ISSN: 2456-9348
Vol (03) _Issue (03) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

SPATIO-TEMPORAL VARIATION AND SIMILARITY INDEX OF THE POLLEN TYPES FROM MELISSOPALYNOLOGY OF EASTERN MAU *APIS MELLIFERA* LINN OGIEK HONEYS, KENYA

Philip O. Onyango
Department of Botany, School of Physical and Biological Sciences, Maseno University

ABSTRACT
The pollen within honey provides a long term indication of plants being used for both nectar and pollen.Honey pollen profile reflects forest vegetation diversity and species composition of the plants foraged by honey bees. Although Apis mellifera is an important bee in plant-bee interaction network, they are in a vulnerable situation due to habitat loss. Because of this vulnerability and lack of knowledge about the plant species that sustains this native bee species pollen analysis of 27 honey samples collected from Ogiek bee keepers in Eastern Mau have been analysed against reference slides. Pollen types refereable to 39 botanical families were obserevd. Fabaceae (19.7%) and Acanthaceae (6.6%) Asteraceae (6.6%) contributed the highest number of pollen types. Non entomophilous pollen were also observed from Pinus type and the gramineae . The family gramineae was appreciably represented by four pollen types (5.3%).Jaccards similarity index ranged from 0.00 to 0.588 based on pairwise comparison between individual honey samples. The highest similarity was observed in a comparison between (NE-S3-8) and NE-S1-8) within same site. The number of pollen types ranged from 8 (MA-S3-DE,NE-S3-DE) to 15(MA-S1-AP, MA-S2-AP,MA-S3-AP) the mean number of pollen types was 11.3. The mean number of pollen types were highest in April (12.8), and lowest in December (9.7). There is a significant positive correlation (r=0.607*, 0.05) between number of pollen types and pollen density,

KEYWORDS:
Apis mellifera, pollen types, Ogiek honeys, Eastern Mau, Melissopalynology

INTRODUCTION

Honey bee (*Apis mellifera*) colony maintenance depend on food resouces from flowering plants year round. Because diverse floral diet has an implication on the colony health, the identification of plants prefered by the foragers provides valuable information towards the sustainace of bee friendly habitats. Recent studies have best utilised to understand *Apis mellifera* nectar foraging preferences (Perre and Bryant, 2017). Identifying pollen returned to the hive provides a direct measure of pollen foraging, whilst the pollen within honey provides a longer term overview of plants being used for both nectar and pollen (Hawkins et al., 2015). In order to assess the influence of seasons on the exploitation of mellliferous plants (Nguemo et al., 2016). The reasons for this require further investigation in order to better understand honey bee nutritional requirements (Hawkins et al., 2015). It has also been used to assess correlations with in situ climatic parameters such as rainfall and temperature important in the context of external factors influencing pollinators and pollination networks (Nascimento and Nascimento, 2012; Ponnuchamy et al., 2014). When melissopalynology is used together with field observations involving phenology and floral biology, it provides reliable information on minor and major nectar sources for honey bees at various periods and elevations of honey production. The occurrence of pollen grains in honey can be attributed to their presence in the floral nectar or exogenous sources (Salonen et al., 2009). Honey pollen profile reflects forest vegetation diversity and species composition of the plants foraged by honey bees. The knowledege achieved through melissopalynology and bee botanical studies and nectar plants helps in beekeeping potential areas to provide better honey production and to improve pollination services. Large horticultural undertakings may not flourish in the in the long run in the absence of large scale scientific bee keeping (Singh and Chaturvedi, 2017).Taxonomic identification of bee-collected pollen has the potential to address specific questions related to plant–insect interaction dynamics, habitat use, and habitat and forage quality from both ecological and policy standpoints. This information may go on to influence decisions directed toward evaluating and enhancing pollinator habitat, thus contributing to the future security of plant and bee populations and pollination services. There is need for methods that can quickly, accurately, and efficiently quantify honey bee foraging resources across varying landscapes (Smart et al., 2017). The knowledege obtained through melissopalynology and bee botanical studies and is useful beekeeping potential areas to provide better honey production as well as improving pollination services. Large horticultural undertakings may not flourish in the the absence of large scale scientific bee keeping (Singh and Chaturvedi,2017)

Network of species interactions support diversity and directly impact community dynamics. Habitat loss predisposes decrease in the diversity and abundance of pollinators. During mutualistic interactions , bees are attracted to flowers primarily because of the nectar and pollen as reward towards their food resources. A generalist foraging habit regarded as standard for many bees of the Family Apidae. Colonies of Apis mellifera have high reproductive rates thus require food resources throughout the year. Additionally these bees have extreme taxonomic diversity in collecting pollen from phylogenetically distant taxa . Although Apis mellifera is an important bee in plant-bee interaction network, they are in a vulnerable situation due to habitat loss. Because of this vulnerability and lack of knowledge about the plant species that sustains thi native bee species.

OBJECTIVES

The objective of this study is to document the pollen types from the Eastern Mau Honeys, the spatio-temporal variation in their use , and the similarity in exploitation of pollen sources by *Apis melifera* Linn colonies. The results of this study will provide necessary information for the development of conservation plans and sustainable management of biodiversity in the Eastern mau forest, Kenya

METHODOLOGY

Study site: Eastern Mau is one of the largest blocks in the Mau forest complex.The area is made up of class V vegetation of about 50-75% plant density. There is up to 40% dependence on honey production in Eastern Mau. The study site is located about 50 Km south of Nakuru Town. The altitude ranges from 1200 and 2600 m. It is approximately 280 km^2 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 for honey sample collection based on the strata made prior to the survey.

Strata and sampling: Honey from three forest strata units were purposively sampled 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). Three honey samples were collected from each of strata (Mariashoni, Kapkembu, and Nessuit) at the end of April, 2016; August 2016; December, 2016) from the hives of Bee keeping Ogieks of the Eastern Mau forest region. Only the honey processed by straining using fine sieves or cheese-cloth shall be collected from the beekeepers, placed in sealed food grade screw cup bottles, and transported to the laboratory in cooler boxes. Samples from 3 beekeepers (three replicates) per population substratum shall be collected. *Laboratory sample* consisted of 100-200 g of honey. The laboratory sample was transformed into the test sample by thorough stirring. Granulated hard samples were softened by slight warming. Dirty samples were liquefied at 40°C and strained through cheese-cloth. 10.0 g of honey was weighed and dissolved in 20 ml of hot distilled water at 39°C. and further processed and observed against reference slides

ISSN: 2456-9348
Vol (03) _Issue (03) Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

according to Louveaux et al., (1978). Means, Standard deviation, Correlations , and ranges were determined for quantitative data using SPSS Version 17. Jaccards similarity index was calculated by dividing number of pollen types present in both sample under comparison by the total number of pollen types within the two samples.

RESULTS AND DISCUSSION

Table 1. Representation pollen types from various botanical families in studied honey samples.

FAMILY	Number of Pollen types	% of total pollen types
Acanthaceae	5	6.6%
Agavaceae	1	1.3%
Amaranthaceae	2	2.6%
Anarcardiaceae	2	2.6%
Araliaceae	1	1.3%
Asphodelaceae	1	1.3%
Asteraceae	5	6.6%
Bignoniaceae	1	1.3%
Borognaceae	1	1.3%
Cactaceae	1	1.3%
Capparaceae	1	1.3%
Caricaceae	1	1.3%
Combrateceae	2	2.6%
Convolvulaceae	1	1.3%
Cucurbitaceae	2	2.6%
Euphorbiaceae	2	2.6%
Fabaceae	15	19.7%
Gramineae	4	5.3%
Lamiaceae	2	2.6%
Lauraceae	1	1.3%
Malvaceae	2	2.6%
Meliaceae	1	1.3%
Moraceae	2	2.6%
Moringaceae	2	2.6%
Musaceae	1	1.3%
Myrtaceae	3	3.9%
Oleaceae	2	2.6%
Passifloraceae	1	1.3%
Pinaceae	1	1.3%
Proteaceae	1	1.3%
Rhamnaceae	1	1.3%
Rosaceae	2	2.6%
Rutaceae	2	2.6%
Sterculaceae	1	1.3%
Tiliaceae	1	1.3%
Ulmaceae	1	1.3%
Verbenaceae	1	1.3%
Vitaceae	1	1.3%
Zygophyllaceae	1	1.3%

There were 76 pollen types observed in the 27 honey samples, referrable to 39 botanical families. Fabaceae (19.7%) and Acanthaceae (6.6%) Asteraceae (6.6%) contributed the highest number of pollen types. Non entomophilous pollen were also observed from *Pinus* type and the Gramineae . The family Gramineae was appreciably represented by four pollen types (5.3%).

Vol (03) _Issue (03)

ISSN: 2456-9348
Impact Factor: 4.520

iJETRM
International Journal of Engineering Technology Research & Management

Table 2. Jaccard similarity index of pollen types between Ogiek honey samples in Eastern Mau forest.

		Jaccards Index	
Sample	Min	Max	Average
KA-S1-4	0.000[MA-S2-12]	0.471 [KA-S3-4]	0.174
KA-S2-4	0.000[NE-S3-12]	0.375 [NE-S2-4]	0.134
KA-S3-4	0.000[MA-S2-12]	0.471 [KA-S1-4]	0.177
MA-S1-4	0.353[KA-S1-4]	0.500[NE-S3-4]	0.219
MA-S2-4	0.217[KA-S1-4]	0.318[MA-S1-4]	0.165
MA-S3-4	0.273[KA-SI-4]	0.318[MA-S1-4]	0.210
NE-S1-4	0.000[MA-S2-12]	0.368[MA-SI-4]	0.210
NE-S2-4	0.042[NE-S1-8]	0.412[KA-S3-8]	0.181
NE-S3-4	0.000[MA-S2-12]	0.500[MA-S1-4]	0.195
KA-S1-8	0.038[MA-S1-4]	0.250[KA-S2-8]	0.153
KA-S2-8	0.080[MA-S1-4]	0.278[NE-SI-12]	0.185
KA-S3-8	0.048[MA-S2-12]	0.412[NE-S2-4]	0.214
MA-S1-8	0.048[MA-S2-12]	0.333[KA-S3-8]	0.195
MA-S2-8	0.048[KA-S1-12]	0.316[MA-S1-8]	0.202
MA-S3-8	0.042[KA-S1-12]	0.316[KA-S3-8]	0.184
NE-S1-8	0.040[NE-S3-12]	0.588[NE-S3-8]	0.184
NE-S2-8	0.000[NE-S3-12]	0.350[NE-S1-8]	0.170
NE-S3-8	0.000[NE-S3-12]	0.588[NE-S1-8]	0.184
KA-S1-12	0.042[MA-S3-8]	0.313[KA-S2-12]	0.161
KA-S2-12	0.043[MA-S3-8]	0.429[KA-S3-12]	0.177
KA-S3-12	0.042[MA-S2-4]	0.429[KA-S2-12]	0.199
MA-S1-12	0.100[KA-S1-4]	0.357[KA-S3-12/NE-S1-12]	0.203
MA-S2-12	0.000[KA-S1-4/KA-S3-4/NE-S1-4/NE-S34]	0.250[KA-S3-12/NE-S1-12]	0.135
MA-S3-12	0.167[KA-S1-4/KA-S2-8]	0.385[KA-S3-12]	0.203
NE-S1-12	0.150[KA-S1-4]	0.357[MA-S1-12]	0.210
NE-S2-12	0.045[MA-S1-4]	0.267[MA-S2-8]	0.145
NE-S3-12	0.000[KA-S2-4/NE-S2-8/NE-S3-8]	0.333[MA-S1-12/NE-S1-12]	0.146

Jaccards similarity index ranged from 0.00 to 0.588 based on pairwise comparison between individual honey samples collected from the 3 mesoregions. The highest Jaccards similarity was observed in a comparison between (NE-S3-8) and NE-S1-8) within same site , Nessuit but different samples obtained from different colonies in different sites, but same period of August. Maximum dissimilarity was observed in samples from different seasons/months as well as sites. On average the most similar honey sample to the rest was (MA-S1-AP=21.9%) while the least similar to the rest of the samples was (KA-S2-AP).

iJETRM
International Journal of Engineering Technology Research & Management

Table 3. Number of pollen types observed in honey samples in various regions and seasons.

	SAMPLE	MESOREGION	SAMPLE MONTH	POLLEN TYPES
1	KA-S1-AP	Kapkembu	April	13
2	KA-S2-AP	Kapkembu	April	10
3	KA-S3-AP	Kapkembu	April	12
4	MA-S1-AP	Marioshoni	April	15
5	MA-S2-AP	Marioshoni	April	15
6	MA-S3-AP	Marioshoni	April	15
7	NE-S1-AP	Nessuit	April	11
8	NE-S2-AP	Nessuit	April	12
9	NE-S3-AP	Nessuit	April	12
10	KA-S1-AU	Kapkembu	August	12
11	KA-S2-AU	Kapkembu	August	13
12	KA-S3-AU	Kapkembu	August	12
13	MA-S1-AU	Marioshoni	August	12
14	MA-S2-AU	Marioshoni	August	11
15	MA-S3-AU	Marioshoni	August	15
16	NE-S1-AU	Nessuit	August	14
17	NE-S2-AU	Nessuit	August	12
18	NE-S3-AU	Nessuit	August	13
19	KA-S1-DE	Kapkembu	December	11
20	KA-S2-DE	Kapkembu	December	10
21	KA-S3-DE	Kapkembu	December	10
22	MA-S1-DE	Marioshoni	December	9
23	MA-S2-DE	Marioshoni	December	10
24	MA-S3-DE	Marioshoni	December	8
25	NE-S1-DE	Nessuit	December	10
26	NE-S2-DE	Nessuit	December	8
27	NE-S3-DE	Nessuit	December	11

The number of pollen types ranged from 8 (MA-S3-DE,NE-S3-DE) to 15(MA-S1-AP, MA-S2-AP,MA-S3-AP) the mean pollen types was 11.307. The highest number of pollen types was observed in honey samples collected in April and August.The number of pollen types ranged from (10-15) in April; (11-15) in August; and (8-11) in December. Variations were observed on the number of pollen types in samples collected during various seasons and sites.

Table 4. Pollen type means and variations of honey samples collected in various seasons in Eastern Mau.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
April	9	12.8	1.86	.62	11.4	14.2	10.0	15.0
August	9	12.7	1.22	.41	11.7	13.6	11.0	15.0
December	9	9.7	1.12	.37	8.8	10.5	8.0	11.0
Total	27	11.7	2.02	.39	10.9	12.5	8.0	15.0

The mean number of pollen types were highest in April (12.78), and lowest in December (9.67). There was highest deviation in pollen types within the samples in April (1.86) and lowest in (1.12).

iJETRM
International Journal of Engineering Technology Research & Management

Table 5. Pollen type means and variations of honey samples collected in various regions in Eastern Mau.

	N	Mean	S.Deviation	Std. Error	95% Confidence Interval Lowerbound	Upper bound	Min.	Max.
Kapkembu	9	11.4	1.24	.41	10.5	12.4	10.00	13.0
Mariashoni	9	12.2	2.86	.95	10.0	14.4	8.00	15.0
Nessuit	9	11.4	1.74	.58	10.1	12.8	8.00	14.0
Total	27	11.7	2.02	.39	10.9	12.5	8.00	15.0

The number of pollen types ranged from 8 to 15. The highest number of pollen types was observed from Mariashoni mesoregion (15). The mean number of pollen types was highest (12.2) in Mariashoni and 11.4 in both Kapkembu and Nessuit.

Table 5. Correlations between number of pollen type and other variables of honey collected from Eastern mau forest, Kenya.

Statistic	Variable x	Variable y	Correlation coeffecient	Sig. (2-tailed)
Pearson	Pollen types	Shannon Weaver	0.047	0.815
Pearson	Pollen types	Pollen density	0.679**	0.000
Spearmans rho	Pollen types	Sites	0.12	0.953
Spearmans rho	Pollen types	Seasons	-0.657**	0.000
Spearmans rho	Pollen type	Honey types	0.407*	0.037

Linear regression analysis has shown a positive correlation between the number of taxa in bloom and the number of pollen types ($p<0.001$, Pearson Correlation 0.458). Similar correlation have been noticed between the population size of the taxa and the respective weight contribution of the foraged pollen types (Maria and Andreas , 2007). A correlation analysis between pollen density and pollen types of honey samples during three seasons revealed that there was no significant positive correlation between pollen density and pollen types in dearth season and brood rearing season ,0.03 and 0.12 respectively. A negative correlation, not statistically significant was recorded during honey flow season (-0.06) (Aswini , 2013). These associations are attributable to the fact that rain during dearth season limits honey bees foraging from a wide range of plants for nectar and pollen consequently low pollen density in honey samples collected. In the onset of winter season *Apis mellifera* collects pollen and nectar from a wide range of plants which is reflected in the honey samples (Chaturvedi and Temsunungula, 2008). Beekeepers have also been reported to provide sugar syrup and artificial food during dearth season thus decreasing the pollen count into honey. Samples studied by (Boudilio et al., 2002) reported high number of families and pollen types were represented in each honey sample whether multifloral or monofloral. The number of pollen types in monofloral honeys hardly differed from multifloral samples making it difficult to find a relation between the kind of honey and its pollen richness.

The plant families found in this study corroborate reports that Africanized bees in the neotropical region forage primarily on members of Asteraceae, Anacardiaceae, Euphorbiaceae, Lamiaceae, Fabaceae, Moraceae, Myrtaceae, Arecaceae, Rubiaceae (Poderoso et al., 2012). Various honey studies from different regions have documented contrasting numbers of pollen types across the area of study. Upto 50 pollen types (Ashok, 2014; Cenet et al., 2015; Agwu et al.,2013). Between 50 to 80 pollen types have been reported by Sunita and Mattu (2018), Ponnuchamy et al., (2014) and over 100 pollen types (Francois et al., 2017; Laura and Cynthia, 2018). Although the number of pollen types may be contrasting , the results of this study are comparable to studies by Sunita and Mattu (2018) who reported 84 pollen types and Laura and Cynthia (2018) and Ponnuchamy et al., (2014) whose number of pollen types were referrable to 43 and 41 botanical families respectively. West Bengal, India (25 pollen types, 19 families) (Ashok, 2014); 27 pollen types in Turkey; Sunita and Mattu (2018) has reported 84 pollen types belonging to 41 different families. Plants with a broad taxonomic range composed of 46 families have also been reported by (Hawkins et al., 2015), while 32 pollen types have been identified by Agwu et al. (2013). 114 and 142 pollen types reported by Laura and Cynthia, 2018 and Francois et al., (2017) respectively are relatively higher than that observed in this study. The results of this study corroborates well with earlier observations of Samir et al., (2007) that honey bees foraged on more than 10% of the total

iJETRM
International Journal of Engineering Technology Research & Management

angiospermic flora of the area. Richness of pollen types also demonstrates great diversity of flora visited by Apis mellifera (Samir et al. (2007).

While a range of , 1-10 (Boff et al., 2011), 4 to 7 pollen types in Argentina (Ciapinni et al., 2013), 4-9 pollen types (Ashoke, 2014), 6-21 throughout the year (Suzane et al, 2013).This is in contrst with studies by (Cenet et al., 2015) which reported a pollen type range from 7 to 12. Pollen diversity ranged from 11-29 (Ana and Francisco, 2014). Number of pollen types per sample varied betwen 11-47 (Caccavari and Guillermina, 2016) , 16 pollen types (Sunita and Mattu, 2018), 17-26 (Agwu et al., 2013); Highest richness 56 types and lowest in December 11 types (Laura and Cynthia, 2018). Higher average number of pollen types in honey samples were reported as 17, (Laura and Cynthia, 2018; Ana and Francisco, 2014), 26 (Caccavari and Guillermina (2016), 28.52 (Laura and Cynthia, 2018). The more the pollen type , the more diverse the source of nectar collection, and the more the richness of the honey. The broad presence of pollen type in large number of samples show preference for nectar from these plants attributed to their production of sweet nectar inviting to the honey bees (Ige and Apo, 2007). Going by pollen diversity classification accroding to Yedemonhan (2009) cited in Francois et al., (2017), 100% of the honey samples in this study are classified as relatively rich honey (with 5-15 species). The number of pollen types is smaller in monofloral honeys than in multifloral honeys (Caccavari and Guillermina (2016). The pollen richness observed in this study is proof that A.mellifera use a broad spectrum of pollen resources, characteristic of polylectic bee species. Generalist foraging habit based on the number of pollen types was observed. Such foraging habit is characteristic of many bee species of Apidae (Suzane et al, (2013).

Our results corroborate with other reports (Maria and Andreas , 2007; Giovanna et al, 2012; Boff et al., 2011, Francois et al., 2017; Nguemo et al., 2016; Ponnuchamy et al., 2014) in which the number of pollen types varied based on seasons, years, or months. Such variations, according to (Ponnuchamy et al., 2014) makes it possible for honey samples and taxa groups be well delineated based on locations, years or months and classification of additional pollen spectra, low overall replicability notwithstanding. Apart from the temporal variation in the number of pollen types, other studies have reported variation in biological type foraged by bees (Nguemo et al., 2016), variation due to time, frequency and species richness (Boff et al., 2011), number of pollen types due to regions or sites, even within the same zone (Ashoke, 2014). The results of this study correlate well with the floral rewards of nectar and pollen in chronological terms, giving proof that in different periods during the year, certain flowers can be nectariferous or polliniferous, while in other periods both floral resources are available (Mathew et al., 2018). Pollen spectra equally comparable between months or year (Ponnuchamy et al., 2014) demonstrates the complexity of ecological and environmental phenomena in shaping the foraging of bees in a heterogeneous landscape, implying a substantial variation from year to year or season to season in terms of the pollen contents of honey produced in the same hive.

The variation in the number of pollen types could implicate Apis mellifera for selection of botanical sources according to diversity of sorrounding vegetation, resource availability, seasonality, interractions with other bees, and hive requirements, bee dietary preferences in relation to flowering periods, flower colour and or morphology, or nectar distribution and dynamics (Giovanna et al., 2012). Most pollen types were collected during spring because the brood population was expanding and pollen was needed as a protein source for growth (Maria and Andreas, 2007). Bees collect pollen mainly from plants with large population sizes near colonies . Sorrounding vegetation significantly affects the amount of pollen collected and the number of pollen types collected. Although the number of taxa earlier recorded in an area would be high , the honeybees only utilise around 50% of them (Maria and Andreas, 2007). In other reports it was demonstrated that the pollen that the bees utilise in the study areas did not exceed 25% of the taxa recorded by previous studies in the region (Hawkins et al., 2015).

It is suggested , by Aswini (2013) that during dearth season because of rains, the foraging range of plants for the nectar and pollen is limited, while on the onset of honey flow season, *Apis mellifera* collect nectar and pollen from a wide range of plants. This phenomenon is reflected in the honey samples of honey flow season. A significant difference ($P \leq 0.05$) (Chi square test) in the spectrum of families and species of bee-plants exploited between the rainy and the dry seasons. have been reported by Nguemo et al., 2016), with about 85% and 40% of pollen types identified in the honey of rainy season, and dry season respectively in honey samples from the Sudano-Guinean highland, Cameroon. Our results are contrary to those obtained by Bastos et al. (2003) in studying honey samples from four sites in Brazil, where the spectra of melliferous plants identified in honey of dry season were always more diversified compared to the rainy season. Similarly, in studying honeys of the phytogeographical zones in Benin , Francois et al., (2017) reported such differences, though not significant rises

or decreases, independence of pollen grains in the honeys to the seasons of a given zone was deduced. Differences could be attributed to floristic richness of a given area. Low richness in rainy season could be the reason to either absence of numerous species in bloom.
Our results of Jaccards similarity Index are distant from those reported by Vanessa et al (2014). Similarity ranged from 35% to 72%. Nine out of the 11 studied municipalities (Group B) had a similarity of about 0.24, while the rest of the samples had the highest similarity index of 0.48; sharing 10 pollen type (Ana and Francisco, 2014). Observed differences in similarity are attributable to low frequency pollen types in a region, and quantity of pollen types in samples. Honey samples with high quantity of pollen types display the highest similarity forming an axis of about 50% similarity. Dissimilarity occur among the pollen sources between the flowering periods and not among the main pollen types in the monthly samples. This incidence could indicate the difference in blossom phases and the phenological plant development in the colony sourroundings (Luz et al, 2010) or foraging behaviour of colonies (Dukku, 2013).

CONCLUSION

Non anemophilous as well as entomophilous pollen are foraged by *Apis mellifera* from 39 botanical families. Fabaceae provides for the highest proportion of ollen types. The similarity of pollen types range from 0.00% to 58.8% between (NE-S3-8) and NE-S1-8) within same site and season. About 8-15 plant pollen sources are available during the yearto support the Apis mellifera colonies in Eastern Mau forest. The pollen types present in Ogiek honeys are affected by the honey types, seasons and pollen density in the honey.

REFERENCES

[1] Ana, P. C. S. and Francisco de Assis Ribeiro dos Santos (2014). Pollen diversity in honey from Sergipe, Brazil. 53:2, 159-170. DOI:10.1080/00173134.2014.896941
[2] Agwu, C. O. C., B. C. Essien and S. A. Badmus (2013). Melissopalynological Study of Honey Samples from four localities in Dekina Local Government Area of Kogi State, Nigeria.J. Biol. Chem. Research 30(2): 921-928.
[3] Ashoke, B. (2014). Melissopalynological study of Nadia District, WEST Bengal, India. International Journal of Current Research 6 (5): pp.6521-6526.
[4] Aswini S. (2013) Melissopalynology of Indian Honey bee (Apis cerana indica) Apiaries in Southern Kerala. Thesis. Kerala Agricultural University. Pp 1-114.
[5] Bastos, E., Silveira, V.M and Soares AEE, 2003. Pollen spectrum of honey produced in Cerrado areas of minas gerais State (Brazil), Braz. J. Biol. 63(4): 599-615.
[6] Boff, S., C.F.P Luz, A.C. Araujo, A,Pott. (2011).Pollen analysis reveals plants foraged by Africanised honeybees.Neotropical Entomology 40 (1):47-54. ISSN:1519-566X
[7] Boudilio, H., Rosa, M.V., Roberto ,S.M., Valentin, P. (2002). Characterisation of honeys by melissopalynology and statistical analysis. Canadian Journal of plant science. 82:pp75-82.DOI:10.4141/P00-187.
[8] Chaturvedi, S. K. and Temsunungla. 2008. Melissopalynological studies at Kupza village of Mokokchung District, Nagaland. J. Palynol. 45(2):89-100.
[9] Caccavari, M. and Guillermina, A. F (2016). Pollen specetra of honeys from the Middle delta of the Parana River (Argentina)and their environmental relationship. Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria (INIA) Pp 1-12. DOI:10.5424/sjar/2010081-1142.
[10] [Cenet, M, Bozdogan, A., Sezer, G., Acar, L., Ulukanli, Z. (2017). Antimicrobial activities, pollen diversity and physicochemical properties of natural honey from Southeastern
[11] Dukku, U.H. (2013). Identification of Plants Visited by the Honeybee, Apis mellifera L. in the Sudan Savanna Zone of Northeastern Nigeria. African Journal of Plant Science, 7, 273-284. http://dx.doi.org/10.5897/AJPS2013.1035
[12] Francois, A.E., Armand, A.P., Tossou, M.G., Haziz, S.(2017). Pollen analysis of the honey samples produced in three phytogeographical zones of Benin .European Scientific Journal Vol 13(18) :ISSN 1857-7431)
[13] Giovanna, A., Manuela, G., Mario, R.G., Veronica de M. (2012). Functional ecology 12 (26):1186-1196)

[14] Hawkins, J., Griffith, A., Ford, C.R., Allainguillaume, J., Hegarty, M.J., et al. (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/journal.pone.0134735
[15] Ige, O.E. and K. A. Apo (2007). Pollen analysis of honey samples from two vegetation zones in Nigeria. Sci. Focus, 13: 36-43.
[16] Jaetzold, R, Schmidt, H. (1982). Farm management handbook for Kenya. Nairobi, Kenya:Ministry of Agriculture.
[17] KFS (Kenya Forest Service), (2012). Forest status, Nakuru County: KFS (unpublished report).
[18] 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.
[19] Langat, D., Maranga, E.K., Cheboiwo, J., and 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.
[20] Laura, B. and Cynthia, Fernandes, P. (2018). Grana Vol. 57 (1-2):144-157. Pollen analysis of Atlantaic forest honey from the Vale do Ribeira REgion, state of Sao Paulo, Brazil.)
[21] Luz, C. F.P. , Gabriel, L. B.J., Rafael, L.S. E F. and Priscila, R. D.S. (2010). Comparative pollen preferences by africanized honeybees Apis mellifera L. of two colonies in Pará de Minas, Minas Gerais, Brazil.Anais da Academia Brasileira de Ciências 82(2): 293-304.
[22] Louveaux, J., A. Maurizio and G. Vorwohl (1978). Methods of melissopalynology. Bee World, 59:139-153
[23] Mathew Pound, Alice Dalgleish, Jessica McCoy and Jessica Partington (2018). Melissopalynology of honey from Ponteland, UK, shows the role of Brassica napus in supporting honey production in the suburban to rural setting,Palynology (42) 3:pp 400-405, DOI:10.1080/01916122.2017.1362485.
[24] Maria, D. and Andreas, T. (2007). Seasonal variation in vegetation and pollen collecetd by honeybees in Thessaloniki, Greece, Grana , 46:4, 292-299, DOI:10.1080/00173130701760718.
[25] Nascimento DL, Nascimento FS (2012) Extreme effects of season on the foraging activities and colony productivity of a stingless bee (Melipona asilvai Moure, 1971) in Northeast Brazil. 2012: Article ID 267361, 6 pages. doi:10.1155/2012/267361.
[26] Nguemo, D.D, J. Tchoumboue, and E. Youmbi (2016). Seasonal variation in Honey pollen composition in the Sudano-Guinean Hoghland Zone of Cameroon D. Asian J Agri Biol, 2016, 4(3): 45-54.
[27] Nguemo, D., Mapongmetsem, P.M. and Abdoulaye, M. (2016). Plants Foraged by Apis mellifera adansonii Latreille in Southern Chad. Open Access Library Journal, 3: e2831. http://dx.doi.org/10.4236/oalib.1102831
[28] 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.
[29] Perre Lau , Vaughn Bryant (2017)-Determining the minimum number of pollen grains needed for accurate honey bee(Apis mellifera) colony pollen pellet analysis. Palynology(42) 1:pp 36-42 .DOI:10.1080/01916122.2017.130681.
[30] Poderoso, J. C. M. and Maria, E. C., Carlos da Paz, L. (2012). Botanical preferences of Africanised bees Apis mellifera on the Coast and in the Atlantic forest of Sergipe, Brazil.
[31] Ponnuchamy, R., Bonhomme, V., Prasad, S., Das, L., Patel, P.,Ce´dric, G.,Arunachalam P., Krishnamurthy, A. (2014). Honey Pollen: Using Melissopalynology to Understand Foraging Preferences of Bees in Tropical South India. PLoS ONE 9(7): e101618. doi:10.1371/journal.pone.0101618
[32] Salonen, A., and Julkunen-Tiito, R. 2012. Characterization of two unique unifloral honeys from the boreal coniferous zone: Lingonberry and mire honeys. *Agricultural and Food Science*, (21) 159–170.
[33] Samir, K.M., Sudha, G., A.P. Das, Subir, B. (2007). The beekeeping potential of Sub Himalayan West Bengal, India: A palynological assessment of honey.Journal of Apicultural research and Bee world. 46(3): 164-177.
[34] 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)

[35] Singh N and Chaturvedi SK 2017. Melissopalynological studies of Honey samples from Bastar District,Chhattisgarh. The Int. J. Pl. Repr. Biol. 8(1)37-40.
[36] Smart M.D., R. S. Cornman,D. D. Iwanowicz,M. McDermott-Kubeczko, J. S. Pettis, M. S.Spivak, and C.R.V. Otto (2017). A Comparison of Honey Bee-Collected Pollen From Working Agricultural Lands Using Light Microscopy and ITS Metabarcoding, Environmental Entomology, 2017,1–12 DOI:10.1093/ee/nvw159
[37] Sunita, S. and V. K. Mattu (2018). Pollen Analysis of Honey Samples From Hamirpur District, Himachal Pradesh, India.The International Journal of Plant Reproductive Biology 10 (2) 145-150. DOI 10.14787/ijprb.2018 10.2.
[38] Suzane, B. H., Carla, A. N., Sidia, M. C., Betina, B.(2013). Pollen sources and trophic niche breadth of Apis mellifera and melipona obscurior (Hymnoptera, Apidae) in subtropical climate in Atlantic rain forest of southern Brazil. Apidologie. DOI:10.1007/s13592-013-0234-5. Pp 1-13.
[39] UNEP, KFWG, DRSRS and EU-BCP. (2006). Eastern and south western Mau forests reserves: assessment and way forward. Nairobi, Kenya: UNEP.
[40] Vanessa, R. M., Severino, M. A. and Fransisico, A.R.S.(2014). Pollen types and levels of total phenolic compounds in propolis produced by Apis mellifera L. (Apidae) in an area of Semi arid Region of Bahia ,Brazil. Annals of the Brazilian Academy of Sciences 86(1):407-418. ISSN 1678-2690. DOI 10.1590/0001-37652014013-0109.
[41] Yédomonhan, H., Houenon, G.J, Akoègninou, A., Adomou, A.C., Tossou, G.M. and Van Der Maesen L.J.G. (2012). The woody flora and its importance for honey production in the Sudano-Guinean zone in Benin. Intl. J. Sci. Adv. Tech. 2(3): 64-74.