The study also showed that wind speed out of all weather variables is very important to the bees for survival on one hand as well as to the beekeeper for honey production and /or enhancement of crop production through artificial bee pollination of farms.

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ŹRÓDŁA POŻYTKU ORAZ WPŁYW WYBRANYCH CECH ROŚLINNYCH I ZMIENNYCH POGODOWYCH NA INTENSYWNOŚĆ OBLATYWANIA PRZEZ PSZCZOŁĘ MIODNĄ, *Apis mellifera adansonii* W POŁUDNIOWO-ZACHODNIEJ NIGERII

Omoloye A. A., Akinsola P. A.

Streszczenie

W pracy podano źródła pożytków oraz wpływ wybranych cech roślinnych i zmiennych pogodowych na intensywność odwiedzania przez pszczołę miodną, *Apis mellifera adansonii* na wybranych stanowiskach w Ibadanie i Ogbomosho w południowo-zachodniej Nigerii. Uzyskane wyniki wskazały na występowanie ogólnej liczby 41 źródeł pożytków, z których 36 było wspólnych dla obu stanowisk, a dwa inne występowały wyłącznie w jednej z badanych miejscowości. Nawet w przypadku gdy roślina, *Helianthus annuus*, wytwarzała w tym samym czasie zarówno nektar jak i pyłek, poszczególne pszczoły w czasie oblotu pozyskiwały albo pyłek albo nektar, a nigdy oba pożytki na raz. Intensywność oblotu była istotnie wyższa ($p<0,05$) w przypadku *Cochlospermum tinctorium* (2732 razy) niż w przypadku innych źródeł pożytku, a najniższa była w przypadku *Helianthus annuus* (184). Preferowane były rośliny wysokie o większych płatkach. Nie stwierdzono istotnej zależności między barwą kwiatów a odwiedzaniem ich przez pszczoły. Szybkość wiatru wpływała istotnie ($p<0,05$) na intensywność oblotu, ale korelacja między intensywnością oblotu a innymi czynnikami pogodowymi takimi jak promieniowanie słoneczne, temperatura i wilgotność była ujemna. Maksimum zbierania pożytku przez pszczoły występowało pomiędzy godziną 9 przed południem a 1 czasu lokalnego w zależności od warunków pogodowych w danym dniu.

Słowa kluczowe: Źródła pożytku, intensywność oblotu, *Apis mellifera adansonii*, cechy roślinne, zmienne pogodowe.