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Research Article

DIVERSITY ASSESSMENT OF BEES (HYMENOPTERA) ASSOCIATED WITH CROPS AND ORNAMENTAL PLANT IN OBAFEMI AWOLOWO UNIVERSITY, NIGERIA

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ABSTRACT

This study investigated the various species of bees in the Order Hymenoptera responsible for pollinating crop and ornamental plants in Obafemi Awolowo University (O.A.U.), Ile-Ife, and the study covered habitat preference, abundance and distribution of the bee species in various seasons. This was with a view to identifying and documenting the diversity of bees pollinating agricultural and ornamental plants for a meaningful conservation and management of insects in Nigeria. Bees collection was done using standard sweep net, to collect free range bees species on the sites. Standard yellow pan traps were also set using pineapple as bait to entice bees. Trapped bees were collected and baits were changed on daily basis. The bees were described and identified to species level using existing bee taxonomic keys. Host plants visited by the bee species were identified in the Natural History Museum Herbarium (UNIFEM) and Department of Botany Herbarium (IFE) in Obafemi Awolowo University, Ile-Ife. Paleontological Statistic Software Package (PAST) was used to analyze the collected data. The results of the study revealed that five (5) families of the bees - Apidae, Andrenidae, Anthophoridae, Megachilidae and Halactidae visited the habitats in the study area. Twenty four (24) bee species belonging to these families were collected in the five (5) habitats over the studied period. The family Apidae recorded the largest prevalence of nineteen (19) species collected while the families Anthophoridae, Megachilidae and Halactidae recorded the least prevalence of one (1) species each. The bee species found to be most responsible for pollinating crop and ornamental plants in O.A.U. were *Apis cerena, Apis mellifera* and *Apis dorsata*. The habitat of preference is Habitat A (Teaching and Research farm). The month of August was the peak period of bees visit in the study area while the months of July, August and September reflect the optimum time of bee species prevalence. This coincided with the peak period of rainy season and full inflorescence of crop and ornamental plants. Bee species in the study area prefer Habitat A (Teaching and Research Farm) in O.A.U. especially the Genus *Apis* due to the abundance, diversity of ornamental and crop plants.

Keywords: Abundance, Prevalence, Diversity, Conservation, Species.

INTRODUCTION

Bees are specialized type of flying insects that can be described as a key component of global diversity very much like the wasps and ants that are known for honey production, bee wax, royal jelly and propolis (Woodley *et al*., 2015). Varieties of their morphological features have adapted bees to collect, manipulate, convey and store pollen collected from flowers effectively. Bees feed on nectar (carbohydrate) for vitality and pollen for protein and other nutrient. Species of bees include the honeybees, bumble bees and stingless bees which are in various sizes, from the tiny stingless bee species (*Megachile pluto*) of about 2 mm long to the biggest species of leaf cutter bee about 39 mm long. They breathe socially in colonies while some characters are solitary in nature; they are very important in the ecosystem for the conservation of ecological processes for instance plant pollination (Genaro & Franz, 2008). The production of native and cultivated plants rests on pollination. According to Cardinal *et al*., (2010); Danforth *et al*., (2006) about 20,000 species of bees

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with seven recognized biological families; the super family Apoidea of a monophyletic lineage; reflected a clade Anthophilia common on every continent except the Antarctica. Bee keeping practice existed from the times of Ancient Greece and Egypt but there is a decline in wild bees' population (Berthoud *et al*., 2010). Cultured honey bees (*Apis mellifera*) are on the extinction in many regions of the world with growing evidence of inhabitants decline in population of the natural pollinators (Cameron *et al*., 2011; Carvalheiro *et al*., 2013). Bees have predators: their vertebrate predators comprise birds such as the bee devourers; insect hunters such as bee wolves; their invertebrate predators include the dragonflies and mites.

Bees are known to make a huge impact on people worldwide, providing food and proven medicinal components to science. Stingless bees in particular are extraordinary insects in that they act as pollinators to even the smallest plants. People have used stingless bee honey to cure a variety of sicknesses. For instance, bacteria population can be controlled using honey and have been used as anti-inflammatory. The immune system could also be boosted with honey consumption. Honey has also been used in regulating weight gain, fights fatigue and as energy booster. It has also been used to treat or prevent infections of the bladder and urinary tracts, relieves depression, and fights malnutrition. For example, the Luhya tribes of Kakamega forest are known to use honey to cure cough, chest pains, abdominal pains, ulcers and kidney stress. Some species of bees are known to facilitate large yield of fruits thereby increasing the profit and economic value of farm crops (UNICEP., 2010). Most plants depend on pollinators for their reproduction and productivity process even when there is no accurate figure attached to the degree of plant dependence (Jones *et al*., 1994; Klein *et al*., 2006). Bees show significant part in the imitation of flowering foliage contributing to the conservation and maintenance of genetic diversity of flowering plants (Bradbear, 2009). Insects' role in agriculture directly or indirectly cannot be over emphasized; the foraging role of insects either as generalist or specialist makes them very vital in ecological perspective and in the local economies such as gardens or farm settlements (Kremen *et al*., 2002). Bees preserve the ecosystem as they are also dependent on its balance (Roubik *et al*., 1995). Apart pollination, bees are indicator of quality habitat in areas where their community structure is ongoing (Dauber *et al*., 2003).

According to (Chacoff & Aizen, 2006) observed that in negative forest, Africanized honeybee *A. mellifera* present itself as the key pollinator to grapefruit flowers donating about 90% visit. Because of the capacity of *A. mellifera* to persist in agricultural landscapes, the frequency of visits of *A. mellifera* to grapefruit flowers decreased by more than twofold as distance to the forest increased and the flower-visiting fauna became reduced the negative forest special effects on flower- visiting insects inside grapefruit cultivated area had become increasingly prevalent. (Kremen *et al.*, 2002; Silveira, 2004) pointed out increased Agricultural activities in America has been a major threat to bees: deforestation, logging and clearance of pasture for cattle, mechanized farming has reduced animal and crop diversity intensely. There is diminish bee nesting and nurturing prospects through soil ploughing; extermination of adult and larval bees through the use of agrochemicals. According to (Santos Leal, 2006) in similar studies (Morandin & Kremen, 2013) that in coconut plantations (*Cocos nucifera*) bee abundance is low seemingly due to reduced nest site and hunting resources limited to *Cocos nucifera* due to declination of other plant species through clearance of grass for coconut.

MATERIAL AND METHODS

Study Area

The investigated site in this study was Obafemi Awolowo University (O.A.U.) campus, Nigeria which lies between longitudes 7º 33´ N and 7º 28´ N and latitudes 4º 27´ E and 4º 35´ E. The study area within Obafemi Awolowo University campus lies within 391600^{m}N and 385800^{m}N and 232000^{m}E and 237200^{m}E (Howell, 1997). The survey covered an area of Teaching and Research Farm, OAU Dam, Oxidation pond area, Commercial farm, Biological garden and Parks and Garden. (Figures 1-3). Obafemi Awolowo University campus is in the low-lying forest area (Tirvengadum, 1978) with semi-deciduous humid forest zone which (Chater, 1970; White, 1979) called Guinea-Congolean dry forest type. The dry nature of Ife forest is characterized by the shallow soil area on the inselberg (Hill 1, Hill 2 and Hill 3), where humid savannah vegetation developed. The campus of the University covers an area of 5600 ha which constitute the built-up area. The central campus area and the university farms occupy 3349 ha. As at 1985, forest regrowth which occupied an estimated 1234 ha were noticed around Hill 1 and Hill 2 on the Northwestern corner of the central campus area (Adejuwon, 1967).

Sampling period

The period of study cover April 2017 to March 2018 when local and wild bees were abundant in the area with abundant floral resources.

Collection Methods

The methods used for specimen collection on agricultural crops and ornamental plants included a standard Sweep net of about 38 cm in diameter (Plates 1-2) used to collect free range specimens that were spotted on the sites, and five (5) standard yellow pan traps, set on the sites (Plates 2-3), which bees visited every day. Bees were trapped and collected on daily basis and sweetener baits such as pineapple and rotten banana were used to entice them into the traps. All habitats were sampled throughout the period of collection. The host plants were also recorded. The trapped bees were captured in the sweep net or yellow pan trap; gently picked by hand into the killing jar (with a water-tight stopper containing 70-80% Chloroform in a

cotton wool which acted as an anesthesia and preservative pending the time of mounting, drying and storage.

Preservation of collected bees

The hairs and some other important morphological diagnostic features on the body of bees mat together when the specimen is not yet dried: bee preservation is best done dry with all cleanliness using entomological pin to mount the insect on the thorax before they were dry in the oven at temperature of about 10ºC for about 15 min making the specimen ready for identification and storage in an insect box. All the collected bees were carefully mounted, dried and stored in an insect box properly labelled.

The diagnostic characters of the bee were identified using a loop-LED light magnifying lens (20 × 21 mm). The specimens identified, and described to species level using existing bee taxonomic keys for proper identification after Apoid Systematic by Winfree, (2011) with data labels showing date, time and habitats of collection (Figure 4-12). Troublesome couplets were avoided from the key in the study and for convenience using current species names listed in the Bees of the World by Michener, (2013). Host plants were identified in the Natural History Museum Herbarium (UNIFEM) and Botany Department Herbarium in O.A.U., Ile-Ife. Paleontological Statistic Software Package (PAST) was used to analyze the collected data. The representative samples of the collected bee species were deposited in the Natural History Museum, O.A.U., Ile-Ife.

Bees' identification

Identification keys are important taxonomic tools for identifying insects (bees inclusive). The time of the year (months and season) and host plants visited by bees gave clues to the identification of the bees. As a result of all this, more than one set of taxonomic features were used to confirm the identity of bees. This study made use of dichotomous characters for proper identification and morphological descriptions that are presented not as definitive treatises, but bee morphology guides to the structures that has taxonomic significance. Much of the terminology used herein is taken after that of (Michener, 2013) which is widely accepted in Apoid systematics.

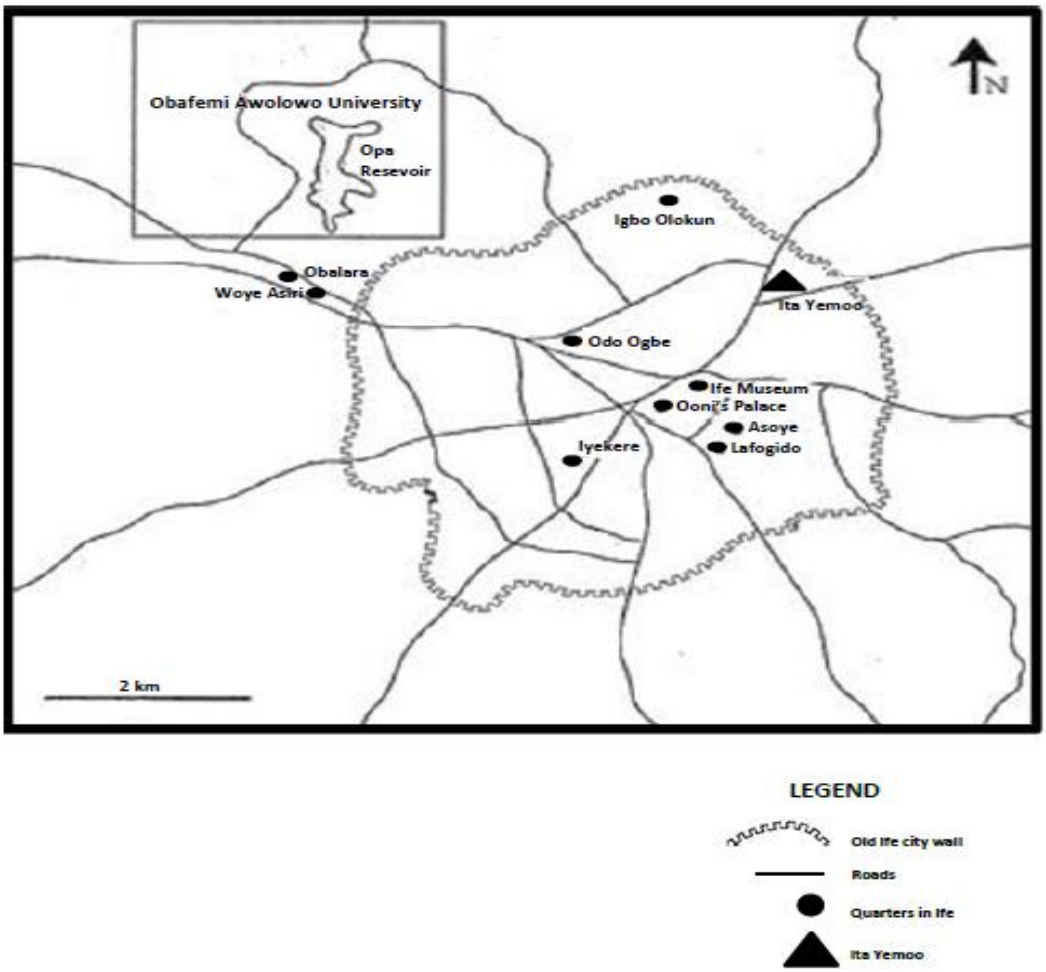

Figure 1. Map of Ile-Ife showing location of Obafemi Awolowo University, some quarters and expands of Old Ife city walls (Source: Babalola, 2015).

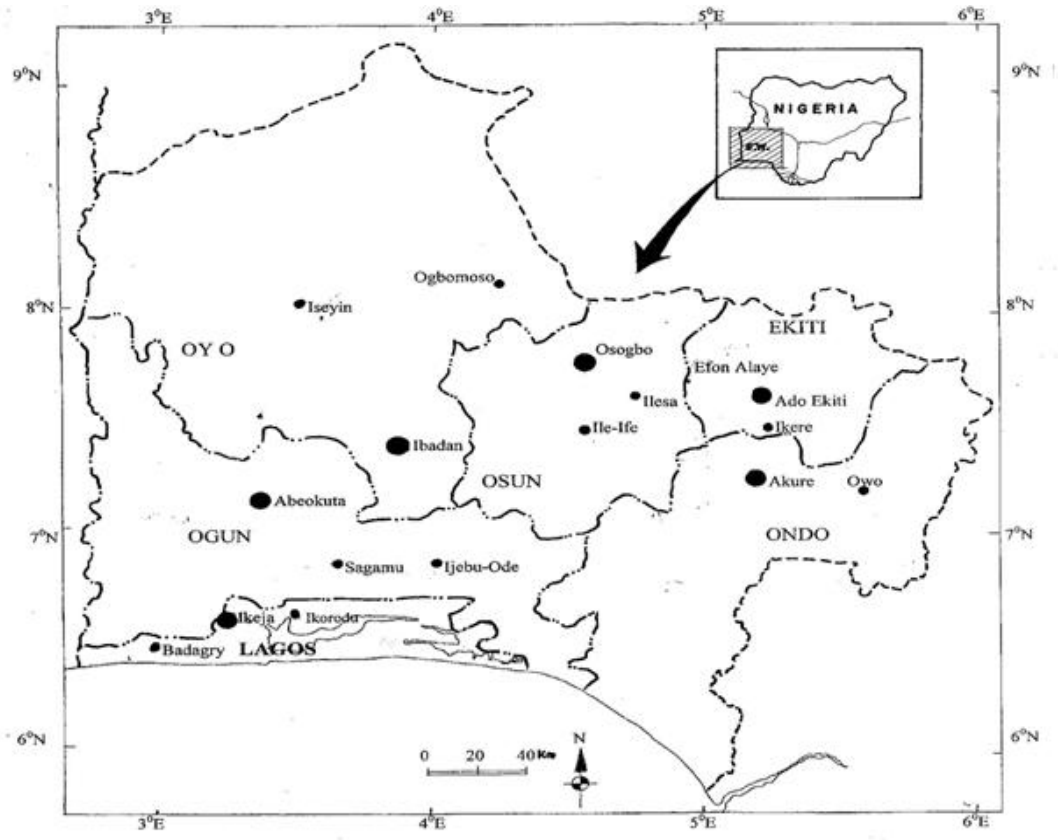

Figure 2. Southwestern Nigeria map showing State of Osun with location of Ile-Ife (Inset: Map of Nigeria).

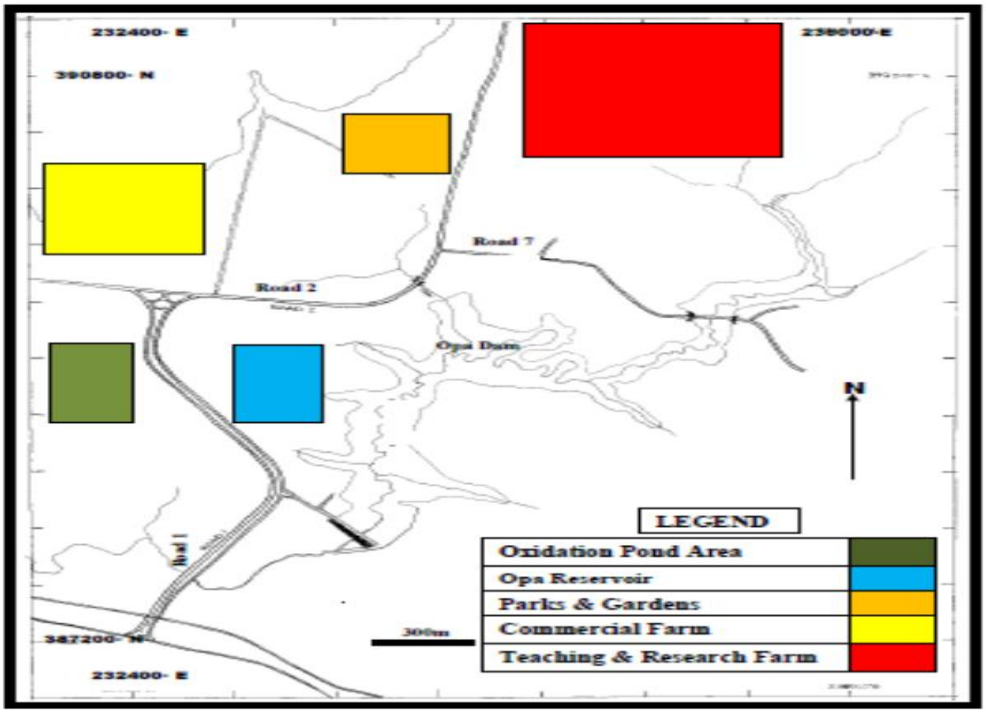

Figure 3. The build-up area Obafemi Awolowo University studied habitats (Source: Oyewole, 2013).

Figure 4. Yellow pan trap.

Figure 5. Close-up viewof yellow pan trap with trapped bees.

RESULTS AND DISCUSSION

Obafemi Awolowo University campus is an urban residential area with highly constructed built environment and has been managed by people over the decades; the campus habitats are completely different from the original vegetation cover, it's an environment with managed spaces, cultivated with indigenous and exotic ornamental and crop plants in the native flora. (Frankie *et al*., 2005) made similar assertions in their study of the ecological patterns of Bees and host ornamental flowers in two northern California cities of Albany and Berkeley which has been in consonance with the description of Obafemi Awolowo University landscape. McKinney, (2006) posited that Urbanization is a human activity that causes severe and irreversible habitat alteration; therefore, in accordance with (Tommasi *et al*., 2004) urbanization affects insect fauna negatively, therefore, some habitats in Obafemi Awolowo University campus may have been disturbed due to human activity (Westrich, 1996) however posited that in as much as the previous statements are true (i.e. Tommasi *et al*., 2004), man-made environments such as cultivated lands and gardens host a rich and abundant wild bee fauna; for any bee species to be present in an habitat, food and nesting substrates must be within its specific range of activity which is in accordance with the landscapes of Obafemi Awolowo University campus being investigated with the diversity assessment of bees associated with both ornamental and crop plants.

Table 1. Names of the collected bee species along family, genus, species and subspecies levels.

S.No.	Family	Genus	Species	Subspecies
1	Anthophoridae	Amegilla	Cingulate	
2	Andrenidae	Andrena	Cineraria	
3	Andrenidae	Andrena	Flavipes	
4	Megachilidae	Anthidium	Manicatum	
5	Apidae	Allodapula	Variegate	
6	Apidae	Apis	Cerena	
7	Apidae	Apis	Dorsata	
8	Apidae	Apis	Mellifera	Adansonii
9	Apidae	Apis	Mellifera	
10	Apidae	Apis	Mellifera	Iberiensis
11	Apidae	Apis	Mellifera	Mellifera
12	Apidae	Apis	Mellifera	Scutellata
13	Apidae	Exoneura	Robusta	
14	Apidae	Heterotrigona	Itama	
15	Halactidae	Lasioglossum	Malachrum	
16	Apidae	Tetragonula	Carbonaria	
17	Apidae	Tetragonula	Geissleri	
18	Apidae	Trigona	Carbonaria	
19	Apidae	Trigona	Fulviventris	
20	Apidae	Xylocopa	Caffra	
21	Apidae	Xylocopa	Micans	
22	Apidae	Xylocopa	Latipes	
23	Apidae	Xylocopa	Tabaniformis	
24	Apidae	Xylocopa	Varipuncta	

Table 2: Bee family and the names of the host plants family visited by the bees during the period of study

	Plant family	Bee family				
		Andrenidae	Anthophoridae	Apidae	Halactidae	Megachilidae
1	Asteraceae	X	O	X	O	X
2	Balsaminaceae	X	O	X	O	O
3	Boringaceae	X	O	X	O	O
4	Buxaceae	O	X	O	X	O
5	Caprifoliaeae	X	O	X	O	O
6	Caesalpinaceae	X	O	O	X	X
7	Caryophyllaceae	X	X	O	X	X
8	Combretaceae	O	O	X	X	O
9	Convolvulaceae	O	X	X	O	O
10	Elaeagnaceae	X	O	X	O	X
11	Geraminaceae	O	X	O	X	O
12	Lamiaceae	O	O	X	O	X
13	Myrtaceae	X	O	X	O	O
14	Monimiaceae	X	O	O	X	O
15	Oleaceae	X	O	X	O	X
16	Papaveraceae	X	O	X	X	O
17	Ranunculaceae	X	O	X	O	X
18	Rosaceae	O	X	X	X	O
19	Scrophuloniaceae	X	O	X	O	O
20	Solanaceae	X	O	X	X	X
21	Rubiaceae	O	X	O	X	O
22	Sapindaceae	O	X	X	O	X

23	Tiliaceae	X	O	X	X	O
24	Acanthaceae	X	O	X	X	O
25	Apocynaceae	X	O	X	O	O
26	Apiaceae	X	O	O	O	X
27	Arecaceae	O	X	O	X	O
28	Brassicaceae	O	X	X	X	X
29	Bromeliaceae	X	O	O	O	O
30	Corcubitaceae	O	X	X	O	O
31	Euphorbiaceae	X	O	O	X	O
32	Fabaceae	X	X	X	X	X
33	Lanraceae	X	O	X	O	O
34	Leguminoceae	X	O	O	O	X
35	Liliaceae	O	X	X	O	O
36	Malvaceae	O	X	O	X	O
37	Musaceae	O	O	X	O	X
38	Mimosaceae	X	O	X	O	O
39	Myrisinaceae	O	O	X	O	O
40	Meliaceae	X	O	X	O	O
41	Moringaceae	O	O	X	O	O
42	Nacardiaceae	X	O	X	X	O
43	Poaceae	X	X	X	X	O
44	Portulaceae	O	X	O	X	O
45	Pinaceae	O	O	X	O	O
46	Rutaceae	O	X	O	O	O
47	Rhamnaceae	X	O	X	O	X

Legend Present = X Not Present = O.

Table 3. Prevalence of the collected bees in their choice habitats

		Habitats				
Bee species	Family	A	B	C	D	E
Amegilla cingulate	Anthophoridae	X	X	X	-	X
	Andrenidae					
Andrena cineraria		X	X	X	-	-
Andrena flavipes		X	X	-	-	-
	Megachilidae					
Anthidium manicatum		X	X	X	-	X
	Halictidae					
Lasioglossum malachrum		-	-	X	X	X
	Apidae					
Allodapula variegate		X	X	X	X	X
Apis cerena		X	X	-	-	X
Apis dorsata					X	X
Apis mellifera adansonii		X	-	X	X	X
Apis mellifera		X	X	-	-	-
Apis mellifera iberiensis		X	X	-	-	X
Apis mellifera mellifera		X	X	-	-	X
Apis mellifera scutellata		X	X	X	X	X
Exoneura robusta		X	-	X	X	X
Heterotrigona itama		X	-	X	X	X
Tetragonula carbonaria		X	X	X	-	-
Tetragonula geissleri		-	X	X	X	X

Trigona carbonaria	X	X	X	-	X
Trigona fulviventris	-	-	X	X	-
Xylocopa caffra	X	X	-	-	X
Xylocopa micans	X	-	X	X	X
Xylocopa latipes	X	-	X	-	X
Xylocopa tabaniformis	X	-	-	-	X
Xylocopa varipuncta	X	X	X	-	X

Legend: A= Teaching and Research farm, B= Commercial farm, C= Oxidation Pond Area, D= Opa Reservoir, E= Parks and Garden, X= Present, - = Not Present.

Table 5. Prevalence of bee species in the study area.

Identification No.	Species	Number collected	Per cent Occurrence
1	*Apis cerena*	11	7.64
2	*Apis mellifera*	11	7.64
3	*Apis dorsata*	10	6.94
4	*Xylocopa caffra*	9	6.25
5	*Xylocopa latipes*	7	4.86
6	*Xylocopa tabaniformis*	7	4.86
7	*Anthidum manicatum*	7	4.86
8	*Exoneura robusta*	6	4.17
9	*Heterotrigona itama*	6	4.17
10	*Xylocopa micans*	6	4.17
11	*Xylocopa varipuncta*	6	4.17
12	*Amegilla cingulata*	5	3.47
13	*Andrena flavipes*	5	3.47
14	*Apis mellifera mellifera*	5	3.47
15	*Tetragonula carbonaria*	5	3.47
16	*Tetragonula geissleri*	5	3.47
17	*Trigona carbonaria*	5	3.47
18	*Apis mellifera adansonii*	5	3.47
19	*Andrena cineraria*	4	2.78
20	*Allodapula variegata*	4	2.78
21	*Apis mellifera iberiensis*	4	2.78
22	*Apis mellifera scutellata*	4	2.78
23	*Lasioglossum malachrum*	4	2.78
24	*Trigona fulviventris*	3	2.08
Total		144	100%

Figure 6. Inflorescense of Musca spp. (Musaceae) with visiting spices (arrowed).

Figure 7. Host plant *Manihot* spp.

Figure 8. A bee species (arrowed) visiting an inflorescence of *Musa* spp. (Musaceae).

Figure 9. A bee species visiting another inflorescence of *Musa* spp. (Musaceae) with pollens (arrowed).

Figure 10. A bee species inside an inflorescence of *Musa* spp. (Musaceae) (arrowed).

Figure 11. A bee species (arrowed) visiting an inflorescence of *Curcubita* spp. (Curcubitaceae).

Figure 12. A bee species (arrowed) visiting an inflorescence of *Curcubita* spp. (Curcubitaceae).

The findings of (Klein *et al*., 2006) suggest more diverse pollinator communities provide a higher quality and stable level of pollination activities to a greater number of crops. Five (5) families- Apidae, Andrenidae, Anthophoridae, Megachilidae and Halactidae with twenty four (24) species in the order Hymenoptera exist in five (5) habitats of O.A.U. Campus. This satisfies the first objective of this research which requires the determination of the various bee species visiting the study site; this is also in line with the second objective of the research which seeks to determine bee species responsible for pollinating crop and ornamental plants in O.A.U. These are the bee's species of Apis and Xylocopa species which ranked topmost among the pollinator recorded in the study; these are followed by *Apis dorsata*, then to be followed by *Xylocopa caffra*. The remaining species recorded in the study were also adjudged to be the pollinators of crop and ornamental plants on O.A.U campus even though their abundance are not as high as the initial four(4) species mentioned above.

Klein *et al*., (2006) stipulate intensely managed agricultural landscapes establishes local floral enhancements which increases pollinator richness, Habitat A (Teaching and Research farm) is an intensely managed agricultural landscape was highly preferred (least discriminated against) by the bees, which satisfy the requirement of third objective which seek to establish the habitat preference, prevalence of bee species within the season. Teaching and Research farm, O.A.U., is a restored habitat specifically meant to serve as a ground for studying both ornamental and crop plants; in accordance with (Kennedy *et al*., 2013) with many agricultural landscapes pollinators are at the risk of the use of pesticides and habitat loss reason why some bees species were not recorded. Though Habitat A has vegetative diversity,

studies revealed increasing local vegetative diversity boosts pollinator species richness and abundance this is in accordance with (Garibaldi *et al*., 2013) which stipulate that pollinators play critical role in plant reproduction in both natural and agricultural systems.

The finding of (Funk *et al*., 2008) suggested that by habitats restoration, conservation biologists and restoration ecologists recommends the reassembly of diverse ecological communities, while also enhance the ecosystem services these communities provides. In a similar vein, (Garibaldi *et al*., 2011; Potts *et al*., 2010) establish conservation and restoration of native pollinator communities is conservation imperative. Habitat E (Parks & Gardens) is a restored and conserved habitat with fairly similar conditions to Habitat A; Habitat E (Parks & Gardens) was the next preferred habitat.

CONCLUSION

Bee species in Obafemi Awolowo University prefer is Habitat A (Teaching and Research farm) where the highest prevalence of all the studied bee species were recorded during the months of July, August and September; the peak period of prevalence of bees was in the month of August when all the bee species collected in the study area were recorded. This period however coincided with the period of the raining season when plants were in full inflorescence. The abundance of Allodapula variegate (stingless bee) and *Apis cerena* and *Apis mellifera adansonii* (sting bee) were recorded especially in Habitat A which is a restored, conserved and well-managed habitat with both ornamental, crop and flowering plants which guarantee pollinators species such as bees sources of nectar and pollens and are not being threatened with the use of herbicides and pesticides which is always the case in the commercial farms.

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