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Plant-pollinator interactions of three selected plant species in Gullele Botanic Garden, Addis Ababa, Ethiopia

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Abstract

Assessment of plant-pollinator interaction in three selected naturally grown plant species (Rosa abyssinica, Hypericum revolutum, and Vernonia leopoldi) was conducted using pollination observation method in the Gullele Botanic Garden, Addis Ababa, Ethiopia. Critical observation of pollinators was conducted while visiting the floral parts of each species, capturing a photo of each pollinator on the floral part, and at the same time recording the time and giving the general name of pollinators. This observation activity was conducted by walking along the garden, choosing any flowering individual for about 30 min observations for five flowers. Data was collected in five weeks between November and December 2021 about the plant-pollinator visits, pollinators' diversity, number of visits to each species, and pollinators' preferred time in a day were analyzed using descriptive analysis. A total of six functional groups (bees-Hymnoptera, beetles-Coleoptera, flies-Diptera, moths and butterflies-Lepidoptera, and bird) were recorded from pollination observation. Bees were the most flower-visiting/pollinating insect group for the three species. Beetles were the second most visited insects on the flowers of the three species, followed by flies, moths, butterflies, and birds. Plants attracted a range of insects, with bees as the most abundant visitor/pollinator, accounting for 88% of the total visits. The rate of insect flower visits for the three species indicated a decrease from the first to the fifth week of floral blooming. For mutual benefit and sustainable conservation of selected flowering plants and pollinating insects, it would be important to promote the botanic garden by establishing a pollinator garden as part of the thematic garden.

Keywords/Phrases: Functional groups, Gullele Botanic Garden, Insect-flower visitation, Plant-pollinator interaction

1 Introduction

The pollinators in a plant-pollinator interaction consume the nectar and pollen from the bloom. As it forages for food rewards, the pollinator transfers pollen from one flower to another, benefiting the plant in exchange. In order to help pollinators, plants make investments in producing pollen and nectar. Pollen facilitates reproduction and the exchange of genetic information between plants during the plant-pollination contact process (Nicolson & Wright, 2017). Plant-pollinator interactions can be assessed by methods such as pollination observations, bagging, and cage experiments to indicate the effectiveness of specific pollinators. Pollination observations, among others, have been the widely used method in pollination ecology (Yamaji & Ohsawa, 2016). In both urban and rural settings, pollinators guarantee seed production and provide healthy plants for gardens. Many wild animals depend on pollinators as vital elements of their habitats and ecosystems for sustenance and protection. Moreover, it has been a natural extension of the work of botanic gardens, conservatories, and arboreta dedicated to plants. More than 100,000 invertebrate species and 1,000 vertebrate species serve as pollinators globally

(FAO, 2018). These animal pollinators are essential for the reproduction of 75% to 95% of the world's blooming plants, including one-third of our food crops (Ollerton *et al*., 2011).

Pollinators are animals that visit the flowers of various plants to gather or eat rewards. But they are not visited by animals specifically to pollinate them. The benefits of flowers include nectar, which is consumed by insects, bats, birds, and non-flying mammals as a source of sugar; pollen, which is used by the majority of bees that gather it to supply their larval cells as well as by beetles, flies, birds, and some bats and non-flying mammals for protein, vitamins, fatty acids, and minerals; oils, which are collected by some bees to supply their larval cells; and resins, which are collected by different bees for use in nest building (Woodcock *et al*. 2014). Insects, such as bees, butterflies, moths, flies, and beetles, are the primary animal pollinators crucial to plant reproduction. Approximately 290,000 insect species have been identified globally that visit flowers (Nabhan & Buchmann, 1997). In both naturally occurring and human-managed terrestrial ecosystems, insect pollinators play a crucial role in determining a plant's ability to mate. Due of their adequate body hair and behavioral habits, solitary bees, bumblebees, and honeybees are the largest insect groups for pollination (Du Toit, 1988). Bees obtain their primary food sources from the nectar and pollen found in the blooms of various plant types. Because pollinators and plants may have co-evolved, distinct plant blossoms may need a certain bee pollinator or pollinators in order for pollination to take place (Michener, 2000). More crucially, bees are pollinators, as are bats, birds, butterflies, beetles, flies, moths, wasps, and small mammals. When these insects visit flowering plants, they either eat on pollen or drink nectar. As they migrate from one flower to another, they carry pollen grains.

As moisture, sunlight, and soil fertility, the availability of pollinators is essential to the reproductive success of nearly half the world's flowering plants (Nabhan & Buchmann, 1997). Wasps and beetles, with rare exceptions, have short tongues and are unable to take advantage of nectar in deep tubular blooms. They are most commonly observed as parts of the visitor fauna of generalist flowers that have exposed nectar and a shallow perianth. Furthermore, a large number of nectar-producing flower examples are tailored for wasp and beetle pollination (Johnson, 2005; Shuttleworth and Johnson, 2006). In addition to providing us with food, pollinators are vital to the health of ecosystems that sustain soil ecosystems, clean the air, shield us from extreme weather, and provide habitat for other creatures. Animal pollinators have an incalculable impact on biological variety throughout Africa's diverse landscapes and ecosystems.

Very recently, urban greenery, as part of the Green Legacy campaign launched by the Ethiopian government, is getting new attention. The green legacy, which includes plantation and reforestation, has been practiced to maximize biodiversity recovery, enhancing carbon sequestration, reducing air pollution, beautification, and climate change mitigation, and soil and water erosion control. The most appealing plants for flower-visiting insects in the developed world are among the many varied plant types and cultivars that gardeners can choose from. The advantages of pollinators have been included into the greening of urban and suburban areas in industrialized nations, with the possibility that gardens and urban areas might serve as a vast network of habitats that are conducive to pollinator populations (Baldock, 2020). This is not true in countries like Ethiopia and other similar countries. Studies conducted about which pollinators prefer which plants, insect-flower visitation rate, and plant pollinators' interactions are lacking in Ethiopia in general and in Gullele Botanic Garden in particular. Because of the gaps in the knowledge of pollinator diversity, plant-pollinator interactions, and pollinator gardens, there has been no information regarding the conservation of both plants and their pollinators in the Gullele Botanic Garden. Thus, the present study was conducted to identify the functional groups of pollinators/visitors and their visitation rate, timing preference for pollination, and interactions for the sustainable conservation and management of pollinators and flowering plants. The selected plant species for the present study are the naturally grown indigenous and endemic ones, such as *Hypericum revolutum*, *Rosa abyssinica*, and *Vernonia leopoldi*. These plant species have unknown visitation rates and plant-pollination interaction. The selection was made based on the plant availability for sampling, flowering season, germination failure, proximity, and they are indigenous to the country.

2 Materials and Methods

2.1 Description of the Study Area

This study was conducted in Gullele Botanic Garden (Figure 1), which was established in 2010. The GBG was established with the objective of research-based conservation of plant species, particularly, endemic, endangered, and economically important (3E) ones, among others. The GBG is located on the outskirts of northwestern parts of Addis Ababa, Ethiopia. Geographically, it belongs to the central plateau of Ethiopia with coordinates extending between latitudes of 8055'N and 90 05'N and longitudes of 380 05'E and 390 05'E. It is located in the northwestern direction of Addis Ababa city, 4 km away from the center. The GBG was established in the slopped and semi-slopped topography of Addis Ababa. The average annual rainfall is between 1100-1300 mm while the annual temperature is between 15-18 0C. February is the hottest month (20.7 OC), and December (7.5 OC) is the coldest month regarding the weather in the area. GBG is part of the green lung of Addis Ababa city, where varieties of collections of plants from various parts of the country exist. The garden area is silicics in rock types and the nitosols, cambisols & vertisols in soil type. Historically, the GBG was dominantly covered by the *Eucalyptus globulus*, *Juniperus procera*, and a combination of many other species.

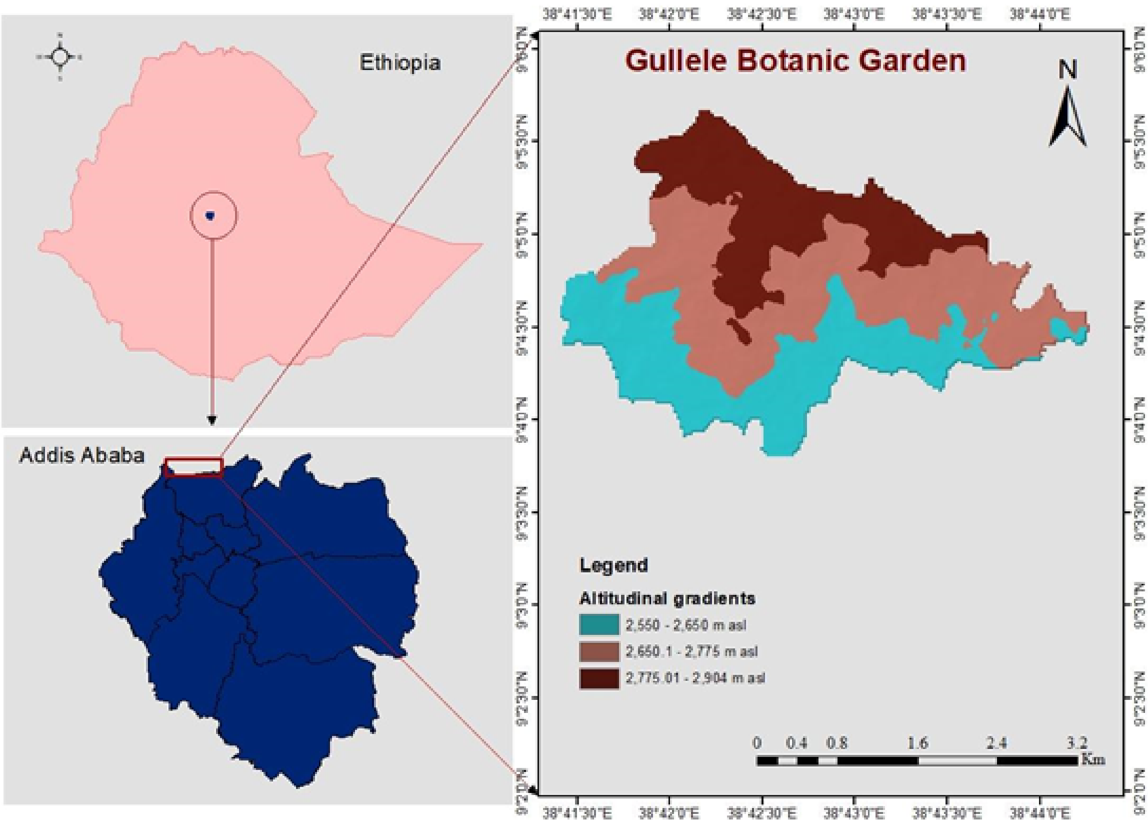

Figure 1. Map of Gullele Botanic Garden where the study was conducted

According to Ethiopia's vegetation categorization, the research region is part of the Dry Afromontane forest, which is home to a variety of naturally occurring plant species (Table 1).

Table 1. Some of the plant species in the Gullele Botanic Garden

Scientific Name	Family Name	Scientific Name	Family Name
Juniperus procera	Cupressaceae	*Apodytes dimidiata*	Icacinaceae
Carissa spinarum	Apocynaceae	*Myrica salicifolia*	Myricaceae
Rhus glutinosa	Anacardiaceae	*Smilax aspera*	Smilacaceae
Olinia rochetiana	Oliniaceae	*Rosa abyssinica*	Rosaceae
Maesa lanceolata	Myrsinaceae	*Erica arborea*	Ericaceae
Hypericum revolutum	Hypericaceae	*Osyris quadripartita*	Santalaceae
Jassminium abyssinicum	Oleaceae	*Maytenus arbutifolia*	Celasteraceae
Rubus steudneri	Rosaceae	*Nuxia congesta*	Loganiaceae
Olea europaeae subsp. *Cuspidata*	Oleaceae	*Vernonia amygdalina*	Asteraceae
Dovyalis verrucosa	Flacourtaceae	*Vernonia leopoldi*	Asteraceae
Bersama abyssinica	Melianthaceae	*Buddleja polystachya*	Loganiaceae

2.2 Selection of plants for pollination study

Several naturally growing plants are found in the botanic garden, including climbers, lianas, and herbs to large trees. However, their flowering, fruiting season, and seed-forming time varies from species to species. For the present study, the three plant species: *Hypericum revolutum*, *Rosa abyssinica*, and *Vernonia leopoldi* were selected to identify their dominant pollinators and visitors. They were selected due to the same flowering seasons (October to December), fruiting seasons (January to March), and their floral structures, which are very attractive to pollinators and visitors. Besides, we have personal information that these species have a low level of propagation by seed. However, there has been evidence from our nursery that propagation by cutting is not as successful as was expected, particularly for *Hypericum revolutum*. For the sake of observation, five flowers/individuals were sampled for each species, totaling 15 observations for the three species.

2.3 Description and ecology of the selected plants

2.3.1 Ecology of *Rosa abyssinica* Lindley (Family: Rosaceae)

Rosa abyssinica is an endemic rose in Ethiopian highlands locally called *Arbeq*, *Qega, Kega*, *Engocha*, *Qegga* in Amharic and Abyssinian Rose in English (Figure 2).

Figure 2. *Rosa abyssinica* (Photo taken by Talemos Seta, Nov. 2021)

The plant is a creeping or climbing shrub forming a small tree up to 7 m, with prickly stems usually curved from a wide base and evergreen leaves. Leaflets of abyssinian rose are ovate to almost lanceolate with toothed margins. Flowers are sweet-smelling with white or pale yellow petals and numerous yellow stamens.

Sweet-smelling white-pale yellow flowers are typically 3 to 20 in dense heads, each stalked, with long, narrow, hairy sepals that fall off quickly. The petals are about 2 cm long, with a rounded to square tip and numerous stamens. Initially green, the fruits eventually turn orange-red as they ripen. The fruits are edible and collected and eaten by children (Flora of Ethiopia, Vol.3). There is a report that indicates the fruits are being used against hookworms. The plant flowers throughout the year and honey bees visit the flowers for pollen. Habitat: rocky areas, riparian formations, and dry grasslands; it can also be found in various man-made habitats, occasionally standing by itself as a tiny tree; it can be found at elevations of 1900–3300 meters (Fichtl and Adi, 1994).

2.3.2 *Vernonia leopoldi* (Sch. Bip. *ex* Walp.) Vatke (Family: Asteraceae)

An upright shrub or infrequently woody herb that reaches a height of 2.5 meters and is covered with soft hairs (Figure 3).

Figure 3. The *Vernonia leopoldi* with its pollinators (Photo by Talemos Seta, Dec 2021)

Grey-green leaves with crenate edges, petiole (2-) 3-6(-8) mm long, base obtuse to decurrent, glabrescent, pilose or briefly strigose above, and thicker hair, particularly on the veins beneath. Flower heads are purple and in large terminal corymbs. The leaves and flowers are used for dressing wounds. The roots are used against gastric disorders. Flowering from October to January, honeybees collect pollen and nectar from the flowers very frequently, and in dense stands, it can provide a good nectar flow. It thrives on shallow soil on open forest edges like Acacia-wooded grassland with scrub of *Rosa abyssinica*, Maytenus, and Carissa. It is frequently found in roadside thickets, ravines, and wasteland at elevations between 1850 and 2850 meters.

2.3.3 *Hypericum revolutum* Vahl. (Family Guttiferae)

A plant locally called Amija in Amharic and Curry bush in the English language. It is a glabrous, bushy, or slender shrub or tree that can grow up to 12 meters in height (Figure 4). It is an evergreen plant with opposing leaves that are crowded and closely spaced at the tips of branches. The leaves are about 20 x 5 mm, green to slightly glaucous, sessile, and clasp at the base.

Figure 4. *Hypericum revolutum* (Photo by Talemos Seta; Dec.2021)

Flowers of this plant are terminal solitary, 35-80 mm in diameter, and showy, very attractive, bright yellow color. Nectar appears as a little drop at the base of each petal on its five nectaries, which are arranged in a yellow, radially symmetrical flower. Flowers typically survive two days, and each flower produces more than 19 μl of nectar over that time (Bartos *et al*., 2012). According to research by Janecek *et al*. (2012), sunbirds rarely visit *H. revolutum*, yet they have a very small role in pollinating it. At an elevation of 2250–3650 meters above sea level, it grows in open forests, forest margins, montane savannas, and grasslands, frequently alongside *Erica arborea* and/or *Hagenia abyssinica*. The plant occurs nearly in all Ethiopian regions, south to Cape Province, and also in Nigeria, Cameroon, and S.W. Arabia. The roots of this plant are used for stomach and tooth problems.

2.4 Methods of Data Collection

In order to collect information on the three species related to pollination processes, the following activities were conducted. Data collectors were grouped into three by assigning one individual to each species. Three plants from each species and the same area were included in the data collection. The data collected from the present study include critical observation of pollinators while visiting the floral parts of each species, taking a photo of each pollinator/visitor on the floral part, and at the same time recording the time and naming the general name of pollinators (for example, bees, flies, birds, etc). During observation, flower visitors were sampled for a total 8-9 h period (from 7 a.m. to 6 p.m., with extra observation hours on major visitation periods by the researcher) for each tree species, with five flowers/individuals selected based on the exposure to pollinators. For this observation exercise, participants were instructed to go along planting lines and select any blossoming individual to observe for around half an hour. The observation time was a day time and separated into four classes. These are 7 to 9 a.m., 10 to 12 a.m., 1 to 3 p.m., and 4 to 6 p.m. to identify the visitation frequency of pollinators. The observations in each time interval were recorded, and photos of the pollinator/visitor/robber on the flower were taken. This data collection was conducted for about five flowering periods from November to December 2021.

2.5 Identification and Data Analysis

From pollination observation, the observed insects pollinating/visiting flowers of the selected species were identified by entomologists into their functional groups, such as bees, beetles, flies, moths, butterflies, and birds. Data collected from the field for three flowering plants in five weeks about the insect visitation, pollinators' diversity, number of visits to each species, and pollinators' preferred time in a day were analyzed using qualitative and quantitative analysis. In order to make this study complete, it requires further taxonomic research to identify the insects and determine insect diversity. Moreover, it is important to further extend studies toward pollen and nectar analysis to identify which insects, indeed, pollinate which specific plant species during interactions.

3 Results

3.1 Insect-flower pollination in three species

Though identification to the taxa level is not conducted, the total insect pollination observed during the flowering season of the three plant species was categorized into six functional groups, such as bees family, Apidae (Hymnoptera), beetles (Coleoptera), flies (Diptera), moths and butterflies (Lepidoptera), and birds. Wasps were rarely observed in the flowers of the selected three species. Types of bees encountered in the flower-visiting process of the three plant species were carpenter bees (Xylocopa spp.), honey bees (Apis mellifera), and solitary bees in Apidae. Generally, bees were the most flower-visiting insect group for the three species. For example, the *Vernonia leopoldii* flower was visited 24610 times, the *Hypericum revolutum* flower 25170 times, and the *Rosa abyssinica* flower 26240 times in the study period. The insect visitation rate by bees for the three species was 6-10 times/minute. Bees, particularly honey bees, visited more flowers per time at any time of the day for *Rosa abyssinica* and *Hypericum revolutum*. Beetles were the second most visited insects on the flowers of the three species, followed by flies, moths, butterflies, and birds (Figure 5). The current study found that while plants drew a variety of insects, the honeybee was the most frequent visitor, making up 88% of all visits for the three plant types. All three plants had variable amounts of each of the six functional groups, with the exception of birds.

During data collection, it was observed that more frequent flower visitation (Rosa abyssinica) of beetles next to bees, particularly, happened in the morning session of the day. From the present study, the average visitation rate of beetles in the three species was 0.5-3/ minute. Moreover, flies visit the flower of all species at a rate of 2-2.6/minute followed by butterflies (1/minute), and moths (0.76/minute birds (0.6/minute). In general, it has been reported that the flowers that beetles visit the most share the following traits: bowl-shaped, with exposed sexual organs, white to dull white or green, densely fruity, open during the day, moderately nectar-producing, and capable of producing both huge single flowers and clusters of tiny ones.

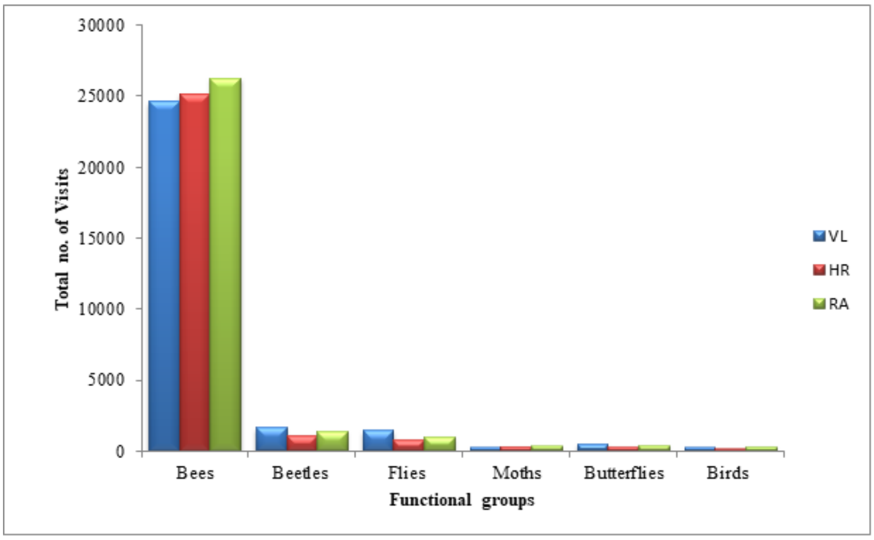

Figure 5. Visitation frequency by six functional groups

Among the functional groups, butterflies were least actively engaged in visiting flowers of the three species. More frequency of butterflies' visitation was observed in *Vernonia leopoldii* in the late morning and early afternoon session compared to the other two species in the garden.

3.2 Insect visitation to flowers in each observation time

As can be seen from Fig 6, the visitation rate for bees is much higher than the other insects in four consecutive periods of a day. The flower visitation rate decreases from morning to late afternoon in each time interval, particularly for bees. However, the flower visitation rate by beetles was high in the late afternoon from 4 to 6 p.m. On top of this, total visits by birds were very low compared to other functional groups. In the relationship between plants and pollinators, the pollinators that visit the plants affect the flower's form, color, odor, nectar, and structure. During data collection, it was noted that insects occasionally visited several nearby plants in addition to several flowers on the same plant. In all three species, insect flower visitation in the morning session was comparatively higher. The rate of insect flower visitation for the three species indicated a decrease from the first week to the fifth week of floral blooming. In *Vernonia leopoldi*, there was a high number of floral visits by all the insect functional groups in the first and second week of the flowering period.

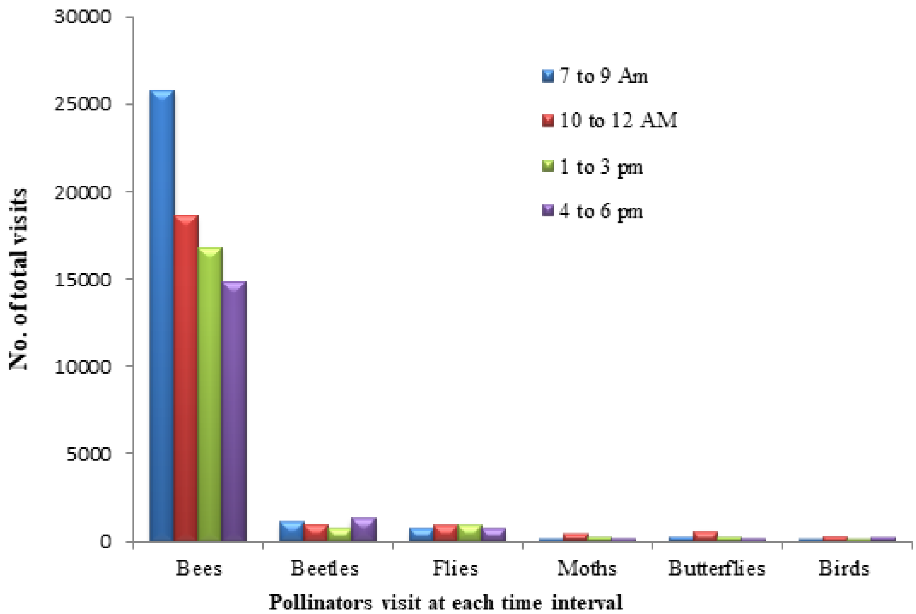

Figure 6. Pollinators visit at each time interval

3.3 Total insect-flower Visitation in the three species

It was observed from Figure 7 that the total insect visitation to the floral parts of *Rosa abyssinica* (29722) is higher than the other two species, *Hypericum revolutum* and *Vernonia leopoldi*. Of all the six functional groups, only flower visitation by bees accounted for 88% of *Rosa abyssinica*, 90% of *Hypericum revolutum*, and 85.6% of *Vernonia leopoldi*. This result shows that most of the insect-flower visitation for the three species is taken role by bees. The remaining two species have a limited role either in pollination, robbing, visiting, or stealing in the three species. The morning session of visitation hours (7 to 9 AM and 10 to 12 AM) were preferred by visiting insects for *Rosa abyssinica*. The total visitation by bees is more active in the early morning and then eventually less active in the late afternoon for the three species. Later on after flowering season, it needs further studies a number of seeds have been set as indicated as was confirmed by researcher observation.

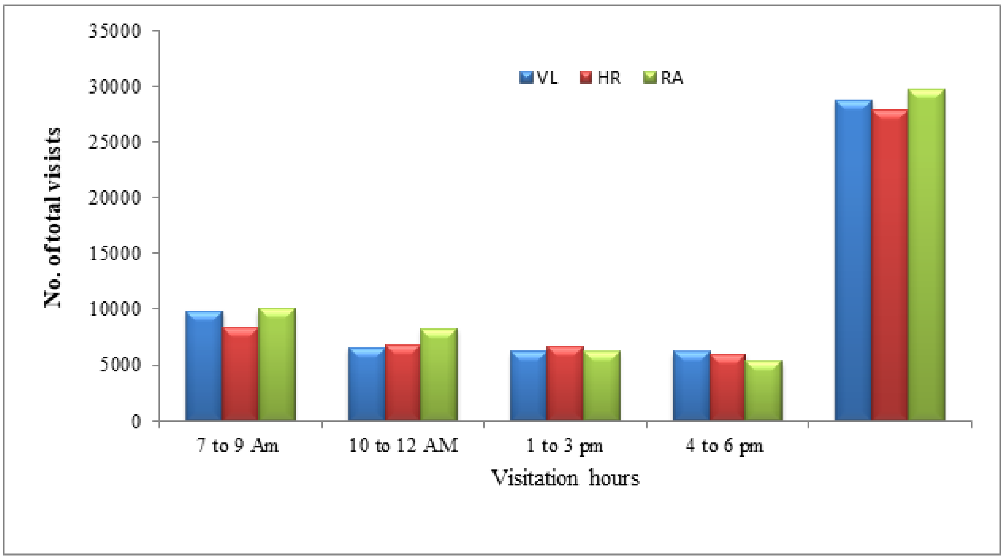

Figure 7. Total insect-visits in three species

4 Discussions

In this five-week observational study, six functional groups of insects either, visiting or pollinating flowers of *Rosa abyssinica*, *Vernonia leopoldi*, and *Hypericum revolutum* were identified. These plant species have brightly colored flowers (white, purple, and bright yellow) with nectars and pollen in them. Of the six functional groups, bees were the most common visitor/pollinators in the three species, which may be attributed to the flower structure, flower colour, odour, and availability of nectars. It is estimated that 80–85% of pollination is carried out by insects, with honeybees accounting for 75–80% of this total (Johannsmeier and Mostert, 2001).

Moreover, the development of the modern flower caused the evolution of some pollinating insects like moths and butterflies (Lepidoptera).Almost all species of Lepidoptera possess a tongue/proboscis adapted for sucking (https://www.britannica.com).

In their comprehensive and up-to-date overview of Ethiopia's lepidoptera, Tujuba *et al.* (2019) listed and described 2,438 taxa in 48 families, 664 of which are endemic. Even though this study did not identify this level of classification, solitary bees, bumblebees, and honeybees are the largest groupings of insects for pollination due to their sufficient body hair and their behavioral habits (Free, 1993; Du Toit, 1988), however, bees took the first place in the pollination. A high frequency of bees' visitation was recorded in three study species, indicating the high possibility for bees to be a major pollinating group for the three flowering plants in the GBG.

Of the total pollinators of major crops in Ethiopia, honeybees contribute 80% of the pollination service (Getachew Worku, 2018). The primary pollinators in Ethiopia are the bee and butterfly families, whose diet consists solely of pollen and nectar gathered from flowers, especially for bees. In the study published by Kevan and Baker (1983), for instance, the only insects that visited every type of olive tree were *Apis mellifera* and *Trigona spinipes*, making them the most generalist visitors. There are many more insect pollinators that are worth mentioning besides bees. Important pollinators include moths (order Lepidoptera), wasps (order Hymenoptera), beetles (order Coleoptera), butterflies (order Lepidoptera), and flies (order Diptera). Some of these insects have particular connections with their preferred host plants. Additionally, these pollinators have a crucial role in many flower and fruit crops' seed set, seed/fruit quality, early flowering, oil content, pyrethrin content, rubber content, and lavender oil content (Free, 1993).

Bees visited many flowers per minute for the three species compared to other insect groups. Bees, as the quickest visitors/pollinator visit, flowers in all three species over four to five times faster than beetles, flies, butterflies, and moths in this study. But according to reports, bee and butterfly families are well-known pollinators once their diet—particularly for bees—is essentially made up of pollen and nectar that is acquired from flowers (Goulson, 2003).

Because of their highly perched, long, thin legs, which do not pick up much pollen on their bodies and lack specialized structures for collecting it, butterflies are less effective than bees at moving pollen from one flower to another, even though they are active during the day and visit a variety of wildflowers. The flat, grouped flowers that offer a landing platform and plenty of rewards are usually preferred by butterflies, who search for nectar, their flight fuel. Furthermore, butterflies have a keen sense of sight but a poor sense of smell. Butterflies have the ability to perceive red, unlike bees (Lewis, 1995).

The insect visitation in five weeks to the floral parts of *Rosa abyssinica* is higher than the other two species, which may be attributed to the floral structure, odour, and color. The floral structure of this species is very suitable for insects such as pollinators, visitors, robbers, and thieves. This species has open, fragrant, white-pale yellow floral parts. The sepals are long, slender, and hairy, and they fall off quickly. The petals are about 2 cm long, with a squared-off tip and lots of stamens (Fichtl and Adi, 1994).

The current study supports a previous study that described interspecific patterns of plant-pollinator interactions and found that hymenopterans visited lavender at a faster rate than either lepidopterans or dipterans (Herrera, 1989; Garbuzov and Ratnieks, 2014). Moreover, bees in urban environments are keystone species for pollination purposes. Bees' pollination services aid in the growth of ornamental and wild plants, which in turn provide fruit and seeds to birds and other urban wildlife while also serving as a home for insects (Biesmeijer *et al.*, 2006; Ollerton *et al.*, 2011). In addition to providing chances for conservation and natural interaction, bees also directly help humans by pollinating foods planted in communal and household gardens (Matteson and Langellotto, 2009). (Colding *et al.*, 2006).

Insect visitation rates were most significantly influenced by floral shape, temperature, light, and season, among other parameters. In this study, the visitation frequency by bees and butterflies was higher in the early morning than afternoon and eventually became low in the late afternoon for the three species. This variation could be because of reduced secretion of sugar with increased sugar concentration due to the higher evaporation. Another reason could be the higher rate of nectar production in the morning than afternoon and lowest around the midday. This finding was supported by a similar study reported in Herrera (1990). Moreover, studies indicate that pollinator efficiency depends on visitation frequency and the total number of visits from a given functional group (Couvillon, 2015; Herrera, 1990; Garbuzov and Ratnieks, 2014). The present observational study demonstrates the density of insect functional groups and visitation rate varies across the visitation hours for the three species in the GBG, which would impact the process of pollination and production of seed set.

From an ecological point of view, studies showed the decline of pollinators, which affects ecosystem stability and loss of biodiversity and, in turn, the plants they pollinate (Biesmeijer *et al.*, 2006; Taki and Kevan, 2007). Human activities have contributed to the loss of wild and flower-rich ecosystems, which has resulted in a fall in pollinator populations. To help maintain these important pollinator species, we can alter some of our habits, such as how we care for flowering plants in our farms and gardens. Unless the bee population and other pollinators in the botanic garden are not maintained, there will be a decrease in flowering plants and other plant biodiversity, including the species considered in this study. As a consequence, a decrease in the population size of bees and other pollinators will usually result in inadequate pollination of the three species, which in turn affects the reproductive capability of the sampled species and other flowering plants (Meixner *et al.*, 2010; Winfree *et al.*, 2009).

5 Conclusion and Recommendations

It is concluded from the present study that bees were the most frequent pollinators/visitors for the three selected flowering plants. The most active period for pollinators in a day was the early morning session compared to other periods for the three flowering plants. Of the five flowering weeks, the high frequency of visiting or pollinating by insects was recorded in the first flowering week, where all flowers were at the stage of blooming with plenty of nectar and pollen. The number of functional groups identified was fewer than in other similar studies, indicating that insect conservation should be integrated into the Gullele Botanic Garden. Bee-attractive native plants should be promoted in the Garden, particularly by establishing a pollinator garden as an additional theme for the sustainable conservation of other essential plant species, as well as its pollinators. Adding plants through tree planting and increasing plant diversity in the garden could enhance pollinators and their abundance. Finally, studies related to pollinator diversity, the taxonomy of pollinators, pollinators, and floral structures of animal-pollinated plants in the garden should be conducted as the second phase after this baseline study on three selected species.

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Conflict of Interest

The author declares that there is no conflict of interest.

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