Composition and interaction network of flower-visiting insects in Obafemi Awolowo University, Parks and Gardens, Ile Ife, Nigeria

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Abstract

Insect-flower interactions in crop fields and native vegetation habitats have been well studied. However, there is paucity of information on the flower-visiting insect communities of ornamental flower gardens and lawns especially in south-west Nigeria. This study examined the flower-visiting insect community of Obafemi Awolowo University Parks and Garden and their interactions with ornamental plants. Flower-visiting insects were sampled using three complementary sampling methods (Coloured pan traps, sweep netting along transects and timed observation within quadrat). The combination of sampling methods was to prevent bias of individual methods against some insect taxa. The insects collected belonged to 21 species classified into 10 different taxa. Bees (23.14%) and butterflies (26.24%) had the highest percentage composition of the insects collected while the least was observed in beetles (0.74%), wasps (1.49%) and midges (1.36%). Significant variation was observed in the attractiveness of the different species of ornamental plants to flower-visiting insects. *Hemilia patense* and *Caluna vulgaris* had the highest attractiveness in terms of mean abundance value 3.100 ± 1.434 and 1.800 ± 0.604 respectively of flower-visiting insects. Obafemi Awolowo University Parks and Gardens support a diverse community of flower-visiting insects and ornamental plants. The potential of these ornamental plant species as alternative source of floral rewards for flower-visiting insects and for promoting insect-flower interactions in urban ecosystems should be further investigated.

Keywords: Biodiversity; conservation; pollinators; ornamentals; flowering plants.

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Introduction

Insects are known to play several important ecological roles in the ecosystem through interaction with other fauna and flora. The interaction could be to provide food, shelter, and for defense and reproduction. These interactions are significant in our ecosystem stability (Burkle and Alarcón, 2011). According to Heil and McKey (2003) some plant species make food or housing to attract ants which defend the plants against herbivores or other enemies. However, one of the leading roles that flower-visiting insects play in the ecosystem is in their ability to effectively pollinate flowering plants (Potts *et al* 2010).

Insects mediate crucial ecosystem functions such as pollination and nutrient recycling (Frost and Hunter, 2004). Plant-pollinator interaction is one of the most common mutualistic relationships observed in nature through which plants offer floral reward to pollinators, and they eventually transfer pollen among plants to effect reproduction (Sahil and Conner, 2007). Associated with the pollination process are suitable anatomical and morphological fitness of the plant and the pollinator. These include the appropriate floral display as well as the availability of needed floral resources in plants and the pollinator's sensory capabilities (Vrdoljak *et al* 2016).

Munyuli (2011) described immense agricultural and economic importance of pollinators. According to Klein *et al* (2007), the value of pollination to agriculture globally has been estimated to worth US$226 billion. Most insects visit flowering plants for nectar and other floral rewards as a basic or secondary nutritional source for energy and other life processes (Nicolson and Thornburg, 2007). These insects are known for their pollination service to wild plants and crops among other important services rendered in the ecosystem. This group is broadly known as flower-visitors and the insect taxa involved are mostly species of bees, wasps, and ants (Hymenoptera), true flies (Diptera), butterflies and moths (Lepidoptera), some families of beetles (Coleoptera), thrips (Thysanoptera), specialized members of Zaprochilidae (Orthoptera) and springtails (Collembola) (Kevan and Baker, 1999).

In recent years, the conservation of insect pollinators has become a significant concern (Potts *et al* 2010; Vanbergen *et al* 2013; Teichroew *et al* 2017). Despite the important role of insects and other visitors involved in pollination service in terrestrial ecosystems, basic information about plant – pollinator interactions such as attractiveness and floral reward of different flowering

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plants; as well as effectiveness of different species of pollinators are lacking or incomplete for many flowering plant species (National Research Council, 2007). These gaps in knowledge have made it difficult to develop management strategies for the conservation of important pollinator species (Shepherd *et al* 2003). Parks, gardens, ornamental flower lawns and other areas allocated for the cultivation of flowering plants in urban settlements are associated with high species diversity of flower-visiting insects (Helden and Leather, 2004; Fetridge *et al* 2008; Owen, 2010) with a large proportion of this found on private established gardens (Goddard *et al* 2010). According to Baiyewu *et al* (2005), garden plants are usually ornamental flowering plant species, often grown to serve the purpose of ornamentals and for aesthetic values, although many gardeners promote wildlife friendly ecosystems by cultivating these plants to attract insects and other pollinators (Good, 2000).

In Nigeria, ornamental plants are planted mostly for aesthetic values and little is known about their potential value for conservation purposes and for promoting insect-flower interactions in gardens. Elsewhere, a number of recommended lists of plants for the purpose of promoting wildlife-friendly ecosystems have been published by different professional organizations such as the Royal Horticultural Society, (Rice, 2011) and Xerces Society, (Mader *et al* 2011). However, these data vary in its application between regions and countries. According to Bankole, (2002), there has been under-cultivation of ornamentals in the country. Oseni (2004) also emphasized the need for more cultivation of ornamentals for the purpose of conservation as well as for agricultural and horticultural development in Nigeria. The objectives of this study are, therefore to determine the taxonomic composition and abundance of flower-visiting insects, and to determine the composition of ornamental plants and their attractiveness to flower-visiting insects on Obafemi Awolowo University (OAU), Ile Ife Parks and Gardens.

Materials and methods

Study site

The study site is the OAU Parks and Gardens, a flower-rich horticultural garden in a university campus in south-west Nigeria. This area lies between Latitudes 07° 26'N and 07° 32′N and Longitudes 004° 31′E and 004° 35′E (Figure 1). The ambient temperature of this area is between 20°C and 30°C, with a mean of 26°C. The plant community of the site consists of ornamental and non-ornamental plants like *Hibiscus rosa-sinensis* Linn., *Sida acuta* Burm., *Aspilia Africana* Pers., and common trees like *Alstonia boonei* De Wild., *Azadirachta indica* A. Juss. as well as common weeds such as *Tridax procumbens* Linn., *Commelina congesta* Clarke, *Synedrella nodiflora* (L.) Gaertn., *Sida acuta* Clarke.

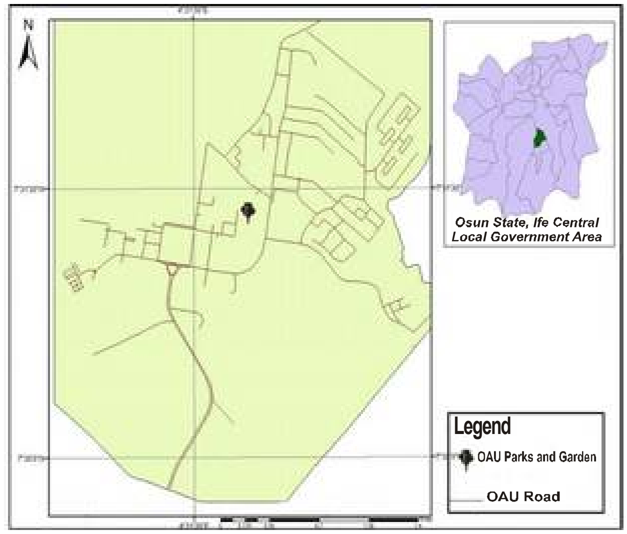

Figure 1. Map showing the study location on Obafemi Awolowo University, Ile Ife.

Source: ArcGIS version 10.1.

Sampling of flower-visiting insects

Flower-visiting insects were sampled on a monthly basis for five months, from November 2014 to March 2015 on the study-site using three different sampling methods. Insects were sampled using sweep nets across two 50 m transects placed along the length of Parks and Garden premises in each month of sampling. Sampling was conducted between 09:00 and 16:00 on days with no rain and low cloud cover. A 4 m^2 quadrat was placed around ornamental plant species such that the plants being sampled were at the centre of the quadrat, Insects observed visiting flowers within the quadrat during a 15 minutes observation were collected with sweep net and stored in 70% ethyl alcohol for subsequent identification. The third sampling method involved the use of coloured pan traps (blue, yellow and white) to trap insects. Twelve coloured bowls (50 ml each, four bowls of each of the three colours), were placed randomly on the site during each month of sampling. The bowls were half filled with water with a few drops of liquid detergent to break surface tension and enhance insect trapping. The bowls were left on the site for a period of 48 hours and insects collected were sieved and preserved in 70% ethyl alcohol for identification. Transect observation complemented the use of pan traps in sampling the flower-visitor community of the garden. This is in keeping with previous studies in which the need to combine sampling methods to reduce the biases of individual sampling methods was emphasized (Williams *et al* 2001). This will ensure that flower-visitors with different life history traits are represented in the sampled-insect community. Insects were identified with the aid of reference collection in the Department of Zoology, Obafemi Awolowo University, Ile Ife, Nigeria.

Identification of flowering plants

The list of ornamental plants in the garden was obtained from the garden managers at the commencement of the study. The plant specimens were collected using pocket knife to cut the plants with shoots, leaves and flowers which was placed into moistened polythene bags. The collected flowering plants were identified at Ife Herbarium, Obafemi Awolowo University, Ile Ife. The identified plants were compared with the list of plants obtained from the garden managers to ascertain the identity.

Statistical analyses

The difference in the overall abundance of flower-visitors among different taxa was analysed using one-way analysis of variance (ANOVA). Post hoc analysis for mean significance was performed using Student-Newman-Keuls test. Species diversity was also estimated using Shannon Weiner's diversity index. Similarly, one-way ANOVA was used to analyse the difference in abundance among insect taxa for each sampling method. Two-way ANOVA was used to analyse the attractiveness of the ornamental plant species to flower-visitors in terms of their abundance and species richness. All analyses were performed using SPSS version 22. An insect-flower interaction network was plotted using bipartite package in R (version 3.0.1, R Development Core Team, 2013).

Results

Taxonomic composition and abundance of flower-visiting insects

A total of 820 insects were collected during the study. The samples constitute 4 orders, 15 families, 16 genera and 20 insect species. Butterflies had the highest percentage composition followed by bees with values of 25.80% and 22.80% of the total insect composition respectively while scarabid beetles showed the least percentage composition of 0.73% (Table 1). There was a significant difference in the mean abundance of flower-visiting insect taxa collected during the study ($F_{8,36}$= 9.168, *p*=0.000). The highest mean abundance was observed for butterflies and bees followed by hoverflies and ants while the insect taxa with the least mean abundance were moths and wasps (Figure 2).

Table 1. Percentage composition of flower-visiting insects sampled.

Order	Common names	Percentage % composition	Total	Species	Percentage % composition
Hymenoptera	Bees	23.14	187	*Meliponula bocandei*	3.97
				Apis mellifera	6.26
				Lasioglossum sp.	12.91
Lepidoptera	Buttterflies	26.24	212	*Danaus chrysippus*	3.20
				Leptotes pulcher	1.25
				Nepheronia argia	5.50
				Nymphalidae sp.	0.50
				Neptis morose	2.06
				Papilio demodocus	2.97
				Acraea pseudoginia	8.80
				Nepheronia pharis	0.50
				Nepheronia thalassina	1.46
Hymenoptera	Wasp	1.49	12	*Ichneumonoidea* sp.1	0.86
				Ichneumonoidea sp.2	0.63
Coleoptera	Beetle	0.74	6	Scarabaeidae sp.	0.74
Diptera	Hoverflies	20.17	163	Syrphidae sp.	20.17
Diptera	Housefly	3.71	30	*Musca domestica*	3.71
Diptera	Mosquito	4.83	39	Culicidae sp.	4.83
Hymenoptera	Ants	18.32	148	Formicidae sp.	18.32
Diptera	Midges	1.36	11	Blephariceridae sp.	1.36
	Total	**100**	**808**		**100**

Pan trap and transect sampling

The total collection from the pan traps was 102 individuals of flower-visiting insects made up of seven families, eight genera and nine insect species. The mean abundance of insects collected with pan traps varied significantly ($F_{5, 30}$ = 2.836, *p*<0.05) with hoverflies having the highest mean abundance and house flies having the least (Figure 3). Also, significant difference was observed in the mean abundance of insects collected in different colour of bowls ($F_{2, 21}$ = 31.336, *p*<0.05) with yellow bowls having the highest mean abundance (Figure 4) and containing all the insect species collected in the blue and white bowls.

A total of 523 insects belonging to 11 families, 13 genera and 14 species were collected along the transects. Insect-flower interactions were observed on nine ornamental flowering plant species (Plate 1, Table 2). There was significant difference in the abundance of insects sampled using this method ($F_{5, 24}$=10.284, p<0.05) (Figure 4). Mean abundance was lowest for wasps but it was highest for butterflies (Figure 5).

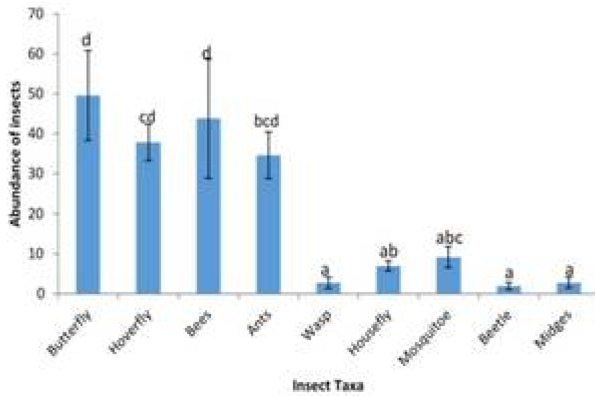

Figure 2. Mean abundance (±SE) of insects collected with all sampling methods. Bars with the same alphabets are not significantly different at p>0.05.

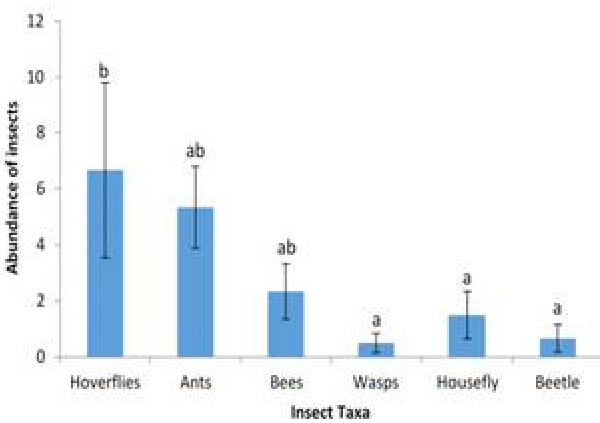

Figure 3. Mean abundance (±SE) of insects collected with pan traps. Bars with the same alphabets are not significantly different at p>0.05.

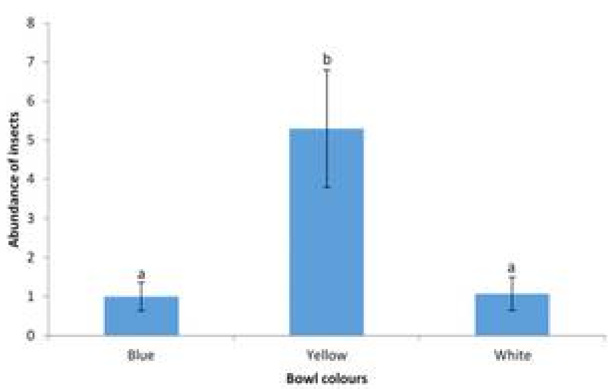

Figure 4. Mean abundance (±SE) of insects collected in pan traps of different colours. Bars with the same alphabets are not significantly different at p>0.05.

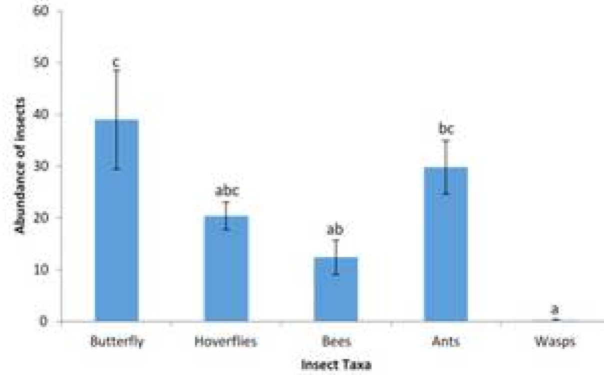

Figure 5. Mean abundance (±SE) of insects collected along transects. Bars with the same alphabets are not significantly different at p>0.05.

Plates 1. (A) *Hamelia patens,* (B) *Brunfelsia* sp., (C) *Catharanthus roseus,* (D) *Euphorbia milii,* (E) *Hibiscusrosa-sinensis,* (F) Unidentified purple-grass, (G) *Calluna vulgaris,* (H) *Mussaenda elegans,* and (I) White dracaena.

Table 2. List of ornamental flowering plants sampled during the study.

Plant species	**Common name**	**Origin**
Calluna vulgaris Linn.	Heather plants	Europe
Euphorbia milli Moul.	Christ thorn	Madagascar
Brunfelsia sp.Linn	Raintree	Brazil
Haemelia patens Jacq.	Fire bush	Tropical and sub-Tropical America
*Hibiscus rosa-sinensis*is Linn.	China rose	Tropical Asia
Catharanthus roseus Linn.	Rose periwinkle	Madagascar
Mussaenda elegans Linn.		Tropical Asia and Africa
Unidentified species	–	–

Table 3. Mean difference in abundance and species richness of flower-visiting insects observed on different plant species.

Plant	Mean insect abundance ± SE	Mean species richness ± SE	Mean species diversity ± SE
Calluna vulgaris	1.800 ± 0.604ab	4.200 ±2.200a	0.844 ± 0.405a
Euphorbia milli	0.758 ±0.331ab	1.800 ± 0.917a	0.489 ± 0.262a
Brumfelsis sp	0.350 ± 0.136a	1.400 ± 0.872a	0.456 ± 0.281a
Mussaenda elegans	0.975± 0.216ab	3.400 ± 1.778a	0.834 ± 0.305a
White dracaena	0.45±0.153a	1.800 ± 1.114a	0.560 ± 0.343a
Purple grass	0.950 ± 0.328ab	1.600 ± 1.122a	0.328 ± 0.328a
Catharanthus roseus	0.725± 0.428ab	0.800 ± 0.583a	0.199 ± 0.199a
Hibiscus rosa-sinensis	1.500 ± 0.366ab	2.200 ± 1.428a	0.731 ± 0.452a
Haemelia patens	3.100 ± 1.434b	2.800 ± 2.800a	0.383 ± 0.383a

Means with the same alphabets are not significantly different at *p*>0.05.

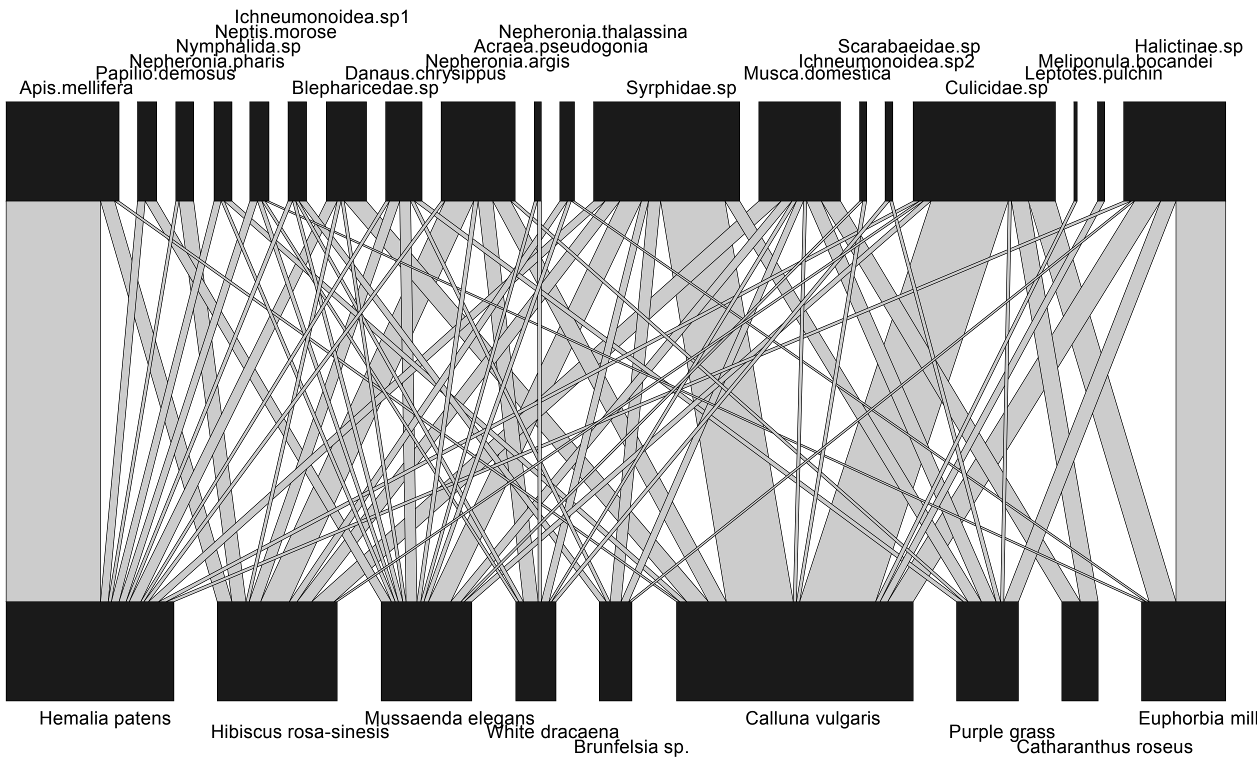

Figure 6. Insect-flower interaction web of flower-visitors and blooming ornamental plants sampled on OAU Parks and Garden.

Interaction network and flowering plant attractiveness

A total of 21 insect species were observed in interaction with 9 ornamental flowering plant species (Figure 6). There was a significant difference in the attractiveness of different flowering plant species based on the abundance of flower-visiting insects observed on individual plant species ($F_{8,171}$ = 2.170, *p*=0.032).

H. patens and *C. vulgaris* had the highest mean abundance of flower-visitors (Table 3, Figure 4). However, no significant difference was observed in the species richness ($F_{8,36}$ = 0.457, p>0.05) and the species diversity ($F_{8,36}$ = 0.427, *p*>0.05) of flower-visiting insects visiting different species of flowering plants. *Apis mellifera adansonii* was observed to be the most dominant visitor with the highest abundance of 41.90% of the total visitors observed on *H. patense.* However, *C. vulgaris* attracted greater percentage of Syrphidae, Culicidae and Halictidae with a composition of 25.00%, 19.44% and 19.44% respectively, compared to other species of insects observed visiting the flowers.

Discussion

This is the first published account of the flower-visiting insect community of OAU Parks and Gardens, a site established for aesthetic and recreation purpose with a rich community of ornamental flowering plants, shrubs and few trees that could be beneficial to flower-visitng insects. Urban areas are often with low native plant diversity but could support rich community of ornamental plants often cultivated for aesthetic purpose (Goddard *et al* 2010). Kehinde and Samways (2014) also recorded high abundance of flower-visiting insects comprising of butterflies and bees in rich flowering areas. In addition to their aesthetic value ornamental plants if carefully selected and well managed could serve as alternative source of floral resources for flower-visitng insects hence supporting their biodiversity (Kehinde *et al* 2013). Bees, hoversflies and butetrflies have been identified as the most important flower-visiting insects collecting floral rewards and contributing significantly to the pollination of crop and native vegetation globally (Klein *et al* 2007). The dominance of bees and butterflies in the flower-visitor community of agricultural and native vegetation areas have often been reported (Munyuli, 2011), with little knowledge of their ornamental and exotic plants species as shown in this study. A recent study on flower-visitors of garden plants in the United Kingdom reported bees as the most abundant flower-visitor to 32 native and ornamental plant species (Garbuzov and Ratnieks, 2014).

Apart from bees, this study also showed that nine butterfly species contributed significantly to the abundance of flower-visitors sampled in OAU Parks and Gardens. The diversity of nectar feeding butterflies have been reported to reach its peak in the tropics (Scoble, 1995). Amusan *et al* (2014) showed that OAU Parks and Gardens and other flower rich habitats supported the highest abundance and composition of butterflies on OAU campus. Butterflies, bees and hoverflies which had higher abundance compared to other flower-visitor taxa in this study are known to be obligate florivores which could out-compete other facultative flower-visiting taxa in the forage for flower resources and become the dominant flower-visitors in the habitat as observed in Larson *et al* (2001).

This study also showed that pan traps were effective in sampling two of the flower-visiting taxa but less effective for sampling butterflies. It has been reported that the sampling effectiveness of pan traps could be affected by pan trap colour and the colour of the floral part of flowering plants (Leong and Thorp, 1999; Meyer, 2005). The yellow coloured pan trap was the most effective as it had the highest abundance and richness of flower-visitors compared to the other two colours used in this study. The use of high reflectance colour like yellow for pan traps has often been reported for its effectiveness in sampling flower-visiting insects, most especially bees (Munyuli, 2012) and in studies of other groups of pollinators (Vrdoljak and Samways, 2012).

The insect-flower network showed that all ornamental flowering plants on this site were visited by insects. In establishing native and exotic flower gardens in the environment, preference should be given to flowering plants providing the richest floral rewards for the flower-visitng insect community. This will ensure that gardens and parks in urban areas serve as alternative resource habitat to flower-visitors hence promoting biodiversity while providing aesthetic and recreational functions (Stelzer *et al* 2010). This study found two flowering plants species; *H. patens* and *C. vulgaris* as the most attractive to flower-visiting insects. Futher studies should be carried out to establish the floral ecology of these flowering plant species, the accessibility and nutritional value of their floral resources to flower-vistors and their potential for mass cultivation in parks, gardens and urban areas in south-west Nigeria. *H. patens* showed high attractiveness to *A. mellifera* and it could be futher investigated for its potential to provide rich floral reward to honeybees hence the possibility for its mass cultivation by apiculturists in addition to other indigenous plant species.

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