Inventory, reward value and diversity of Apis mellifera nectariferous and polleniferous forage in Eastern Mau forest, Kenya

Article *in* International Journal of Scientific and Research Publications (IJSRP) · February 2019

DOI: 10.29322/IJSRP.9.02.2019.p8608

4 authors, including:

Regina Nyunja
Jaramogi Oginga Odinga University of Science and Technology
13 PUBLICATIONS **232** CITATIONS
SEE PROFILE

George TIMOTHY Opande
KAIMOSI FRIENDS UNIVERSITY COLLEGE
22 PUBLICATIONS **94** CITATIONS
SEE PROFILE

Stephen Fedha
Maseno University
16 PUBLICATIONS **29** CITATIONS
SEE PROFILE

Inventory, reward value and diversity of *Apis mellifera* nectariferous and polleniferous forage in Eastern Mau forest, Kenya

Philip Onyango [1] , Regina Nyunja [2], George Opande [1], Stephen Fedha Sikolia [1]

1. Department of Botany, School of physical and Biological Sciences, Maseno University, Kisumu, Kenya

2. Department of Biological Sciences, School of Physical and Biological Sciences , Jaramogi Oginga Odinga University of Science and Technology, Bondo, Kenya

DOI: 10.29322/IJSRP.9.02.2019.p8608
http://dx.doi.org/10.29322/IJSRP.9.02.2019.p8608

Abstract: The study was conducted in Eastern Mau is one of the East Mau forest is an important watershed within the Mau Forest Complex, feeding major rivers and streams that make up the hydrological systems of Lake Victoria and inland Lakes of Nakuru, Baringo and Natron to document the bee flora and their respecetive reward value to compliment the participatory forest conservation approaches incorporating the Ogieks who are predominant forest dwellers, and known for bee keeping skills, to aid in bee keeping extension services and by extension forest conservation. Transects were made in three randomly selected strata according to stratifiedrandom sampling procedures. The flowering plants were observed for their foraging value based on the *Apis mellifera* foraging activities using appropriate determination techniques. The study has revealed a total of 86 plant speceis and 36 families foraged by *Apis mellifera*. *Cissus rotundiflora* (Vitaceae), *Trema orientalis* (Ulmaceae), *Maerua triphylla* (Capparaceae), *Aloe secundiflora* (Asphodelaceae), *Tribulis terrestis* (Zygophyllaceae) and *Polyscias fulva* (Araliaceae) Some of the bee plants are reported for the first time in Eastern Mau. Trees formed 41.86%, Herbs (25.58%), Shrubs (23.25%), and climbers (9.3%) of the bee forage. Fabaceae, Asteraceae, Acanthaceae, Myrtaceae, Euphorbiaceae, and Graminae families contribute the majority of the bee plants in Eastern Mau forest.

Index terms: *Apis mellifera*, bee keeping, bee plants, conservation, Eastern Mau forest

I. INTRODUCTION

Tropical forests are facing annihilation due to unsustainable harvesting of their timber and non-timber products for economic gains and also due clearing for agricultural use. Mau forest ecological functions are in jeopardy. The current threat to Mau Forest complex are predisposed by encroachment, logging for timber ad charcoal production. The Mau forest complex is under severe threat of degradation from the forest dwellers and adjacent communities. This has been attributed to non-involvement of communities along the Eastern Mau in forest conservation. Although the Mau Forest task force (2009) has recommended synergy between traditional and scientific knowledge in forest management, conservation of threatened species, as well as participatory forest management to enhance livelihood of the local communities e.g. the Ogieks, there is still lack of extensional , technological support to supply a full record of bee plants. Although apiculture has the potential to improve livelihoods to local communities and incentivize them to participate in the conservation of its vital forests, the extensive knowledge of type, density and quality of bee flora in a region are prerequisites for successful beekeeping. Beekeeper Ogieks in Eastern Mau lack the inventory of melliferous species for purposes of synergizing traditional and scientific knowledge. for successful forest management. Since conservation of natural resources might not appeal to local residents as a desirable goal in its own right, it is important to identify a target audience for the message , bee keepers who believe more could be done to bee plants could initially be receptive to such a message and could act as a link between partners in environmental conservation and local communities. This establishes a framework for negotiating desired outcomes with the affected people in the long run (Vlek et al., 2014).

Apiculture plays a significant role in national economy of a country. It serves as additional cash income for hundreds and thousands of farmer keepers in the country. Beekeeping plays an important role in conserving the natural resources and contributes to the globe through environmental protection. In Kenya, charcoal burning in Mwingi district was successfully reduced by introducing bee keeping as an alternative economic activity and has become a good example for other areas. Apiculture has the potential to improve livelihoods of the local communities and to give them an incentive to participate in the conservation of vital forests. Furthermore, managed bee colonies are important pollinators and pollination is a crucial step in re-establishment of deforested areas (Okoth, 2010).

The production of honey depends on the abundance of nectaferous plants within easy flight range of the bee colony. After studies on the patterns of nectaferous plant diversity, Awka and Agulu areas in South East Nigeria have been indicated as potential sites for apiculture as a cottage industry and recommended conservation of the nectaferous plants, demarcation and safeguarding of Agulu lake areas as 'bee sanctuaries for Honeybees' (Akunne et al., 2016). The knowledge of plants visited by bees is essential in guiding prospective beekeepers in the choice of suitable sites for locating apiaries. It is also essential in the identification of crops that may benefit from pollination by honeybees. (Dukku , 2013). There are three types of bee flora : plants that only supply nectar, plants that only supply pollen, and plants that provide both (Waykar et al., 2014).The identification and registration of honeybee flora in different agroeceological zones and their potential for honey production in an apiary is important for successful honey production to enable beekeepers determine when to carry out various management practices with their colonies. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability (Wubie et al., 2014). Against this background, this study was intended to generate knowledge in order to advise beekeepers on locally available flora that can be conserved or planted for purposes of beekeeping in Eastern Mau forest region, an area that suffers annihilation. Some of the bee forage lists are based on anecdotal information and generally lack a firm evidence base (Hawkins et al., 2015). This is the first study ever carried out to document the apifloral taxa and to enhance bee keeping and subsequent conservation of the bee plants in Eastern Mau Ogiek inhabited areas with an intention of synergizing both scientific and traditional knowledge. The identification and registration of honeybee flora in different agroeceological zones in Eastern Mau and their potential for honey production will enable beekeepers determine when to carry out various management practices with their bee colonies successfully.

II. METHOD

Study site: The study site is located about 50 Km south of Nakuru Town. The altitude ranges from 1200 and 2600 m. It is approximately 280 km2 with the highest number of indigenous forest dwellers dominantly belonging to the Ogiek community. East Mau forest is an important watershed within the Mau Forest Complex, feeding major rivers and streams that make up the hydrological systems of Lake Victoria and inland Lakes of Nakuru, Baringo and Natron. It hosts endangered mammals (Sang, 2001). The forest ecosystem is therefore an important resource base for the local communities, national and international community. The total forest area has gone down by more than one half due to excision for human settlement in 2001(UNEP et al., 2006). The remaining area consists high forest, grassland and planted forest mainly of Cypress and Pines (KFS, 2012). Eastern Mau area terrain ranges from escarpments, hills, rolling land to plains with slopes ranging from 2% above 30% in the foothills. The soil is composed of quaternary and tertiary volcanic deposits. The adjoining settlements have gentle slopes with deep-fertile-volcanic soils suitable for maize, wheat, potatoes, horticultural crops and livestock keeping (Jaetzold and Schmidt, 1982). The area receives trimodal precipitation pattern with the long and intense rains from April to June; short rains in August; and shorter, less intense rains from November to December. Mean monthly rainfall ranges between 30 mm to 120 mm and total annual precipitation of 1200 mm (Kundu, 2007; Okello, 2008). The mean annual temperatures are in the range of 12 -16°C (Kundu, 2007).
Reconnaissance**:** survey was employed to become familiar with the area, to get an insight on the vegetation distribution in the landscape, to observe and locate the possible traverse during the actual study. Stratified random sampling procedure was followed to select the representative sites based on the strata made prior to the survey.
Strata and **sampling:**Three forest strata units were purposively sampled in consultation with local administrative officials using two main criteria: ethnic composition, presence of indigenous Ogiek community. The following administrative locations were selected: Mariashoni representing an old settlement predominantly occupied by Ogiek indigenous community (65%), Kapkembu – representing a recent settlement with a homogenous community of the Kipsigis and Ogiek (7.5%) , Nessuit – representing a recent settlement with a heterogeneous population of indigenous (Ogiek, 50%) and immigrant ethnic groups (Langat et al., 2015)
Data collection and recording**:** Three transects measuring 5m x 50m were laid out in selected sites representative of the main land uses in the study area and every 120 degrees of an identified hive. In order to retain accuracy, a smaller transect measuring 5mx10m was laid out then replicated 5 times. Plants were categorized as trees when they exceeded 3 m in height, as shrubs when they attained a total height of 1-3m. Plants that grew below 1m in height were taken to be undergrowth layer or herbs in the transects and studied in nested quadrats of 1-2m squared (Vlek et al., 2014). This was replicated in Mariashoni, Kapkembu, and Nessuit in Eastern Mau.
Field data was collected through regular monthly visits to the study sites. Each study visit served as pseudo replicates for the site and all observations were made between 0700-1800hrs (winter) and 0700-1830hrs (Summer) . Primary data was collected through direct

identification of bee flora in the region mainly by observing the bee visitation. The flower species was identified as bee plant only after visual confirmation and collection of food by honey bees (Sivaram, 2014). The observation on nectar and pollen source was based on activities performed by honey bees on different flowers. Honey bees with their activity of extending their proboscis into the flowers are considered a nectar source and bees carrying pollen on their hind legs were determined as pollen source. Bees with activities of extending proboscis and carrying pollen are recorded as both pollen and nectar source. Their foraging behavior was observed for period of 10 minutes. If the success of any foraging attempt was ascertained, the plant was scored as bee foraging species after at least 3 honeybees visited the flowers simultaneously or within observation period (10 minutes) (Okoth, 2010).

Plant identification: Plants visited by the honey bees were identified in the field to species level by the Flora of East Africa. Samples of plants that could not be identified in the field were collected and saved in Herbarium sheets, and subsequently identified in the Department of Botany, Maseno University by taxonomists after comparing with material held in Maseno University Herbarium as well as published reports. Subsequent identification was aided by Flora of Tropical East Africa (FTEA, 2010).

III. RESULTS

Table 1. Melliferous plant species in Eastern Mau forest and their reward values.

	Family	**Species**	**Reward**	**Form**
1	Acanthaceae	*Acanthus pubescens* (Thomp ex Oliv.)	N	Herb
2	Acanthaceae	*Asystasia gangetica* (L.)	N	Herb
3	Acanthaceae	*Justicia exigua* S.Moore	NP	Herb
4	Acanthaceae	*Justicia flava* (Vahl.) Vahl.	NP	Herb
5	Acanthaceae	*Odontonema strictum* Kuntze	N	Shrub
6	Agavaceae	*Agave sisaliana* Perrine ex Engelm.	N	Shrub
7	Amaranthaceae	*Achyranthes aspera* L.	N	Herb
8	Amaranthaceae	*Pupalia lappacea* (L.)A.Juss.	N	Herb
9	Anacardiaceae	*Mangifera indica* L.	NP	Tree
10	Anacardiaceae	*Rhus nataliensis* Bernh.	NP	Tree
11	Araliaceae	*Polyscias fulva*J.R. Forst. &G.Forst.	NP	Tree
12	Asphodelaceae	*Aloe secundiflora* Engl.	N	Herb
13	Asteraceae	*Aspilia mossambicensis*(OLiv.) Wild	P	Herb
14	Asteraceae	*Bothriocline fusca* (S.Moore) M.G.Gilbert	P	Herb
15	Asteraceae	*Hellianthus Annuus* L.	P	Herb
16	Asteraceae	Tithonia diversifolia Hemsl.	P	Shrub
17	Asteraceae	Vernonia auriculifera Hern	NP	Shrub
18	Astercaeae	*Solanecio mannii* (Hook.f.)	P	Shrub
19	Bignoniaceae	*Jacaranda mimosifolia* D.Don	P	Tree
20	Boraginaceae	*Cordia abyssinica* R.Br. ex A.Rich.	NP	Tree
21	Cactaceae	*Opuntia ficus-indica* (L.)Mill.	P	Shrub
22	Capparaceae	*Maerua triphylla* A.Rich.	N	Shrub
23	Caricaceae	*Carica papaya* (L.)	NP	Tree
24	Combretaceae	*Combretum molle* R.Br.ex G.Don.	N	Tree
25	Combretaceae	*Terminalia brownii* Fresen.	P	Tree
26	Convolvulaceae	*Ipomoea batatas* (L.)Lam	N	Climber
27	Curcubitaceae	*Cucurbita pepo* L.	NP	Climber
28	Curcubitaceae	*Mormadica foetida* Schumach	P	Climber

29	Euphorbiaceae	*Croton macrostachyus* Hotchst.	NP	Tree
30	Euphorbiaceae	*Croton megalocarpus* Hutch.	NP	Tree
31	Eurphobiaceae	*Euphorbia hirta* L.	NP	Tree
32	Fabaceae	*Albizia coriaria* Welw. ex Oliv.	NP	Tree
33	Fabaceae	*Acacia brevispica* (Harms) Seigler & Ebinger	NP	Tree
34	Fabaceae	*Acacia elatior* Brenan.	NP	Tree
35	Fabaceae	*Acacia mellifera* (M. Vahl.)	NP	Tree
36	Fabaceae	*Acacia polyacantha* (Willd)	NP	Tree
37	Fabaceae	*Acacia senegal*(L.)Willd.	NP	Tree
38	Fabaceae	*Acacia tortilis* (Forssk.)	NP	Tree
39	Fabaceae	*Acacia xanthophlea*(Benth.)	NP	Tree
40	Fabaceae	*Crotalaria brevidens* L.	P	Herb
41	Fabaceae	*Delonix regia* (Bojer ex Hook.)	NP	Tree
42	Fabaceae	*Erythrina abyssinica* Lam. ex DC	NP	Tree
43	Fabaceae	*Glircidia sepium* (Jacq.)Kunth ex Walp.	N	Tree
44	Fabaceae	*Leucaena Leucocephala* (Lam.)de Wit	N	Shrub
45	Fabaceae	*Mimosa invisa*	NP	Shrub
46	Fabaceae	*Pentaclethra macrophylla* Benth.	N	Tree
47	Fabaceae	*Phaseolus vulgaris* L.	N	Herb
48	Fabaceae	*Sesbania sesban (L.)Merr.*	N	Shrub
49	Fabaceae	*Tamaridus indica* L.	NP	Tree
50	Fabaceae	*Tephrosia vogelii* Hook.f.	P	Shrub
51	Fabaceae	*Trifolium repens* L.	NP	Herb
52	Fabaceae	*Tylosema fassoglensis* Schweinf.	P	Climber
53	Graminae	*Pennisitem purpureum* Schumach.	N	Herb
54	Gramineae	*Cynodon dactylon* L.	P	Her
55	Gramineae	*Sorghum bicolor* (L.)Moench	P	Herb
56	Gramineae	*Zea mays* L.	P	Herb
57	Lamiaceae	*Leucas deflexa* Hook.f.	N	Herb
58	Lamiaceae	*Ocimum gratissimum* L.	NP	Shrub
59	Lauraceae	*Persea americana* Mill.	N	Climber
60	Malvaceae	*Hibiscus rosa-sinensis* L.	NP	Shrub
61	Malvaceae	*Malvaviscus arboreus* Cav.	N	Shrub
62	Malvaceae	*Sida acuta* Burm f.	NP	Herb
63	Meliaceae	*Melia azedarach* L.	NP	Tree
64	Moraceae	*Morus mesozygia* Stapf.	P	Shrub
65	Moringaceae	*Moringa oleifera* Lam	N	Tree
66	Musaceae	*Musa acuminata* Colla	N	Herb
67	Myrtaceae	*Callistemon citrinus* (Curtis)	NP	Tree
68	Myrtaceae	*E.grandis* (W.Hill)	N	Tree
69	Myrtaceae	*E.resinifera* (Smith)	NP	Tree
70	Myrtaceae	*Psidium Guajava* L.	NP	Shrub

71	Oleaceae	*Jasminum fluminense* L.	N	Climber
72	Oleaceae	*Olea europaea* ssp *Africana* L.	P	Tree
73	Passifloraceae	*Passiflora edulis* Sims.	NP	Climber
74	Proteaceae	*Grevillea robusta* A.Cunn.ex R. Br.	NP	Tree
75	Rhamnaceae	*Zizyphus mucronata* Willd	P	Tree
76	Rosaceae	*Eriobotrya japonica* (Thunb.)Lindl.	P	Tree
77	Rosaceae	*Prunus africana(*Hok.f.)Kalkman	NP	Tree
78	Rutaceae	*Citrus limon* (L.)	NP	Tree
79	Rutaceae	*Teclea nobilis*	NP	Tree
80	Sterculaceae	*Dombeya torrida* (J.F.Gmel)	NP	Shrub
81	Tiliaceae	*Grewia bicolor* Juss.	N	Shrub
82	Ulmaceae	*Trema orientalis* L	NP	Shrub
83	Verbenaceae	*Lantana camara* L.	P	Shrub
84	Verbenaceae	*Stachytarpheta jamaicensis* (L.)Vahl.	N	Herb
85	Vitaceae	*Cissus rotundiflora* Vahl.	P	Climber
86	Zygophyllaceae	*Tribulis terrestris* L	P	Herb

86 bee plants belonging to 36 families were identified. Fabaceae, Compositae and Acanthaceae families were the biggest sources of bee forage. Gramineae largely provided for pollen. The bee forage was contributed by trees, shrubs, herbs, and climbers.

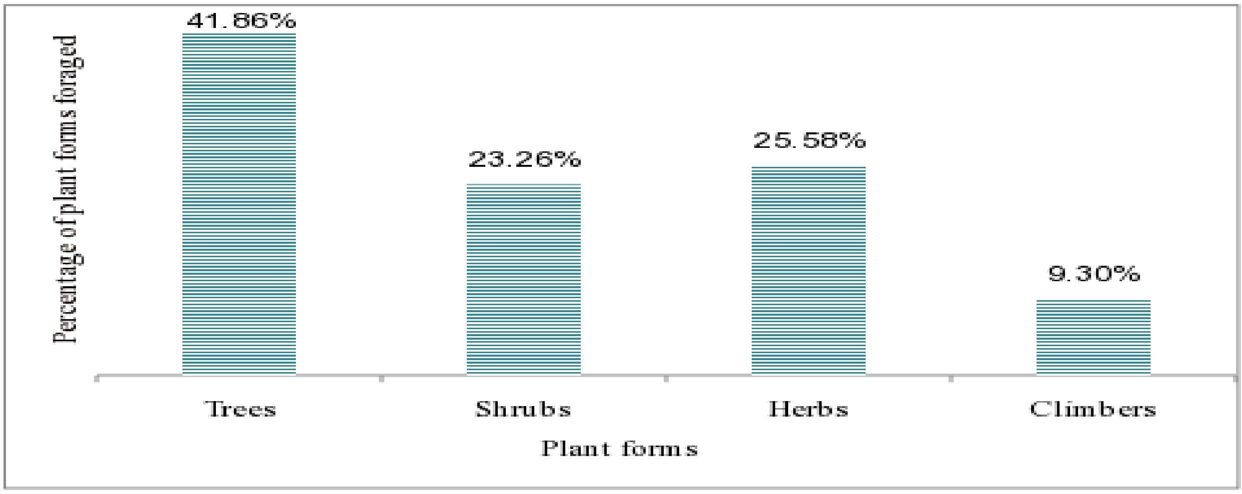

Figure 1. Percentage plant forms foraged by *Apis mellifera.*

41.86% of beeforage were tree species. Climbers offered least of the bee forage sources while shrubs and herbs offered bee forage in almost equal proportions 23.26% and 25.58% respectively. Almost a half of the bee plants forage during the year are tree species.

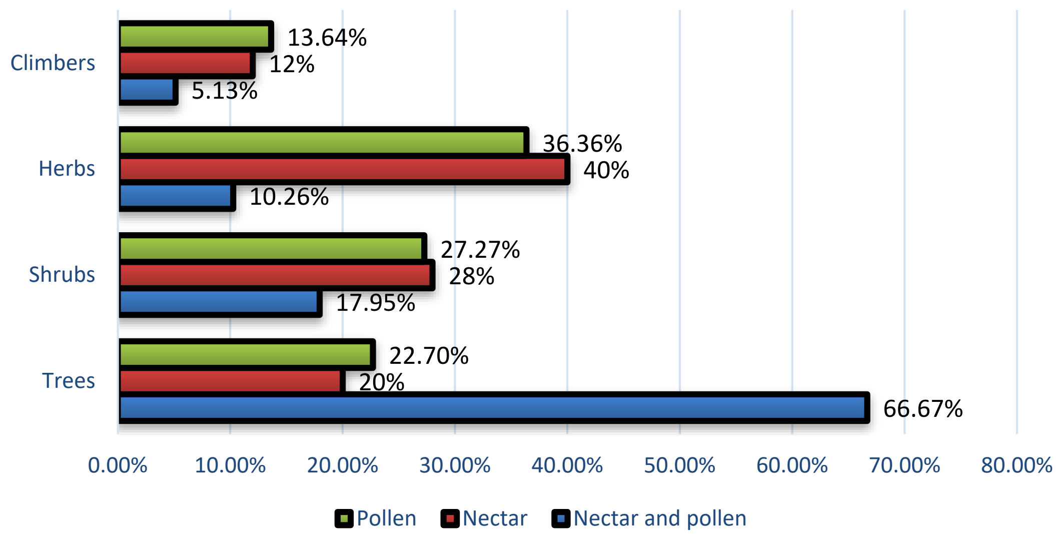

Figure 2. Bee plant forms and their percentage reward of pollen ,nectar and both pollen and nectar

The tree species provided 66.67% of the both nectar and pollen sources while the climbers offered only 5.13% of the both nectar and pollen sources. Herbs provided for the highest proportion of nectar only sources (40%)

IV. DISCUSSION

This study identified 86 plant speceis that bee foraged over for pollen, nectar and both pollen and nectar. The 86 speceis belonged to 39 families. These results are comparible to the Akunne et al (2016) reporting 83 melliferous species in Akwa and Agulu environs, South East Nigeria. Trees formed 41.86%, Herbs (25.58%), Shrubs (23.25%), and climbers (9.3%). This is in consort with Devi and Mattu (2017) who reported honeybees as using trees, shrubs, herbs and cultivated crops as sources of pollen and nectar. Asteraceae, Acathaceae, Fabaceae, Gramineae, Euphorbiaceae, and Myrtaceae recorded 47.67% of the total population of bee plants .The studies are in consort with Nuru et al., (2017). Similar results were also reported by Ejigu et al (2017) with herbs , trees, shrubs being source of forage for the bees. Herbaceous plants that grow as weed on cultivated field , negelcted open land wastelands and as ornamentals are important source of bee forage because they grow and flourish in a short period and their seeds are collected easily and sown for the next growing season. Short flower shedding time may may be only used for colony build up (Kifle et al, 2014). The density value for herbaceous plant species for the Families Fabaceae and Asteraceae have also been reported in higher altitudes by Wubie et al., (2014) in altitudes ranging from 1500m to 2200m in Ahmara region Ethiopia and such higher plant frequencies have been attributed to adaptation to the study area and local climate.

The largest proportion of tree bee plants were cotributed by the Fabaceae (36.11%) . Trees contributed the most significant pollen sources. This was both in form of providing for both Nectar and pollen (66.67%) and as purely pollen sources (22.72%). This is in agreement with studies by (Taha , 2015) who reported trees to represent the most important pollen sources, offering more than 80.00% of the total amount of collected pollen. And also studies by (Dukku, 2013) that further reported that the major honey sources are sources species are mainly trees and species. In this study 84.61% of the bee plants providing both pollen and nectar were trees and shrubs with the remaining proportion representing the herbs and climbers.

Fabaceae contributed to all growth forms of the bee plants. Amaranthaceae, Compositae and Acanthaceae made large part of the herbs and undergrowth. These results support observations reported by Vlek et al., (2014) that showed similar trends of distribution, but further determined *Justicia* spp as of higher importance than *Leucas* speceis in the undergrowth. In general trees are more productive in nectar secretion than herbs due to their larger biomass, dense flowers , deep roots and resistance to moisture stress. Moreover in most trees, flowers are not colourful and are expected to secrete more nectar and strongly attract sufficient pollinators. Herbaceous plants have conspicous colours and may not need to produce large amount of nectar (Nuru et al., 2017). This study is largely comparable to Larinde et al (2014) for the families Asteraceae, Anarcardiaceae, Rutaceae, Lamiaceae, and Cucurbitaceae were reported as bee plants in both studies. The *Apis mellifera* was observed to show some level of constancy by visiting a majority of the trees and shrubs for pollen and nectar as earlier suggested by Larinde at al., (2014) which reported *Apis mellifera* while studying bee flora in Southern Nigeria to be constant on plant food source that are rewarding in terms of nectar and pollen. Wubie et al., (2014) in the study of honey plants revealed that the herbs, trees, and shrubs supplied varied floral rewards and this was further observed in this study where the diffrent plant forms supplied various forage rewards with highest number of trees supplying both pollen and nectar at the same time.

39 families and 86 plant species were observed as bee plants in the stuudy area: Acanthaceae, Amaranthaceae, Anarcardiaceae, Araliaceae, Asphodelaceae, Asteraceae, Bignonaceae, Boraginaceae,Cactaceae, Capparaceae, Caricaceae, Combreataceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Gramineae, Laminaceae, Lauraceae, Malvaceae, Meliaceae, Moraceae, Moringaceae, Musaceae, Myrtaceae, Oleaceae, Passifloraceae, Proteaceae, Rhamnaceae, Rosaceae, Rutaceae, Sterculaceae, Tiliaceae, Ulmaceae, Verbinaceae, Vitaceae, Zygophylaceae. This results are diffrent from reports by Haragude et al (2016), 100 species; Devi and Mattu (2017), 219 species; Villanueva-Gutierrez et al., (2015), 168 plant species; Dukku (2013), 61 species; and Akunne at al., (2016), 83 melliferous plant species.This in agreement with observations of Iler et al., (2013) that *Apis mellifera* is a generalist visiting a range of blooming flowers.

Previous studies (Carroll, 2006) have revealed similar results in Kenya. In Nandi hills *Persea americana*, *Dombeya torrida*, *Grevillia robusta*, *Musca* spp, *Carica papaya*, *Phaseolus vulgaris*, *Coffea arabica*, *Eucalyptus saligna*, *Croton macrostachyus* and weeds were identified as bee plants. In Molo: *Dombeya goetzentii*, *Zea mays*, *Callistemon citrinus*, *Eucalyptus saligna*, *Vernonia* spp, *Croton megalocarpus*, *Artemesia tridentata*, *Dahlia pinnata*, *Fuchsia* spp, *Raphanus raphanistrum.* In Kirinyaga :The main nectar bearing trees in the area are *Coffea* spp, *Musa* spp), *Grevillia robusta*, *Persea americana*, *Macadamia tetraphylla*, *Mangifera indica*, *Croton* sp, *Carica papaya*, *Phaseolus vulgaris*. Flowering *Zea mays* is an important source of pollen. Mwea division : *Grevillea robusta*, *Acacia mellifera*, *Eucalyptus saligna*, *Acacia lahai*, *A. seyal*, *A. abyssinica*, *A. brevispica*, *A. gerrardii*, *Azadirachta indica*, *Calliandra calothyrsus*, *Callistemon citrinus*, *Cajanus cajan*, *Kigelia africana*, *Carica papaya*, *Musa* sp., *Phaseolus* sp., *Mangifera indica*, *Psidium guajava* and *Macadamia tetraphylla*. In Kakamega forest, honey production is reliant on the flowering of forest trees and other plants including *Leucaena leucocephala*, *Musa* spp, Isungusa (Luyhia), Isirimoi (Luyhia), and Iludolio (Luyhia). The flowering of *Croton megalocarpus* (Musine, Luyhia) is an indicator of when to harvest honey. In Transmara *Olea africana*, *Thunbergia alata*, *Scutia myrtina*, *Cordia moncica*, *Acacia seiberiana* have been reported as bee plants (Carroll, 2006). Some of the bee plants are reported for the first time *Cissus rotundiflora* (Vitaceae), *Trema orientalis* (Ulmaceae), *Maerua triphylla* (Capparaceae), *Aloe secundiflora* (Asphodelaceae), *Tribulis terrestis* (Zygophyllaceae) and Polyscias fulva (Araliaceae) in Eastern Mau forest studies.

39 plant species were sources of both nectar and pollen, 25 species provided for nectar while 22 species provided for pollen. This agrees with reports by Akunne et al (2016) which revealed that generally the honey bee visitation and exploitation of the plant speceis varied from one species to another. High number of the plant species producing nectar alone and both nectar and pollen is an indication of honeybees colony performance and productivity is sutainable. The variation in plant types based on their floral reward also agrees with the findings of Waykar and Baviskar (2014) that there are plants that supply nectar, pollen and plants that provide both. The trend in bee plant reward also seems to agree with report by Waykar and Baviskar (2014) in order of both nectar and pollen, nectar, and pollen. Colour , odour, and morphology of flowers determine the preference of honey bees for a particular nectar or pollen source and there is high reliance on a few species (Villanueva-Gutierrez et al., 2015). Plant speceis that only offer pollen as a reward vary tremendously in their floral displays including anther and corolla colours, suggesting that visual cues might be useful for bees to learn. Anther and corolla colours may allow bees to discriminate among pollen rewarding plants speceis, bees seem to attend to corolla more than anther colour (Muth et al., 2016). Flowering plants both ornamental and wild were observed as visted by honey bees for nectar and pollen . This in in ageement with reports by Devi and Mattu (2017).

The results of this study are comparable to the study of Nuru et al., (2017). The families Asteraceae, Leguminosae, Lamiaceae, Acanthaceae, and Malvaceae accounted for the majority (35%) of the total bee forage species of the region (Nuru et al., 2017), while in this study Asteraceae , Acathaceae, Fabaceae ,Gramineae, Euphorbiaceae, and Myrtaceae recorded 47.67% of the total population of bee plants even though in this study there were only a total of 86 plant species studied, in Nuru et al., (2017) upto 111 speceis were observed. This could be attributed to the variation in the ecological distribution of bee floral resources and periods of availability according to the flowering times as reported by Abou-Shaara (2015). Bees also collect nectar and pollen from many different plant species. Production of pollen and nectar may vary in various ecological zones . Plants considered a major nectar source in one region may only be a minor source in others. Yearly variations may also cause minor honey plants to occassionally yield heavily, or major plants to yield poorly (Haragude et al., 2016). Abundance , distribution and diversity of nectar and pollen plants vary from place to place due to variation in topography, climate and farming practises . Slight variation in nectar resources accross areas are common, and this may not pose serious challenge to profitable apiculture (Akunne et al, 2016). Forage use Patterns has also shown that itsnot simply the number of good pollen and nectar species that occur in the area that determine forage use but also their abundance (Hutton-Squire, 2014). Because of the current threats in bee flora, beekeepers should be encouraged to plant multipurpose tree speceis that are not only nectar and polen producing plants but also good trees in terms of timber and medicinal value. Despite the fact that some annuals provide quick and abundant bee forage, perennia herbs and shrubs are superior bee forage , compared to annuals perennials are generally richer sources of nectar because of their longevity and provide more or less dependable food source year after year. However heavily wooded areas in the forest ecosystem are not always suitable for honey bees although the bees are able to forage on high canopies (Mwangi et al., 2012).

Section of plants being the major bee plants has been reported by Crane (1990) where only six plant species served as major nectar sources in the region of study. Larinde et al., (2014) while studying ecological zones in Southern Nigeria reported the foraging of members of the families Asteraceae (23.810%), Anarcardeaceae (9.523%) , Rutaceae (9.523%) , Lamiaceae (4.762%), and Curcubitaceae (94.762%) by *Apis mellifera* for nectar and pollen. Although the same families were foraged by the *Apis mellifera* in Eastern Mau, in this study Fabaceae family (24.41%) was the most visited followed by Asteraceae (6.98%) and then Acanthaceae (5.81%). The variations could be attributed by constancy of *Apis mellifera* on plant food source that are rewarding in terms of nectar and pollen as reported by Omoloye and Ayansola (2006). High frequency by Compositae is in conformity with similar results obtained by Olusola and Oluwatoyin (2009) that Asteraceae had the highest pollen and being of great importance to bees for production of honey. In the 39 families studied, Fabaceae, Acanthaceae, Astercaeae, Myrtaceae, Euphorbiaceae, and Gramineae, had more than 2 plant species, the rest of the 33 families had either 1 or 2 species. This is in consort with Dukku (2013) that reported 2 or 1 species in the Sudan Savanna zone of North Eastern Nigeria. Akunne et al. (2016) also reported other families apart from Asteraceae, Euphorbiaceae, Verbeneceae, and Malvaceae to be represented scantily.

Rosaceae (*Prunus* spp) have been reported as bee forage by Decourtye et al (2010) as creating favourable landscapes for *Apis mellifera*. *Pennisitem purpureum* Schumach, *Cynodon dactylon*, *Sorghum bicolor* (L.) Moench, *Zea mays* L. (Gramineae) were observed as bee plants. Villanueva-Gutuerez (2015) while studying the Yucatan Peninsula reported up to 168 bee forage plants species including with Gramineae among the families that contributed the largest number of species. Investigations by Devi and Mattu (2017), Haragude and Chaphalkar (2013), Vlek et al., (2014) similarly reported *Sorghum vulgare* and *Zea mays* and *Cynodon dactyon* as pollen sources. Similar results have also been reported by Wubie et al., (2014) in which all grass plants were recorded as only pollen sources. *Ipomoea batatus* (Convolvulacae) as a bee plant confirms previous studies by Devi and Mattu (2017) while preparing floral calendar for adjoining areas of Himachal Pradesh. *Ipomoea batatas* (L.) Lam was repoted as both pollen and nectar plant, however in this study was recorded as a nectar plant.

Justicia flava (Acanthaceae) observed in this study had been earlier reported (Mwangi et al., 2012) in Kakamega and sorrounding farmlands. However farmers rarely notice the plants as source of forage for bees but as source of firewood and as boundaries. Tree and shrub bee plants may require farmer intervention compared to freely growing herbs eg *Justicia flava* which they take less notice of (Mwangi et al., 2012). *Sida acuta* (Malvaceae) has been reported as both nectar and pollen plant by Akunne et al., 2016. Studies by Akunne et al., 2016 has similarly reported *Psidium guajava* (Myrtaceae) as both nectar and pollen plant and *Lantana camara* and *Stachytarpheta jamaicacensis* (Verbenaceae) as both nectar and pollen forage. Honey prooduction is made possible by *Eucalyptus* in South Africa; in the Western Cape alone, two thirds of honey production is supported by *Eucalyptus* . *Eucalyptus cladocalyx* is one of the best nectar yielding and is said to be number one honeybee forage in South Africa. Not only do *Eucalyptus* species provide high quality nectar necessary for good honey production, they also play a crtical role in strengthening honeybee colonies which can then be used for agricultural crop pollination (Hutton-Squire, 2014).

This study has reported of Fabaceae being the most visited. Similar results have been reported by Forman et al (2003) , legumes being the most frequently visited plant species due to their long flowering periods of the plura annual flowering pattern species and their being attractive. Fabaceae have been reported as bee forage by Decourtye et al. (2010). Despite these reported benefits, the slow growth of some legumes may be a limiting factor in some cases because an absence of flowers in the first year (Decourtye et al., 2010). Bee forage taking a long time for blooming to shedding are very important for honey production (Kifle et al., 2014). Despite the long term value of perennial legumes to honey plants , farmers always prefer the annual species due to their low cost . In bee pustures such concerns have been addressed with mixture of annual, biannual and perennial plants (Decourtye et al., 2010). Studies by Hutton-Squire (2014) on the relationship betwen honey-bee and its forage did reveal that *Citrus* spp (Rutaceae) , *Medicago sativa* and *Lucerne* spp as valuable nectar and pollen sources. *Persea americana* (Lauraceae) , though reported as a bee plant by Ish-Am and Eisikowitch (1993), the flower is shallow, greenish yellow, and the nectar is fully exposed. The pollen and nectar though easily collected, are not very attractive to bees. The flower has lackslanding platform and is somewhat small for the honey bees. The infloresence is too sparse to be visited as a unit, and seem to have difficulties holding tightly to the single flower. Despite there being of less species diversity, trees and shrubs are the major sources of honey in the region ,which could be due to their deep rooted nature and their adaption to low precipitation. Trees and shrubs may not be affected equally by intermittent rainfall conditions ofan area for instance annual herbs (Okoth, 2010).

VI. CONCLUSIONS

Eastern Mau has 86 plant species from 39 plant families. *Cissus rotundiflora* (Vitaceae), *Trema orientalis* (Ulmaceae), *Maerua triphylla* (Capparaceae), *Aloe secundiflora* (Asphodelaceae), *Tribulis terrestis* (Zygophyllaceae) and *Polyscias fulva* (Araliaceae) Some of the bee plants are reported for the first time in Kenyan studies. Trees formed 41.86%, Herbs (25.58%), Shrubs (23.25%), and climbers (9.3%) of the bee forage. Fabaceae, Asteraceae, Acanthaceae, Myrtaceae, Euphorbiaceae, and Graminae families contribute the majority of the bee plants in Eastern Mau forest.Trees, Herbs, Shrubs, Climbers provide nectar, pollen and both pollen and nectar to *Apis mellifera* in Eastern Mau. 45.35%, 29.07%, and 25.58% melliferous plants reward *Apis mellifera* with both nectar and pollen, nectar and pollen respectively. Local names of the bee plants should be generated to compliment the binomial names alongside the participatory extension approaches with the Ogiek bee keepers to conserve the melliferous species in Eastern Mau forest. A quantitative determination of bee forage values should be carried out, while more trees and shrubs providing both pollen and nectar should be planted to supply both pollen and nectar for both colony build up and food reserves.

REFERENCES

[1] Abou-Shaara, H.F., Ahmed, M.E. (2015). Characterisation and tracking changes of morphological characteristics in honey bee, Apis mellifera, colonies. Journal of Entomological and Acarological Research .47:5120 . DOI:10.4081/jear.2015.5120.

[2] Akunne, C.E., Akpan, A.U., and Ononye, B.U. (2016). Pattern of nectariferous plant diversity of African honeybee (Apis mellifera adansonii L.) in Awka and Agulu Environs, Southeast Nigeria. Journal of Apiculture 31 (4):281-91.DOI;17519/apiculture. 2016.11.31.4.281.

[3] Ayansola, A. A. and Davies, B. A. (2012). Honeybee floral resources in South Western Nigeria. Journal of Biology and Life Science 3(1): 127-139.

[4] Carroll, T., (2006). A beginners guide to bee keeping in Kenya Pp 1-70.www.apiconsult.com

[5] China, S.S. (1993). Land Use Planning Using GIS, PhD Thesis, University of Southampton, England.

[6] Crane, E. (1990). Bees and beekeeping: science, practice and world resources. Oxford Heinemann Newnes.

[7] Decourtye, A., EricMader, Nicolas, D. (2010). Landscape enhancement of floral resources for honey bees in agroecosystems. Apidologie 41(2010) 264-277). DOI:10.1051/apido/2010024.

[8] Devi, A. , Mattu, V.K. (2017). Preparation of floral calendar of honey plants of Kangra and adjoining areas of Himachal Pradesh. Vol 6 (2): ISSN 2319-7064.International Journal of Science and Research (IJSR) pp 371-378

[9] Dukku, U.H. (2013). Identification of plants visited by the honeybee, Apis mellifera L. in the Sudan Savanna zone of northeastern NigeriaVol. 7(7), pp. 273-284,DOI: 10.5897/AJPS2013.1035

[10] Ejigu, K., Tesfa, A., Dagnew, D. (2017). Identification and characterisation of honey bee Flora in WesternAmhara Region, Ethiopia.Journal of Natural Sciences Research. 7(13), ISSN 2224-3186. pp 36-42.

[11] Flora ot Tropical East Africa (FTEA) (1952–2010). Various editors and authors.Crown Agents for Oversea Governments, London and others.

[12] Forman, R.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R., Goldman, C.R., Heanue, K., Jones, J.A., Swanson, F.J., Turrentine, T., Winter, T.C. (2003). Road Ecology: Science and Solutions, Island Press, Washington, DC.

[13] Harugade, S. , Gawate, A.B., and Shinde, B. (2016). Bee floral diversity of medicinal plants in Vidya Pratishthan campus, Baramati, Pune, District (M.S.) International journal of current microbiology and Applied Sciences 5(11):425-431.ISSN:2319-7706

[14] Hawkins, J., Natasha, de Vere, Griffith A, Ford, C.R., Allainguillaume, J., Hegarty, M.J., Baillie L., Adams-Groom, B. (2015). Using DNA Metabarcoding to identify the floral composition of honey:A new tool for investigating honey bee foraging preferences. PLoS ONE 10(8):e0134735.doi:10.1371/jounal.

[15] Hutton-Squire, J.P. (2014).Historical relationship of the Honeybee(*Apis mellifera*) and its forage; and the current state of beekeeping within South Africa. Stellenbosch University http://scholar.sun.ac.za pp 1-82.

[16] Iler, A. M. , Toke, T. H, David, W., Niels, M. S. (2013). Long term trends mask variation in the direction and magnitude of short term phenological shifts. American Journal of Botany, 100(7).

[17] Ish-Am, G. and Eisikowitch, D., (1993). The behaviour of honey bees (Apis mellifera) visiting Avocado (Persea Americana) Journal of Apicultural Research 32 (3/4):175-186

[18] Jaetzold, R, Schmidt, H. (1982). Farm management handbook for Kenya. Nairobi, Kenya: Ministry of Agriculture.

[19] Kifle, T. B., Kibebew, W. H., Admassu, M. (2014). Screening of potential Herbaceous honey plants for bee keeping development. Agriculture, Forestry and Fisheries. Vol 3(5)pp 386-391. doi:10.11648/j.aff.2014040305.

[20] KFS (Kenya Forest Service), (2012). Forest status, Nakuru County: KFS (unpublished report).

[21] Kumar, R., Rajput, G.S., Mishra, R.C., Agrawal, O.P. (2013). A study on assessment of duration of dearth period for Honey bees in Haryana, India. Munis Entomology & Zoology, 2013; 8 (1):434-437.

[22] Kundu, P.M. (2007). Application of Remote Sensing and GIS Techniques to Evaluate the Impact of Land Use Cover Change on Stream flows: The case of River Njoro in Eastern Mau- Kenya, PhD Thesis, Egerton University, Kenya

[23] Langat, D., Maranga, E.K., Cheboiwo, J., Aboiud, A.A. (2015). Forest use and dependence by adjacent households on East Mau forest ecosystem. Journal of Agricultural economics, Extension and rural development . ISSN-2360-798X. 3(10):Pp 326-337.

[24] Larinde, S.L., Adedeji, G.A. and Ogbuehi, E. (2014). Bee foraging plant in selected ecological zones in Southern Nigeria: Implications for Apiary Management, J.of Trop. For.Res.Vol.30(2)109-118.

[25] MaMaSe (Mau Mara Water Initiative) (2017). Trees and plants for bees and beekeepers in the Upper Mara Basin. Guide to useful melliferous trees and crops for beekeepers.Pp 2-56. https://www.researchgate.net/publication/322100810.

[26] Mau Forest Complex Report (2009). Report of the Prime ministers taskforce on the conservation of Mau forests complex. Pp 1-75. Accessed on https:www.kws.go.ke.

[27] Muth, M., Papaj, D.R., A.S., Leornard (2016). Colour learning when foraging for nectar and pollen: bees learn two colours at once. Biol Lett 11: 20150628. doi: 10.1098/rsbl.2015.0628

[28] Mwangi, D., Muo, K., Nderitu, J., Melanie, H., Gikungu, M.,Manfred, K. (2012): Diversity and abundance of native bees foraging on hedgerow plants in the Kakamega forest. Journal of Apicultural Research 51(4):298-305.DOI 10.3896/IBRA.1.51.4.02

[29] Nuru, A., Awad, A. M., Al-Ghamdi1, A. A., Alqarni, A. S., Radloff, S. E. (2017). Nectar of Ziziphus spina-christi (L.) WILLD (Rhamnaceae): Dynamics of nectar secretion and potential for honey production. Journal of Apicultural Science, Vol. 56 No. 2 2012 DOI: 10.2478/v10289-012-0023-9.

[30] Okelo, M.O. (2008). Analysis of soil erosion, infiltration and runoff in different land uses in upper river Njoro, watershed, Kenya. Msc Environmental Science thesis, Egerton University, Njoro, Kenya.

[31] Okoth, S.S. (2010).Beekeeping and forest conservation:A case study of Arabuko Sokoke Forest,Kenya.University of Pretoria. pp 1-56.

Olusola A., Oluwatoyin O.(2009) Nectar Sources for the Honey Bee (*Apis mellifera adansonii*) Revealed by Pollen Content. Not. Bot. Hort. Agrobot. Cluj 37 (2), 211-217

[32] Omoloye, A.A. and Akinsola, P.A. (2006). Foraging source and effect of selected plant characters and weather variables in the intensity of honey bees “Apis mellifera adansoni” (Hymenoptera:Apidae) in the south west Nigeria. Journal Apiculture in science. 50(1): 39-48.

[33] Sang, J.K. (2001). The Ogiek in Mau Forest: Case study 3-Kenya - Forest Peoples Program. http://www.forestpeoples.org/sites/fpp/files/publication/2010/10/kenyaeng.pdf).

[34] Sivaram, V. (2014). Honey bee flora and bee keeping in Karanataka State, India. Proc. 37th Int. Apic. Congr., 28 October- 1st Nov 2001, Durban, South Africa

[35] Taha, E.A. (2015). A study on nectar and pollen sources for honeybee, Apis mellifera L. in Al-Ahsa Saudi Arabia .Journal of Entomology and Zoology Studies 2015; 3(3): 272-277. ISSN: 2320-7078

[36] UNEP, KFWG, DRSRS and EU-BCP. (2006). Eastern and south western Mau forests reserves: assessment and way forward. Nairobi, Kenya: UNEP.

[37] Villanueva-Gutierrez, R., Roubik, D.W., and Porter-Bolland, L. (2015). Bee-plant interractions; competition and phenology of flowers visited Springer International Publishing Switzerland 2015.pp 131-152.DOI:10.1007/978-3-319-06529-8_6.

[38] Vlek, P. L.G., Christopher, M., Manfred D., Nick van de Giesen. (2014). Towards realisation of Kenyas full beekeeping potential: A case stdy of Baringo District. Ecology and Development Series 6 (2003) pp 84-111

[39] Waykar, B., Baviskar, R.K., Nikam, T.B.(2014). Diversity of nectariferous and polleniferous bee flora at Anjaneri and Dugarwadi hills of Western Ghats of Nasik distict (M.S.)India. Journal of Entomolgy and Zoology Studies. 2(4) PP244-249. ISSN 2320-7078.

[40] Waykar, B.and Baviskar, R.K., (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.

[41] Wubie, A.,Benzabeh A.,kefelegen, K. (2014). Floral phenology and pollen potential of honey bee plants in NorthEast dry lands of Amhara region, Ethiopia.IOSR Journal of Agriculture and Veterinary Science. 7:36-49.10.9790/2380-07513649.

Authors:

First Author- Philip Onyango, Department of Botany, School of Physical and Biological Sciences, Maseno University, Kenya, philiponyango1@gmail.com
Second Author- Regina Nyunja, Department of Biological Science,School of Physical and Biological Sciences, Jaramogi Oginga Odinga University of Science and technology,Kenya, reginanyunja@yahoo.com
Third Author-George Opande **,**Department of Botany, School of Physical and Biological Sciences, Maseno University, Kenya, opandeg@gmail.com
Fourth Author- Stephen Sikolia Fedha, Department of Botany, School of Physical and Biological Sciences, Maseno University, Kenya, stefedha@gmail.com
Corresponding Author-Philip Onyango, philiponyango1@gmail.com, +254707930931.