Available online at www.easletters.com

ISSN No: 2349-2864

Entomology and Applied Science Letters, 2015, 2, 2:32-39

Floral Visitors and Pollinators of Sesame (*Sesamum indicum L)* from Kichi Forest to the Adjacent Local Communities' Farms

Kelvin Ngongolo[1], Samuel Mtoka[2] and Chrispinus D Rubanza[1]

[1]The University of Dodoma, College of Natural and Mathematical Science, Department of Conservation Biology, P.O. Box 338 Dodoma, Tanzania
[2]Tanzania Wildlife Research Institute-Kingupira Wildlife Research Center, P.O. Box 16, Utete-Rufiji, Tanzania
Correspondence: kelvinkngongolo@yahoo.com

(Received: 18/06/15) *(Accepted:02/08/15)*

ABSTRACT

Sustainable supply of forest ecosystem services by many tropical habitats including Kichi forest reserve and the associated agro-ecologies is threatened by the ongoing high extent of degradation due to deforestation, incidences of bush fires, illegal lumbering as well as poor agricultural practices Less is known on the impact of anthropogenic activities on the net flow of ecosystem offered by Kichi forest reserve. Pollination services to most crops including Sesame (Sesamum indicum L) represents one of the potential ecosystem service among farming communities neighboring the forest reserve. Sesame farming is an increasing economic venture to local communities surrounding the forest. If the forest is not conserved, it is anticipated to disappear in near future. One way of conserving this forest, is to realize its benefits to the local communities such as pollination services to their sesame crop. A study was carried out to identify the pollinators of the sesame crop from the Kichi forest. Direct observation, time constrained sampling, photographing, satellite images were used in sampling the floral visitors and pollinators in the three randomly selected farms. Potential pollinators were Apis mellifera L; Apidae (31.92%), (Nectariniidae) (23.69%) and Xylocopa caffra L; Apidae (8.73%). There was no differences in terms of diversity and abundances of floral visitors and probers for the three farms ($P>0.05$). Also the relationship between the floral visitors and probers was positively correlated ($P<0.05$). In addition, time spent to the flowers by the floral visitors and number of flowers probed were positively correlated ($P<0.05$). The findings concluded that, the chance of sesame flowers to be visited by the pollinators from Kichi forest was equal. The conservation of Kichi forest is essential for donating pollinators to the Sesame and other crops grown by local communities around the forest.

Key words: Floral Visitors, Pollinators, Kichi Forest, Sesame, Local communities.

INTRODUCTION

Kichi forest is among of the few coastal forests existing in Tanzania. It is a home of endemism and biodiversity that are threatened by human activities. Kichi is part of Selous ecosystem with mega biodiversity [1]. It has species which are endemic and highly threatened like Wild dogs (*Lycaon pictus D*) and African Elephants (*Loxodonta africana B*). Human activities including lumbering, wood harvest, charcoaling, farming, fire burning, poaching represent mega threats accelerating the disappearing of this vital biodiversity values and thus their associated ecosystem services [1]. According to the Millennium Ecosystem Assessment report [14] Ecosystem services includes; air and water purification, mitigation of droughts and floods, soils conservation and renewal of their fertility, detoxification and decomposition of wastes, pollination, seeds dispersal, nutrients cycling, control of agricultural pests, maintenance of biodiversity, control of erosion, protection from the sun's harmful ultraviolet

rays, partial stabilization of climate, weather modification, provision of aesthetic value and spiritual benefits like baptism. One of the ecosystem services offered to the crop is pollination. Sesame (*Sesamum indicum L*) which grows 50 to 100 cm in height with opposite leaves 4 to 14 cm long is an annual drought resistance plant with flowers varying in colors with some being white, blue or purple [2]. *Sesamum indicum L* is an insect pollinated plant originated in Africa. The crop is grown by local communities around the Kichi forest in Rufiji District and the demand from the market is high. The seeds are of high market value worldwide and from Rufiji in particular due to their nutritional value [2]. However the biology and pollination services provided to it from the Kichi forest was unknown.

Hymenopterans, Dipterans, Lepidopterans and Coleopterans are known to be floral visitors for different plant species including *Sesamum indicum L* in Egypt [3]. But the documentation of bona fide pollinators of sesame has not been undertaken anywhere in Tanzania. Insects (open pollination) were observed to increase the number of seeds per pod, weight of pods, seedling vigour, weight of seeds, germination success and oil contents [4]. However in the local communities' farms around the Kichi forest, no work has been done on influence of insect pollinators on crops. For instance it was noted that more intact forest offered more pollinators to *Mesogyne insignis E* than the fragmented Amani forest which suggest that, well conserved bush has a great potential to provide pollinators to plants/crops around it [5]. In this case there is a need to identify the current pollinators and determine the roles of conserved area in pollinators offering. This supports the assertion that pollinators in Kichi forest especially for *S. indicum L* are unknown thus made this study crucial.

Sesame is an emerging profitable crop to people thus attracting high population in this area. The cultivation of the crop using simple equipment like hand hoe in 2009 started by burning the cut trees. Currently, the local communities are using herbicide to control the vegetation so as to quickly acquire large area for Sesame farming. In this case new areas are being opened for agriculture thus threatening large habitats for wildlife and other biodiversity. This is new challenge in this area which needs to be addressed by identifying the benefit acquired from the biodiversity like in Kichi forest so as to gain community support in conservation of the forest.

The findings from this study are essential for conservationists to convince the local communities on the positive impacts of the forest on the sesame production. The support from the local communities is anticipated if they are realizing the benefits accrued from of the forest. In addition, the pollinators of the crop will be conserved if the protection of the forest will be enhanced thus boosting the economy of local communities through sustainable conservation. Furthermore, the poverty of the local communities will be alleviated through improved sesame production. The study aimed to determine the pollination ecological services to sesame (*Sesamum indicum*) of the farms around Kichi forest.

MATERIALS AND METHODS

1.1. Study area

The study took place in the farms adjacent Kichi forest in Namakono and Tapika villages. These villages are found in Rufiji district and adjacent to Kingupira sector of Selous Game Reserve which is located at $7^{o}20'$-$10^{o}30'$S to $36^{o}00'$-$38^{o}40'$E, in eastern side of the reserve. The villages produce Sesame as cash crop.

Kichi and Matumbi Hills covers more than 26,000 hectares of coastal closed canopy forest. Matumbi hill forests (31,602 ha) is composed of Kiwengoma Territorial Forest Reserve (3,561 ha), Namakutwa-Nyamuete Forest Reserve (4,705 ha), Nambunju proposed Village Forest Reserve (19,961 ha), Tawi proposed Village Forest Reserve (2,775 ha) and Mbwara proposed Village forest Reserve (600 ha). All of these forests occur in one contiguous area with similar ecological, cultural and socio-economic characteristics. These forests are known for high their high species diversity and endemism. They are important for their catchment values and to the local communities adjacent to these forests due their dependence on these forests for various forest products and services. The main threats to the forests are human activities such as logging, pit sawing, shifting cultivation (Plates 1, 2 and 3), forest fires, poaching, hunting and other cultural uses [6].

The general climate of the area is of the tropical where rainfall is up to 1250 mm per annum and the temperature ranges from 13°C to 41°C.

Plate 1: The closed canopy aerial section of the Kichi forest with high diversity of plant species and varied habitats for wildlife species [7].

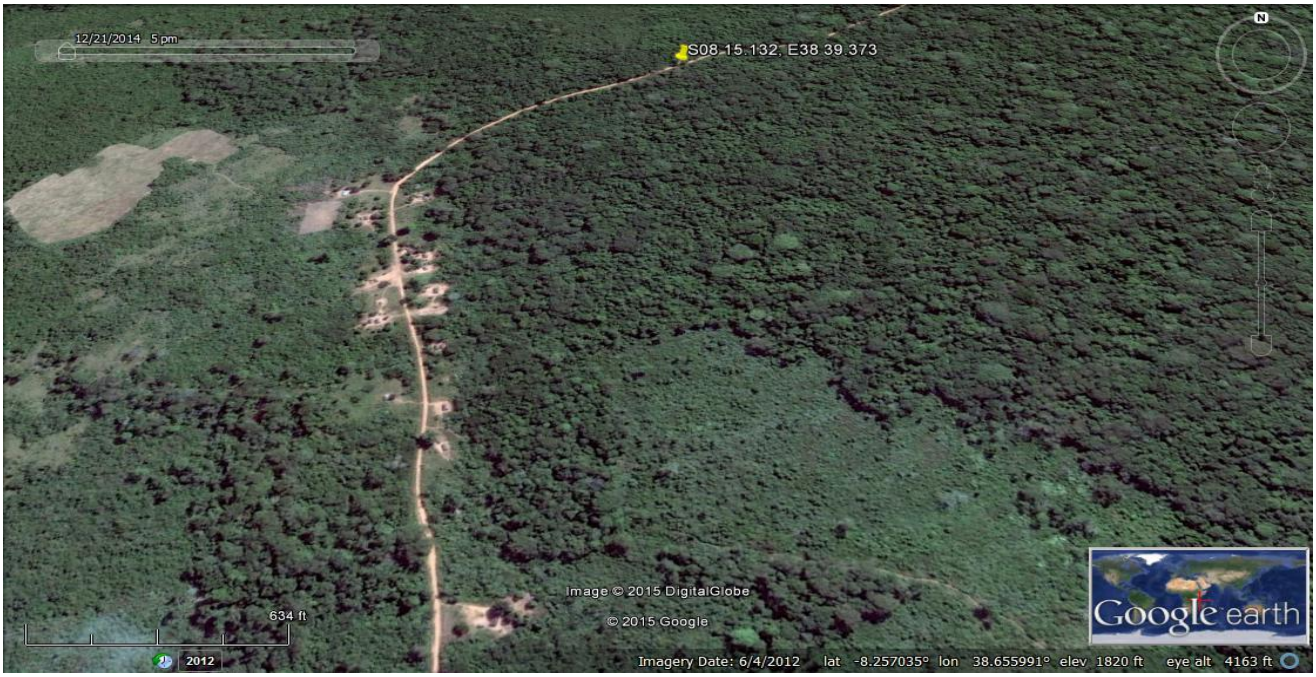

Plate 2: Areas adjacent Kichi forest (Kunguruwe) showing cleared forest patches for agriculture particularly Sesame cultivation [7].

Plate 2: Clearing of vegetations and burning is among common ways used in the preparation of the farms [7].

1.2. Pollinators diversity and frequent floral visitors to sesame

Three farms each of size between 5000m^2-44100m^2 were randomly selected for the study. In each farm, 3 plots each 30-50 plants were chosen. In each plot the diversity, frequency of floral visitors and pollinators (probers) was determined.

The 10 minutes systematic period was used for monitoring flowers for the floral visitors from 8:00am to 3:00pm. During monitoring of the flowers, the floral visitors, individual probing (pollinators) were identified and the visitation frequency was scored by recording time spent at the flower. Finally, the diversity of floral visitors and pollinators was determined by using the Shannon wiener index and Margalef index. The difference in diversity between sites was tested using randomization test [15]. The variation in abundance of floral visitors and pollinators between the plots was determined using Kruskal Wallis test at α=0.05. The difference in weight of seed, harvest, germination and seedling vigor from each between the two treatment for the study plots was anticipated to be determined using t-test for parametric data and Mann-Whitney U test statistic for none parametric data at α=0.05.

RESULTS

A total of 11164 seconds were spent in monitoring the flowers in the three farms for floral visitors and pollinators. The maximum and range time spend by pollinators in fixed sampling flowers was 421seconds. There was positive correlation between the time spent and frequency of floral visitation with Durbin-Watson D Statistic of 1.758. The relationship was statistically significant (r= 0.493, F-ration=68.687, P=0.000). The time spent in among the three farms varied. The time spent by floral visitors was 6632seconds (Mean=51.015±6.766, Max=421, Range=421, S.D=77.149 and n=130, Skewness (G1)=2.379) in the first farm, also there was 1014 floral visitors for the second farm (Mean=24.143±6.412, Max and range=180, S.D=41.555, SE Skewness=2.304 and n=42) while the third farm had 3518 floral visitors (Mean=79.955±10.541, Max= 300 , Range=295, Skewness (G1)= 1.475 and n=44). Due to data being not normally distributed, Kruskal-Wallis One-Way Analysis of Variance was used to test variation of floral visitors in the three farms. The result showed that, the variation was statistically significant (Kruskal-Wallis Test Statistic = 27.643, P=0.000).

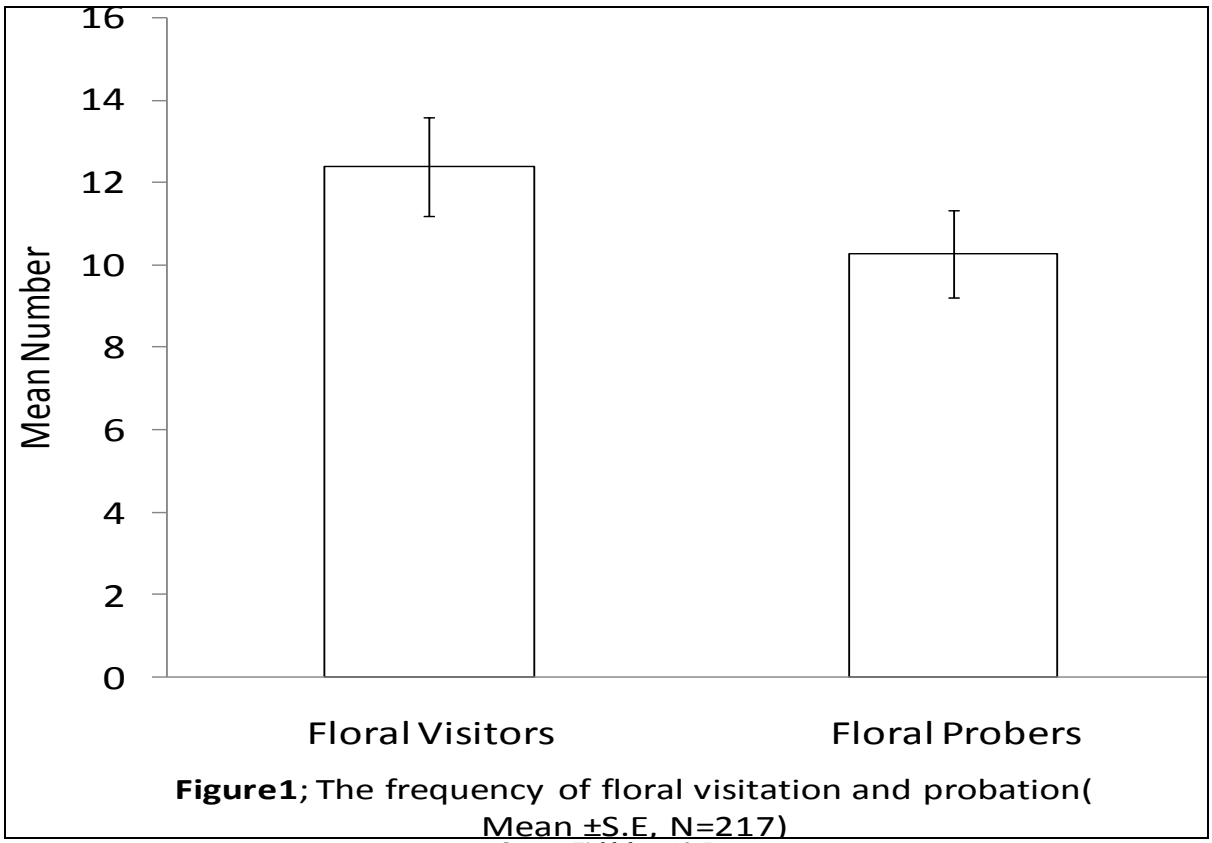

Figure1; The frequency of floral visitation and probation(Mean ±S.E, N=217)

Source: Field data, 2015

3.1.1. Frequency of floral visitation and probing

A total of 434 samples yielded the frequency accumulation (Visitors and Probers) of 4919 (Mean=11.334±0.794, Max=100, Range=100, S.D=16.545, Skewness (G1)= 2.632). However the frequency of floral visitation was higher

(Max=100, range= 100, S.D=17.427) than frequency of flowers probing (Max=94, range= 94, S.D= 15.582), see figure 1. The difference between frequency of visitation and probing was observed to be statistically significant (Mann-Whitney U test statistic=20584, P= 0.023, n=217).

Linear regression was used to test if there was any relationship between individual visiting the flowers with those probing. The result showed that, there was a positive relationship (Durbin-Watson D Statistic=1.403, r=0.934, r^2=0.872), which is statistically significant (f-ratio=462.459, p=0.000).

3.1.2. Abundance and Diversity of Floral Visitors

4.1.2.1. Abundance of floral visitors

Generally, a total of 401 individuals (Mean=1.848±0.136, S.D=2.009, Max=18 and range=18) were observed for single count. Single count, means the individual visiting the flowers was counter once in sampling interval regardless of number of flowers visited. For instance 1 individual of *Apis mellifera* was able to visit 10 flowers for 1 minute. Different species varied in abundances. The highest abundance was observed for *Apis mellifera;* Apidae (31.92% equivalent to 128), followed by sunbird (Nectariniidae) (23.69%) and *Xylocopa caffra*: Apidae (8.73%). The least abundance of floral visitors was observed for (*Sarcophaga* spp): Sarcophagidae (0.25%), (*Colotis* spp): *Colotis* spp (0.25%) and *Eurema brigitta*; Pieridae (0.50%). However the variation in abundance among species was statistically insignificant (Kruskal-Wallis Test Statistic = 22.959, P=0.404). In addition, there was variation on the abundance of the individual visiting the flowers. The highest mean abundance was observed in farm3 followed by farm1 while farm2 had the least mean abundance (Also See table 1). The variation in abundance among farms was statistically insignificant (Kruskal-Wallis Test Statistic = 3.919, P= 0.141).

Table1: Parameters for Basic statistical on the abundance of floral visitors for the three farms adjacent Kichi Forest in Rufiji, Tanzania.

Parameters	Farm 1	Farm2	Farm3
N of cases	131	42	44
Minimum	0.000	0.000	1.000
Maximum	8.000	5.000	18.000
Range	8.000	5.000	17.000
Sum	224.000	60.000	117.000
Median	1.000	1.000	1.000
Mean	1.710	1.429	2.659
95% CI Upper	1.942	1.752	3.750
95% CI Lower	1.478	1.105	1.568
Std. Error	0.117	0.160	0.541
Standard Dev	1.344	1.039	3.589
Variance	1.808	1.080	12.881
C.V.	0.786	0.728	1.350
Skewness(G1)	2.185	1.911	3.103
SE Skewness	0.212	0.365	0.357
Kurtosis(G2)	5.784	3.500	10.015
SE Kurtosis	0.420	0.717	0.702

Source: field data, 2015

3.1.2.2. Diversity of floral visitors

During sampling 24 species was observed to carry the pollination services to flowers in which farm1 had the highest number of species (23species) followed by farm2 with 12 species while farm3 had only 10 species. The Shannon Weiner index was 2.1788, Margalef Index was 3.84 and Simpsons Index was 5.60. Different species were observed to vary among farms, for instance *Xylocopa caffra L*; Apidae (Plate 4) was observed to occur in all farms in a ration of 5:1:2 for farm1, Farm2 and farm3 respectively. Also *Apis mellifera L*; Apidae (Plate 3) was observed to occur in all three farms in the ratio of 7:1:3 for farm1, farm2 and farm3 respectively. Other species were observed to occur in only one farm. For instance *Dysdercus nigrofasciatus*; Hemiptera was observed to occur in farm1 only.

Different diversity indices showed highest diversity in farm1 while being least in the farm3. For instance Shannon wiener index showed higher diversity in the farm1 with H=2.2837 and farm2 with H=2.14 while farm3 had H=1.54 (Table2). Regardless of variation in diversity index, randomization test using Shannon wiener index revealed that, the differences between farms were statistical insignificant (Randomization test (δ) =.-0.145094, P=0.5262).

Plate 3; *Apis mellifera* the most efficient species in pollinating Sesame of the crop to the farms adjacent Kichi forest (2015).

Plate 4; *Xylocopa caffra* pollinating the Sesame crop in farms around Kichi Forest, (Field Photo, 2015).

Table 2: Comparison on the species diversity between farms using different diversity indices

Diversity Indices	Farm1	Farm2	Farm3
Shannon Weiner (H)	2.28	2.14	1.54
Margalef Index (D)	4.07	2.69	1.89
Simpsons Index (D)	5.84	7.56	3.59
Equitability index (J)	0.72	0.72	0.67

Source: Field Data, 2015

DISCUSSION

4.1.1. Frequency of floral Visitation and probing

The rate of visitation frequency was observed to be higher than those probing. The difference between the two processes was facilitated by the variation in purpose of visiting the flowers. Other visitors visited the flowers for rest, predation, seeking shade and some were potential pollinators. For instance Dragonflies (*ordonata*), common bulbul (*Pycnonotus barbatus*) were observed to prey on the insects visiting the flowers and Grasshopper and (Streblognatus spp) were observed to take resting on the flowers while *Apis mellifera, Xylocopa caffra*, sunbird (Nectariniidae) were observed to visit and pollinate (probe) the flowers. However in some occasion, Sunbird was observed to be unfaithful pollinators by obtaining nectar through near bases of the patel. Unfaithful pollinators are individual who gets rewards (Nectar, pollens) while the flower does not get the pollination services from the individual. Other study shown that, individual do visit the flowers not only for probing but also for resting and predation [8].

5.1.2. Abundance and Diversity of floral visitors

The abundance and diversity among farms was equal, which means they received the same species of pollinators from the Kichi forest. The forest played a great role to ensure that, the diversity and abundance of pollinators for the Sesame crops of the local communities' farms surrounding the forest were supplied. The availability of the pollinators to the crop is very important for the success of seed setting of the crop thus crop yield to the farmers. Several studies have revealed that, pollination is essential for seed setting. Also crop which were grown near the forest were advantaged by receiving highest pollination services than those grown far away from the forest [5, 8, 9, 10, 11, 12]. This suggests that, to ensure sustainable production to the local communities, the pollination services need to be maintained. The maintenance of pollination services is cascaded by the proper conservation of Kichi forest and other associate ecosystems like Selous game reserve. For instance species which were observed in Kichi forest like *Streblognatus sp, Xylocopa caffra L, Apis mellifera L, Catopsilia florella. F* and *Colotis* spp were also observed in farms adjacent to the forest pollinating the Sesame crops. Also, species like *Streblognatus sp, Catopsilia florella. F* and *Colotis* spp were observed in Selous game Reserve *which* is the associate ecosystem to the Kichi forest[1]. This suggests that, integral conservation of interconnected ecosystems is essential to guarantee ecosystem health which provides ecosystem services to local communities.

CONCLUSION

From this study it was concluded that, the diversity and abundance of floral visitors among farms was equal, due to the fact that, all farms received the same amount of species and abundances of pollinators from the Kichi forest. In addition, there was positive relationship between the individual visiting the flowers and this pollination. Also the number of individual visiting the flower and those probing were almost equal. Furthermore, the time spent to flowers by the floral visitors was positively correlated. This is to show that, most of the floral visitors from Kichi forest to the sesame farms were potential pollinators. Sunbirds from Kichi forest however were observed to benefit from the sesame flowers visiting while they did not pollinate the flower (Unfaithful pollinators).

The conservation of Kichi forest is essential for the sustainable production of sesame crop to the local communities around the forest. The Kichi forest is potential donor of pollinators to the Sesame crop. The conservation of Kichi forest needs to be achieved in multi-stakeholders including the local communities around it because local communities are custodian for the forest resource in Kichi.

Acknowledgements

We are very thankful to National Geographic Society through Waitt Grants Program (NGS) for funding this project. We thank the University of Dodoma especially the school of Biological Sciences and Tanzania Wildlife Research

Institute for the technical and material support offered during the study. We are also grateful to Herbert Ndunguru and Kibu Ngalunda for the field assistance that enabled smooth data collection.

REFERENCES

[1] K. Ngongolo, *Impact of fire on Insects Diversity of Selous Game Reserve. ent on the award of Msc Biodiversity Conservation. University of Dar-es-Salaam. Tanzania*, **2013.**
[2] R. D. Ram, J. Catlin, C. Romero, *Advances in new crops. Timber Press, Portland*,**1990**.
[3] S.M. Kamel, Blal, A.H., Mahfouz, H.M. Said, M. *Arthropods*, 2**013**, 2,2, 66-74.
[4] F.M. Mahmoud, *Pestic . Phytom d . (B el gr a d e)*, **2012**, 27,2, 117--129.
[5] I.M. Olotu, J.H Ndangalasi, A.B Nyundo, *African Journal of Ecology*, **2011**, 50, 109--116.
[6] A.I.M. Dallu, http://coastalforests.tfcg.org/pubs/CFNationalSynthesis-Tz.pdf (Retrieved 29th May 2015)
[7] Google Inc. (GI), Google.earth. Server kh.google.com,**2015**.
[8] K. Ngongolo, *Quarry Life Award Report. Tanzania*, **2014**.
[9] G.N. Nzunda, O.L Randriamiharisoa, A. Westhoek, *Tropical Biology Association*, **2013**.
[10] K. Ngongolo, S. Mtoka, *Journal of Entomology and Zoology Studies*, **2013**,1,4,81-86.
[11] K. Ngongolo, Mtoka, A. Mahulu, and A. Sigala, *Entomology and Applied Science Letters*, **2014**,1,3,36- S. 42.
[12] K. Ngongolo, S. Mtoka, A. Mahulu, *Journal of Zoological and Bioscience Research*, **2014**,1,2,6-10.
[13] K. Ngongolo, S. Mtoka, A, Mahulu, A. Sigala, *et al*. *Journal of Entomology and Applied science Letter*, **2014**, 1, 3.
[14] G.C. Daily, Introduction: What are ecosystem services? Island Press, Washington, **1997**.