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Original Article

Beekeeping Potential, Richness, and Distribution of Plant Species Foraged by Stinging Honey Bee (*Apis Mellifera* L.) in West Kilimanjaro Tanzania Forest Service Agency (TFS) Plantation.

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ABSTRACT

An assessment of beekeeping potential, richness, and distribution of plant species foraged by stinging honey bee *Apis mellifera* L. in West Kilimanjaro Tanzania Forest Service Agency (TFS) Plantation area was conducted in 2020. A total of 40, 20 m x 20 m plots were set on the 5 natural vegetation remnants within the plantation forest ranges of Sanya juu, Lemosho, Hill wood, Wasendo, and Londrosi at an interval of 100 m. Within the 20 m x 20 m, 1 m x 1 m nested plots were established to assess herbs, sedge, grasses, and seedlings, while 2 m x 5 m were established to determine shrubs. Agriculture crops grown by the bordering villagers were identified and evaluated for the bee forage potential. Plant species richness (S) was determined from the total number of plant species identified from every site using the Shannon Weiner Diversity Index (H'). Plant species distribution was determined grounded on the frequency (F) and evenness (E) were determined. The sites were revealed to have high plant species diversity foraged by stinging honey bees. A total of 204 plant species belonging to 76 families and 178 genera were identified. The calculates H' of 2.37 for non-wood plants and 3.05 for wood plants implied high plant diversity. The most distributed plant species had a relative frequency (RF) of 6.250 ± 3.0303 , while the rest had an $RF < 3.0303$. The disappearance of one species does not cause any significant effect on bees, as they can go for another species in the area. 92% of non-woody plants and 94% of the identified woody plants were known to be foraged by stinging honey bees. The evenness (E) of 0.7484 for non-wood plants and 0.795 implied that the plants in all categorize were not evenly distributed. West Kilimanjaro Forest Plantation (WKFP) natural forest patches are potential for honey beekeeping. Stinging honey bee

fodder plants should be planted, regular visits to the project sites should be exercised to protect honey theft, spot clearing to give a room for naturally germinated seedlings covered by climbers. Further study should be done on the biological species diversity, training to beekeeping staff, and plan for regular inspection of the honey bee colony strength will help to reveal any challenges facing the venture including diseases and hives strengths and weakness.

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INTRODUCTION

Worldwide beekeeping products have been known for their role such as to provide high-value products as a source of income and nutrition value (FAO, 2015). It has been stated that beekeeping is an economic development venture that has existed for a long period of time (Tutuba & Vanhaverbeke, 2018). Beekeeping is an environmentally friendly intervention, provides employment, education, food, and significant contribution to plant diversity, conservation, and honey bees as famous pollinators improves agriculture crop production (Bradbear, 2009). The tropical people depend on very small-scale crop production relying on shifting cultivation that clears vegetation, and hence beekeeping is a panacea for sustainable community development and biodiversity conservation (Minja & Nkumilwa, 2016). The indigenous flowering plants in Africa benefit from honey bee pollination, and

approximately one-third of all food produced is the result of honey bee pollination (Gupta et al., 2014). URT (2014) mentioned that until that year, TFS was managing six declared bee reserves with a total area of 31,374 ha and three proposed bee reserves covering an area of 8,392 ha. However, Tanzania had a capacity of 9.2 million bee colonies and the potential production of 138,000 tons of honey and 625 tons of beeswax annually (URT, 2014). The Tanzania Beekeeping Policy (URT, 1998) mentions beekeeping as among potential socio-economic activities that sustain biodiversity because the honey products depend on protected vegetation playing a vital role as a source of bee fodder.

Beekeeping Potential in West Kilimanjaro Plantation

West Kilimanjaro Forest plantation was gazetted as a forest reserve in 1921 and regazetted in 1940 under the Government Notice No. 227 Cap. 132.

The plantation was established in 1954 planted with *Pinus patula*, *Cupressus lusitanica*, *Pinus radiata*, and *Juniperus procera* to increase the watershed protective capacity, to reduce erosion problem on the slopes of Mount Kilimanjaro and to supply wood products in the Arusha and Kilimanjaro regions (Tanzania Forest Service Agency, 2020). It has been insisted that beekeeping area or be reserve is recognized through scientific research to reveal the necessary conditions supporting the production of honey crops (Tanzania National Beekeeping Act 2002). Amulen et al. (2019) highlighted that the potential of beekeeping for poverty alleviation is lacking because the value of honey products has not been evaluated thoroughly. Apart from the West Kilimanjaro being planted with exotic trees, there are still natural vegetation (thicket, woodland, and forest) patches with high plant diversity that can support honey beekeeping. However, little is known on the beekeeping potential, richness and distribution of the plant species foraged by honey bees. This survey intended to survey the potential, richness and distribution of plant species foraged by honey bees in West Kilimanjaro Plantation.

Richness and Distribution of plants Species Foraged by *Apis mellifera*

Plant species richness which is the total number of species of a given locality forms the plant community properties together with evenness

(abundance equality of species) and composition (Dorji et al. 2014; Fischer et al., 2018). The West Kilimanjaro plantation lies on the Kilimanjaro mountain with high plant diversity of which among them are treated as endangered such as *Juniperus procera*. Abrha et al. (2018) pointed out that *J. procera* is the most preferred tree in Ethiopia; it is an endangered tree species enumerated in the IUCN red list.

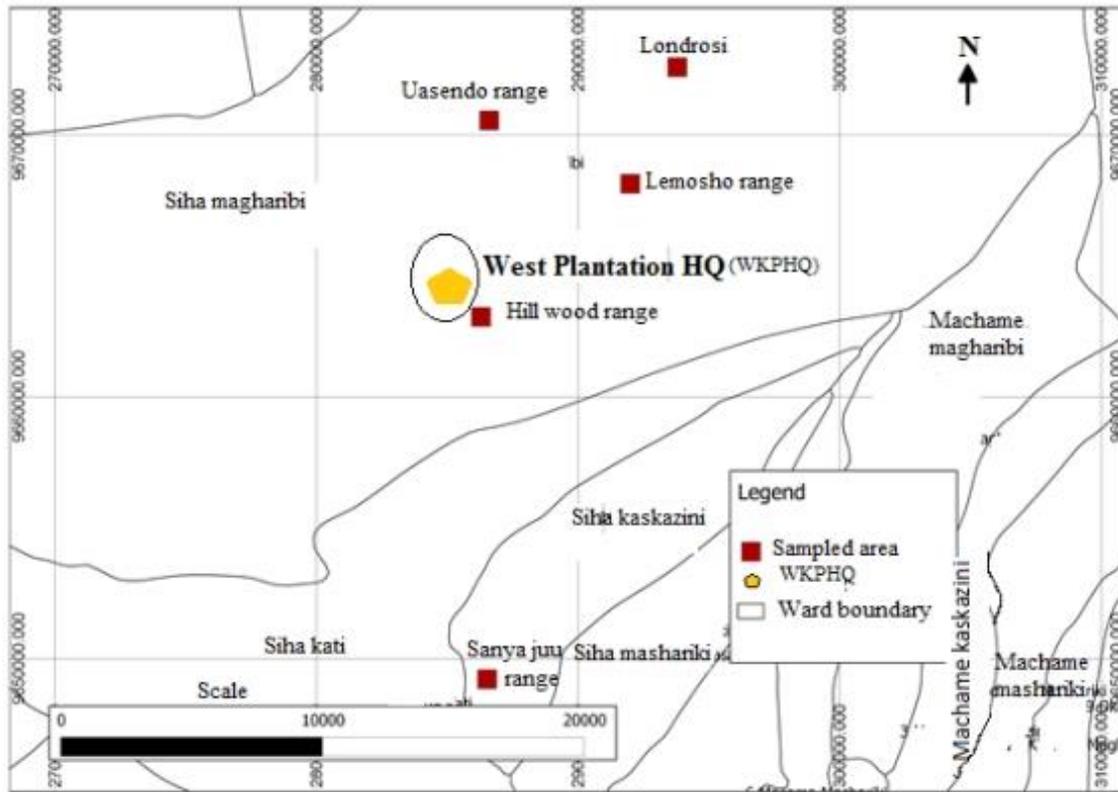
The distribution (the spreading of plant species) has a great role in the availability of pollinators that are important organisms for the fertility of plants in the wild environment and on farms. *A. mellifera* is well supported by the widely distributed plants that can be foraged on (Hung et al. 2018). The quantity and diversity of collected pollen can influence the growth and health of honey bee colonies (Requier et al., 2015), but little is known on the potential foraged ecosystem resources. This study aimed to assess the beeping potential, richness and distribution of plant species foraged by the stinging honey bee in West Kilimanjaro Plantation.

MATERIAL AND METHODS

Description of Study Site

The study was conducted in five targeted areas (*Table 1 & Figure 1*) for beekeeping intervention within the West Kilimanjaro Plantation.

Figure 1: Beekeeping project sites in West Kilimanjaro Forest Plantation



The five sites are natural forest remnants or patches left within the plantation. Those areas are known for their potential in terms of plant species diversity, of which most of them are being foraged by honey bees. The West Kilimanjaro Plantation occupies an area of 7,500 hectares including staff quarters area,

plantation area, and the remnants of natural vegetation patches inclusive of Londrosi in Wasendo range with an area of 4,460 Ha including the 1,156 Ha remnant of natural vegetation, Sanya Juu range (200 Ha), Lemosho range (2,200.5 Ha), and Hill wood range (121 Ha).

Table 1: Sampled sites for beekeeping project in West Kilimanjaro Plantation

S/No.	Range/project site	Coordinates
1	Sanya juu	37M 0286459 UTM 9648800 Alt. 1276 m. a.s.l
2	Wasendo	37M 0287955 UTM 9669797 Alt. 1754 m. a.s.l
3	Lemosho	37M 0291150 UTM 9668860 Alt. 2013 m. a.s.l
4	Londrosi	37M 0292809 UTM 9672618 Alt. 2146 m. a.s.l
5	Hill wood	37M 0285976 UTM 9663016 Alt. 1557 m. a.s.l

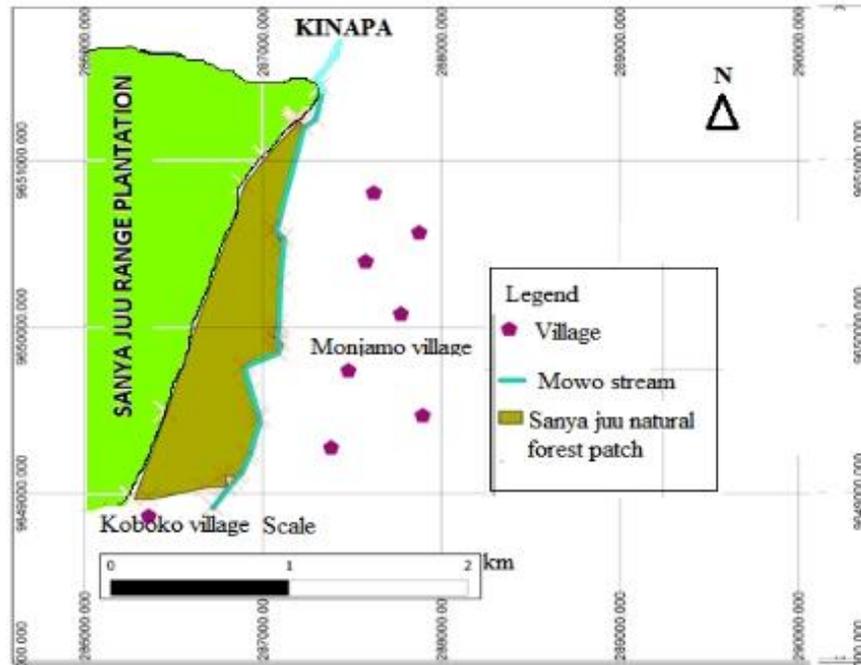
Description of Beekeeping Project Sites

Sanya Juu Range Natural Forest

This natural forest remnant borders the Monjamo village on the east, Koboko village on the south, and

on the east and north, it borders the West Kilimanjaro plantation (*Figure 2*). The site is characterized into two major parts; the seasonally dry forest and the riverine forest on the eastern margin.

Figure 2: Sanya juu range natural forest patch



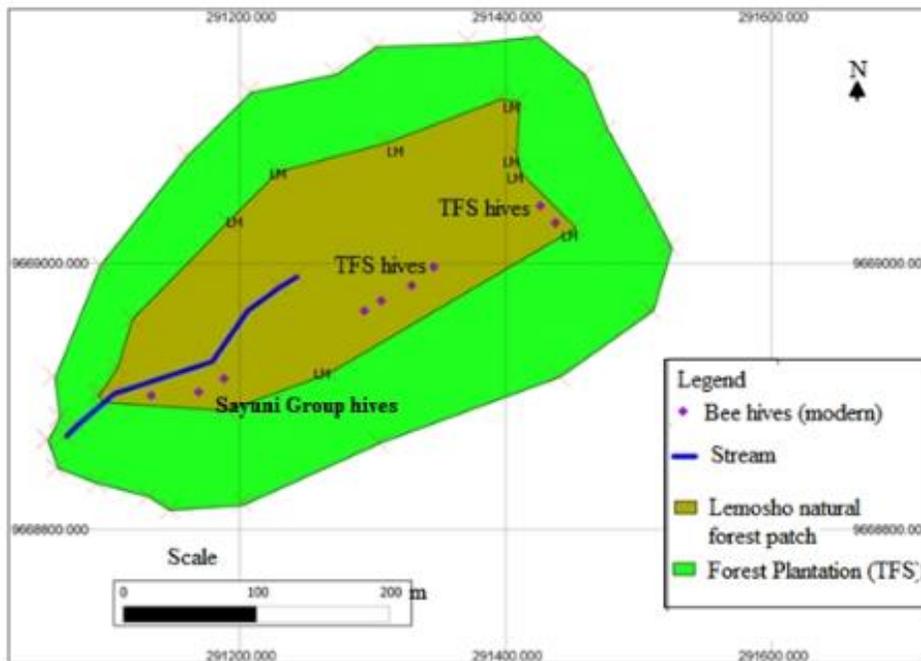
Wasendo Range Natural Forest

The Wasendo natural forest borders the plantation area on the north, east, and on the south, it borders the Rozilini.

Lemosho Range Natural Forest

This is a very open secondary forest within the plantation. It is completely bordered by the plantation (it borders the plantation land on the west, north, east, and south) (*Figure 3*).

Figure 3: Lemosho plantation forest range



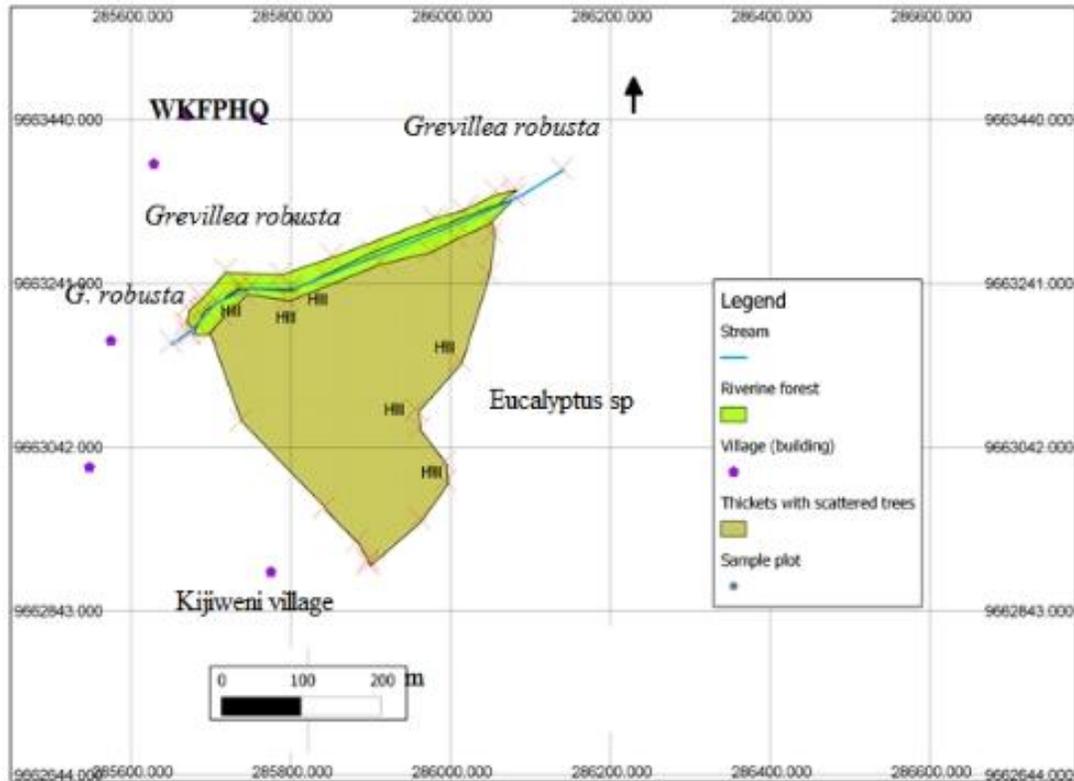
Near Londrosi Gate Natural Vegetation

The Londrosi borders the plantation on the west and east, while on the north, it borders the Kilimanjaro National Park (KINAPA).

Hill Wood Natural Vegetation

This comprises thickets with scattered trees and the riverine forest on the western part. It borders the plantation on the west (*Grevillea robusta*), north (*Grevillea robusta*) and east and south-east (*Eucalyptus saligna*), while on the south, it borders the Kijiweni village (Figure 4).

Figure 4: Hill wood natural vegetation



Data Collection and Analysis

Data Collection

In this survey, a total of 40, 20 m x 20 m plots were set in the 5 natural vegetation remnants (Sanya juu range, Hill wood range, Lemosho range, Wasendo range, and Londrosi) within the plantation at an interval of 100 m. Within the 20 m x 20 m, 1 m x 1 m quadrants were established to identify herbs, sedge, grasses, and seedlings, while 2 m x 5 m subplots were established to determine shrubs and saplings. The observed plant species were identified for their botanical names and counted for their number of individuals. Also, all plants were indicated for whether bee fodder or not using local

informants and observing the flowers visited by honey bees. Furthermore, tree canopy cover was estimated percentage-wise. Water sources (ponds, rivers, streams) were recorded. The agriculture crops being grown by the nearby or bordering villagers near the natural vegetation were identified and evaluated for the bee forage potential.

Data Analysis

The plant species richness (S) was determined from the total number of plant species identified from every site. The Shann index of diversity (H') as per Ifo et al. (2016) was calculated through:

$$H^1 = \sum_{i=1}^s p_i \ln p_i \dots\dots\dots [1]$$

where: \sum = summation; p_i = proportion of individuals of a single species to the total individuals of all plants identified in the sample plots; \ln = natural logarithm. Plant species distribution was determined based on the frequency (F) (number of plots the plant species occurred or was found), and from this, a relative frequency (Loehle, 2012) was calculated through $RF = \frac{\sum n!}{\sum N!} \times 100\%$; where RF = relative frequency; \sum = summation; $n!$ = frequency of one plant species; $N!$ = total frequency of all plant species in the sample plots.

RESULTS AND DISCUSSION

Beekeeping Potential of West Kilimanjaro Plantation

The available abundant pollen in the natural vegetation and agricultural landscapes is essential

for the successful growth and reproduction of honey bee colonies (*Apis mellifera* L.) (Danner et al. 2017). The natural vegetation within the West Kilimanjaro plantation is potential for beekeeping because of its high diversity, availability of water and relatively security assurance. The results have been reported based on the plantation ranges in order to expose their separate potential for honey bee forage. Ferrier et al. (2018) pointed out that each site known to be of importance in terms of bee fodder has to be reported thoroughly. The study revealed that 92% of non-woody plants and 94% of the identified woody plants were known to be foraged by stinging honey bees (Table 3). Among foraged plants species include *Albizia gummifera*, *A. petersiana*, *Asparagus setaceus*, *Dombeya burgessiae*, *D. kirkii*, *Lagenaria abyssinica* (Plate 1), *Zehneria scabra* (Plate 1), *Brugmansia suaveolens* (Plate 1), *Bothriocline longipes* (Plate 1), *Momordica foetida* (Plate 1), and *Vernonia lasiopus* (Plate 1), to list a few.

Plate 1: Plant species foraged by honey bees in west Kilimanjaro Plantation



Plant Species Foraged by Stinging Honey Bees per Range***Sanya Juu Range***

A total of 26 non-woody (Table 2) and 89 woody plants (Table 3) were identified at Sanya Juu. Of the

26 non-woody plants, only one was not known not to be foraged by stinging honey bees, and one (1) not known whether was being foraged or not. Most of the woody plants were foraged by stinging honey bees (Table 3).

Table 2: Non-woody plant species foraged by stinging honey bees at Sanya Juu Range

S/No	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Rhipsalis baccifera</i>	EPH	1	1	0.379	0.035	X*	
2	<i>Oplismenus compositus</i>	GR	40	2	0.758	0.358	BF*	
3	<i>Acalypha volkensii</i>	HB	10	1	0.379	0.189	BF	
4	<i>Achyranthes aspera</i>	HB	5	1	0.379	0.120	BF***	
5	<i>Asparagus setaceus</i>	HB	4	3	1.136	0.102	BF**	
6	<i>Asystacia gangetica</i>	HB	10	2	0.758	0.189	BF**	
7	<i>Basella alba</i>	HB	2	1	0.379	0.061	BF*	
8	<i>Celosia trigyna</i>	HB	2	1	0.379	0.061	BF**	
9	<i>Cinerari deltooides</i>	HB	11	3	1.136	0.201	BF**	
10	<i>Commicarpus pedunculatus</i>	HB	2	1	0.379	0.061	BF*	
11	<i>Cyathula orthocantha.</i>	HB	16	2	0.758	0.249	BF**	
12	<i>Cyphostemma adenocaula</i>	HB	1	1	0.379	0.035	BF**	
13	<i>Desmodium repandum</i>	HB	2	1	0.379	0.061	BF***	
14	<i>Ipomoea wightii</i>	HB	4	1	0.379	0.102	BF***	
15	<i>Jasminum fluminense</i>	HB	2	1	0.379	0.061	BF***	
16	<i>Justicia flava</i>	HB	3	1	0.379	0.083	BF**	
17	<i>Lagenaria abyssinica</i>	HB	2	1	0.379	0.061	BF**	
18	<i>Mikania cordata</i>	HB	3	1	0.379	0.083	BF***	
19	<i>Momordica foetida</i>	HB	3	1	0.379	0.083	BF***	
20	<i>Rhynchosia sp.</i>	HB	3	1	0.379	0.083	BF***	
21	<i>Rubia cordifolia</i>	HB	3	1	0.379	0.083	BF**	
22	<i>Scadoxus multiflorus</i>	HB	1	1	0.379	0.035	X	
23	<i>Solanecio angulatus</i>	HB	5	1	0.379	0.120	BF***	
24	<i>Thunbergia alata</i>	HB	2	1	0.379	0.061	BF**	
25	<i>Tragia brevipes</i>	HB	2	1	0.379	0.061	UN	
26	<i>Cyperus alternifolius</i>	SG	10	1	0.379	0.189	BF	
Total			149	33	13.637	2.828		0.868

Key: GF = Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Most of the woody plant species identified at Sanya Juu were known to be foraged by stinging honey bees (Table 3), while only a few were not.

Table 3: Woody plant species foraged by stinging honey bees at Sanya Juu Range

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Aspilia mossambicensis</i>	SR	15	1	0.3788	0.088	BF***	
2	<i>Aspilia pluriseta</i>	SR	5	1	0.3788	0.038	BF***	
3	<i>Carissa edulis</i>	SR	3	1	0.3788	0.025	BF**	
4	<i>Crotalaria axillaris</i>	SR	5	2	0.7576	0.038	BF***	
5	<i>Grewia similis</i>	SR	12	3	1.1364	0.075	BF***	
6	<i>Hoslundia opposita</i>	SR	32	8	3.0303	0.150	BF***	
7	<i>Indigofera trita</i>	SR	1	1	0.3788	0.010	BF***	
8	<i>Maerua triphylla</i>	SR	3	1	0.3788	0.025	BF*	
9	<i>Montanoa hibicifolia</i>	SR	10	1	0.3788	0.065	BF*	
10	<i>Pavonia urens</i>	SR	33	9	3.4091	0.153	BF***	
11	<i>Phyllanthus ovalifolius</i>	SR	9	2	0.7576	0.060	BF*	
12	<i>Phyllanthus fischeri</i>	SR	5	1	0.3788	0.038	BF	
13	<i>Psiadia punctulata</i>	SR	2	1	0.3788	0.018	BF***	
14	<i>Psychotria riparia</i>	SR	7	4	1.5152	0.049	BF***	
15	<i>Rumex usambarensis</i>	SR	6	1	0.3788	0.044	BF**	
16	<i>Senecio hadiensis</i>	SR	5	2	0.7576	0.038	BF***	
17	<i>Senna bicapsularis</i>	SR	2	1	0.3788	0.018	BF*	
18	<i>Vernonia tolypophora</i>	SR	26	2	0.7576	0.130	BF***	
19	<i>Vernonia lasiopus</i>	SR	12	2	0.7576	0.075	BF***	
20	<i>Vernonia myriantha</i>	SR	3	2	0.7576	0.025	BF***	
21	<i>Vitex strickeri</i>	SR	10	2	0.7576	0.065	BF**	
22	<i>Alangium chinense</i>	TR	1	1	0.3788	0.010	BF*	
23	<i>Albizia gummifera</i>	TR	1	1	0.3788	0.010	BF***	
24	<i>Albizia petersiana</i>	TR	3	1	0.3788	0.025	BF***	
25	<i>Allophylus africanus</i>	TR	2	4	1.5152	0.018	BF***	
26	<i>Allophylus ferrugineus</i>	TR	2	2	0.7576	0.018	BF***	
27	<i>Bersama abyssinica</i>	TR	12	5	1.8939	0.075	BF***	
28	<i>Bridelia micrantha</i>	TR	2	1	0.3788	0.018	BF***	
29	<i>Celtis africana</i>	TR	9	5	1.8939	0.060	BF**	
30	<i>Celtis gomphophylla</i>	TR	2	1	0.3788	0.018	BF**	
31	<i>Chaetacme aristata</i>	TR	31	8	3.0303	0.147	BF*	
32	<i>Chionanthus battiscombei</i>	TR	9	4	1.5152	0.060	BF*	
33	<i>Clausena anisata</i>	TR	9	6	2.2727	0.060	BF***	
34	<i>Croton macrostachyus</i>	TR	4	2	0.7576	0.032	BF**	
35	<i>Croton megalocarpus</i>	TR	18	7	2.6515	0.100	BF**	
36	<i>Cussonia holstii</i>	TR	2	1	0.3788	0.018	BF*	
37	<i>Deinbolia borbonica</i>	TR	4	1	0.3788	0.032	BF***	
38	<i>Diospyros abyssinica</i>	TR	19	7	2.6515	0.104	BF**	
39	<i>Dombeya buregessiae</i>	TR	5	1	0.3788	0.038	BF***	
40	<i>Dracaena fragrans</i>	TR	5	1	0.3788	0.038	BF**	
41	<i>Ehretia cymosa</i>	TR	3	2	0.7576	0.025	BF**	
42	<i>Ekebergia capensis</i>	TR	2	1	0.3788	0.018	BF***	
43	<i>Elaeodendron buchananii</i>	TR	5	3	1.1364	0.038	BF**	
44	<i>Erythrococca fischeri</i>	TR	5	2	0.7576	0.038	BF	
45	<i>Euclea divinorum</i>	TR	24	8	3.0303	0.123	BF**	
46	<i>Fagaropsis angolensis</i>	TR	1	1	0.3788	0.010	BF***	
47	<i>Ficus sur</i>	TR	2	1	0.3788	0.018	X*	
48	<i>Ficus thonningii</i>	TR	11	3	1.1364	0.070	X*	

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
49	<i>Flacourtia indica</i>	TR	37	9	3.4091	0.165	BF***	
50	<i>Lannea schweinfurthii</i>	TR	1	1	0.3788	0.010	BF***	
51	<i>Mimusops kummel</i>	TR	1	1	0.3788	0.010	BF**	
52	<i>Mystroxydon aethiopicum</i>	TR	10	4	1.5152	0.065	BF***	
53	<i>Newtonia buchananii</i>	TR	1	1	0.3788	0.010	BF***	
54	<i>Obetia radula</i>	TR	4	3	1.1364	0.032	UN	
55	<i>Ochna holstii</i>	TR	1	1	0.3788	0.010	BF**	
56	<i>Olea capensis</i>	TR	4	9	3.4091	0.032	BF**	
57	<i>Oxyanthus speciosus</i>	TR	3	1	0.3788	0.025	BF**	
58	<i>Persea americana</i>	TR	1	1	0.3788	0.010	BF***	
59	<i>Pittosporum viridiflorum</i>	TR	1	1	0.3788	0.010	BF***	
60	<i>Rauvolfia caffra</i>	TR	4	2	0.7576	0.032	BF*	
61	<i>Rawsonia lucida</i>	TR	5	3	1.1364	0.038	BF**	
62	<i>Rhus natalensis</i>	TR	2	1	0.3788	0.018	BF***	
63	<i>Rothmania fischeri</i>	TR	9	4	1.5152	0.060	BF***	
64	<i>Schrebela alata</i>	TR	1	1	0.3788	0.010	BF*	
65	<i>Trema orientalis</i>	TR	2	1	0.3788	0.018	BF**	
66	<i>Trichilia emetica</i>	TR	6	2	0.7576	0.044	BF***	
67	<i>Trilipesium madagascariensis</i>	TR	4	2	0.7576	0.032	X*	
68	<i>Turraea robusta</i>	TR	3	2	0.7576	0.025	BF***	
69	<i>Vangueria infausta</i>	TR	9	3	1.1364	0.060	BF***	
70	<i>Vangueria madagascariensis</i>	TR	2	9	3.4091	0.018	BF***	
71	<i>Vepris simplicifolia</i>	TR	33	2	0.7576	0.153	BF***	
72	<i>Vernonia tolyp amygdalina</i>	TR	3	2	0.7576	0.025	BF***	
73	<i>Acacia brevispica</i>	WC	8	2	0.7576	0.055	BF***	
74	<i>Adenia gummifera</i>	WC	8	3	1.1364	0.055	BF***	
75	<i>Ampelocissus tomentosa</i>	WC	4	5	1.8939	0.032	BF*	
76	<i>Ampelocissus africana</i>	WC	10	1	0.3788	0.065	BF**	
77	<i>Bauhinia tomentosa</i>	WC	3	1	0.3788	0.025	BF	
78	<i>Capparis tomentosa</i>	WC	3	1	0.3788	0.025	BF*	
79	<i>Clematis simensis</i>	WC	2	1	0.3788	0.018	BF**	
80	<i>Clerodendrum johnstonii</i>	WC	3	1	0.3788	0.025	BF*	
81	<i>Combretum aculeatum</i>	WC	6	2	0.7576	0.044	BF***	
82	<i>Helinus mystacinus</i>	WC	5	2	0.7576	0.038	BF*	
83	<i>Landolfia buchaananii</i>	WC	4	2	0.7576	0.032	BF**	
84	<i>Paulinia pinnata</i>	WC	3	1	0.3788	0.025	BF*	
85	<i>Phytolacca dodecandra</i>	WC	4	1	0.3788	0.032	BF	
86	<i>Salacia madagascariensis</i>	WC	11	5	1.8939	0.070	BF**	
87	<i>Secamone punctulata</i>	WC	2	1	0.3788	0.018	BF**	
88	<i>Tiliacora funifera</i>	WC	10	3	1.1364	0.065	BF*	
89	<i>Toddalia asiatica</i>	WC	8	2	0.7576	0.055	BF***	
Total			640	228	86.364	4.036		0.899

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Wasendo Range

Most of the plant species were known to be foraged by stinging honey bee at the Wasendo range (Table 4).

Table 4: Non-woody plants foraged by stinging honey bee at Wasendo Range Natural Forest

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Acalypha volkensii</i>	HB	2	1	0.417	0.023	BF	
2	<i>Achyranthes aspera</i>	HB	92	7	3.333	0.451	BF***	
3	<i>Asparagus racemosus</i>	HB	7	2	0.833	0.061	BF***	
4	<i>Asparagus setaceus</i>	HB	31	10	4.167	0.176	BF***	
5	<i>Asystacia gangetica</i>	HB	11	2	0.833	0.086	BF**	
6	<i>Basella alba</i>	HB	2	1	0.417	0.023	BF*	
7	<i>Commelina benghalensis</i>	HB	15	1	0.417	0.107	BF**	
8	<i>Conyza bonariensis</i>	HB	5	1	0.417	0.047	BF***	
9	<i>Crassocephallum montuosum</i>	HB	2	1	0.417	0.023	BF***	
10	<i>Cyathula cylindrica</i>	HB	24	3	1.250	0.149	BF***	
11	<i>Cyathula uncinulata</i>	HB	11	4	1.667	0.086	BF***	
12	<i>Cyphostemma adenocaula</i>	HB	3	1	0.417	0.031	BF**	
	<i>Cyphostemma</i>							
13	<i>kilimandscharicum</i>	HB	2	1	0.417	0.023	BF**	
14	<i>Dipsacus pinnatifidus</i>	HB	3	1	0.417	0.031	BF*	
15	<i>Drymaria cordata</i>	HB	5	1	0.417	0.047	BF	
16	<i>Galinsoga parviflora</i>	HB	6	1	0.417	0.054	BF*	
17	<i>Girardinia diversifolia</i>	HB	5	2	0.833	0.047	UN	
18	<i>Hypoestes aristata</i>	HB	64	1	0.417	0.267	BF**	
19	<i>Impatiens meruensis</i>	HB	15	1	0.417	0.107	BF**	
20	<i>Ipomoea wightii</i>	HB	28	3	1.250	0.164	BF***	
21	<i>Kalanchoe densiflora</i>	HB	1	1	0.417	0.013	BF*	
22	<i>Lagenaria abyssinica</i>	HB	2	1	0.417	0.023	BF**	
23	<i>Momordica foetida</i>	HB	2	2	0.833	0.023	BF***	
24	<i>Plectranthus longipes</i>	HB	30	1	0.833	0.258	BF**	
25	<i>Rubus niveus</i>	HB	3	1	0.417	0.031	BF**	
26	<i>Rumex abyssinica</i>	HB	5	1	0.417	0.047	BF**	
27	<i>Secamone punctulata</i>	HB	2	1	0.417	0.023	BF*	
28	<i>Solanum anguivi</i>	HB	1	1	0.417	0.013	BF	
29	<i>Sonchus schweinfurthii</i>	HB	2	1	0.417	0.023	BF*	
30	<i>Stephania abyssinica</i>	HB	2	1	0.417	0.023	BF*	
31	<i>Urtica massaica</i>	HB	26	2	0.833	0.157	UN	
32	<i>Vernonia galamensis</i>	HB	1	1	0.41	0.013	BF***	
33	<i>Zehneria scabra</i>	HB	14	7	2.91	0.102	BF**	
	Total		424	66	28.33	2.491		0.71 2

Key: GF=Growth form; Indiv=individuals(stems); F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Table 5: Woody plant species foraged by stinging honey bee at Wasendo Range

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Bothriocline longipes</i>	SR	2	1	0.417	0.020	BF***	
2	<i>Crotalaria axillaris</i>	SR	1	1	0.417	0.011	BF***	
3	<i>Maerua triphylla</i>	SR	2	1	0.417	0.020	BF*	
4	<i>Pavonia urens</i>	SR	13	5	2.083	0.089	BF***	
5	<i>Vernonia tolypophora</i>	SR	19	2	0.833	0.116	BF***	
6	<i>Vernonia lasiopus</i>	SR	33	4	1.667	0.169	BF***	
7	<i>Allophyllus abyssinica</i>	TR	4	1	0.417	0.036	BF***	
8	<i>Allophyllus ferrugineus</i>	TR	3	2	0.833	0.028	BF***	
9	<i>Bersama abyssinica</i>	TR	15	9	3.750	0.098	BF***	
10	<i>Cassipourea malosana</i>	TR	95	13	5.417	0.304	BF*	
11	<i>Celtis africana</i>	TR	5	5	2.083	0.043	BF**	
12	<i>Clausena anisata</i>	TR	7	5	2.083	0.056	BF***	
13	<i>Cussonia holstii</i>	TR	2	3	1.250	0.020	BF**	
14	<i>Diospyros abyssinica</i>	TR	52	12	5.000	0.223	BF**	
15	<i>Dombeya buregessiae</i>	TR	24	3	1.250	0.137	BF***	
16	<i>Ekebergia capensis</i>	TR	2	1	0.417	0.020	BF***	
17	<i>Elaeodendron buchananii</i>	TR	12	8	3.333	0.084	BF**	
18	<i>Erythrococca fischeri</i>	TR	29	11	4.583	0.155	BF	
19	<i>Euclea divinorum</i>	TR	8	2	0.833	0.062	BF**	
20	<i>Fagaropsis angolensis</i>	TR	15	12	5.000	0.098	BF***	
21	<i>Ficus thonningii</i>	TR	1	1	0.417	0.011	X*	
22	<i>Ficus thonningii</i>	TR	2	1	0.417	0.020	X*	
23	<i>Hagenia abyssinica</i>	TR	3	1	0.417	0.028	BF**	
24	<i>Ilex mitis</i>	TR	2	2	0.833	0.020	BF**	
25	<i>Maesa lanceolata</i>	TR	17	3	1.250	0.108	BF***	
26	<i>Maytenus heterophylla</i>	TR	7	1	0.417	0.056	BF***	
27	<i>Maytenus undata</i>	TR	2	1	0.417	0.020	NF***	
28	<i>Momordica foetida</i>	TR	3	1	0.417	0.028	BF***	
29	<i>Mystroxydon aethiopicum</i>	TR	26	8	3.333	0.144	BF**	
30	<i>Olea capensis</i>	TR	3	1	0.417	0.028	BF**	
31	<i>Olea europaea</i>	TR	1	1	0.417	0.011	BF**	
32	<i>Polysias fulva</i>	TR	2	1	0.417	0.020	BF	
33	<i>Rawsonia lucida</i>	TR	1	1	0.417	0.011	BF*	
34	<i>Ritchiea albersii</i>	TR	1	5	2.083	0.011	BF*	
35	<i>Rytignia uhilgii</i>	TR	4	3	1.250	0.036	BF***	
36	<i>Turraea holstii</i>	TR	12	6	2.500	0.084	BF**	
37	<i>Vangueria infausta</i>	TR	3	2	0.833	0.028	BF***	
38	<i>Vepris simplicifolia</i>	TR	67	15	6.250	0.257	BF***	
39	<i>Xymalos monospora</i>	TR	2	1	0.417	0.020	BF*	
40	<i>Azima tetracantha</i>	WC	18	6	2.500	0.112	BF	
41	<i>Toddalia asiatica</i>	WC	20	2	0.833	0.121	BF***	
42	<i>Urera hypselodendron</i>	WC	9	3	1.250	0.067	BF*	
Total			472	150	62.50	2.546		0.711

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency

Londrosi Gate

A total of 21 non-woody plant species were identified at the Londrosi range. Of those, only two

of them were not foraged, while only one was not known as to whether they can be foraged or not (Table 6).

Table 6: Plant species foraged by sting honey bees at Londrosi gate vegetation

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Asparagus racemosus</i>	HB	2	1	2.222	0.074	BF**	
2	<i>Asparagus setaceus</i>	HB	4	1	2.222	0.122	BF**	
3	<i>Basella alba</i>	HB	9	2	4.444	0.207	BF*	
4	<i>Crotalaria sp.</i>	HB	1	1	2.222	0.043	BF***	
5	<i>Cyathula uncinulata</i>	HB	8	2	4.444	0.193	BF***	
6	<i>Cyphosetemma adenocaula</i>	HB	2	1	2.222	0.074	BF**	
7	<i>Jasminum fluminense</i>	HB	2	1	2.222	0.074	BF**	
8	<i>Lagenaria abyssinica</i>	HB	5	1	2.222	0.142	BF**	
9	<i>Momordica foetida</i>	HB	2	1	2.222	0.074	BF***	
10	<i>Nicandra physaloides</i>	HB	2	1	2.222	0.074	BF***	
11	<i>Polygonum snegalense</i>	HB	10	1	2.222	0.220	BF**	
12	<i>Pteridium aquilinum</i>	FN	50	2	0.8333	0.234	X*	
13	<i>Pteris catoptera</i>	FN	2	1	2.222	0.074	X*	
14	<i>Rubus pinnatus</i>	HB	2	1	2.222	0.074	BF**	
15	<i>Thalictrum rhynchocarpum</i>	HB	3	1	2.222	0.100	BF*	
16	<i>Trapeolum majus</i>	HB	5	1	2.222	0.142	BF	
17	<i>Urtica massaica</i>	HB	31	3	6.667	0.358	UN	
18	<i>Verbena bonariensis</i>	HB	1	1	2.222	0.043	BF	
19	<i>Vernonia galamensis</i>	HB	2	1	2.222	0.074	BF***	
20	<i>Zantedeschia elleollitiana</i>	HB	8	1	2.222	0.193	BF	
21	<i>Zehneria scabra</i>	HB	7	2	4.444	0.177	BF**	
Total			158	27	56.389	2.766		0.940

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Of the 16 identified woody plants at Londrosi, only one was known not to be foraged by stinging honey bees (Table 7).

Table 7: Woody plant species identified at Londrosi gate

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Acacia melanoxydon</i>	TR	5	1	2.222	0.113	BF***	
2	<i>Allophylus abyssinica</i>	TR	2	1	2.222	0.058	BF**	
3	<i>Bersama abyssinica</i>	TR	1	1	2.222	0.033	BF***	
4	<i>Brugmansia suaveolens</i>	TR	60	3	6.667	0.367	BF	
5	<i>Casearia battiscombei</i>	TR	2	1	2.222	0.058	BF**	
6	<i>Croton megalocarpus</i>	TR	1	1	2.222	0.033	BF**	

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
7	<i>Cupressu lusitanica</i>	TR	1	1	2.222	0.033	X*	
8	<i>Dombeya buregessiae</i>	TR	3	1	2.222	0.078	BF***	
9	<i>Ensete edule</i>	TR	3	1	2.222	0.078	BF***	
10	<i>Euryops chryssanthemoides</i>	SR	15	1	2.222	0.230	BF***	
11	<i>Olea europaea</i>	TR	21	2	4.444	0.275	BF**	
12	<i>Pavonia urens</i>	SR	2	1	2.222	0.058	BF***	
13	<i>Solanum aculeastrum</i>	SR	4	1	2.222	0.097	BF	
14	<i>Urera hypselodendron</i>	WC	5	1	2.222	0.113	BF	
15	<i>Vepris simplicifolia</i>	TR	1	1	2.222	0.033	BF***	
16	<i>Vernonia lasiopus</i>	SR	9	1	2.222	0.169	BF***	
Total			135	19	42.222	1.827		0.645

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Hill Wood Range

All non-woody plants identified from this range were known to be foraged by honey bees, even though at different levels (Table 8).

Table 8: Plant species foraged by stinging honey bees at Hill woody range

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Acalypha volkensii</i>	HB	15	2	1.887	0.200	BF	
2	<i>Asparagus setaceus</i>	HB	4	1	0.943	0.081	BF*	
3	<i>Conyza bonariensis</i>	HB	1	1	0.943	0.027	BF***	
4	<i>Crotalaria [pubescent fruits]</i>	HB	2	1	0.943	0.048	BF***	
5	<i>Crotalaria axillaris</i>	HB	2	1	0.943	0.048	BF***	
6	<i>Crotalaria incana</i>	HB	3	1	0.943	0.065	BF***	
7	<i>Cyphostemma adenocaula</i>	HB	1	1	0.943	0.027	BF**	
8	<i>Exothea abyssinica</i>	GR	12	1	0.943	0.174	BF*	
9	<i>Helichrysum kirkii</i>	HB	5	1	0.943	0.095	BF***	
10	<i>Melinis minutiflora</i>	GR	115	2	1.887	0.305	BF**	
11	<i>Panicum maximum</i>	GR	13	2	1.887	0.183	BF**	
12	<i>Pentas lanceolata</i>	HB	7	1	0.943	0.121	BF***	
13	<i>Rhynchosia sp.</i>	HB	3	1	0.943	0.065	BF***	
14	<i>Solanecio angulatus</i>	HB	1	1	0.943	0.027	BF***	
15	<i>Solanum anguivi</i>	HB	2	1	0.943	0.048	BF	
16	<i>Tinnea aethiopicum</i>	HB	3	1	0.943	0.065	BF*	
17	<i>Triumfetta rhomboidea</i>	HB	2	1	0.943	0.048	BF**	
Total			191	20	18.868	1.629		0.57

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency

Woody plants of Hill wood range as shown in *Table 9*

Table 9: Woody plant species foraged by stinging honey bee at Hill Wood Range

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Aspilia mossambicensis</i>	SR	7	3	2.830	0.088	BF***	
2	<i>Carissa edulis</i>	SR	17	3	2.830	0.163	BF**	
3	<i>Clutia abyssinica</i>	SR	2	1	0.943	0.033	BF*	
4	<i>Coffea robusta</i>	SR	1	1	0.943	0.019	BF***	
5	<i>Grewia similis</i>	SR	18	4	3.774	0.169	BF***	
6	<i>Heteromorpha trifoliata</i>	SR	2	1	0.943	0.033	BF**	
7	<i>Hibiscus fuscus</i>	SR	2	1	0.943	0.033	BF***	
8	<i>Indigofer trita</i>	SR	11	3	2.830	0.121	BF***	
9	<i>Lippia javanica</i>	SR	5	1	0.943	0.068	BF***	
10	<i>Microglossa densiflora</i>	SR	11	2	1.887	0.121	BF***	
11	<i>Pavonia urens</i>	SR	2	1	0.943	0.033	BF***	
12	<i>Plectrunthus comosus</i>	SR	2	2	1.887	0.033	X*	
13	<i>Psiadia punctulata</i>	SR	4	1	0.943	0.058	BF***	
14	<i>Senecio hadiensis</i>	SR	2	1	0.943	0.033	BF***	
15	<i>Acacia drepanolobium</i>	TR	2	1	0.943	0.033	BF	
16	<i>Afrocarpus falcatus</i>	TR	1	1	0.943	0.019	X*	
17	<i>Albizia gummifera</i>	TR	2	1	0.943	0.033	BF***	
18	<i>Calodendron capense</i>	TR	2	1	0.943	0.033	BF**	
19	<i>Celtis africana</i>	TR	2	1	0.943	0.033	BF**	
20	<i>Combretum molle</i>	TR	10	3	2.830	0.114	BF**	
21	<i>Croton megalocarpus</i>	TR	1	1	0.943	0.019	BF**	
22	<i>Cupressu lusitanica</i>	TR	2	1	0.943	0.033	x*	
23	<i>Cussonia holstii</i>	TR	5	3	2.830	0.068	BF*	
24	<i>Diospyros abyssinica</i>	TR	1	1	0.943	0.019	BF**	
25	<i>Dodonaea viscosa</i>	TR	32	4	3.774	0.239	BF**	
26	<i>Dombeya buregessiae</i>	TR	2	1	0.943	0.033	BF***	
27	<i>Dombeya kirkii</i>	TR	10	3	2.830	0.114	BF***	
28	<i>Elaeodendron buchananii</i>	TR	2	1	0.943	0.033	BF**	
29	<i>Euclea divinorum</i>	TR	2	1	0.943	0.033	BF**	
30	<i>Ficus sur</i>	TR	3	1	0.943	0.046	X*	
31	<i>Ficus thonningii</i>	TR	2	1	0.943	0.033	X*	
32	<i>Grevillea robusta</i>	TR	1	1	0.943	0.019	BF***	
33	<i>Juniperus procera</i>	TR	5	2	1.887	0.068	X*	
34	<i>Maytenus heterophylla</i>	TR	3	1	0.943	0.046	BF***	
35	<i>Mimusops kummel</i>	TR	2	1	0.943	0.033	BF**	
36	<i>Mystroxydon aethiopicum</i>	TR	2	1	0.943	0.033	BF**	
37	<i>Olea europaea</i>	TR	10	3	2.830	0.114	BF**	
38	<i>Olinia rochetiana</i>	TR	21	4	3.774	0.187	BF**	
39	<i>Protea gagedii</i>	TR	19	2	1.887	0.175	BF**	
40	<i>Rhus natalensis</i>	TR	29	5	4.717	0.226	BF***	
41	<i>Schrebela alata</i>	TR	1	1	0.943	0.019	BF**	
42	<i>Sclopiya zeyheri</i>	TR	5	1	0.943	0.068	BF**	
43	<i>Syzygium cordatum</i>	TR	2	1	0.943	0.033	BF***	
44	<i>Trichilia emetica</i>	TR	2	1	0.943	0.033	BF***	
45	<i>Trimeria grandifolia</i>	TR	13	3	2.830	0.136	BF*	
46	<i>Turraea robusta</i>	TR	3	1	0.943	0.046	BF***	

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
	<i>Vangueria</i>							
47	<i>madagascariensis</i>	TR	2	1	0.943	0.033	BF***	
48	<i>Vepris simplicifolia</i>	TR	3	1	0.943	0.046	BF***	
49	<i>Dalbergia lactea</i>	WC	1	1	0.943	0.019	BF***	
50	<i>Helinus mystacinus</i>	WC	2	1	0.943	0.033	BF**	
51	<i>Pterolobium stellatum</i>	WC	4	2	1.887	0.058	BF**	
52	<i>Rhoicissus tridentata</i>	WC	2	1	0.943	0.033	BF***	
	Total		299	86	81.132	3.412		0.86

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Lemosho Range

Non-woody plant species foraged by stinging honey bees at Lemosho Range, Only one not foraged, and one unknown as being foraged was identified (Table 10).

Table 10: Non-woody plant species foraged by stinging honey bees at Lemosho Range

S/N	Botanical Name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Acalypha volkensii</i>	HB	2	1	1.724	0.031	BF*	
2	<i>Achyranthes aspera</i>	HB	21	2	3.448	0.176	BF***	
3	<i>Asparagus racemosus</i>	HB	5	1	1.724	0.064	BF**	
4	<i>Basella alba</i>	HB	2	1	1.724	0.031	BF*	
5	<i>Conyza bonariensis</i>	HB	5	1	1.724	0.064	BF***	
6	<i>Crassocephallum montuosum</i>	HB	2	1	1.724	0.031	BF***	
7	<i>Cyathula cylindrica</i>	HB	10	1	1.724	0.107	BF***	
8	<i>Cyathula uncinulata</i>	HB	5	2	3.448	0.064	BF***	
9	<i>Cynodon dactylon</i>	GR	12	1	1.724	0.121	BF*	
10	<i>Cyphostemma adenocaulis</i>	HB	3	1	1.724	0.043	BF**	
	<i>Cypphostemma</i>							
11	<i>kilimandscharicum</i>	HB	2	1	1.724	0.031	BF**	
12	<i>Dipsacus pinnatifidus</i>	HB	3	1	1.724	0.043	BF	
13	<i>Drymaria cordata</i>	HB	5	1	1.724	0.064	BF	
14	<i>Galinsoga parviflora</i>	HB	6	1	1.724	0.073	BF**	
15	<i>Impatiens meruensis sp.</i>	HB	15	1	1.724	0.141	BF**	
16	<i>Ipomoea wightii</i>	HB	28	3	5.172	0.210	BF***	
17	<i>Kalanchoe densiflora</i>	HB	1	1	1.724	0.018	BF*	
18	<i>Lagenaria abyssinica</i>	HB	2	1	1.724	0.031	BF**	
19	<i>Momordica foetida</i>	HB	2	2	3.448	0.031	BF***	
20	<i>Plectranthus longipes</i>	HB	11	1	1.724	0.114	BF**	
21	<i>Pteridium aquilinum</i>	FN	50	2	3.448	0.287	X*	
22	<i>Rubus niveus</i>	HB	3	1	1.724	0.043	BF**	
23	<i>Rumex abyssinica</i>	HB	5	1	1.724	0.064	BF**	
24	<i>Sonchus schweinfurthii</i>	HB	2	1	1.724	0.031	BF*	
25	<i>Stephania abyssinica</i>	HB	2	1	1.724	0.031	BF*	
26	<i>Urtica massaica</i>	HB	21	3	5.172	0.176	UN	

S/N	Botanical Name	GF	Indiv.	F	RF	H'	Status	E
	Total		225	34	58.621	2.123	0.652	

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Only six of the identified woody plants were not foraged by stinging honey bees, while the rest were potential bee fodder at varying levels (Table 11).

Table 11: Woody plant species foraged by stinging honey bee at Lemosho range

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
1	<i>Aspilia mossambicensis</i>	SR	7	3	2.830	0.088	BF***	
2	<i>Carissa edulis</i>	SR	17	3	2.830	0.163	BF**	
3	<i>Clutia abyssinica</i>	SR	2	1	0.943	0.033	BF*	
4	<i>Coffea robusta</i>	SR	1	1	0.943	0.019	BF***	
5	<i>Grewia similis</i>	SR	18	4	3.774	0.169	BF***	
6	<i>Heteromorpha trifoliata</i>	SR	2	1	0.943	0.033	BF**	
7	<i>Hibiscus fuscus</i>	SR	2	1	0.943	0.033	BF***	
8	<i>Indigofer trita</i>	SR	11	3	2.830	0.121	BF***	
9	<i>Lippia javanica</i>	SR	5	1	0.943	0.068	BF***	
10	<i>Microglossa densiflora</i>	SR	11	2	1.887	0.121	BF***	
11	<i>Pavonia urens</i>	SR	2	1	0.943	0.033	BF***	
12	<i>Plectranthus comosus</i>	SR	2	2	1.887	0.033	X*	
13	<i>Psiadia punctulata</i>	SR	4	1	0.943	0.058	BF***	
14	<i>Senecio hadiensis</i>	SR	2	1	0.943	0.033	BF***	
15	<i>Acacia drepanolobium</i>	TR	2	1	0.943	0.033	BF	
16	<i>Afrocarpus falcatus</i>	TR	1	1	0.943	0.019	X*	
17	<i>Albizia gummifera</i>	TR	2	1	0.943	0.033	BF***	
18	<i>Calodendron capense</i>	TR	2	1	0.943	0.033	BF**	
19	<i>Celtis africana</i>	TR	2	1	0.943	0.033	BF**	
20	<i>Combretum molle</i>	TR	10	3	2.830	0.114	BF**	
21	<i>Croton megalocarpus</i>	TR	1	1	0.943	0.019	BF**	
22	<i>Cupressu lusitanica</i>	TR	2	1	0.943	0.033	x*	
23	<i>Cussonia holstii</i>	TR	5	3	2.830	0.068	BF*	
24	<i>Dalbergia lactea</i>	WC	1	1	0.943	0.019	BF***	
25	<i>Diospyros abyssinica</i>	TR	1	1	0.943	0.019	BF**	
26	<i>Dodonaea viscosa</i>	TR	32	4	3.774	0.239	BF**	
27	<i>Dombeya buregessiae</i>	TR	2	1	0.943	0.033	BF***	
28	<i>Dombeya kirkii</i>	TR	10	3	2.830	0.114	BF***	
29	<i>Elaeodendron buchananii</i>	TR	2	1	0.943	0.033	BF**	
30	<i>Euclea divinorum</i>	TR	2	1	0.943	0.033	BF**	
31	<i>Ficus sur</i>	TR	3	1	0.943	0.046	X*	
32	<i>Ficus thonningii</i>	TR	2	1	0.943	0.033	X*	
33	<i>Grevillea robusta</i>	TR	1	1	0.943	0.019	BF***	
34	<i>Helinus mystacinus</i>	WC	2	1	0.943	0.033	BF**	
35	<i>Juniperus procera</i>	TR	5	2	1.887	0.068	X*	
36	<i>Maytenus heterophylla</i>	TR	3	1	0.943	0.046	BF***	
37	<i>Mimusops kummel</i>	TR	2	1	0.943	0.033	BF**	

S/N	Botanical name	GF	Indiv.	F	RF	H'	Status	E
38	<i>Mystroxydon aethiopicum</i>	TR	2	1	0.943	0.033	BF**	
39	<i>Olea europaea</i>	TR	10	3	2.830	0.114	BF**	
40	<i>Olinia rochetiana</i>	TR	21	4	3.774	0.187	BF**	
41	<i>Protea gagedii</i>	TR	19	2	1.887	0.175	BF**	
42	<i>Pterolobium stellatum</i>	WC	4	2	1.887	0.058	BF**	
43	<i>Rhoicissus tridentata</i>	WC	2	1	0.943	0.033	BF***	
44	<i>Rhus natalensis</i>	TR	29	5	4.717	0.226	BF***	
45	<i>Schrebela alata</i>	TR	1	1	0.943	0.019	BF**	
46	<i>Sclopia zeyheri</i>	TR	5	1	0.943	0.068	BF**	
47	<i>Syzygium cordatum</i>	TR	2	1	0.943	0.033	BF***	
48	<i>Trichilia emetica</i>	TR	2	1	0.943	0.033	BF***	
49	<i>Trimeria grandifolia</i>	TR	13	3	2.830	0.136	BF*	
50	<i>Turraea robusta</i>	TR	3	1	0.943	0.046	BF***	
51	<i>Vangueria madagascariensis</i>	TR	2	1	0.943	0.033	BF***	
52	<i>Vepris simplicifolia</i>	TR	3	1	0.943	0.046	BF***	
Total			299	86	81.132	3.412		0.86

Key: GF=Growth form; Indiv=individuals(stems)'; F=frequency; RF=Relative frequency; H'=Shannon wiener index of diversity; E=species evenness; BF=foraged by bees; BF***=the most foraged; X=not foraged; X*=not foraged but bees seen collecting water on either leaves & stem; UN=unknown or data deficiency.

Agriculture Crops Foraged by Stinging Honey Bees

The West Kilimanjaro plantation borders villages where community members practice agriculture, of which most of them offer ecosystem services, among them being flowers for stinging honey bees

(Plate 2 & Table 12).

Plate 2: Village farm with crops foraged by honey bee



The income in households and ecosystem services depends on pollinators including honey bees across the world (Fikadu, 2019). The pollinators also rely on plants that are found on natural vegetation and agriculture crops (Altieri et al., 2015). Of the five sites, Sanya juu, Hill wood, Lemosho, and near Londrosi gate were revealed to be the most supportive sites grounded on plant species diversity within such small patches, of which most plants were known to be foraged by honey bees. Bradbear

(2009) pointed out that a high diversity of plants foraged by honey bees guarantees honey bee yields. On the other hand, Wasendo natural forest apart from being the largest of all was revealed to accommodate relatively fewer species per plot compared to the others. Also, the very tall trees that are also being foraged by honey bees could probably support beekeeping the least of all others because they have most plants with moderate height and wind effect may be to the minimal.

Table 12: Agriculture crops identified at villages bordering West Kilimanjaro Plantation

Botanical Name	Swahili/Common name	Village/ area of range
<i>Phaseolus vulgaris</i>	Maharage	Monjamo
<i>Musa acuminata</i>	Mgomba/Banana tree	Monjamo
<i>Grevillea robusta</i>	Grevilea	Monjamo, west of hill wood
<i>Coffea arabica</i>	Kahawa/Coffee	Monjamo
<i>Mangifera indica</i>	Mwembe/Mango tree	Monjamo
<i>Persea americana</i>	Mpalachichi/Avocado	Monjamo
<i>Solanum aethiopicum</i>	Nyanya chungu	Monjamo
<i>Cordia africana</i>	Mringaringa	Monjamo
<i>Eriobotrya japonica</i>		Monjamo
<i>Lycopersicon esculentum</i>	Nyanya/Tomato	Monjamo
<i>Jacaranda mimosifolia</i>	Mjakaranda/Jacaranda	Monjamo
<i>Psidium guajava</i>	Mpera/Guava	Monjamo
<i>Solanum tuberosum</i>	K. mviringo/Irish potatoes	Lemosho, Wasendo
<i>Prunus persica</i>	Tipis/Pitches	West of hill wood
<i>Zea mays</i>	Mahindi	Monjamo, west of hill wood
<i>Brassica oleracea</i>	Sukuma wiki	Monjamo
<i>Pisum sativa</i>	Njegere	Monjamo

Availability of Water

Beekeeping intervention, among other requirements, water sources are vital. The five sampled areas are well supplied with water. The Sayuni range natural forest remnants are well supplied with water on the eastern side from Mowo

stream, which flows down from the waterfall in the Kilimanjaro National Park (KINAPA) (Plate 3). Hill wood is also supplied with water from KINAPA (Plate 3). Lemosho is in the area with a small wetland/stream on the small valley. The Wasendo and Londrosi target areas are well supplied with water from small wetlands, pipes at the Wasendo range quarters and Londrosi gate.

Plate 3: Water supply at Sanya Juu and Hill wood ranges



Plant Species Richness and Distribution in Natural Vegetation Patches

The natural vegetation patches of West Kilimanjaro Plantation consist of high plant species diversity. During the survey, an overall 204 plant species were identified as belonging to 76 families and 178 genera (Table 13). The average plant species

richness (S) per surveyed site was 25 for non-woody plants and 50 for the woody plants. The calculates H' of 2.37 for non-wood plants and 3.05 for wood plants implied high plant diversity as supported by Kent and Coker (1994) and Kent (2012) that the H' for high diversity ranges from 3.5± 1.5, and exceptionally can go beyond 4.5.

Table 13: Plant families, genera, richness and index of diversity (H') per growth form

Variable	Families	Genera	Richness (S)	H'	
				NWP	WP
Value	76	178	204	2.37	3.05

The non-woody plants were revealed to be more distributed than the non-woody plants for both surveyed ranges of West Kilimanjaro. The H' of 2.37 for non-woody and 3.05 for woody plants revealed high diversity for all growth forms. The most distributed plant species had an RF of 6.250 ± 3.0303, while the rest had an RF < 3.0303. The most distributed plants include *Hoslundia opposita*, *Pavonia urens*, *Chaetacme aristata*, *Euclea divinorum*, *Flacourtia indica*, *Olea capensis*, *Vangueria madagascariensis*, *Asparagus setaceus*, *Cassipourea malosana*, *Bersama abyssinica*, *Elaeodendron buchannanii*, *Fagaropsis angolensis*, *Erythrococca fischeri*, *Mystroxyton aethiopicum*,

Vepris simplicifolia and nearly all of them are foraged by sting honey bees. The most occurred plant species in the sample plots are meant to be the most distributed in a specified locality (Loehle, 2012). Even though most of the plant species are treated under the least distributed, the area remains very potential for beekeeping because nearly every plant is being foraged by the bees. The disappearance of one species does not cause any significant effect on bees, as they can go for another species in the area. The calculated evenness (E) of 0.7484 for non-wood plants and 0.795 (Table 14) implied that the plants in all categorize were not evenly distributed.

Table 14: Plant richness, distribution, H', E and stinging honey bee forage status

Range Name	S		RF		H'		E		BF	
	NW	P	WP	NWP	WP	NWP	WP	NWP	WP	NW
Sanya juu	26	89	13.63	86.36	2.82	4.03	0.86	0.89	23	87
Wasendo forest	33	42	28.33	62.51	2.49	2.54	0.71	0.71	31	40
Londrosi	21	16	56.38	42.22	2.76	1.82	0.94	0.64	19	15
Hill wood	17	52	18.86	81.13	1.62	3.41	0.57	0.86	17	46
Lemosho	26	52.0	58.62	81.13	2.12	3.41	0.65	0.86	24	46
Total	123	251	175.82	353.35	11.81	15.21	3.73	3.96	114	234
Average	25	50	35.17	70.67	2.3674	3.04	0.7484	0.795	23	47

Key: S = plant richness; RF = relative frequency; H' = Shannon Weiner Diversity Index; E = Evenness; BF = bee fodder; NWP= nonwoody plant; WP = woody plant

Conservation status of trees as per IUCN

A total of two tree species, *Osyris lanceolata* (Santalaceae) (Plate 4) (Andiego et al., 2019) and *Juniperus procera* (Plate 4), are internationally known to be endangered as per IUCN. The two trees *Fagaropsis angolensis* identified at the Sanya juu range and Wasendo range and *Afrocarpus falcatus* (Podocarpaceae), identified at Hill wood are known

to be widely distributed in African countries but maybe locally extinct due to their demand for timber (Doda & Abuelgasim, 2019). *F. angolensis* is low in abundance wherever it is found growing. Its local extinction is owing to severe logging because of its high-quality timber. The *Juniperus procera*, *Osyris lanceolata*, and *Afrocarpus falcatus* are also treated as national reserve trees of Tanzania.

Plate 4: Endangered trees identified at Hill wood range: Endangered trees identified at Hill wood range



CONCLUSION AND RECOMMENDATIONS

CONCLUSION

West Kilimanjaro Forest Plantation (WKFP), natural forest patches are potential for honey

beekeeping. The high plant species diversity, of which most of them (> 90%) are foraged by bees, ensures the project sustainability. The Sanya juu, Hill wood, Lemosho, and Londrosi sites are suitable areas for beekeeping. The average species richness (S) for Wasendo was the least of all other sites, with

very tall trees and fewer honey bees observed than on other sites. The Wasendo, being planned for tourism for the Wasendo natural forest, implies suitable use of resources. Nearly all sites have very few foraged plants that seem to be the most distributed; however, nearly all of them are honey bee fodder. The sites are situated at a reasonable distance from the local community's settlement.

RECOMMENDATIONS

The survey on the five sites revealed a high diversity of honey bee foraged plant species. The recommendations have been that:

- High-quality bee fodder plants should be planted: these include *Albizia gummifera* and *Dombeya burgesiae*.
- Security: regular visits to the project sites should be exercised to protect any kind of honey theft
- Spot clearing: most seedlings have been overed by the climbers, especially at the Lemosho range. The most preferred *D. burgesiae* seedlings and saplings are covered by herbaceous and woody climbers. Opening up the cover could encourage the growth of *D. burgesiae*.
- Wasendo natural forest is more suitable for tourism because of its size, tall trees with very high canopy cover, and suitable areas for camping sites.
- Further study on the biological species diversity should be done. The information can be used to inspire tourism.
- Sample of honey should be collected and checked at the laboratory to check for the content (chemical content?).
- Education or seminar to responsible beekeeping staff: beekeeping is a venture that needs specific expertise in putting hives, harvesting and extracting honey.
- Regular inspection of the honey bee colony strength will help to reveal any challenges

facing the venture including diseases and hives strengths and weakness.

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