

The Merits of Ecological Restoration to Floral Visitors and Pollinators of *Leucaena leucocephala* In Wazo Hill, Tanzania.

Quarry Life Award Report: September 2014

Researcher: Kelvin Ngongolo

Country: Tanzania

**Contact Address: Tanzania Wildlife Research Institute (TAWIRI),
Kingupira Wildlife Research Center (KWRC),**

Box 16, Utete-Rufiji, Tanzania

kelvinkngongolo@yahoo.com,

kelvinkngongolo@tawiri.or.tz,

+255686820180

26/09/2014

Abstract

Restoration activities are well known for rejuvenating the ecosystem health. Wazo hill is carrying the restoration in the quarried area through re-vegetation to which *Leucaena leucocephala* is among the plants used in the restoration. The plant is well known to livestock keepers for protein contents as well its young pod being used as vegetable. It is grown in Dar-es-Salaam as ornament and also used for firewood. However if not well managed it can turn into invasive species. In this study the pollination ecology of the plant was investigated through determining its pollinators, pollinators' predators, pollination impact on seed setting and abundance of the plants in restored and un-restored areas. The findings showed that, there was positive correlation between number of flowers and floral visitors ($r=0.2532$, $P<0.05$). About 17 species of insects were observed to visit the flowers while only 12 species were active probers. Randomization test revealed that, The diversity of species visiting the flowers and those probing was statistically different ($P<0.05$). The restored area had significant higher number of seed setting per pod than in un-restored (Mann-Whitney U test statistic = 2728.000, $P<0.05$). Predation by dragonflies did not have impact on the pollination activities of the plants. The restoration program in Wazo hill attracted pollinators like butterflies, bees and beetles which facilitate the reproduction success of the *L. leucocephala* through high seed production. It is recommended that the conservation of pollinators in this area should base in ecosystem approach not on single species. However, if the *L. leucocephala* become invasive, its propagation should be controlled through several ways, among them is depriving its pollinators.

1. INTRODUCTION

Ecological restoration in Wazo hill quarry is part of the activities going on under the Tanzania Portland Cement Company (TPCC) (Ngongolo. et al, 2014). *Leucaena leucocephala* is among of the plant species which are used in the restoration program. *L. leucocephala* is an angiosperm, thornless long-lived shrub or tree in the order of fabales and family of fabaceae. *L. leucocephala* may grow to heights of 7-18 m with bipinnated leaves of 6-8 pairs of pinnae bearing 11-23 pairs of leaflets having 8-16 mm length. *L. leucocephala* is a small, fast-growing mimosoid tree commonly known as white leadtree, jumbay, and white popinac (Shelton and Brewbaker, 1998).

A study done in Wazo hill showed that, *L. leucocephala* has a positive potential in alleviating poverty of the local communities around the restored quarries through its use as fodder for meat and milk production from the livestock as the plant is known for its high protein value (Maleko and Mtupile, 2012). The potential of *Leucaena leucocephala* for human use is well known worldwide. Brewbaker and Sorensson (1990) reported that, the leafs of *L. leucocephala* have high nutrition values to ruminant animals, necklaces production from seeds and the young leaves and seeds

used as vegetables. However the influence of restoration process to the pollinators of this valuable plant species was unknown in Wazo hill quarry.

The diversity and abundance of potential pollinators like butterflies was observed to be higher in the restored area than un-mined and un-restored areas (Ngongolo and Mtoka 2013a&b). Several studies have showed that, the pollination efficiency has impacts on the seed setting to the plants thus impacting the reproduction success of the plants (Kamel. *et al*, 2013; Ngongolo and Mafuwe, 2013). It is anticipated that, the restored area with high diversity and abundance of pollinators will have high abundance, fruit setting per pods and vigor *L. leucocephala* than the unrestored areas. Regardless of this information, no work on the subject has been done in Wazo hill, thus necessitated this study.

It is our expectation that, the finding from this study will provide a clue for monitoring the pollinators in the Wazo hill quarry. Also, it will help the TPCC factory administration to incorporate pollinators in the integrated ecosystem management. The ecological knowledge in this area will be added. Pupils, local communities and university students will learn the importance of pollinators to ecological restoration and on our daily food. This will help the company to gain public support in the conservation effort in the Wazo restoration Quarry site. Also poverty can be alleviated from local communities depending on *L. leucocephala* plants through increased productivity from pollinators' activities.

2. OBJECTIVES

2.1. The main objective

The main objective of the study is to determine the influence of the ecological restoration on the diversity and abundance of the floral visitors, pollinators and reproductive success of the *L. leucocephala*.

2.2. Specific objectives

- 2.2.1. To determining the abundance of floral visitors and potential pollinators of the *L. leucocephala* .
- 2.2.2. To determining the diversity of floral visitors and potential pollinators of the *L. leucocephala*.
- 2.2.3. To determine the impact of predation on the pollination process of the *L. leucocephala*.
- 2.2.4. To determine the impact of pollination in restored area on seed set per pods.
- 2.2.5. To determine the abundance of *L. leucocephala* in the restored and unrestored quarry sites.

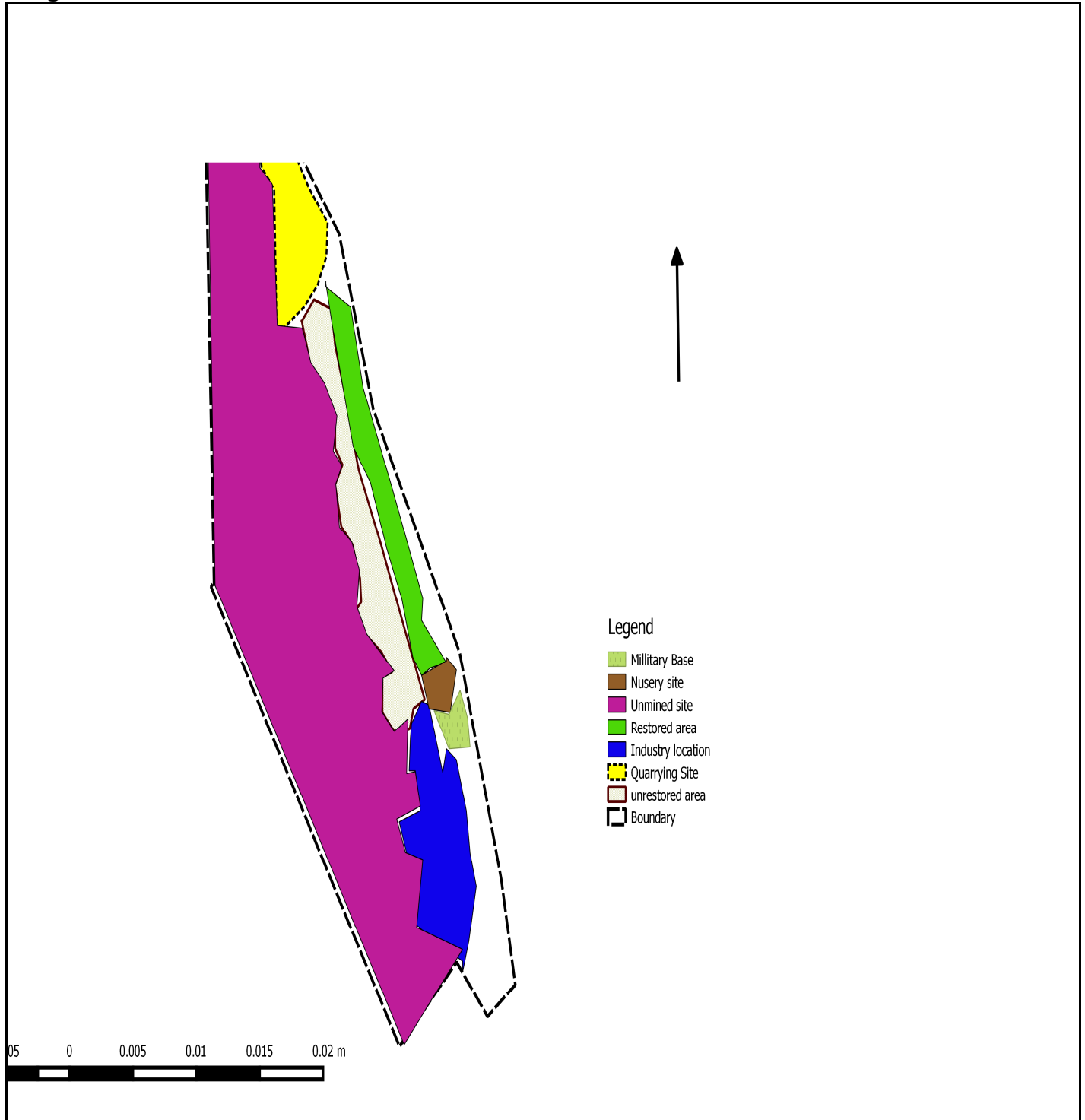
3. MATERIALS AND METHODS

3.1. Study area

The study took place at Wazo hill quarry area, Dar-es-Salaam. Wazo Hill is located between latitude 6°34' south and longitudes 39°23' and 39°25' East at Tegeta area with a distance of 25Km from the Dar es Salaam city centre. The rich rock material extends for about 2.5 km parallel to Dar es Salaam-Bagamoyo Road, has 15M thick coral limestone bed reserve estimated at 20Mt (Ngongolo *et al*, 2014). Dar es Salaam has daily temperatures averaging at 27°Celsius, the highest air temperature goes up to 31°Celsius (Ngongolo and Mtoka, 2013a&b).

The rainfall is high ranging from 1,000 to 1,900 mm per year. The rainfall pattern is bimodal where a period of short rains occurs between October and December and a period of long rains is between March and May. June, July and August are considered to be dry season in this area. The area is dominated by Eastern African Coastal vegetation type.

Map 1; Map of Wazo Hill showing Different activities taking Place including Restoration Program



Map created by QGIS 2.2 from Google earth Map

3.2. Abundance and diversity of Pollinators and Floral Visitors

The pollinator and floral visitors' survey took place in the restored site because no flowerings *L. leucocephala* were present in the unrestored and the unmined sites. Five sampling sites were used for monitor for the pollinators and floral visitors visiting the flowers. At each site ten flowers were monitored with the partitioning of 20minutes. At each partitioning, the visitors were identified, number of flowers visited, probed and time spent. Also for one minute the number of dragon flies that are known to predate pollinators like butterflies were counted. In addition the number of *L. leucocephala* trees surrounding the monitored flowers in the area of 5mx5m were counted and weather conditions such cloudy, sunny and rainy was recorded.

In each study site, three *L. leucocephala* plants each with 80 flowers was chosen randomly at each study day. During the study, the flower was monitored for 5 hours from 9:00am to 14:00pm for partitioning of 20 minutes per treatment.

Shannon wiener index and Margalef index was used to determine the diversity of floral visitors and the potential pollinators. The difference in species diversity between visitation and probing was compared using Randomization Test.

3.3. Abundance of *Leucaena leucocephala*

The abundance of *L. leucocephala* was sampled in both restored and unrestored sites. In each site two transects of 50m apart was set for sampling the *L. leucocephala*. In each transect 5 quadrates of 5mx5m each were set at interval of 50m apart. In each quadrate, the number of *L. leucocephala* was counted and estimated their average height to determine their vigor. Mann-Whitney U test statistic was used to determine the difference in abundance between the two sites at $\alpha=0.05$.

3.4. Seed setting per pod.

Seed setting is among of the outputs of pollination success. The seed setting experiment was conducted in both restored and unrestored sites. Sixty five (65) pods were randomly picked in each study sites. Each pod was opened and seeds on it were counted. Mann-Whitney U test statistic was used to determine the difference seed setting between the two sites at $\alpha=0.05$.

4. RESULTS

4.1 Preamble summary

A total of 1258 (Mean=12.79±0.369897, S.D=3.624236) flowers (with Kurtosis=-1.78402, Skewness=0.242256, range =10, minimum=7) from 96 samples were monitored. The time spent by the floral visitors to the flowers was 1897minutes (Mean=19.7604±3.138, S.D=30.7563), the

relationship between the number of visitors and the number of flowers was positives ($r=0.2532$, $r^2=0.054$, S.E= 3.5181, $F=6.370821$, $P<0.05$).

4.2 Species Visitation and Probing

There were 96 samples which gave the total of 216 floral visitors. The individual probed the flowers of *L. leucocephala* were 56.01% (Equivalent to 121 individuals) of all of the floral visitors. High visitation, probing frequencies and time spent was observed to Honey bee (*Apis mellifera*: Apidae) 33.79% (equivalent to 73 Individual) followed by Wasp and *Megachille* sp: Hymenoptera. Low visitation rate, probing and time spend was observed to order Coleoptera, *Tetramorium* sp: Formicidae (Table 1). The visitation frequency was higher than the probing frequencies. F-Test Two-Sample for Variances showed that the difference was not statistically significant (Mean=0.7494, $F=0.74943$, S.E= $P>0.05$). The relationship of individual probed and individual visited was evaluation. The result showed that, the relationship was significantly positive co-related ($r=0.8108$, $r^2=0.6537$, $F=180.3802$, S.E= 0.5622, $P<0.05$). In addition, the probing was related with the time spent by the floral visitors, the results were significant positive relationship ($r=0.3803$, $r^2= 0.135$, $F= 15.898$, S.E= 1.026, $P<0.05$).

Table1. Potential *Leucaena leucocephala* Floral visitors and pollinators in Wazo Hill

Order	Family	Species	Abundances	Number of Floral Visitors	Number of Individuals Probed	Time spend to the flower
Lepidoptera	Nymphalidae	<i>Acreea sp</i>	3	3	1	13
Hymenoptera	Apidae	<i>Apis mellifera</i>	37	73	64	1379
Coleoptera		Beetle	1	1	0	2
Lepidoptera	Pieridae	<i>Belenois Sp</i>	3	4	3	16
Hemiptera		Bug sp1	2	2	1	95
Lepidoptera	Pieridae	<i>Colotis eupe</i>	7	8	7	43
Diptera	Tachinidae	<i>Trichopoda sp</i>	16	19	7	49
Odonata		Dragon fly	8	8	0	98
Lepidoptera	Pieridae	<i>Eurema Brigitta</i>	2	4	4	18
Hemiptera		Bug sp2	1	1	0	20
Lepidoptera	Lycaenidae	<i>Lepidochrysops sp</i>	1	3	0	5
Hymenoptera	Megachilidae	<i>Megachile sp</i>	28	35	11	190
Lepidoptera	Pearidae	Pearinae sp	2	3	3	35
Hymenoptera	Apidae	<i>Ceratina sp</i>	2	2	1	20
Diptera	Tachinidae	<i>Tachnidae sp</i>	2	2	2	15
Hymenoptera	Formicidae	<i>Tetramorium Sp</i>	1	1	0	5
Hymenopterira		Wasp	37	47	17	290
Total			153	216	121	2293

4.3 Impact of Predators

Dragonflies were considered predators to the floral visitors in this area. This is due to the previous studies in this area which showed that, Dragon flies (odonata) are predators to the potential pollinators including the butterflies. A total of 576 (Mean=6±0.585834, S.D=5.73998, Max=22, Min=0) Dragonflies (Kurtosis=0.614684, Skewness=1.026271) were encountered during the study.

The increases of predators in the study sites cascaded to the decreased in the floral visitors and floral probing for sampling time between 1-13, 37-49, 65-73 and 85-93. However in some sampling time, the relationship was positive, thus during the increase in the predators abundance there was an increase in visitation and probing rate (Figure 1). Generally the relationship between the probing and presence of predators was insignificant positive ($r= 0.11962$, $r^2=0.0038$, $f=1.3646$, $S.E=1.1016$, $P>0.05$). If the presence of predators were to be compared with the visitation frequencies, the relationship was insignificant negatively correlated ($r=-0.01063$, $r^2=3.684E-06$, $f=0.000346$, $S.E=0.9606$, $P>0.05$).

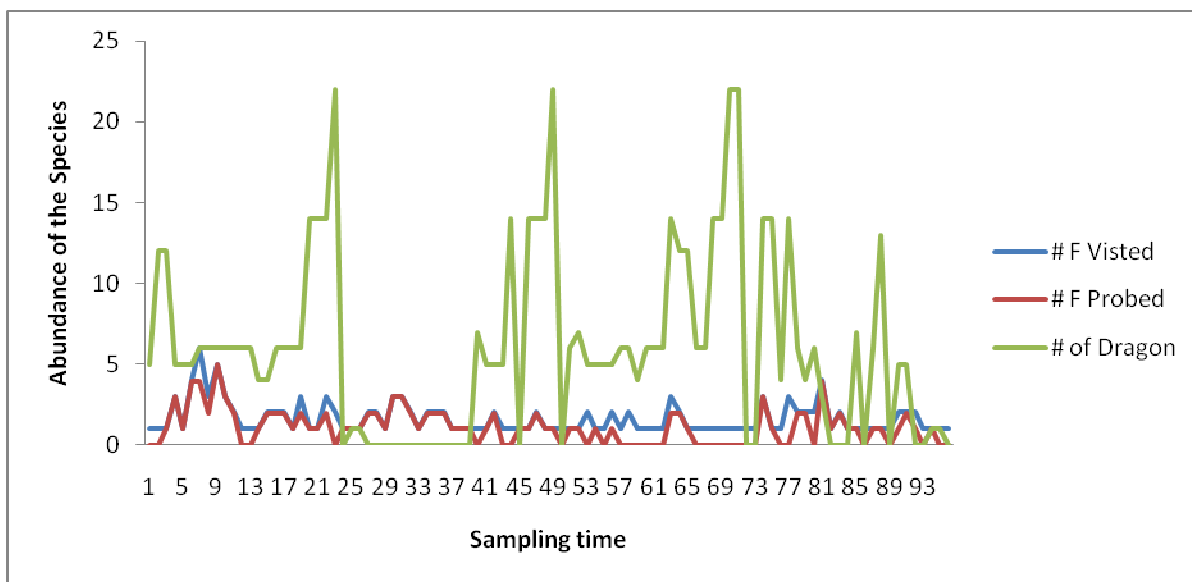


Figure 1: The relationship between the abundance of Predators (Dragonflies) with the Floral Visitors(F-Visited) and the Floral Probers (F-Probed).

4.4 Species diversity of the floral visitors

Total of 17 species visited the flowers and 12 species probed the flowers. The diversity indices showed that, diversity of floral visited and those probing were different. Through randomization Test, Most indices showed that, the different was significant (Table 3).

Table 2. Diversity Indices of the floral visitors and potential pollinators, where H= Shannon Weiner Index, N Number of Species, D=Margaret Index, J=Equitability, S=Simpson Index

Diversity Indices	Generally In the study site	Visiting flowers	Probing flowers
N	17	17	12
H	2.0981	1.981	1.6431
D	3.1806	2.9766	2.2937
J	0.74053	0.69956	0.57996
S	6.1245	5.0977	3.2095

Table 3. Testing for difference in diversity between the Floral Visitors and Individual Probing using indices by randomization Test. Where NS=not significant, *=significant, **=Very significant

Indices used to test	Probability P	Conclusion
H	0.017	*
D	0.0767	NS
J	0.015	*
S	0.0061	**

4.1. Abundance of *Leucaena leucocephala*

A total of 20 quadrates (equivalent to 5000m²) were surveyed in the four transects with equal number in restored and unrestored area. In both sites the total abundance of *L. leucocephala* was 219 (Mean=10.950±3.325, S.D= 4.870). The range was 64.000 with minimum of 0, kurtosis of 8.511 and Skewness of 2.715. The unrestored area (Mean= 16.700± 6.204, S.D=19.619, Range=2.000, Mim=0.000) had higher abundance of *L. leucocephala* than restores site (Mean=5.200±0.917, S.D=2.898, Range=10.000, mim=1.000). However the difference was statistical insignificant (Mann-Whitney U test statistic = 36.500, P>0.05). In comparison to plant vigor in terms of height, the restored site showed significant higher than the unrestored (Mann-Whitney U test statistic = 86.000, P<0.05) also see figure 1below. There was slightly correlation between the abundance and average height. The relationship was not significant ($y=-0.0058x+4.2384$, $R^2=0.0013$, $P>0.05$).

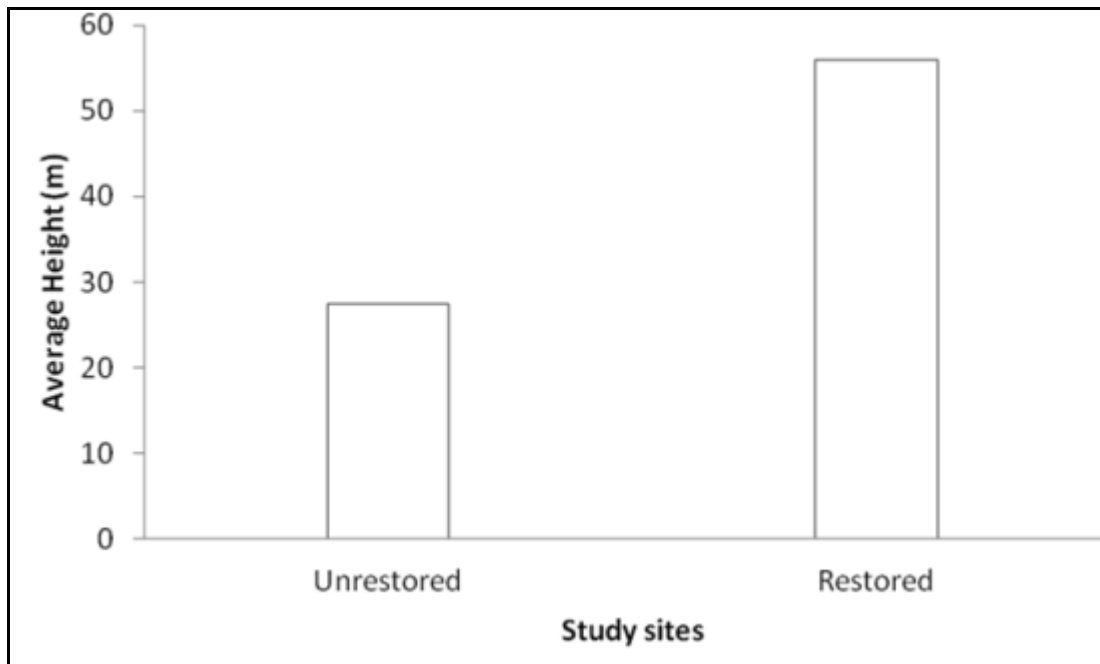


Figure 1: The average height of *L. leucocephala* in unrestored and restored sites in Wazo hill quarry.

4.2. Seed setting per pod.

A total of 130 pods of *L. leucocephala* was sampled in the study sites, this yielded a total amount of 2454 seeds. Generally, there was significant higher number of seeds per pods in the restored

area with than unrestored area (Mann-Whitney U test statistic = 2728.000, $P < 0.05$) (Also See Table 1).

Table 1: Statistic summary for the seed set per pods in two study sites, namely. Restored area and unrestored area

Statistic measure	Unrestored site	Restored site
Minimum	4.000	11.000
Maximum	23.000	30.000
Range	19.000	19.000
Sum	1155.000	1299.000
Median	19.000	21.000
Mean	17.769	19.985
95% CI Upper	18.751	21.110
95% CI Lower	16.787	18.859
Std. Error	0.492	0.564
Standard Dev	3.964	4.543
Variance	15.712	20.640
C.V.	0.223	0.227
Skewness(G1)	-1.137	-0.189
SE Skewness	0.297	0.297
Kurtosis(G2)	1.692	-0.658
SE Kurtosis	0.586	0.586

5. DISCUSSION

5.1 Species Visitation and Probing

The finding from this study showed that the difference in number of individuals visited the flowers and those probing was not significant. The slight variation different between visitation and probing is attributed by different factors. This showed that, not all species who visit the flowers are potential pollinators. The different species visits the flowers for different reasons. Some species visits the flower for predation, rest, shelter and protection. During the study we observed *Tachnidae sp* visiting for rest, dragonflies (odonata) visiting for predation and ants (*Tetramorium Sp*) visiting flowers for unidentified reasons. Previous study in this area was showed that dragonflies were good predators of butterflies (Ngongolo and Mtoka, 2012). Willmer (2011) also reported that, different species visits the flowers for different reasons including finding shelter, predation, rest and pollination. The increase in floral visitors leads to higher chance of potential pollinators to the flower. This is proven in this study to which, the higher the visitation frequencies the higher the probing rate. This suggests that, conservation of pollinators should be in integration manner to which complex ecosystem should be involved. This agrees with (Ngongolo

and Mtoka, 2013; Ngongolo and Mafuwe, 2013, Ngongolo et al, 2014) who suggested that conservation should be in integration manner while considering multiple species is essential for ecosystem monitoring. Conservation of pollinators in this area is very important, the previous finding have observed that restored area with higher pollinators had positive impacts on the seed setting and vigor of the *Leucaena leucocephala* (Ngongolo et al, 2014).

5.2 Impact of Predators

In this study we hypothesized that, the presence of predation surround the flowers will affects the pollination activities. However the finding revealed different scenario. From this study it was noted that, predation did not have impact on the floral visitation and probing of the flowers of the plants. This is contrast to the study which was done in higher Andean in Bolivia for *Chuquiraga oppositifolia*, which showed that, the predation to pollinator insects had negative impacts on their abundance and seed setting of the *Chuquiraga oppositifolia* (Muoz and Arroyo, 2004). Their finding agreed with Arnord (1982) who also found similar impact on the predation to the pollinators. Our study showed different results possibly due to considering only one species (Dragonflies) as predator. We recommend more studies should be done for other species and impacts on the setting.

However the relation varied, the increases in predation reduced the visitation of the insects but while increases the probing. This can suggest that, those species which were visiting the flower and inhibiting the potential pollinators like *Apis mellifera*: Apidae are the one who were affected by the predation from the Dragonflies. In addition to that, other factors especially weather need to be considered in the interpretation of this finding. For it was observed that, during rainy season, the visitation and probing of the insects to the flowers of *L. leucocephala* were low while being higher in dry season. Other study also has observed that, weather has significant impact on pollination activities and the plants productivity (Nielsen, 2012).

5.3 Abundance of *Leucaena leucocephala*

Generally there was variation between the restored area and unrestored area in terms of abundance and seed set of the *L. leucocephala*. The restored area showed positive respond in terms of abundance and seed set per pod. This agrees with the study done by Ngongolo and Mtoka, (2013) in this site which showed that restoration has positive impacts on the welfare of biodiversity including the *L. leucocephala*. Through this study it was observed that, the restored area had higher biodiversity than other sites such as the unrestored site.

The abundance in the two sites were not observed to be significant different. This can be explained by the fact that, some quadrats in the same transect of unrestored site were observed to have few or none *L. leucocephala* while other quadrats had crusted *L. leucocephala* plants. This was different with those observed in the restored site where, the plants were observed to be evenly distributed. For instance the quadrat with highest abundance in the unrestored site was found to have 64 plants (at GPS co-ordinates of 0517783, 9294522) while the lowest had 0

plants (at GPS coordinate of 0516442, 9264690). In the restored area the quadrat with highest abundance was observed to have 11 plants (at GPS co-ordinate of 0 518035, 9264466) while the lowest had 1 plant (at GPS co-ordinate of 517932, 926455). The high clustering of plants in the un-restored area caused the elevation of resources competition among the plants which resulted into reduced vigor in terms of their height. Other studies have showed that, the resources like light, and nutrients have high impact on the survival and vigor of *L. leucocephala*. For instance (Shelton and Brewbaker, 1998) revealed that, nitrogen content in the soil has implication in the growth rate and performance of the plant while salt stress lead to negative performance.

5.4 Seed setting per pod

In comparison between the restored and unrestored areas in terms of seed setting, significantly higher numbers of seeds were observed in the restored area. The impacts of pollinators on the seed setting are essential to explain this. The previous study showed that, the diversity of pollinators such as butterflies were found to be in the restored area (Ngongolo and Mtoka, 2013). The highest diversity of pollinators in this area can elucidate that, visitation and flower probing by the pollinators is expected to be soaring in this site. Other studies have proven this phenomenon. For example, Insects (open pollination) were discovered to increase the number of seeds per pod, weight of pods, seedling vigor, weight of seeds, germination success and oil contents of *Sesamun indicum* in Egypt (Mahmoud, 2012). However other factors like nutrients, sunlight, pest and diseases need to be considered too.

5.5 Public education

The Public have gained access to the knowledge generated here through public talk education and the Papers Publications. The student and other people who visited the area for environmental education were enlightened the important pollination to the ecosystem (Appendix 2). So far, two papers have been published in the international journals as means of reaching scientific community and general public at global level (appendix 1). In addition, the presentation in the Biannual TAWIRI scientific conference is being prepared for sharing the finding of this project. In every Public outreach, the Heidelberg cement group through Quarry life award is being acknowledged for support rendered in this project.

5.6 Implication to the Twiga Cement Company

The impact of this project to the cement company should be considered. The *L. leucocephala* in Wazo hill is well known for their important to the local communities surrounding the Twiga cement company. The plant species in Dar-es-Salaam is well known for provision of fuel (Firewood and charcoal), used as source of shade in this very hot city, provide aesthetic value (ornamental plant), as well as modification of the climate. However in some area where the plant can grow without control, it may lead into invasion. In this case, if the positives are to be considered, the Twiga cement should utilize the plant to generate income while considering that pollination service is vital for the production success of the plant. In addition, if the plant was to be considered in the negative way, the controls of over production need to be limited by depriving

the pollination of the plant. The income from the plant can be obtained through selling the products of the plants such as firewood, seedlings and leaves as fodder to cattle.

6. CONCLUSION AND RECOMMENDATIONS

From this study it is evident that, the floral visitors of the *L. leucocephala* are highly correlated with the frequency of floral probing. That is the higher the visitation the privileged the probing. However the predation by dragonflies in this area did not have impacts on the floral visitation and probing of the flowers.

In addition, the abundance of *L. leucocephala* is not affected by the restoration program but their vigor is highly impacted due to proper management like weed control, spacing and nutrient supply in the restored area. However seed setting were highly impacted by the restoration programme in Wazo hill. The high impacts of the restoration in Wazo hill was due to the attracted pollinators like butterflies, bees and beetles which facilitated the reproduction success of the *L. leucocephala* through high seed production. The ecosystem restoration in mined area has positive impact not only on the *L. leucocephala* but also biodiversity at large.

From this study, it is recommended that, the conservation of the pollinators in this area should not only consider single species but it should be in integration manner which consider ecosystem at large. The previous study showed that, pollination has positive impacts on the seed setting thus reproduction success. This implies that, if the *L. leucocephala* is to be propagated for human consumption, there is a need to ensure that, the supplies of the pollinators through effective conservation is ensured. However, proviso the plant was to be considered as invasive in given area, the conservationists need to deprive their pollination services so as to retarded their reproduction success.

7. ACKNOWLEDGEMENT

Quarry Life Award 2014 is thanked for funding this project. The support and technical advice offered by National Juries of the Quarry Life Award especially Dr. Flora Ismail (University Of Dar es Salaam, Head Of Botany Department), Leonard Lugali (WWS Design and Development Company Limited, Manager), William Mwegoha, Senior Lecturer at Ardhi University-ARU, Richard Magoda, Environmental Manager (Tanzania Portland Cement Company Limited), Alphonso Rodriguez, Managing Director (Tanzania Portland Cement Company Limited) is appreciated. Furthermore I recognize the materials and technical support offered by Tanzania Wildlife Research Institute (TAWIRI), specifically Kingupira Wildlife Research Center (KWRC).

8. REFERENCES

Arnold, M.R. (1982). Pollination, Predation and Seed set in *Linaria vulgaris* (Scrophulariaceae) American Midland naturalist. **107**(2); 360-369.

Kamel, S.M., Blal, A.H., Mahfouz, H.M. Said, M. (2013). The most common insect pollinator species on sesame crop (*Sesamum indicum* L.) in Ismailia Governorate, Egypt, *Arthropods*, 2(2): 66-74.

Maleko. D and Mtupile. E (2012). The Potential of *Leucaena leucocephala* Pioneer Trees and *Cenchrus ciliaris* understory grass species in Soil Improvement and Forage Production at Wazo Hill Quarry. Quarry Life Award Report:

Mahmoud, F.M (2012). Insects Associated with Sesame (*Sesamum indicum* L.) and the Impact of Insect Pollinators on Crop Production. *Pestic. Phyto. (Belgrade)*, Vol 27(2); 117–129.

Muoz, A.A. Arroyo, K.T.M M. (2004) Negative Impacts of a Vertebrate Predation on Insect Pollinators Visitation and seed Output in *Chquiraga oppositifolia*. A High Andean Shrub. *Oecologia*. **138** (1);66-73.

Ngongolo, K. Mtoka, S. Mahulu, A. (2014). The Abundance and pollinators' impact on seed setting of *Leucaena leucocephala* in Wazo Hill restored Quarry, Tanzania. *Journal of Zoological and Bioscience Research*. Vol 1 (2) :6-10

Ngongolo, K and Mtoka. S. (2012). Can Re-vegetation Quarry in Wazo hill increase the Diversity and abundance of Butterflies. *Research report*. Heidelberg cement. Twiga cement. The Quarry Life Award-Tanzania

Ngongolo, K and Mtoka, S. (2013a). Using Butterflies to Measure Biodiversity Health in Wazo Hill Restored Quarry. *Journal of Entomology and Zoology Studies*, 1(4):81-86.

Ngongolo, K And Mtoka, S. (2013b). Mining And Environmental Conservation In Wazo Hill: What Can Butterflies Offer In Measuring Biodiversity Health In Revegetated Quarry, *The 9th TAWIRI Scientific conference, 4th - 6th December 2013*, Snow Crest Hotel, Arusha, Tanzania.

Ngongolo. K., Mtoka. S and Mahulu. A, (2014). Wet Season Diversity Of Butterflies In Restored Mine Of Wazo Hill Tanzania. *International Journal of Fauna and biological studies*. 1 (3): 01-03.

Ngongolo, K and Mafuwe K, (2013). The Influence of the Invasive Herbs Species *Ageratum conyzoides* and *Stachytarpheta jamaicensis* on the Diurnal Floral Visitors to the Native Herbs Species *Asystasia gangetica* in the Amani Nature Reserve, Tanzania. *Research Report to Tropical Biology Association*.

Nielsen, R.L. (2012). Next Big Hurdle: Pollen Shed and Silking. *Corny News Network*, Purdue Univ.

Shelton H.M. and Brewbaker J.L. (1998). *Leucaena leucocephala* - the Most Widely Used Forage Tree Legume. Forage Tree Legumes in Tropical Agriculture. The Tropical Grassland Society of

Australia . <http://www.fao.org/ag/agp/AGPC/doc/Publicat/Gutt-shel/x5556e06.htm#introduction> (accessed 18 may 2015).

Willmer, P. (2011) *Pollination of Floral Ecology*. Princeton University Press, Princeton and Oxford. 2Pp 5.

9. APPENDIX 1; Front pages of Paper published through this project as part of reaching large Public at global level

Available online at www.easletters.com



EASL
Entomology and Applied
Science Letters

ISSN No: 2349-2864

Entomology and Applied Science
Letters, 2014, 1, 3:36-42

The *Leucaena leucocephala* Floral Visitors, Pollinators and their Predators in the Restored Wazo Hill Quarry, Tanzania

Kelvin Ngongolo^{1*}, Samuel Mtoka², Anna Mahulu² and Atuhombye Sigala³

¹Tanzania Wildlife Research Institute, Kingupira Wildlife Research Centre, Box 16, Utete-Rufiji, Tanzania
²University of Dar-es-Salaam, Box 35064, Dar-es-Salaam, Tanzania
³Gogoni Secondary School, Box 90560 Kinondoni Dar-es-Salaam, Tanzania

Correspondence: kelvinkngongolo@yahoo.com
(Received: 20-6-14) (Accepted: 11-7-14)

ABSTRACT

This study investigated the potential pollinators, floral visitors and predators of the Leucaena leucocephala. Monitoring of the standardized number of flowers was done at specified time interval, and the number of predators was also counted at standardized time interval and the data collected were analyzed and tested using F-test. There was a positive relationship on the floral visitors and individual probing flowers (P<0.05) however the difference between visitation and probing rate was insignificant (P>0.05). The predation had positive correlation with probing while having negative relation with visitation. The relationship between the visitation and probing suggests that, there is a need to conserve the pollinators in integrated approach by considering other species. This will benefit not only Leucaena leucocephala but also other plant species in the restored sites. Further studies should be done to determine the impact of predators other than dragonflies on the pollination and seed setting.

Keywords; Floral Visitors, Pollinators, Predators, *Leucaena leucocephala*, Restored Wazo Quarry

INTRODUCTION

Quarrying in Wazo hill is an extractive activity that produces the raw material to Tanzania Portland Cement Company factory for cement production. It is a fact that in the course of quarrying, the environment and biodiversity in the area are impacted. As means of ameliorating the situation, the Tanzania Portland Cement Company (TPCC) has adopted the ecological restoration program [1,2,3,4]. The *Leucaena leucocephala* is among the plant species used in the restoration program. *L. leucocephala* is angiosperm, thornless long-lived shrub or tree in the order of Fabales and family of Fabaceae. It may grow to the heights of 7-18 meters with bipinnated leaves of 6-8 pairs of pinnae bearing 11-23 pairs of leaflets with a length of 8-16 mm. *L. leucocephala* a small and fast-growing mimosoid tree is also commonly known as white leadtree, jumbay and white popinac [5].

L. leucocephala is well known for being used as livestock fodder due to its high protein contents thus lead to high livestock production. In addition, the young pods are used as vegetable, and the wood is used as fuel. In Dar-es-Salaam region, the plant is utilized as ornament and offers ecosystem service to people through shed provision during sunny weather [3,5,6]. Regardless of all importance of *L. leucocephala*, the predation effect of its pollinators was documented in Wazo hill quarry. The study in this area showed that, dragonflies were predated the potential pollinators such as butterflies.



The Abundance and pollinators' impact on seed setting of *Leucaena leucocephala* in Wazo Hill restored Quarry, Tanzania

***Kelvin Ngongolo¹, Samuel Mtoka¹ and Anna Mahulu²**

¹Tanzania Wildlife Research Institute, Kingupira Wildlife Research Centre, Box 16, Utete-Rufiji, Tanzania

²University of Dar es Salaam, Department of Zoology and Wildlife Conservation, Box 35064, Dar es Salaam, Tanzania

ABSTRACT

Several studies have showed that, restoration has potential to increase the diversity of pollinators thus impacting on the seed setting of the plants. This study aimed at determining the abundance of *Leucaena leucocephala* and impact of high pollinators diversity on seed setting of *Leucaena leucocephala* in restored sites. The number of plants was counted in the quadrats for both restored and unrestored areas. The seeds for 130 pods collected, were counted with equal number of pods from restored and unrestored areas. The abundance of seeds in the two sites was not statistically different ($P>0.05$) while the higher vigor and number of seeds were observed in the restored area ($p<0.05$). Nutrients, sunlight and spacing were suggested to impact the vigor of the plants while pollinators' differences in the two sites led to dissimilarity in the seed setting of the plants. From this study it is evident that, ecosystem restoration in mined areas has positive impact on biodiversity in general and *Leucaena leucocephala* in particular.

Key words: Abundance, *Leucaena leucocephala*, Pollinators, Seed setting, Wazo hill, Restored quarry.

10. APPENDIX 2; Photos in the project area and their Description

Photo	Description
	<p>The Restoration activity is taking place in the mined area by students from Dar-es-Salaam, to which. This involved planting trees like <i>Leucaena leucocephala</i>. They were enlightened by the importance of pollination to the restored plants and ecosystem at large.</p>
	<p>Proper handling of seedling during restoration is vital</p>



The *Leucaena leucocephala* Plant in Wet season were observed to have both pods and flowers. This suggested that, wet season in Wazo hill is a target time for studies dealing with flowers such as pollination ecology



Flowers of the *Leucaena leucocephala* were observed during the Wet season



The researchers in the field identifying species of the floral visitor of the *Leucaena leucocephala*



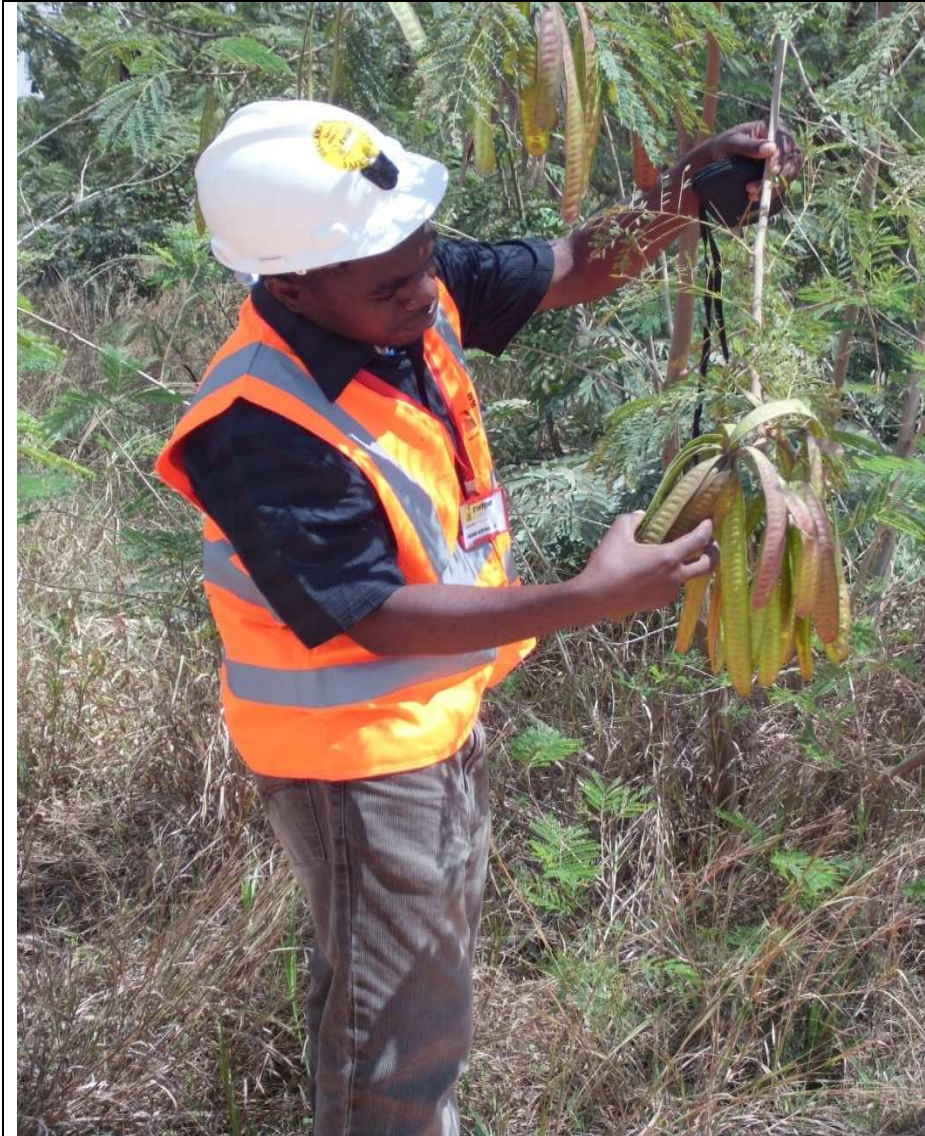
The researchers in the field monitoring the floral visitor of the *Leucaena leucocephala*



Plant of *Leucaena leucocephala* in dry season. The flowers were not observed during this time. This suggested that, dry season in this area, is not appropriate time for carrying studies related to flowers of this plant.



Only Pods for the *Leucaena leucocephala* were observed during the dry season. It was suggested that, during dry season, is appropriate time for harvesting pods and seed of the plant in this area



The Researcher in the fields searching for flowers of the *Leucaena leucocephala* in dry season. However, no flower was observed during the dry season