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Woody plants supporting insect pollinators in Chagga home Gardens, Northern Tanzania

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Abstract

Insects play a great role in the pollination of flowers in many agricultural systems, and they rely on floral resources for their survival. However, a significant decline and extinction of these crucial insects have been witnessed globally as a result of fragmentation and/or loss of their habitat such as floral resources using data from the Chagga home garden (CHGs), we aimed at (1) examining the composition and species richness of pollinator forage plants in the CHGs, (2) determining how elevation affects the diversity of pollinator forage species in CHG, (3) determining the temporal availability of pollinator forage plants in the CHGs, (4) determining the pollinator groups foraging on the plants in the CHGs, (5) determining the type of floral rewards for the insect pollinators in CHGs. It was observed that: (1)of the 302 wood species in the CHGs, 293 (97%) from 62 families were pollinator forage of which 170 species (58.02%) were trees while 123 species (41.98%) were shrubs; (2) pollinator forage species diversity decreased with increase in elevation gradient; (3) Flowering of the pollinator forage plants was spread throughout the year; (4) Bees were the most dominant group of plant visitors, visiting about 93% of the plants; (5) the majority of plants provided both pollen and nectar to insect pollinators. The results from this study suggest that traditional agroforestry systems such as Chagga home gardens can contribute to increasing the spatial and temporal availability of diverse floral resources for insect pollinators.

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Introduction

The importance of pollinators' protection is underscored by the fact that they are essential for pollination of the majority of the world's wild flowering plants (Ollerton *et al.*, 2011) and 75% of crop species (Klein *et al.*, 2007). With regard to crop pollination, understanding factors influencing pollinator populations in farmlands is critical in designing conservation strategies that ensure their longtime survival in agricultural landscapes (Timberlake & Vaughan, 2019).

Insect pollinators are the main pollinator group in agricultural areas and their population is affected by several factors including the availability of floral resources (nectar and pollen) and nesting sites in farmlands (Fowler *et al.*, 2016). One way to ensure the availability of floral and nesting resources for insect pollinators in agricultural areas is by integrating trees and shrubs in farmlands (Bentrup *et al.*, 2019; Centeno-Alvarado *et al.*, 2023). The trees and shrubs in farmlands provide nesting sites and ensure floral resources availability for insect pollinators even when crops are not in bloom (Lowe *et al.*, 2021). However, this depends on whether the integrated trees and shrubs species are suitable for insect pollinators such as supplying food resources in terms of pollen, nectar, or both as well as nest sites.

The Chagga home gardens in Tanzania are one of the agricultural land use systems whereby farmers integrate trees and shrubs with crops and livestock in the same unit of land (Mbeyale &mcharo, 2022). The trees and shrubs in Chagga home gardens are either retained or planted for different purposes such as providing shade to the crops, especially bananas and coffee, fodder, live fences, and fruits (Soini, 2005). According to Hemp (2005), the Chagga home gardens maintain a high diversity of plants with over 500 plant species (including wood and herbaceous plants). However, despite of the high floral diversity of Chagga home gardens, there is little information concerning their potential in supplying floral and nesting resources to insect pollinators. Previous studies such as Arnold *et al.* (2021), Sawe *et al.* (2020), and Elisante *et al.* (2019) focused on assessing the pollination service of insect pollinator communities in the Chagga home garden and not their ecological habitat (floral resources and nesting sites).

The diversity of pollinator forage plants in the landscape reflects the continuous supply of floral resources from different plant species and hence encourages the insect pollinators to remain on site (Mensah *et al.*, 2017a). This is because trees and shrub species differ in flowering time and duration hence due to their intermittently flowering, they provide floral resources for insect visitors throughout the year (Torne-´Noguera *et al.*, 2014). Also, floral availability to insect pollinators in the landscape depends on the flowering time and spatial distribution of pollinator forage plants in the landscapes. In the Chagga home garden, farmers play a great role in determining the species composition in their garden since they plant or retain species based on their preferences and needs (Fernandes *et al.*, 1985). However environmental factors such as elevation affects the composition of plant species in the landscape (Malizia *et al.*, 2020).

This paper aimed at quantifying the availability of forage resources to insect pollinators in CHGs. A survey was carried out in CHGs to: (1) examine the composition and species richness of pollinator forage plants; (2) determine how elevation affects the diversity of pollinator forage species in CHG; (3) determine the temporal availability of pollinator forage plants in CHG, (4) determine the pollinator groups foraging on the pollinator forage species in CHGs (5) determine the type of floral rewards among insect pollinators forage species in CHGs. The results from this study are a crucial part of formulating efficiency policies, plans, and strategies to manage and conserve insect pollinators in agricultural landscapes in Tanzania.

Material and methods

This study was conducted in the Moshi rural district in the Kilimanjaro region located on the lower slopes of Mount Kilimanjaro in northern Tanzania (Fig. 1).

The district receives a bimodal rainfall pattern with a long rainy season around March and May and short rainfall around November and December (Appelhans *et al.* 2016; Røhr and Killingtveit 2003). The mean annual rainfall ranges between 600mm to 2000mm while the daily temperature ranges between 15 ◦C to 29 ◦C depending on location and elevation. Generally, agriculture is the main economic activity of the inhabitant in the district largely attributed to supportive climatic conditions for crops and tree growth. Due to shortage of land exacerbated by high population density, farmers tend to maximize their small homestead's land productivity by integrating different types of crops such as bananas, coffee, and beans; livestock such as cows and goats; and multipurpose trees and shrubs on the same piece of land. This system of farming is locally known as Chagga Home Gardens (CHGs).

The CHGs are mainly practiced between 800m to 1900m elevation on the slopes of the mountain Kilimanjaro (Hemp, 2005) and the average garden/farm size is 0.68 ha with a range of 0.2 to 1.2 ha per farmer (Hemp, 2005; Fernandes *et al.*, 1985).

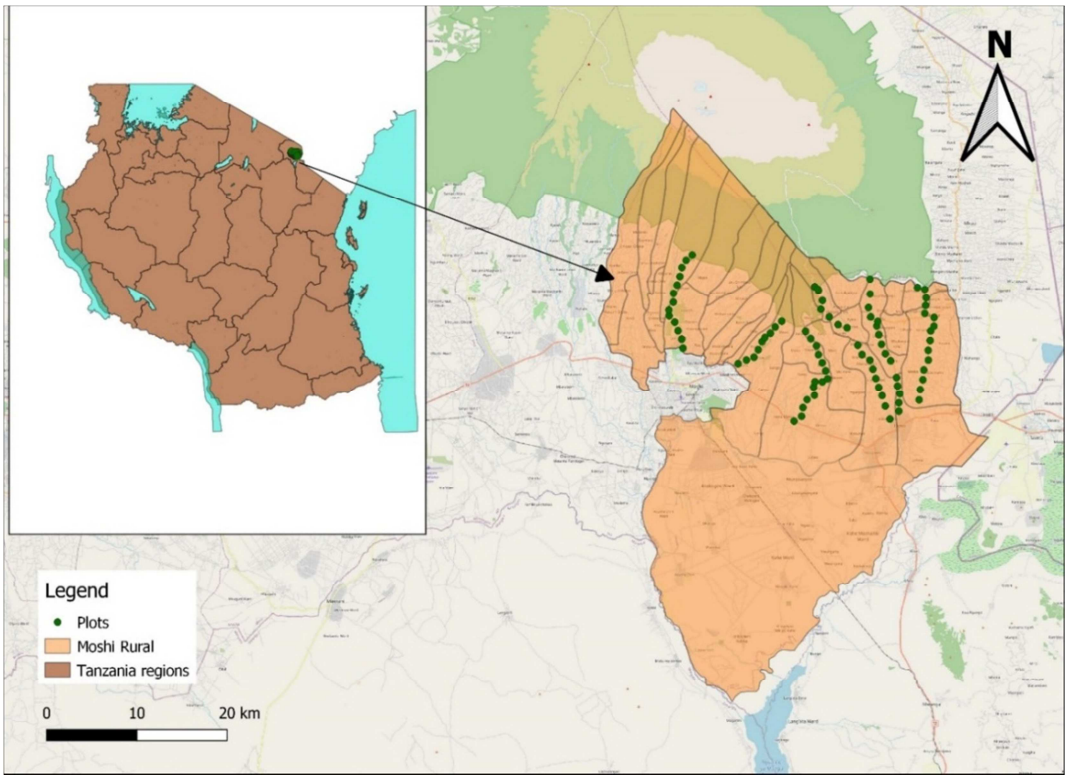

Fig. 1. Location of the study area showing the study plots (green cycles).

Fig. 2. Examples of the structure and composition of Chagga home gardens.

Selection of the study gardens

Systematic random sampling was used to select 101 CHGs along six road transects that pass across elevation gradients (Fig. 1). The distance from one home garden to another was 1km and the distance from the road was 100 m. The number of selected CHGs in each road transect depended on the length of the road. Data collection for the whole study was conducted between January and December 2022.

Data collection methods

In each CHG plot, we started by measuring the size of the home garden, and thereafter identified and counted all trees and shrubs. To determine whether the integrated trees and shrubs are pollinator forage, we monitored their phenology, especially flowering time, and whether they were visited by insect pollinators. This was done by conducting regular visits (at least once per month) in the year 2022. During each visit, we observed and recorded all the flowering trees and shrubs that were visited by insects that are considered pollinators (bees, butterflies, flies, and beetles)(Ollerton, 2017). The insect visitations to the flowers were observed between 9:00 am – 5:00 pm and the plants were considered as pollinator forage if an insect spent at least 5 seconds in the flower (Waykar & Baviskar, 2015). The types of floral rewards (nectar, pollen, or both) were determined by direct observation of the insect visitor's activity with the flower. When insect's activity with the flowers extended their proboscis the plant flower was considered a nectar source and when insects carried pollen on their body, the plant was considered a pollen source (Onyango *et al.* 2019; Waykar and Baviskar 2015). In case where the insect's activity to the flower extended its proboscis and also carried pollen on its body, the plant was considered both a pollen and nectar source (Onyango *et al.*, 2019).

Data analysis

Descriptive analysis such as tables and figures was used to summarize the results in an Excel spreadsheet. R software version 4.1.3 (R Core Team, 2022) was used to calculate the Shannon diversity index of pollinator forage species in CHGs as well as calculate the Pearson correlation coefficient between forage species diversity and elevation. Thereafter, we used the function "ggplot2" in R software to plot the correlation between forage species diversity and elevation in the CHGs.

Results

Pollinator forage species composition in CHG

A total of 302 wood species were identified in CHG and out of them, 293 (97%) species belonging to 62 families were insect pollinators forage (Appendix 1). The *Fabaceae* family had the highest number of forage species (n = 47, 15.8%), followed by *Euphorbiaceae* and *Solanaceae* (n = 18, 6.1% each). Most of the pollinator forage species were trees whereby out of 293 insect pollinator forage species, 170 species (58.02%) were trees while 123 species (41.98%) were shrubs. Among the tree forage species, native species were somewhat higher than exotic, whereby out of the 170 tree species, 88 species (51.8%) were native while 82 species (48.2%) were exotic. Similarly, native pollinator shrub species were somewhat higher than exotic whereby out of 123 shrub species, 63 species (51.2%) were native and 60 species (48.8%). Table 1a and 1b indicate the 10 most dominant forage species in CHG based on frequency of occurance in the sample gardens.

Table 1. The 10 most dominant insect pollinated tree species in the Chagga home gardens.

SN	Forage species	Family	Origin	Frequency of occurrence out of 101 plots
1	*Grevillea robusta*	Proteaceae	Exotic	81
2	*Persea americana*	Lauraceae	Exotic	74
3	*Rauvolfia caffra*	Apocynaceae	Native	65
4	*Mangifera indica*	Anacardiaceae	Exotic	62
5	*Albizia schimperiana*	Fabaceae	Native	61
6	*Cordia africana*	Boraginaceae	Native	44
7	*Cascabela thevetia*	Apocynaceae	Exotic	41
8	*Eriobotrya japonica*	Rosaceae	Exotic	41
9	*Markhamia lutea*	Bignoniaceae	Native	40
10	*Psidium guajava*	Myrtaceae	Exotic	37

Table 2. The 10 most dominant insect pollinated shrub species in the Chagga home gardens.

SN	Forage species	Family	Origin	Frequency of occurrence out of 101 plots
1	*Duranta repens*	Verbenaceae	Exotic	59
2	*Solanum incanum*	Solanaceae	Native	51
3	*Lantana camara*	Verbenaceae	Exotic	49
4	*Bougainvillea glabra*	Nyctaginaceae	Exotic	30
5	*Morus alba*	Moraceae	Exotic	30
6	*Caesalpinia decapetala*	Fabaceae	Exotic	29
7	*Manihot esculenta*	Euphorbiaceae	Exotic	25
8	*Solanum nigrum*	Solanaceae	Native	25
9	*Tithonia diversifolia*	Asteraceae	Exotic	22
10	*Coffea arabica*	Rubiaceae	Exotic	21

Effect of elevation on diversity and spatial distribution of insect pollinator forage species

Although in CHGs farmers play a great role in the type of species to include in their garden, it seems that the composition of pollinator forage species in CHGs is also affected by elevation. Some species were dominant in the lower elevation but were not present or not performing well in the mid or higher elevation and vice versa (Tables 7,8 and 9). There was a significant negative correlation between forage species diversity and elevation whereby as elevation increased, pollinator forage diversity decreased (Fig. 5, R = -0.29, p = 0.002

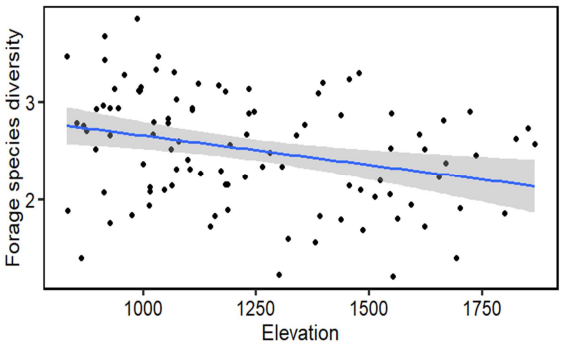

Fig. 3. Relationship between forage species shannon diversity and elevation (m).

Table 3. The 10 most dominant pollinator forage trees and shrub species in lower elevation <1000m in CHG.

SN	Tree forage species	Family	Floral reward	Shrub forage species	Family	Floral reward
1	*Cascabela thevetia*	Apocynaceae	Nectar	*Lantana camara*	Verbenaceae	Nectar
2	*Senna siamea*	Fabaceae	Pollen	*Solanum incanum*	Solanaceae	Pollen
3	*Grevillea robusta*	Proteaceae	Nectar and pollen	*Bougainvillea glabra*	Nyctaginaceae	Nectar and pollen
4	*Mangifera indica*	Anacardiaceae	Nectar	*Duranta repens*	Verbenaceae	Nectar and pollen
5	*Leucaena leucocephala*	Fabaceae	Nectar and pollen	*Manihot esculenta*	Euphorbiaceae	Nectar
6	*Cordia africana*	Boraginaceae	Nectar and pollen	*Senna occidentalis*	Fabacea	Pollen
7	*Commiphora zanzibarica*	Burseraceae	Nectar and pollen	*Tithonia diversifolia*	Asteraceae	Nectar and pollen
8	*Markhamia lutea*	Bignoniaceae	Nectar and pollen	*Caesalpinia decapetala*	Fabaceae	Nectar and pollen
9	*Rauvolfia caffra*	Apocynaceae	Nectar and pollen	*Vernonia brachycalyx*	Asteraceae	Nectar and pollen
10	*Persea americana*	Lauraceae	Nectar and pollen	*Caesalpinia pulcherrima*	Fabaceae	Nectar and pollen

Table 4. The 10 most dominant pollinator forage trees and shrub species in CHGs in mid-elevation 1001 - 1500m.

SN	Tree forage species	Family	Floral reward	Shrub forage species	Family	Floral reward
1	*Grevillea robusta*	Proteaceae	Nectar and pollen	*Duranta repens*	Verbenaceae	Nectar and pollen
2	*Persea americana*	Lauraceae	Nectar and pollen	*Solanum incanum*	Solanaceae	Pollen
3	*Albizia schimperiana*	Fabaceae	Nectar and pollen	*Caesalpinia decapetala*	Fabaceae	Nectar and pollen
4	*Mangifera indica*	Anacardiaceae	Nectar	*Lantana camara*	Verbenaceae	Nectar
5	*Rauvolfia caffra*	Apocynaceae	Nectar and pollen	*Morus alba*	Moraceae	Nectar and pollen
6	*Cordia africana*	Boraginaceae	Nectar and pollen	*Bougainvillea glabra*	Nyctaginaceae	Nectar and pollen
7	*Cedrela toona*	Meliaceae	Pollen	*Manihot esculenta*	Euphorbiaceae	Nectar
8	*Markhamia lutea*	Bignoniaceae	Nectar and pollen	*Vernonia brachycalyx*	Asteraceae	Nectar and pollen
9	*Senna spectabilis*	Fabaceae	Pollen	*Coffea arabica*	Rubiaceae	Nectar and pollen
10	*Margaritaria discoidea*	Phyllanthaceae	Nectar and pollen	*Stachytarpheta jamaicensis*	Verbenaceae	Nectar and pollen

Table 5. The 10 most dominant pollinator forage trees and shrub species in CHGs in higher elevation>1500m.

SN	Tree forage species	Family	Floral reward	Shrub forage species	Family	Floral reward
1	*Eriobotrya japonica*	Rosaceae	Nectar and pollen	*Duranta repens*	Verbenaceae	Nectar and pollen
2	*Persea americana*	Lauraceae	Nectar and pollen	*Lantana camara*	Verbenaceae	Nectar
3	*Grevillea robusta*	Proteaceae	Nectar and pollen	*Coffea arabica*	Rubiaceae	Nectar and pollen
4	*Rauvolfia caffra*	Apocynaceae	Nectar and pollen	*Solanum incanum*	Solanaceae	Pollen
5	*Albizia schimperiana*	Fabaceae	Nectar and pollen	*Morus alba*	Moraceae	Nectar and pollen
6	*Prunus persica*	Rosaceae	Nectar and pollen	*Stachytarpheta jamaicensis*	Verbenaceae	Nectar and pollen
7	*Cussonia arborea*	Araliaceae	Pollen	*Cyphomandra betacea*	Solanaceae	Nectar and pollen
8	*Callistemon speciosus*	Myrtaceae	Nectar and pollen	*Rubus fruticosus*	Rosaceae	Nectar and pollen
9	*Psidium guajava*	Myrtaceae	Nectar and pollen	*Tithonia diversifolia*	Asteraceae	Nectar and pollen
10	*Mangifera indica*	Anacardiaceae	Nectar	*Euphorbia pulcherrima*	Euphorbiaceae	Nectar and pollen

Temporal availability of pollinator forage species in CHG

The general pattern of flowering time of pollinator forage species indicates the availability of forage resources throughout the year (Fig. 3). The flowering time for most species overlapped, however, the period from November to January was the one at which most pollinator forage species produced flowers (from 95 to 82 species for native and 92 to 88 species for exotic). The distribution of duration of the flowering period of pollinator forage species revealed great variation between native and exotic species (Fig. 4). The duration of the flowering period for most native species is 3 and 12 months while for exotic species, the majority of them flower throughout the year (12 months).

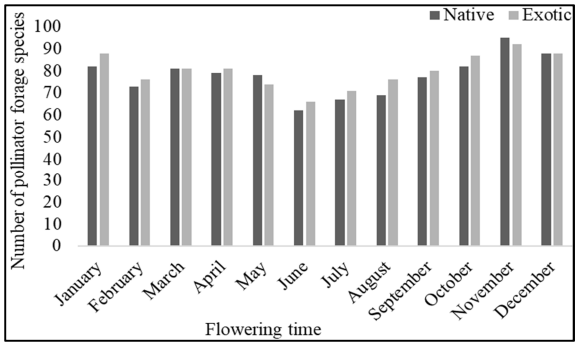

Fig. 4. Flowering time of pollinator forage plants in CHGs.

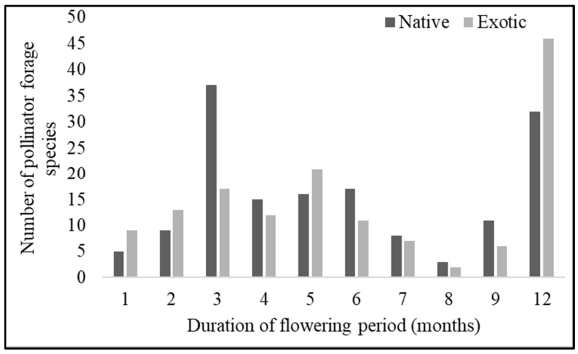

Fig. 5. Duration of the flowering period of pollinator forage species in CHGs (months).

Pollinator groups visited forage plants

The Pollinator forage species in the CHGs were visited by different insect pollinator groups during the survey (Fig. 7). Bees were the most dominant group that visited 275 (141 native, 134 exotic) out of 293 forage species in CHGs, followed by butterflies that visited 127 (61 native, 65 exotic) pollinator species. Wasps visited 74 (37 native, 37 exotic) plant species while flies visited 61 (26 native, 35 exotic). Beetles were the least pollinator group that visited only 50 (20 natives, 50 exotic) forage species out of 293. Of the 275 forage species visited by bees, 152 were trees and 123 were shrubs. Butterflies visited 66 trees and 61 shrubs. Wasps, flies and beetles visited 40 and 35, 35 and 28, and 23 and 28 trees and shrubs respectively.

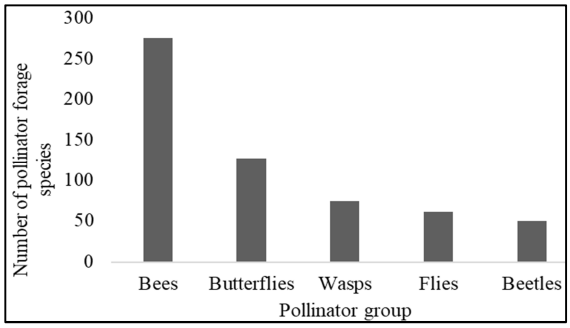

Fig. 6. Number of pollinator forage species that were visited by different pollinator groups.

Floral rewards from pollinator forage species in the home gardens

The pollinator forage species in the CHG provided different floral resources (nectar, pollen, or both) to insect pollinators. Majority of them 189 (63.6%) out of 293 pollinator forage species provided both pollen and nectar to insect pollinators. In the remaining plants, 26 (9.4%) species provided only pollen while 78 (26.9%) species provided only nectar (Fig. 6).

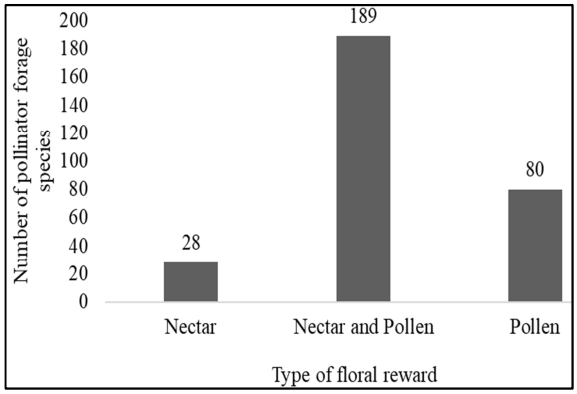

Fig. 7. Number of pollinator forage plants in the CHG and type of their floral rewards to insect pollinators.

Table 6. The 10 most dominant species provided both nectar and pollen to insect pollinators.

SN	Forage species	Family	Life form	Origin	Estimated number of flowers/inflorescences
1	*Grevillea robusta*	Proteaceae	Tree	Exotic	>1000
2	*Persea americana*	Lauraceae	Shrub	Exotic	>1000
3	*Rauvolfia caffra*	Apocynaceae	Tree	Native	>1000
4	*Albizia schimperiana*	Fabaceae	Tree	Native	>1000
5	*Duranta repens*	Verbenaceae	Shrub	Exotic	100-1000
6	*Cordia africana*	Boraginaceae	Tree	Native	>1000
7	*Eriobotrya japonica*	Rosaceae	Tree	Exotic	>1000
8	*Markhamia lutea*	Bignoniaceae	Tree	Native	>1000
9	*Psidium guajava*	Myrtaceae	Tree	Exotic	>1000
10	*Leucaena leucocephala*	Fabaceae	Tree	Exotic	>1000

Table 7. The 10 most dominant species provided only nectar to insect pollinators.

SN	Forage species	Family	Life form	Origin	Estimated number of flowers/ inflorescences
1	*Mangifera indica*	Anacardiaceae	Tree	Exotic	>1000
2	*Lantana camara*	Verbenaceae	Shrub	Exotic	100 - 1000
3	*Cascabela thevetia*	Apocynaceae	Tree	Exotic	>1000
4	*Manihot esculenta*	Euphorbiaceae	Shrub	Exotic	100-1000
5	*Acrocarpus fraxinifolius*	Fabaceae	Tree	Exotic	>1000
6	*Manihot glaziovii*	Euphorbiaceae	Tree	Exotic	>1000
7	*Diospyros fischeri*	Ebenaceae	Tree	Native	>1000
8	*Cestrum nocturnum*	Solanaceae	Shrub	Exotic	100-1000
9	*Odontonema cuspidatum*	Acanthaceae	Shrub	Exotic	100-1000
10	*Harrisonia abyssinica*	Rutaceae	Tree	Native	>1000

Table 8. The 10 most dominant species provided only pollen to insect pollinators.

SN	Forage species	Family	Life form	Origin	Estimated number of flowers/ inflorescences
1	*Solanum incanum*	Solanaceae	Shrub	Native	10-100
2	*Senna siamea*	Fabaceae	Tree	Exotic	>1000
3	*Senna spectabilis*	Fabaceae	Tree	Exotic	>1000
4	*Solanum nigrum*	Solanaceae	Shrub	Native	10-100
5	*Senna occidentalis*	Fabaceae	Shrub	Exotic	100-1000
6	*Cedrela toona*	Meliaceae	Tree	Exotic	>1000
7	*Trichilia emetica*	Meliaceae	Tree	Native	>1000
8	*Cedrela odorata*	Meliaceae	Tree	Exotic	>1000
9	*Jacaranda mimosifolia*	Bignoniaceae	Tree	Exotic	>1000
10	*Sorindeia madagascariensis*	Anacardiaceae	Tree	Native	>1000

Discussion

Many previous studies have reported a positive relationship between floral resources with abundance and diversity of insect pollinators (Plascencia & Philpott, 2017; Fowler *et al.*, 2016; Grundel *et al.*, 2010). This study provides evidence for the potential of traditional agroforestry systems to supply forage resources to insect pollinators by exploring the availability of insect pollinator forage species in Chagga home gardens. It was found that 1) 97% of woody plants in Chagga home gardens were pollinator forage plant species; 2) pollinator forage plant's flowering period was spread throughout the year 3) the majority of plants provided both pollen and nectar to insect pollinators 4) Bee was the most dominant group visiting 93% of all pollinator forage plants 5) Nesting sites were mainly provided by native tree species and 6) pollinator forage species diversity decreased with increase in elevation gradient.

Two hundred and ninety-three wood species (accounting for 97% of all wood plant richness in the selected CHG) with highly diversified families were identified as sources of nectar and/or pollen for insect pollinators. The diversity of pollinator forage plants suggests the diversity of flowers and differences in plant nectar and/or pollen quality (Hülsmann *et al.*, 2015; Di Pasquale *et al.*, 2013; Blüthgen & Klein, 2011) which are prerequisites to attracting and maintaining insect pollinator population. Floral resources (nectar and/or pollen) from different pollinator forage plants may be more nutritious than nectar and pollen from single plant species (Blüthgen & Klein, 2011).

Therefore, the diversity of pollinator forage plants in the Chagga home gardens provides balanced nutrition for insect pollinators through nectar and/or pollen from different plant species (Blüthgen & Klein, 2011).

In this study, it was found that pollinator-foraging plants in the Chagga home garden flower intermittently throughout the year as expected in a landscape with high plant diversity (Mensah *et al.*, 2017). The variation flowering period in addition to the diversity of pollinator forage plants in CHG increases the temporal availability of forage resources to insect pollinators (Blüthgen & Klein, 2011). Some of the pollinator forage plants flower at the same time providing insect pollinators an advantage for resource specialization and differential visiting (Taki *et al.*, 2011). Moreover, the majority of plants in CHG provided both pollen and nectar resources to insect pollinators. Insect pollinators especially bees need both pollen and nectar to meet their nutritional needs (IPBES, 2016). Hence, integrating different wood species in their farmland encourage insect to remain in their fields and pollinate crops. Bees were the most dominant pollinator group visited almost all pollinator forage plants in CHG. This may be because bees are generalist foragers as they fully depend on nectar and pollen for their survival (Rollin *et al.*, 2013). The high abundance of plants that supports bees could be beneficial for crop pollination since bees are the most important pollinator group in agricultural areas (Patel *et al.*, 2021). Moreover, trees especially old natives were the ones providing nesting sites to insect pollinators. This suggests that planting trees in farmlands help in conserving insect pollinators by providing them with nesting site. The decrease in diversity of pollinator foraging plants as the elevation gradient increase may be due to the harsh climatic condition that does not support some plants to survive and perform well.

Conclusion

This study suggests that traditional agroforestry systems such as Chagga home gardens can support insect pollinators. Given the pollinator forage plant species richness in the Chagga home garden, different forage species produce different flowers that provide diverse nutritional resources to insect pollinators. Different flowering pollinator forage plant species' flowers at different times hence providing floral resources throughout the year. Trees in the home gardens provide nesting sites for insect pollinators. Hence, it is suggested that to enhance pollination service in agricultural areas, it is important to integrate trees and shrubs in farmlands as they provide a favorable environment to insect pollinators and encourage them to remain on farms.

References

Appelhans T, Mwangomo E, Otte I, Detsch F, Nauss T, Hemp A. 2016. Eco-meteorological characteristics of the southern slopes of Kilimanjaro, Tanzania. International Journal of Climatology **36(9),** 3245-3258. https://doi.org/10.1002/joc.4552

Arnold SEJ, Elisante F, Mkenda PA, Tembo YLB, Ndakidemi PA, Gurr GM, Darbyshire IA, Belmain SR, Stevenson PC. 2021. Beneficial insects are associated with botanically rich margins with trees on small farms. Scientific Reports **11(1),** 1-11. https://doi.org/10.1038/s41598-021-94536-3

Bentrup G, Hopwood J, Adamson NL, Vaughan M. 2019. Temperate Agroforestry Systems and Insect Pollinators : A Review. Forests **10,** 1-12.

Blüthgen N, Klein AM. 2011. Functional complementarity and specialisation: The role of biodiversity in plant-pollinator interactions. Basic and Applied Ecology **12(4),** 282-291.

Brokaw J. 2013. Pollinator Habitat Availability and Diversity in Various Tropical Agroforestry Management Systems of *Coffea arabica* in Santa Clara, Chiriqui 1-27.

Centeno-Alvarado D, Ariadna Valentina L, Xavier A. 2023. Fostering pollination through agroforestry : A global review. Agriculture, Ecosystems and Environment **351,** 108478.

Di Pasquale G, Salignon M, Le Conte Y, Belzunces LP, Decourtye A, Kretzschmar A, Suchail S, Brunet JL, Alaux C. 2013. Influence of Pollen Nutrition on Honey Bee Health: Do Pollen Quality and Diversity Matter. PLoS ONE **8(8),** 1-13. https://doi.org/10.1371/journal.pone.0072016

Elisante F, Ndakidemi PA, Arnold SEJ, Belmain SR, Gurr GM, Darbyshire I, Xie G, Tumbo J, Stevenson PC. 2019. Enhancing knowledge among smallholders on pollinators and supporting field margins for sustainable food security. Journal of Rural Studies, **70,** 75-86. https://doi.org/10.1016/j.jrurstud.2019.07.004

Fernandes ECM, Oktingati A, Maghembe J. 1985. The Chagga homegardens: A multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania). Agroforestry Systems **2(2),** 73-86. https://doi.org/10.1007/BF00131267

Fowler RE, Rotheray EL, Goulson D. 2016. Floral abundance and resource quality influence pollinator choice 481-494.

Grundel R, Jean RP, Frohnapple KJ, Glowacki GA, Scott PE, Pavlovic NB. 2010. Floral and nesting resources, habitat structure and fire influence bee distribution across an open-forest gradient. Ecological Applications **20(6),** 1678-1692.

Hemp A. 2005. The Banana Forests of Kilimanjaro: Biodiversity and Conservation of the Chagga Homegardens. Biodiversity and Conservation **15(2006),** 1193-1217. https://doi.org/10.1007/978-1-4020-5208-8

Hülsmann M, von Wehrden H, Klein AM, Leonhardt SD. 2015. Plant diversity and composition compensate for negative effects of urbanization on foraging bumble bees. Apidologie **46(6),** 760-770.

Klein AM, Vaissière BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, Tscharntke T. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society: Biological Sciences **274(1608),** 303-313.

Lowe EB, Groves R, Gratton C. 2021. Impacts of field-edge flower plantings on pollinator conservation and ecosystem service delivery- A meta-analysis. Agriculture, Ecosystems and Environment **310,** 107290. https://doi.org/10.1016/j.agee.2020.107290

Malizia A, Blundo C, Carilla J, Acosta OO, Cuesta F, Duque A, Aguirre N, Aguirre Z, Ataroff M, Baez S, Calderón-Loor M, Cayola L, Cayuela L, Ceballos S, Cedillo H, Ríos WF, Feeley KJ, Fuentes AF, Gámez Álvarez LE, Young KR. 2020. Elevation and latitude drives structure and tree species composition in Andean forests: Results from a large-scale plot network. PLoS ONE **15(4),** 1-18.

Mbeyale GE, mcharo N. 2022. Institutional and land use dynamics of Chagga homegardens in Kilimanjaro Region, Tanzania. Tanzania Journal of Forestry and Nature Conservation **91(1),** 101-119.

Mensah S, Veldtman R, Seifert T. 2017a. Potential supply of floral resources to managed honey bees in natural mistbelt forests. Journal of Environmental Management **189,** 160-167.

Mensah S, Veldtman R, Seifert T. 2017b. Potential supply of floral resources to managed honey bees in natural mistbelt forests. Journal of Environmental Management **189,** 160-167. https://doi.org/10.1016/j.jenvman.2016.12.033

Ollerton J. 2017. Pollinator Diversity: Distribution, Ecological Function, and Conservation. Annual Review of Ecology, Evolution, and Systematics **48,** 353-376. https://doi.org/10.1146/annurev-ecolsys-110316-022919

Ollerton J, Winfree R, Tarrant S. 2011. How many flowering plants are pollinated by animals. Oikos **120(3),** 321-326.

Onyango P, Nyunja R, Sikolia SF, Opande G. 2019. Seasonal Availability and Floral Calendar of Apis mellifera Nectar and Pollen forage in Eastern Mau **7(1),** 88-97.

Patel V, Pauli N, Biggs E, Barbour L, Boruff B. 2021. Why bees are critical for achieving sustainable development. Ambio **50(1),** 49-59. https://doi.org/10.1007/s13280-020-01333-9

Plascencia M, Philpott SM. 2017. Floral abundance, richness, and spatial distribution drive urban garden bee communities. https://doi.org/10.1017/S00074853170

Potts SG, Vulliamy B, Roberts S. 2005. Role of nesting resources in organising diverse bee communities in a Mediterranean landscape. Ecological Entomology **30,** 78-85.

Røhr PC, Killingtveit Å. 2003. Rainfall distribution on the slopes of Mt Kilimanjaro. Hydrological Sciences Journal **48(1),** 65-77. https://doi.org/10.1623/hysj.48.1.65.43483

Rollin O, Bretagnolle V, Decourtye A, Aptel J, Michel N, Vaissière BE, Henry M. 2013. Differences of floral resource use between honey bees and wild bees in an intensive farming system. Agriculture, Ecosystems and Environment **179(2013),** 78-86. https://doi.org/10.1016/j.agee.2013.07.007

Sawe T, Eldegard K, Totland Ø, Macrice S, Nielsen A. 2020. Enhancing pollination is more effective than increased conventional agriculture inputs for improving watermelon yields. Ecology and Evolution **10(12),** 5343-5353. https://doi.org/10.1002/ece3.6278

Soini E. 2005. Changing livelihoods on the slopes of Mt. Kilimanjaro, Tanzania: Challenges and opportunities in the Chagga homegarden system. Agroforestry Systems **64,** 157-167.

Taki H, Yamaura Y, Okabe K, Maeto K. 2011. Plantation vs. natural forest: Matrix quality determines pollinator abundance in crop fields. Scientific Reports **1,** 1–4.

Timberlake TP, Vaughan IP. 2019. Phenology of farmland floral resources reveals seasonal gaps in nectar availability for bumblebees. Journal of Applied Ecology **56,** 1585-1596. https://doi.org/10.1111/1365

Torne-´Noguera A, Rodrigo A, Arnan X, Osorio S, Barril-Graells H, Da Rocha-Filho LC, Bosch J. 2014. Determinants of spatial distribution in a bee community: Nesting resources, flower resources and body size. PLoS ONE **9(5),** 1-10. https://doi.org/10.1371/journal.pone.0097255

Waykar B, Baviskar RK. 2015. Diversity of bee foraging flora and floral calendar of *Paithan taluka* of Aurangabad District (Maharashtra), India. Journal of Applied Horticulture **17(2),** 155-159. https://doi. org/10.37855/jah.2015.v17i02.29

Appendix 1

	Species name	Family	Life form	Origin	Flower number	Floral reward (Nectar, Pollen, Both)
1	*Abutilon mauritianum*	Malvaceae	Shrub	Native	100-1000	Nectar and pollen
2	*Abutilon theophrasti*	Malvaceae	Shrub	Native	100-1000	Nectar and pollen
3	*Acacia mearnsii*	Fabaceae	Tree	Exotic	>1000	Pollen
4	*Acacia melifera*	Fabaceae	Tree	Native	>1000	Pollen
5	*Acacia nilotica*	Fabaceae	Tree	Native	>1000	Pollen
6	*Acacia seyal*	Fabaceae	Tree	Native	>1000	Pollen
7	*Acacia tortilis*	Fabaceae	Tree	Native	>1000	Pollen
8	*Acalypha engleri*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
9	*Acalypha fruticosa*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
10	*Acalypha hispida*	Euphorbiaceae	Shrub	Exotic	100-1000	Pollen
11	*Acalypha neptunica*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
12	*Acrocarpus fraxinifolius*	Fabaceae	Tree	Exotic	>1000	Nectar
13	*Agauria salicifolia*	Ericaceae	Tree	Native	>1000	Nectar and pollen
14	*Agave sisaliana*	Asparagaceae	Shrub	Exotic	100-1000	Nectar
15	*Alangium chinense*	Cornaceae	Tree	Native	>1000	Pollen
16	*Albizia anthelmintica*	Fabaceae	Tree	Native	>1000	Nectar and pollen
17	*Albizia glabrescens*	Fabaceae	Tree	Native	>1000	Nectar and pollen
18	*Albizia lebbeck*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
19	*Albizia petersiana*	Fabaceae	Tree	Native	>1000	Nectar and pollen
20	*Albizia schimperiana*	Fabaceae	Tree	Native	>1000	Nectar and pollen
21	*Allamanda cathartica*	Apocynaceae	Shrub	Exotic	100-1000	Nectar and pollen

	Species name	Family	Life form	Origin	Flower number	Floral reward (Nectar, Pollen, Both)
22	*Allophylus calophyllus*	Sapindaceae	Shrub	Native	100-1000	Nectar and pollen
23	*Allophylus rubifolius*	Sapindaceae	Shrub	Native	100-1000	Nectar and pollen
24	*Aloe volkensii*	Asphodelaceae	Shrub	Native	100-1000	Nectar and pollen
25	*Anacardium occidentale*	Anacardiaceae	Tree	Exotic	>1000	Nectar and pollen
26	*Annona reticulata*	Annonaceae	Tree	Exotic	>1000	Pollen
27	*Annona senegalensis*	Annonaceae	Tree	Native	>1000	Nectar and pollen
28	*Annona squamosa*	Annonaceae	Tree	Exotic	>1000	Nectar and pollen
29	*Annona muricata*	Annonaceae	Tree	Exotic	>1000	Nectar and pollen
30	*Araucaria bidwillii*	Araucariaceae	Tree	Exotic	>1000	Pollen
31	*Araucaria columnaris*	Araucariaceae	Tree	Exotic	>1000	Pollen
32	*Araucaria cunninghamii*	Araucariaceae	Tree	Exotic	>1000	Pollen
33	*Artocarpus heterophyllus*	Moraceae	Tree	Exotic	>1000	Nectar and pollen
34	*Azadirachta indica*	Meliaceae	Tree	Exotic	>1000	Nectar and pollen
35	*Bauhinia variegata*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
36	*Blighia unijugata*	Sapindaceae	Tree	Native	>1000	Nectar and pollen
37	*Bombacopsis glabra*	Malvaceae	Tree	Native	>1000	Pollen
38	*Boscia salicifolia*	Capparaceae	Tree	Native	>1000	Nectar
39	*Bougainvillea glabra*	Nyctaginaceae	Shrub	Exotic	100-1000	Nectar and pollen
40	*Bridelia micrantha*	Phyllanthaceae	Tree	Native	>1000	Nectar and pollen
41	*Brugmansia sanguinea*	Solanaceae	Tree	Exotic	>1000	Nectar and pollen
42	*Brugmansia suaveolens*	Solanaceae	Tree	Exotic	>1000	Nectar and pollen
43	*Brunfelsia uniflora*	Solanaceae	Shrub	Exotic	100-1000	Nectar and pollen
44	*Caesalpinia decapetala*	Fabaceae	Shrub	Exotic	100-1000	Nectar and pollen
45	*Caesalpinia pulcherrima*	Fabaceae	Shrub	Exotic	100-1000	Nectar and pollen
46	*Cajanus cajan*	Fabaceae	Shrub	Exotic	100-1000	Nectar and pollen
47	*Calliandra calothyrsus*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
48	*Callistemon speciosus*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
49	*Calpurnia aurea*	Fabaceae	Shrub	Native	100-1000	Pollen
50	*Camellia sinensis*	Theaceae	Shrub	Exotic	100-1000	Nectar
51	*Cananga odorata*	Annonaceae	Tree	Exotic	>1000	Pollen
52	*Carica papaya*	Caricaceae	Tree	Exotic	>1000	Nectar and pollen
53	*Cascabela thevetia*	Apocynaceae	Tree	Exotic	>1000	Nectar
54	*Cassia fistula*	Fabaceae	Tree	Exotic	>1000	Pollen
55	*Cassia occidentalis*	Fabaceae	Shrub	Exotic	100-1000	Nectar and pollen
56	*Casuarina cunninghamiana*	Casuarinaceae	Tree	Exotic	>1000	Nectar and pollen
57	*Casuarina equisetifolia*	Casuarinaceae	Tree	Exotic	>1000	Pollen
58	*Cedrela odorata*	Meliaceae	Tree	Exotic	>1000	Pollen
59	*Cedrela toona*	Meliaceae	Tree	Exotic	>1000	Pollen
60	*Celtis mildbraedii*	Cannabaceae	Tree	Native	>1000	Nectar and pollen
61	*Cestrum nocturnum*	Solanaceae	Shrub	Exotic	100-1000	Nectar
62	*Cinnamomum zeylanicum*	Lauraceae	Tree	Exotic	>1000	Nectar and pollen
63	*Citrus limonia*	Rutaceae	Tree	Exotic	>1000	Nectar and pollen
64	*Citrus sinensis*	Rutaceae	Tree	Exotic	>1000	Nectar and pollen
65	*Clausena anisata*	Rubiaceae	Shrub	Native	100-1000	Nectar and pollen
66	*Clerodendrum speciosissimum*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
67	*Clerodendrum umbellatum*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
68	*Clotalaria laburnifolia*	Fabaceae	Shrub	Native	100-1000	Nectar and pollen
69	*Clotalaria sp*	Fabaceae	Shrub	Native	100-1000	Nectar and pollen
70	*Clotalaria verrucosa*	Fabaceae	Shrub	Native	100-1000	Nectar and pollen
71	*Cnidoscolus aconitifolius*	Euphorbiaceae	Shrub	Exotic	100-1000	Pollen
72	*Cocos nucifera*	Arecaceae	Tree	Exotic	>1000	Nectar and pollen
73	*Coffea arabica*	Rubiaceae	Shrub	Exotic	100-1000	Nectar and pollen
74	*Coffee robusta*	Rubiaceae	Shrub	Exotic	100-1000	Nectar and pollen
75	*Combretum molle*	Combretaceae	Tree	Native	>1000	Nectar and pollen
76	*Combretum zeyheri*	Combretaceae	Tree	Native	>1000	Nectar and pollen
77	*Commiphora zanzibarica*	Burseraceae	Tree	Native	>1000	Nectar and pollen
78	*Commiphora zimmermannii*	Burseraceae	Tree	Native	>1000	Nectar and pollen
79	*Cordia africana*	Boraginaceae	Tree	Native	>1000	Nectar and pollen
80	*Cordia alliodora*	Boraginaceae	Tree	Exotic	>1000	Nectar and pollen
81	*Cordia monoica*	Boraginaceae	Tree	Native	>1000	Nectar and pollen
82	*Cordia ovalis*	Boraginaceae	Tree	Native	>1000	Nectar and pollen
83	*Costus afer*	Costaceae	Shrub	Native	100-1000	Nectar and pollen
84	*Croton macrostachyus*	Euphorbiaceae	Tree	Native	>1000	Nectar and pollen
85	*Croton megalocarpus*	Euphorbiaceae	Tree	Native	>1000	Nectar and pollen
86	*Cuphea hyssopifolia*	Lythraceae	Shrub	Exotic	100-1000	Nectar and pollen
87	*Cuphea ignea*	Lythraceae	Shrub	Exotic	100-1000	Nectar and pollen
88	*Cupressus lusitanica*	Cupressaceae	Tree	Exotic	>1000	Pollen
89	*Cussonia arborea*	Araliaceae	Tree	Native	>1000	Pollen
90	*Cyphomandra betacea*	Solanaceae	Shrub	Exotic	100-1000	Nectar and pollen
91	*Datura wrightii*	Solanaceae	Tree	Exotic	<100	Nectar and pollen
92	*Delonix regia*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
93	*Dichrostachys cinerea*	Fabaceae	Tree	Native	>1000	Nectar and pollen
94	*Diospyros fischeri*	Ebenaceae	Tree	Native	>1000	Nectar
95	*Diospyros mespiliformis*	Ebenaceae	Tree	Native	>1000	Pollen
96	*Diospyros natalensis*	Ebenaceae	Tree	Native	>1000	Pollen
97	*Dombeya rotundifolia*	Malvaceae	Tree	Native	>1000	Nectar and pollen
98	*Dombeya tiliacea*	Malvaceae	Tree	Native	>1000	Nectar and pollen
99	*Dovyalis caffra*	Salicaceae	Shrub	Exotic	100-1000	Nectar
100	*Dracaena steudneri*	Asparagaceae	Tree	Native	>1000	Nectar and pollen
101	*Duranta repens*	Verbenaceae	Shrub	Exotic	100-1000	Nectar and pollen
102	*Dyschoriste radicans*	Acanthaceae	Shrub	Native	100-1000	Nectar and pollen
103	*Englerophytum natalense*	Sapotaceae	Tree	Native	>1000	Nectar and pollen
104	*Eriobotrya japonica*	Rosaceae	Tree	Exotic	>1000	Nectar and pollen
105	*Eriosema* sp	Fabaceae	Shrub	Native	100-1000	Pollen

	Species name	Family	Life form	Origin	Flower number	Floral reward (Nectar, Pollen, Both)
106	*Erythrina abyssinica*	Fabaceae	Tree	Native	>1000	Nectar and pollen
107	*Erythrococca fischeri*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
108	*Eucalyptus grandis*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
109	*Eucalyptus maidenii*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
110	*Euclea divinorum*	Ebenaceae	Tree	Native	>1000	Nectar and pollen
111	*Euclea natalensis*	Ebenaceae	Shrub	Native	100-1000	Nectar and pollen
112	*Eugenia uniflora*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
113	*Euphorbia candelabrum*	Euphorbiaceae	Tree	Native	>1000	Nectar and pollen
114	*Euphorbia pulcherrima*	Euphorbiaceae	Shrub	Exotic	100-1000	Nectar and pollen
115	*Euphorbia tithymaloides*	Euphorbiaceae	Tree	Exotic	>1000	Nectar
116	*Euryops pectinatus*	Asteraceae	Shrub	Native	100-1000	Nectar and pollen
117	*Ficus benjamina*	Moraceae	Tree	Exotic	>1000	Nectar
118	*Ficus exasperata*	Moraceae	Tree	Native	>1000	Nectar and pollen
119	*Ficus lutea*	Moraceae	Tree	Native	>1000	Nectar and pollen
120	*Ficus natalensis*	Moraceae	Tree	Native	>1000	Nectar
121	*Ficus ottoniifolia*	Moraceae	Tree	Native	>1000	Nectar
122	*Ficus sur*	Moraceae	Tree	Native	>1000	Nectar and pollen
123	*Ficus sycomorus*	Moraceae	Tree	Native	>1000	Nectar and pollen
124	*Ficus thonningii*	Moraceae	Tree	Native	>1000	Nectar and pollen
125	*Ficus vallis-choudae*	Moraceae	Tree	Native	>1000	Nectar and pollen
126	*Flacourtia indica*	Salicaceae	Tree	Native	>1000	Nectar and pollen
127	*Flueggea virosa*	Phyllanthaceae	Shrub	Native	100-1000	Nectar and pollen
128	*Gmelina arborea*	Lamiaceae	Tree	Exotic	<100	Nectar and pollen
129	*Grevillea robusta*	Proteaceae	Tree	Exotic	>1000	Nectar and pollen
130	*Grewia bicolor*	Malvaceae	Shrub	Native	100-1000	Nectar and pollen
131	*Grewia holstii*	Malvaceae	Shrub	Native	<100	Nectar and pollen
132	*Gymnosporia senegalensis*	Celastraceae	Tree	Native	>1000	Nectar and pollen
133	*Hamelia patens*	Rubiaceae	Shrub	Exotic	100-1000	Nectar
134	*Harrisonia abyssinica*	Rutaceae	Tree	Native	>1000	Nectar
135	*Hibiscus calyphyllus*	Malvaceae	Shrub	Native	100-1000	Nectar and pollen
136	*Hibiscus rosa-sinensis*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
137	*Hibiscus sabdariffa*	Malvaceae	Shrub	Native	100-1000	Nectar and pollen
138	*Hibiscus sinensis*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
139	*Hoslundia opposita*	Lamiaceae	Shrub	Native	100-1000	Pollen
140	*Hura crepitans*	Euphorbiaceae	Tree	Exotic	>1000	Nectar and pollen
141	*Indigofera arrecta*	Fabaceae	Shrub	Native	100-1000	Nectar and pollen
142	*Indigofera brevicalyx*	Fabaceae	Shrub	Native	100-1000	Pollen
143	*Jacaranda mimosifolia*	Bignoniaceae	Tree	Exotic	>1000	Pollen
144	*Jatropha curcas*	Euphorbiaceae	Tree	Exotic	>1000	Nectar and pollen
145	*Justicia aurea*	Acanthaceae	Shrub	Exotic	100-1000	Nectar and pollen
146	*Justicia brandegeena*	Acanthaceae	Shrub	Exotic	100-1000	Nectar and pollen
147	*Justicia caffra*	Acanthaceae	Shrub	Exotic	100-1000	Nectar and pollen
148	*Khaya anthotheca*	Meliaceae	Tree	Native	>1000	Nectar and pollen
149	*Kigelia africana*	Bignoniaceae	Tree	Native	>1000	Nectar and pollen
150	*Lagascea mollis*	Asteraceae	Shrub	Exotic	100-1000	Nectar and pollen
151	*Lannea fulva*	Anacardiaceae	Tree	Native	>1000	Nectar and pollen
152	*Lannea schweinfurthii*	Anacardiaceae	Tree	Native	>1000	Nectar and pollen
153	*Lannea welwitschii*	Anacardiaceae	Tree	Native	>1000	Nectar and pollen
154	*Lantana camara*	Verbenaceae	Shrub	Exotic	100-1000	Nectar
155	*Lawsonia inermis*	Lythraceae	Tree	Exotic	>1000	Nectar and pollen
156	*Leonotis leonurus*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
157	*Leonotis nepetifolia*	Lamiaceae	Shrub	Native	100-1000	Nectar
158	*Leucaena leucocephala*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
159	*Leucas glabrata*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
160	*Leucas grandis*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
161	*Macaranga kilimandscharica*	Euphorbiaceae	Tree	Native	>1000	Nectar
162	*Maerua angolensis*	Capparaceae	Shrub	Native	100-1000	Nectar
163	*Maesa lanceolata*	Maesaceae	Tree	Native	>1000	Nectar and pollen
164	*Maesopsis eminii*	Rhamnaceae	Tree	Native	>1000	Pollen
165	*Malus prunifolia*	Rosaceae	Tree	Exotic	>1000	Nectar and pollen
166	*Malva sylvestris*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
167	*Malvastrum coromandelianum*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
168	*Malvaviscus arboreus*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
169	*Malviscus penduliflorus*	Malvaceae	Shrub	Exotic	100-1000	Nectar and pollen
170	*Mangifera indica*	Anacardiaceae	Tree	Exotic	>1000	Nectar
171	*Manihot esculenta*	Euphorbiaceae	Shrub	Exotic	100-1000	Nectar
172	*Manihot glaziovii*	Euphorbiaceae	Tree	Exotic	>1000	Nectar
173	*Margaritaria discoidea*	Phyllanthaceae	Tree	Native	>1000	Nectar and pollen
174	*Markhamia lutea*	Bignoniaceae	Tree	Native	>1000	Nectar and pollen
175	*Maytenus undata*	Celastraceae	Shrub	Native	100-1000	Nectar and pollen
176	*Melaleuca alternifolia*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
177	*Melia azedarach*	Meliaceae	Tree	Exotic	>1000	Nectar and pollen
178	*Milicia excelsa*	Moraceae	Tree	Native	>1000	Nectar and pollen
179	*Mimosa pigra*	Fabaceae	Shrub	Exotic	100-1000	Pollen
180	*Mitragyna rubrostipulata*	Rubiaceae	Tree	Native	>1000	Nectar
181	*Moringa oleifera*	Moringaceae	Tree	Exotic	>1000	Nectar and pollen
182	*Morus alba*	Moraceae	Shrub	Exotic	100-1000	Nectar and pollen
183	*Muntingia calabura*	Muntingiaceae	Tree	Exotic	>1000	Nectar
184	*Murraya paniculata*	Rutaceae	Tree	Exotic	>1000	Nectar and pollen
185	*Musa paradisiaca*	Musaceae	Shrub	Exotic	<100	Nectar
186	*Nerium oleander*	Apocynaceae	Shrub	Exotic	100-1000	Pollen
187	*Nicandra physalodes*	Solanaceae	Shrub	Exotic	100-1000	Nectar and pollen
188	*Ochna holstii*	Ochnaceae	Tree	Native	>1000	Nectar and pollen
189	*Ocimum filamentosum*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen

	Species name	Family	Life form	Origin	Flower number	Floral reward (Nectar, Pollen, Both)
190	*Ocimum suave*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
191	*Ocotea usambarensis*	Lauraceae	Tree	Native	>1000	Nectar and pollen
192	*Odontonema cuspidatum*	Acanthaceae	Shrub	Exotic	100-1000	Nectar
193	*Olea capensis*	Oleaceae	Tree	Native	>1000	Nectar and pollen
194	*Opuntia engelmannii*	Cactaceae	Shrub	Native	100-1000	Pollen
195	*Ozoroa insignis*	Anacardiaceae	Tree	Native	>1000	Nectar and pollen
196	*Pachira glabra*	Malvaceae	Tree	Exotic	>1000	Nectar and pollen
197	*Paliurus spina christi*	Rhamnaceae	Shrub	Exotic	100-1000	Nectar and pollen
198	*Pavetta* sp	Rubiaceae	Tree	Exotic	>1000	Nectar and pollen
199	*Pelargonium inquinans*	Geraniaceae	Shrub	Native	100-1000	Nectar and pollen
200	*Persea americana*	Lauraceae	Tree	Exotic	>1000	Nectar and pollen
201	*Phaulopsis imbricata*	Acanthaceae	Shrub	Native	100-1000	Nectar and pollen
202	*Philenoptera violacea*	Fabaceae	Tree	Native	>1000	Nectar and pollen
203	*Philippia excelsa*	Proteaceae	Tree	Native	<100	Pollen
204	*Phoenix reclinata*	Arecaceae	Tree	Native	>1000	Nectar and pollen
205	*Phoenix rupicola*	Arecaceae	Tree	Native	>1000	Nectar and pollen
206	*Phyllanthus amarus*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
207	*Phyllanthus engleri*	Euphorbiaceae	Shrub	Native	100-1000	Pollen
208	*Piliostigma thonningii*	Fabaceae	Tree	Native	>1000	Nectar and pollen
209	*Pinus caribeae*	Pinaceae	Tree	Exotic	>1000	Pollen
210	*Pinus patula*	Pinaceae	Tree	Exotic	>1000	Pollen
211	*Pithecellobium dulce*	Fabaceae	Tree	Exotic	>1000	Nectar and pollen
212	*Plectranthus parviflorus*	Lamiaceae	Shrub	Exotic	100-1000	Nectar and pollen
213	*Pluchea carolinensis*	Asteraceae	Shrub	Exotic	100-1000	Nectar and pollen
214	*Plumeria rubra*	Apocynaceae	Tree	Exotic	>1000	Pollen
215	*Polyalthia longifolia*	Annonaceae	Tree	Exotic	>1000	Nectar and pollen
216	*Pouteria campechiana*	Sapotaceae	Tree	Exotic	>1000	Nectar and pollen
217	*Prunus persica*	Rosaceae	Tree	Exotic	>1000	Nectar and pollen
218	*Psidium cattleianum*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
219	*Psidium guajava*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
220	*Punica granatum*	Lythraceae	Shrub	Exotic	100-1000	Pollen
221	*Pyrus communis*	Rosaceae	Tree	Exotic	>1000	Nectar and pollen
222	*Rauvolfia caffra*	Apocynaceae	Tree	Native	>1000	Nectar and pollen
223	*Rhus natalensis*	Anacardiaceae	Shrub	Native	100-1000	Nectar and pollen
224	*Rhus vulgaris*	Anacardiaceae	Shrub	Native	100-1000	Nectar and pollen
225	*Roystonea regia*	Arecaceae	Tree	Exotic	>1000	Nectar and pollen
226	*Rubus fruticosus*	Rosaceae	Shrub	Exotic	100-1000	Nectar and pollen
227	*Rubus rosifolius*	Rosaceae	Shrub	Exotic	100-1000	Nectar and pollen
228	*Salvia splendens*	Lamiaceae	Shrub	Exotic	100-1000	Nectar and pollen
229	*Sambucus canadensis*	Adoxaceae	Shrub	Exotic	100-1000	Pollen
230	*Sapindus saponaria*	Sapindaceae	Tree	Exotic	>1000	Nectar and pollen
231	*Senna alata*	Fabaceae	Tree	Exotic	>1000	Pollen
232	*Senna auriculata*	Fabaceae	Shrub	Exotic	100-1000	Pollen
233	*Senna bicapsularis*	Fabaceae	Shrub	Exotic	100-1000	Pollen
234	*Senna corymbosa*	Fabaceae	Shrub	Exotic	100-1000	Pollen
235	*Senna didymobotrya*	Fabaceae	Shrub	Native	100-1000	Pollen
236	*Senna obtusifolia*	Fabaceae	Shrub	Exotic	100-1000	Pollen
237	*Senna occidentalis*	Fabaceae	Shrub	Exotic	100-1000	Pollen
238	*Senna siamea*	Fabaceae	Tree	Exotic	>1000	Pollen
239	*Senna spectabilis*	Fabaceae	Tree	Exotic	>1000	Pollen
240	*sesamum angolense*	Pedaliaceae	Shrub	Native	100-1000	Nectar and pollen
241	*Solanecio mannii*	Asteraceae	Shrub	Native	100-1000	Pollen
242	*Solanum aethiopicum*	Solanaceae	Shrub	Native	100-1000	Pollen
243	*Solanum anguivii*	Solanaceae	Shrub	Native	100-1000	Pollen
244	*Solanum betaceum*	Solanaceae	Shrub	Exotic	100-1000	Nectar
245	*Solanum calolinense*	Solanaceae	Shrub	Exotic	100-1000	Pollen
246	*Solanum gilo*	Solanaceae	Shrub	Native	100-1000	Pollen
247	*Solanum incanum*	Solanaceae	Shrub	Native	100-1000	Pollen
248	*Solanum lycopersicum*	Solanaceae	Shrub	Native	100-1000	Pollen
249	*Solanum melongena*	Solanaceae	Shrub	Exotic	100-1000	Pollen
250	*Solanum nigrum*	Solanaceae	Shrub	Native	100-1000	Pollen
251	*Solanum wightii*	Solanaceae	Shrub	Native	100-1000	Pollen
252	*Solanum carolinense*	Solanaceae	Shrub	Native	100-1000	Nectar and pollen
253	*Sorindeia madagascariensis*	Anacardiaceae	Tree	Native	>1000	Pollen
254	*Spathodea campanulata*	Bignoniaceae	Tree	Native	>1000	Nectar and pollen
255	*Stachytarpheta jamaicensis*	Verbenaceae	Shrub	Exotic	100-1000	Nectar and pollen
256	*Steganotaenia araliacea*	Apiaceae	Shrub	Native	100-1000	Nectar and pollen
257	*Stereospermum kunthianum*	Bignoniaceae	Tree	Native	>1000	Nectar and pollen
258	*Syzygium cumini*	Myrtaceae	Tree	Native	>1000	Nectar and pollen
259	*Syzygium guineense*	Myrtaceae	Tree	Native	>1000	Nectar and pollen
260	*Syzygium jambos*	Myrtaceae	Tree	Exotic	>1000	Nectar and pollen
261	*Tabernaemontana ventricosa*	Apocynaceae	Tree	Native	>1000	Nectar and pollen
262	*Tamarindus indica*	Fabaceae	Tree	Native	>1000	Nectar and pollen
263	*Tecoma stans*	Bignoniaceae	Shrub	Exotic	100-1000	Pollen
264	*Tecomaria capensis*	Bignoniaceae	Shrub	Native	100-1000	Nectar and pollen
265	*Tectona grandis*	Lamiaceae	Tree	Exotic	>1000	Nectar and pollen
266	*Tephrosia cinerea*	Fabaceae	Tree	Exotic	>1000	Pollen
267	*Tephrosia villosa*	Papilionaceae	Shrub	Native	100-1000	Pollen
268	*Tephrosia vogelii*	Fabaceae	Shrub	Native	100-1000	Pollen
269	*Terminalia catappa*	Combretaceae	Tree	Exotic	>1000	Pollen
270	*Terminalia ivorensis*	Combretaceae	Tree	Exotic	>1000	Pollen
271	*Terminalia mantaly*	Combretaceae	Tree	Exotic	>1000	Pollen
272	*Terminalia prunioides*	Combretaceae	Tree	Exotic	>1000	Pollen
273	*Terminalia sambesiaca*	Combretaceae	Tree	Native	>1000	Pollen

	Species name	Family	Life form	Origin	Flower number	Floral reward (Nectar, Pollen, Both)
274	*Terminalia sericea*	Combretaceae	Tree	Native	>1000	Pollen
275	*Terminalia superba*	Combretaceae	Tree	Exotic	>1000	Pollen
276	*Tetradenia riparia*	Lamiaceae	Shrub	Native	100-1000	Nectar and pollen
277	*Tibouchina heteromalla*	Melastomataceae	Shrub	Exotic	100-1000	Nectar and pollen
278	*Tithonia diversifolia*	Asteraceae	Shrub	Exotic	100-1000	Nectar and pollen
279	*Trema orientale*	Cannabaceae	Tree	Native	>1000	Pollen
280	*Trichilia emetica*	Meliaceae	Tree	Native	>1000	Pollen
281	*Trichodesma zeylanicum*	Boraginaceae	Shrub	Exotic	100-1000	Nectar and pollen
282	*Turraea nilotica*	Meliaceae	Tree	Native	>1000	Nectar and pollen
283	*Vachellia nilotica*	Fabaceae	Tree	Native	>1000	Pollen
284	*Vachellia tortilis*	Fabaceae	Tree	Native	>1000	Nectar and pollen
285	*Vangueria apiculata*	Rubiaceae	Shrub	Native	100-1000	Nectar and pollen
286	*Vangueria infausta*	Rubiaceae	Shrub	Native	100-1000	Nectar and pollen
287	*Vangueria tomentosa*	Rubiaceae	Tree	Native	>1000	Nectar and pollen
288	*Vepris nobilis*	Rutaceae	Tree	Native	>1000	Nectar
289	*Vernonia amygdalina*	Asteraceae	Shrub	Native	100-1000	Nectar and pollen
290	*Vernonia brachycalyx*	Asteraceae	Shrub	Native	100-1000	Nectar and pollen
291	*Viburnum nudum*	Adoxaceae	Shrub	Exotic	100-1000	Pollen
292	*Xylopia aethiopica*	Annonaceae	Tree	Native	>1000	Nectar and pollen
	Zanthoxylum chalybeum	Rutaceae	Tree	Native	>1000	Nectar and pollen