Asian Journal of Environment & Ecology

16(2): 10-19, 2021; Article no.AJEE.72862
ISSN: 2456-690X

Beneficial Insects Visiting Florals of *Hamelia patens* Rubiaceae (Jacq.) at a University Landscape in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2021/v16i230243
Editor(s):
(1) Prof. Daniele De Wrachien, State University of Milan, Italy.
Reviewers:
(1) Xia-Lin Zheng, Guangxi University, China.
(2) L.D. Amarasinghe, University of Kelaniya, Sri Lanka.
Complete Peer review History: https://www.sdiarticle4.com/review-history/72862

Original Research Article

Received 18 June 2021
Accepted 22 August 2021
Published 25 August 2021

ABSTRACT

Aim: The study was carried out to ascertain how *Hamelia patens* would be valuable in sustaining diversity of beneficial insects.
Study Design: Investigative cross-sectional study.
Place and Duration of Study: The study was carried out at University of Port Harcourt, Nigeria. The insects and plants were processed for identification at the Laboratories of the Department of Animal and Environmental Biology and Plant Science and Biotechnology, University of Port Harcourt, Nigeria. Identification and curation of the insects was done at Insect Museum, Ahmadu Bello University Zaria, Nigeria. The study started in June and ended in September 2018.
Methodology: The heights and canopy sizes of the *Hamelia patens* were measured with range pole and measuring tape. Insects associated with the floral parts of *Hamelia patens* were collected in the morning (08:00-10:00 am) and in the evening (4:00-06:00 pm) hours, with a sweep net. They were knockdown by pyrethrum insecticide and preserved in a bottle containing 70% ethanol. They were

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taxonomically grouped and sent to a taxonomist at Insect Museum, Nigeria for species identification.
Results: Fifteen (15) insect species were collected on the *Hamelia patens*; *Megachile mephistrophelica* (Grib.), *Megachile cinta* (Fab.), *Braunisca bilunta* (Enderloein.), *Pterandus* sp., *Lilioceris* sp. and *Virachola antalus* (Hoph.) restricted their visitation on the plants only in the morning hours, *Chelonus bifoveolatus* (Szepg.) and *Chrysolagria nairobana* (Borch.) restricted their visitation in the evening hours. The remaining species were continuous on the plants. There was no significant difference (P=.05) between the number of insect species collected on taller plants and shorter ones. There was a significant difference between the insects that visited the plants in the morning and evening hours.
Conclusion: The arrival of the insects on the *Hamelia patens* varied but some were time dependent. The clipping of the plant's twigs affected the abundance of insects that visit the plant.

Keywords: Landscape; fragmentation; Hamelia patens; insects.

1. INTRODUCTION

Insect diversity as a biological subset of biodiversity is the assessment of the number and variety of insect species within a specified region. The diversities of insect species that exist in the tropics is so fascinating though many of them have not been identified. Insects provide a lot of ecosystem services for mankind and his environment [1, 2]. Insect diversity explores variety of insects at all levels starting from genetic variants that belong to a single species, to different arrays of species that are arranged to form series of genera through families, orders, classes, phyla and kingdom, and transcends to higher taxonomic level in a variety of ecosystems [3]. Insect diversity in many regions is consistently been threatened by either land-use change (habitat loss and fragmentation), climate change or invasion of exotic organisms [4, 5]. Habitat loss and fragmentation if taken as a single factor, has the potential to cause changes in the distribution and abundance of organisms. It can as well threaten the composition, structure and function of biodiversity [6, 7]. When a particular habitat is naturally or anthropogenically lost or fragmented, insects of that community will respond to the changes because the quantity and quality of food chain ought to diminish as well [8, 9]. Climate change and invasion of exotic organisms on any terrestrial ecosystem are presumably accentuated anthropogenically due to habitat loss and fragmentation [9, 10] hence, its sole dissection in this context as the major threat to biodiversity.

Insects are vast and provide a lot of ecosystem services such bees and butterfly families serve as plant pollinators [11, 12, 13]. This singular ecosystem service is essential for sustainable food production as many crops and vegetables would not have been available for man and animals. Though, few insects are labelled pestiferous by man but they are continually being kept in check by biocontrol agents (natural enemies) such as predators and parasitoids [14]. Biocontrol agents limit the use of insecticides for the benefit of man and his environments as they are susceptible to toxic substances and are easily threatened by fragmentation [15]. Other beneficial insects include a group known as organic recyclers because they return the organic nutrients locked in the bodies of dead plants and animals for maintenance of soil fertility [16]. Ecologically important, is that the presence or absence of some group of insects in a particular ecosystem is an indication of anthropogenic changes within the ecosystem [17]. These valued chain services are inherent in insects; thus, any alteration of their natural landscapes will cause spatial and temporal fluctuation in their diversity [18] at the detriment of man and his environment. In fact, species diversity does not only stabilize ecosystem processes in the face of annual variation in environment but also provides insurance against drastic change in ecosystem structures in response to extreme events Chapin et al. [19]. These anthropogenic alterations are directly or indirectly caused by population increase and technological advancements aimed at the betterment of mankind at the expense of the lower organisms like insects.

It may be agreed that biodiversity is high in the tropics, but the level of habitat losses and fragmentations going on within the last two decades are glaring that biodiversity would be affected negatively in many ways.

Attempt to cushion the effect of habitat loss and fragmentation on biodiversity is poor in the tropics especially in the developing countries. Very few institutions mainly schools, and few hospitality industries would try to modify the natural landscape with selected alien grasses, and ornamental shrubs or trees. These artificial landscapes are solely meant to beautify the visual scenery of the fragmented habitats. Inadvertently, horticulturists and their clients are not aware that these landscapes play crucial roles in providing residence for soil dwelling insects, as well as shelter, nest and food for floral visiting insects while the plants are in turn pollinated by the floral visiting insects.

At the University of Port Harcourt, Nigeria, many ornamental shrubs and trees thrive in its landscape as aesthetic modification of the university scenery. They include; *Mesembryanthemum crystallinum* Aizo. (L.), *Polyalthia longifolia* Anno. (Sonn.), *Dypsis lutescens* Arec. (H. Wendl.), *Terminalia mantaly* Comb. (L.), *Terminalia catappa* Comb. (L.), *Thuja* spp. Cupr., *Croton* sp. Euph., *Acalypha* sp. Euph., *Caesalpinia pulcherrima* Fab. (L.), *Delonix regia* Fab. (Hook.), *Butea monosperma* Fab. (Lam.), *lupinus arboreus* Fab. (Sims.), *Hibiscus rosa-sinensis* Malv. (L.), *Ficus retusa* Mora. (L.), *Boungainvillea* sp. Nyct., *Pinus caribaea* Pina. (Morelet), *Musseanda philippica* Rub. (A.Rich.), *Ixora coccinea* Rub. (L.), and *Hamelia patens* Rub. (Jacq.), *Murraya paniculate* Ruta. (L.), *Duranta repens* Verb. (L.). *Hamelia patens* is one of the ornamental plants that are practically grown in the tropical regions. Its botanical reports, phytochemicals and pharmacological uses was reviewed by Surana and Wagh [20]. It is a perennial shrub in the family Rubiaceae, known to originate from the American subtropics and tropics. Its common names include; firebush, hummingbird bush, scarlet bush and redhead [21]. Its floral morphology is copious in Chauhan and Galetto [14], while the floral visitors include honey bees, butterflies, wasps, house flies, ants and sun birds. Separating house flies that are robbers, others are pollinators and parasitoids [13], which are very important functional groups.

There is a paucity of information relating to floral parts of ornamental plants that are useful in landscape ecology in the tropical rainforest region of Nigeria and insect species diversity associated to their floral parts especially pollinators and predators. The dearth knowledge (that some of these ornamental plants apart from being used as artificial landscape plants, have the sustainable potentials for hosting insect diversity) has continued to elude the use of ornamental plants that have floral parts that are capable of sustaining beneficial insect pollinators, predators and parasitoids. Among the ornamental plants at University of Port Harcourt Nigeria, *Hamelia patens* **(**Jacq.) is the one with its floral parts capable of attracting insects nearly all through the year. In this study, we focused on sampling and identifying diversity of beneficial insect species visiting the floral parts of *Hamelia patens*.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted between June and September, 2018 at University of Port Harcourt, Nigeria (N 4°54'22.0752" E 6°55'9.6456").

2.2 Collection Sites

Three collection sites; 1. (N 4°54'17.3628" E 6°55'7.3992"), 2. (N 4°54'5.1948" E 6°55'24.5748") and 3. (N 4°54'2.5776" E 6°55'21.9432") were used for the study. The study commenced on the 06th of June and ended on the 29th of September, 2018.

2.3 Measurement of Heights and Canopy Sizes of *Hamelia Patens*, Insects Collection, Preservation, Identification and Plants Identification

The plant heights were measured with 6 m pole marked with different colours at 1 m intervals. The pole was held upright on the ground very close to the stem of the plants. Where the peak of the leaves of the plant end was taken as the maximum height. Thus, where the maximum height matches any of the colour bands of the pole was measured with a metre rule. For the canopy size, four cardinal poles were pegged at the terminal edges of the leaves towards the north-south and east-west cardinal points. A measuring tape was to measure the distances between the cardinal poles. At each site location, the heights and the canopy sizes of the plants were measured and denoted as either tall or short respectively.

Insects found specifically on the floral parts of the plants were collected with sweep net. They were collected in the morning between the hours of (08:00-10:00 am), and in the evening (4:00 pm - 06:00 pm) respectively. Collection of insects was done thrice a week at two days interval. To avoid excessive depletion of the insect populations only a few samples of each taxon was collected while their visual observations were noted the subsequent time they were seen. Samples of the insects collected on the floral parts of the plant were preserved in specimen bottles containing 70% ethanol and were taken to the Entomology Research Laboratory, Department of Animal and Environmental Biology, University of Port Harcourt, Nigeria. Total counts of the samples were made based on plant heights, time of the day and locations. They were sorted to their taxonomic ranks and preserved in plastic containers (12 cm depth and 5 cm diameter) with tight screw lids; containing 70% ethanol. At end of the study, the insect samples were sorted to their basic taxon with the aid of insects of Nigeria checklist and bibliography [22]. They were later sent to Insect Museum, Ahmadu Bello University Zaria, Nigeria for their species validation.

Fresh twig samples of the ornamental plants found within the University landscapes were collected and taken to the Herbarium, Department of Plant Science and Technology, University of Port Harcourt for identification. Voucher specimens of the plants were not deposited in any public herbarium and no deposition number was generated on them.

At each of the three sites, both tall and short *H. patens* with distinct heights and canopy sizes were observed and designated as tall and short respectively. Thus, at the front of the University's Administrative building designated as site 1. Tall *H. patens* was 3 m and the canopy size was 2.8 m while the height of the short one was 1.6 m and the canopy size was 2.1 m. At the front of Faculty of Humanities designated as site 2, plants height/canopy sizes range from 2.5/2.8 m and 1.5 m/2.0 m for tall and short plants respectively. At the front of the Department of Linguistics and Communication studies designated as site 3, plants/canopy sizes were 6/4.2 m and 4.5/3.9 m for tall and short pants respectively (Table 1).

2.4 Data Tabulation and Analysis

Insect populations and species numbers per sites and heights were transformed into relative abundance while analysis of variance (ANOVA) was used to determine the significance of their occurrence at the three sites with Microsoft excel, version 2010. Least Significant Difference (LSD) test was used to separate the means of the insect species visiting the plants in the morning and evening periods. *t* test was used to separate the mean of insects collected in the morning and evening sections.

3. RESULTS

The result of the insects collected on the floral parts of the *Hamelia patens* showed that some of the insect species have preference for their time of visiting the floral parts of the plant. Thus, out of the fifteen insect species/taxa collected on the floral parts, 6 of them (*Megachile mephistrophelica* (Grib.), *Megachile cinta* (Fab.), *Braunisca bilunta* (Enderloein.), *Pterandus* sp., *Lilioceris* sp. and *Virachola antalus* (Hoph.)) restricted their visitation only in the morning while two of them *Chelonus bifoveolatus* (Szepg.) and *Chrysolagria nairobana* (Borch.) restricted their visitation in the evening (Table 2). The remaining 7 insect species/taxa; *Belongaster junceus* (Fab.), *Belongaster* sp., *Amonophila tenus* (P-B.), *Eicochrysops dudgeoni* (Riley.), *Ticarinodynerus ventralis* (Sauss.), *Xylocopa torrida* (Westw.) and *Apis melifera* (Linn.) visited both in the morning and the evening. At site 1, eleven insect species were collected on the tall plants while 8 were collected on the short ones. At site 2, insect species collected on the tall and short plants were 4 and 2 respectively. At site 3, insect species collected were 6 on the tall plants and 5 on the short ones.

Analysis of variance showed that there was no significance difference (P=.05) between the insect species collected from the three sites (Table 2). But at site 1, there was significance difference between the insect species collected on the tall and short plants (Table 3).

A total of 52 insects (Table 2) were collected on the plants irrespective of heights/canopy sizes and sites during the study comprising 4 orders (Coleoptera, Diptera, Hymenoptera and Lepidoptera). There are fifteen insect species in these four orders with hymenopterans having 10 species while coleopterans and lepidopterans have 2 species each while dipteran has 1 species only.

Out of the 52 insects collected, *Xylocopa torrida* (Westw.) was the highest, with the relative abundance (RA) of 19.23% i.e. (10/52 x 100). It was closely followed by *Apis melifera* (Linn.) with the RA of 13.46%. Others in the decreasing order include; *Ticarinodynerus ventralis* (Sauss.) with RA of 9.62%, while *Belongaster junceus* (Fab.), *Belongaster* sp. and *Megachile mephistrophelica* (Grib.) have RA of 7.69% respectively. *Amonophila tenus* (P-B.), *Megachile* *cinta* (Fab.) and *Pterandus* sp. have RA of 5.77% each while *Eicochrysops dudgeoni* (Riley.), *Lilioceris ivida,* and *Braunisca bilunta* (Enderloein.) have RA of 3.85% respectively. The least were *Chelonus bifoveolatus* (Szepg.), *Chrysolagria nairobana* and *Virachola antalus* (Hoph.) with RA of 1.92% respectively (Fig. 1).

Table 1. The Height and the canopy size of the *H. patens*, 2018

	Tall (*H. patens*)		Short (*H. patens*)	
	Height (m)	Canopy (m)	Height (m)	Canopy (m)
Site 1	3	2.8	1.6	2.1
Site 2	2.5	2.8	1.5	2
Site 3	6	4.2	4.5	3.9

Table 2. Morning and evening collection of insect species on the floral parts of *H. patens,* 2018

		Tall plant			Short plant			Time of collection		Total
		Site						Morning	Evening	
Insects		**1**	**2**	**3**	**1**	**2**	**3**			
Order	**Species**									
Hymenoptera	*Belongaster junceus* (Fab.)	1	0	2	1	0	0	2	2	4
	Belongaster sp.	1	0	2	0	0	1	3	1	4
	Ticarinodynerus ventralis (Sauss.)	2	1	2	0	0	0	4	1	5
	Megachile mephistrophelica (Grib.)	2	0	0	2	0	0	4	0	4
	Megachile cinta (Fab.)	1	0	0	1	0	1	2	0	2
	Xylocopa torrida (Westw.)	1	2	4	1	0	2	9	3	12
	Apis melifera (Linn.)	2	0	3	1	0	1	6	1	7
	Amonophila tenus (P-B.)	2	0	0	0	1	0	1	2	3
	Braunisca bilunta (Enderloein.)	0	1	0	0	1	0	2	0	2
	Chelonus bifoveolatus (Szepg.)	0	0	0	0	0	1	0	1	1
Diptera	*Pterandus* sp.	1	0	1	1	0	0	1	0	1
Coleoptera	*Lilioceris* sp.	1	0	0	1	0	0	1	0	1
	Chrysolagria nairobana (Borch.)	1	0	0	0	0	0	0	1	1
Lepidoptera	*Virachola antalus* (Hoph.)	0	1	0	0	0	0	2	0	2
	Eicochrysops dudgeoni (Riley.)	0	0	0	2	0	0	2	1	3
	Total	**15**	**5**	**14**	**10**	**2**	**6**	**39**	**13**	**52**

There was no significant difference between sites (P=.05)

Table 3. Mean Occurrence of Insect species on the two heights of *H. patens*, 2018

Sites	Tall *H. patens*	Short *H. patens*
Site 1	1.00±0.756	0.67±0.724
Site 2	0.33±0.617	0.13±0.352
Site 3	0.93±1.335	0.40±0.632
LSD – values	0.06	0.02
Remark	**NS**	S

NS =Not significant; S = Significant

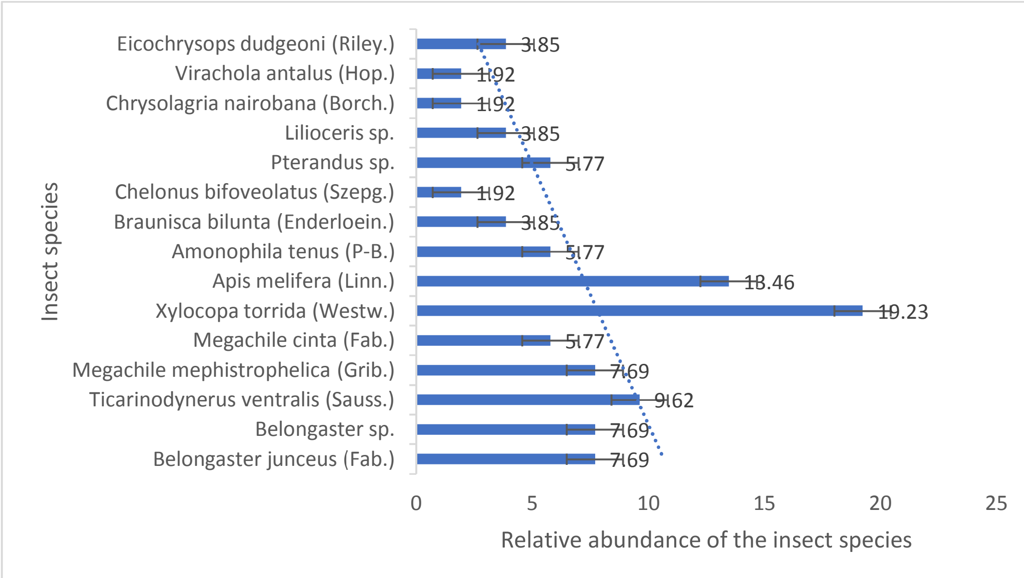

Fig. 1. Relative Abundance of the Insect Species Collected on the *H. patens*

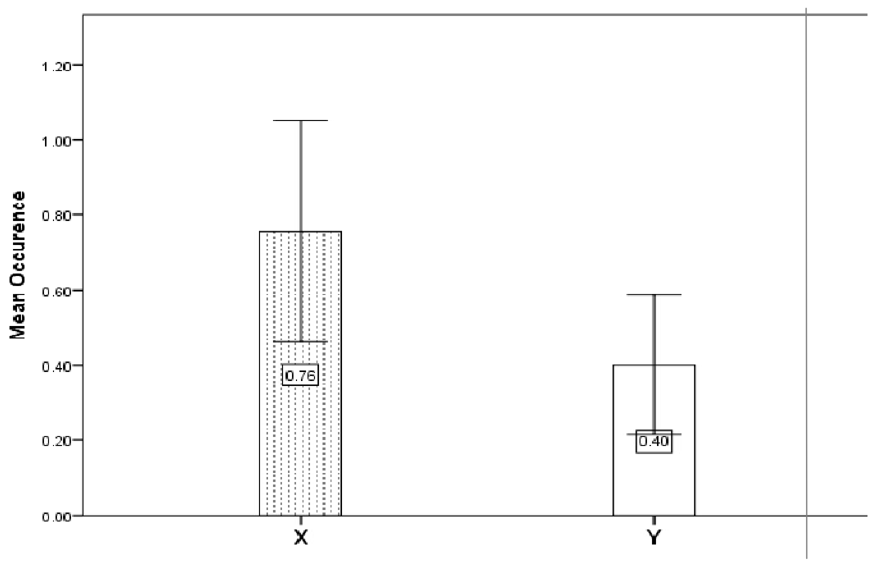

Fig. 2. Mean Occurrence of Insect Species Collected in the Morning and in the Evening on the *H. patens*

Note. X and Y represent Tall and Short H. patens respectively

There was significant difference (t = 2.058, df = 88, P = 0.04) between the insect species collected on the plants in the morning (n= 13) and evening (n=8) sections (Fig. 2).

4. DISCUSSION

Biodiversity science is centered on keeping pace with the changing face of the earth with special emphasis on species annihilations and reshufflings occasioned by anthropogenic activities such as commerce, land excavation and pollution. Therefore, as insect species are uncoordinatedly dispersed, others are threatened, predominantly in the tropics hence, elucidating that extinction is mainly caused by environmental abuse [3]. It is globally accepted that the biosphere supports a great diversity of entomofauna that have not been identified due to few taxonomists notwithstanding the enormous value these insects play for mankind and his environment [3].

Hamelia patens has been discerned in the study as ornamental plant capable of attracting beneficial insects and sustaining their diversity. This validates the reports of Collinge [4] that corridor plants have the potential to bolster exchange of organisms among habitat patches. Natural landscapes provide a good diversity of flowering plants that support a great diversity of insects especially pollinators and predators. These group of beneficial insects as recorded in this study are providing ecosystem services because the *Hamelia patens* provided the pollinators with nectar and pollen while providing resting support and nest for the predators and parasitoids.

Processes that lead to fragmentation of habitats, affect species diversity and their spatial distribution because of area reduction of the original habitat in the landscape due to habitat loss. Others are area reduction of the emerging habitat fragments and the increasing distance between the fragments. It was noted that invertebrates in fragmented lands especially in islands tend to cope better than vertebrates [18]. Thus, our findings in this study corroborate with Kruess and Tscharntke [18] hence, we canvass that ornamental plants capable of sustaining insect diversity in the region should form part of the major caveats for horticulturists and landscape experts.

Crist and Peters [2] opined that intensive agricultural practices negatively affect insect species richness and abundance but that insect species assemblage of patches of grasslands were positively affected due to nearness to agricultural fields. They further stated that bees respond better than beetles because of flower density and forb cover, hence floral density is a good model for bee community in early summer. The practice of clean clearing of lands for many purposes without replacement or leaving some shrubs behind has contributed immensely to decline of insects [23]. The insects of this study are assumed to have been adapted by the fragmented landscape of the University. This may be the reason for the low species richness of its beneficial insects as noted in the report of van Nouhuys [9], that herbivores are not affected the same way pollinators are affected. Therefore, on the average, fragmentation may affect parasitoids and predators more than herbivores. Scriven et al. [24] submitted that flower density is more important to a site for insect diversity of specific habitats. Therefore, in cushioning the effect of fragmentation on beneficial insects, Josee et al. [25] suggested that rigorous selection of flowering plant species has to be adopted to help curb both pests and sustaining beneficial insects.

Based on our findings in this study, it is compelling that efforts should be directed to practice that will encourage sustenance of wild insects especially beneficial ones capable of providing ecosystem services. This is necessary as Clara et al. [26] stated that 35% of global production from crops including at least 800 cultivated plants depend on animal pollination. They suggested that preservation and renewal of hedgerows and other flora landscapes at field margins is consequently essential for harbouring pollinators. Therefore, suggesting that appropriate management and maintenance of uncultivated vegetations to boost wild pollinators may prove to be a cost-effective means of maximizing crop yield [26]. Studies have shown that habitat loss and fragmentation is likely to threatened beneficial insects while proliferating insect pests [27]. To circumvent the population of pestiferous insects in fragmented habitats, it is therefore, necessary to use ornamentals with good floral density as its landscape patches. This ameliorative assumption is in response to the report that in the fragmented agricultural landscape, insect pests such as aphids reached high densities because of the delay in the arrival of predators such as coccinellids to the agricultural fragments and prey patches [27].

Activities of insects as floral visitors are believed to be modulated by exogenous factors that tend to restrict the periodicity of their activities. Hence, we observed in this study that *M. mephistrophelica*, *M. cinta*, *B. bilunta*, *Pterandus* sp., *Lilioceris* sp. and *V. antalus* visited only in the morning while *C. bifoveolatus* and *C. nairobana* visited only in the evening. The explanation of this observation is copious in Thomas et al. [28] as the diel activities and duration of insects on plant is a trait that have been acquired overtime. Thus the characteristics, modify the time the insects seek for food, shelter, mating, nesting, oviposition and resting. Hence, their visitation time and duration on flowers are affected by thermoregulation, air temperature, relative humidity, and light intensity [29, 28].

The study of beneficial insects associated with *Hamelia patens* (Jacq.) has afforded us the insight that its floral parts have the potential to attract and sustain diversity of beneficial insects that are bound to provide ecosystem services. These beneficial insects were continuously found visiting the floral parts of the plant irrespective of the plant heights/canopy sizes and locations. There were no significance differences among the insect species collected from the three locations but the slight difference observed between the insect species collected on the tall and the short plants of the *Hamelia patens* (Jacq.) was as a result of continuous clipping of the twigs holding the floral parts by the university gardeners as observed at site 2. Clipping the twigs and the floral parts of the *Hamelia patens,* no doubt made them aesthetically beautiful. However, the practice obviously affected the intrinsic behaviours and navigational cues of the insects to the floral parts of the plants and thus affect the diversity of the insects [29].

5. CONCLUSION

The results of this study have afforded us the insight of the multiple roles *Hamelia patens* can play in the terrestrial ecosystem; as a resource for artificial landscaping and soil cover, and most importantly serving as host and food resource for insect pollinators, predators and parasitoids that provide useful ecosystem services. The arrival of the insects on the floral parts of the *Hamelia patens* is time dependent and were not affected by the height or the canopy size. Clipping the twigs affected the insects abundance because their primary food resource was temporary depleted. We therefore; recommend that in landscaping, horticulturists and landscape experts should consider plants that can provide an abode for soil dwelling insects, serve as shelter, nest and food for floral visiting insects while still providing aesthetic scenery to the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Insect species collected on *Hamelia patens* (Jacq.) at the three selected sites

Order	Family	Species
Hymenopteraa	Eumenidae	*Belongaster* sp.
		B. junceus (Fab)
	Vespidae	*Ticarinodynerus ventralis* (Sauss)
	Megachilidae	*Megachile mephistrophelicalica* (Grib)
		Megachile cinta (Fab)
	Apidae	*Xylocopa trorridda (Westw)*
		Apis melifera (Linn)
	Specidae	*Amonophila tenus (P-B)*
	Braconidae	*Braunsica bilunata (Enderloein)*
		Chelonus bifoveolatus (Szepg)
	Tephritidae	*Pterandus sp.*
Coleoptera	Chrysomelidae	*Lilioceris ivida*
	Langriidae	*Chrysolagria nairobana*
Lepidoptera	Lycaenidae	*Virachola antalus* (Hoph.)
		Eicochrysops dudgeoni (Riley)

Peer-review history:
The peer review history for this paper can be accessed here:
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