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Using Butterflies to Measure Biodiversity Health in Wazo Hill Restored Quarry

Kelvin Ngongolo and Samuel Mtoka

ABSTRACT

In this study butterflies were used in assessing re-vegetation as a way of biodiversity restoration at Wazo hill quarry. The Butterflies were used as indicator species because of their high sensitivity in ecosystems alteration. The study was done in two different areas each 4.8 acre, namely the re-vegetated and un-quarried areas. Butterfly sweep nets and Butterfly traps baited were used for Butterflies capturing. Thirty six (36) species of Butterflies were identified and voucher specimens were preserved in Kingupira Museum. Variation in species diversity was evaluated using diversity indices and tested using special t-test. Variation in Butterfly abundance in two study sites and in different habitats was determined using Kruskal-Wallis Test Statistic and Mann-Whitney U test statistic. The diversity of Butterflies was significant higher in re-vegetated site than in un-quarried site while the abundance difference in the two sites were insignificance The two sites varied in plants species diversity and level of succession, a condition attributed to variation in Butterfly diversity. The re-vegetated sites were recommended for aesthetic, education purposes and further studies on organisms.

Keywords: Re-vegetation, Wazo Hill, Butterflies, Diversity, Abundance.

1. Introduction

The Tanzania Portland Cement Company (TPCC) factory has been utilizing the limestone from Wazo hill for producing cement since its establishment in 1959. Extraction of limestone at Wazo hill involves excavation of the overburden red soils and blasting of the underlying limestone rock. This clears vegetation, removes top soils, destructs habitats and ecosystem function as well as the general environment, leaving quarried areas barren.

As means of mitigation for environmental destruction, habitat restoration through re-vegetation as explained by [1] has been adopted by TPCC. There is a tree planting programme to the quarry sites and other surrounding areas. It is anticipated that, the restored areas will improve the ecological structure and functioning which in turn will generate aesthetic value, ecosystem services like pollination and nutrient recycling, habitats for wildlife, control soil erosion as well as providing education in biodiversity conservation [3].

This effort by the TPCC of restoration of the quarried areas needs to be assessed. Several methods of assessment can be done one of them is using indicator species. Butterflies were chosen because of their rapid and sensitive responses to subtle habitat or climatic changes and as representatives for the diversity and responses of other wildlife. Their abundances and diversity in an area reflects certain condition of the biodiversity [4, 5, 26]. Butterflies are huge group as per [6]. They are about 20,000 Butterfly species worldwide [6].

Butterflies economical and social importance in Tanzania, calls upon their proper conservation. In the Amani Nature Reserve (ANR), Tanga where Butterfly farming is done by the communities adjacent to the reserve, it was observed that forest quality through sustainable management practices was improved, livelihood security through secure rights to subsistence and commercial traded forest products was improved and there were effective and representative village natural resource management institutions [7]. Also the gross family income for 2004 from Butterfly farming was Tanzanian Shillings 518,386 (US$ 948), and the local community supported the conservation of the ANR as the result the conflict between the local community and the reserve conservationists were eliminated [7].

Butterflies are good predictor of other species. In Portugal, Spain, France, Switzerland, Hungary, Ireland, Finland and the UK, it was observed that, after statistical evaluation with data on other components of biodiversity, Butterflies were found to be a potentially useful indicator of biodiversity, a significant predictor of the richness of birds, lichens and plants but

not a good indicator of soil biodiversity [8].

The study conducted in arable farming to determine the effects of biotic and abiotic factors on the distribution of three species of Satyrid Butterfly (*Aphantopus hyperantus*, *Pyronia tithonus* and *Maniola jurtina*) revealed that, non-floral factors affecting distribution included the degree of shelter, insolation, width of hedge bank or grass verge, and uncultivated habitat, landscape structure, microclimate and resources, while floral variables affecting distribution included the abundance of flowers of bramble (Rubus fruticosus), thistle-like Compositae, marjoram (*Origanum vulgare*) and mayweeds (*Matricaria spp.*) in conservation headlands [24] . Also, small scale mining by the Kwasimba local communities adjacent the rehabilitation site in Wazo Hill were observed to be a destructive activities which altered the habitats for the survival of Butterflies.

Regardless of the potential of the Butterflies in measuring biodiversity health, economic value, aesthetic value, social value, ecological value, no study has been done in this site. The factory management has embarked on restoration of quarried area by tree planting and it was the interest of this study to assess the impact of re-vegetation of Wazo hill quarry site on biodiversity by using Butterflies as indicator species.

Quarry factories including Twiga cement has been restoring the quarried area through tree planting [22, 23]. The effort of restoration has not been assessed ecologically by using Butterfly as indicator species. It was important for the study to be carried out to assess the impact of re-vegetation on biodiversity health of the quarried areas. The findings are to help the conservation stakeholders and the factory to adopt the use Butterflies as indicator for monitoring environmental restoration in the Wazo hill quarry area [24]. Conservation of biodiversity including Butterflies will be emphasised in the area.

Due to significance of Butterflies for example in tourism attraction, Butterfly farming and pollination, the income of the local communities may increase if they will be involved in Butterfly farming and tourism (example through tour guiding) [7]. The importance of the Biodiversity to the communities around the quarry site can provide clue for educating them on the important of protecting the site from deterioration and improving relationship between community members and the factory. Hence this study is important for TPCC and community members to be engaged in Butterfly farming and Tourism as well as other conservationists and environmental students.

The main objective of the study was to assess biodiversity health of the re-vegetation site of the Wazo hill quarry using the Butterflies as indicator species. The following were the specific objectives. To determine the Butterflies diversity and abundances in revegetated area, to determine the Butterflies diversity and abundance in un-quarried area, to describe vegetation of the study sites and their impact in Butterflies diversity and abundance and to assess the influence of the seasons on the diversity and abundance of the Butterflies in Wazo Hill.

2. Materials and Methods

The study was carried out at Wazo hill quarry area, at a site found North of the TPCC factory. Wazo Hill is located at Tegeta area, approximately 25Km from the Dar es Salaam city centre, Tanzania. The quarry is located between latitude 6°34' South and longitudes 39°23' and 39°25' East. The rich rock material extends for about 2.5 km parallel to Dar es Salaam-Bagamoyo Road, has 15M thick coral limestone bed quarried reserve estimated at 20Mt. Dar es Salaam has daily temperatures averaging at 27°Celsius, the highest air temperature goes up to 31°Celsius. 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.

Although the vegetation of the area has been disturbed, it is that of Eastern African Coastal vegetation type. According to [9] the area is in 'Zanzibar-Inhambane' phytochorion, of the vegetation of Africa, consisting of a mosaic of forests, grasses and shrubs.

The Eastern African Coastal forests are rich in endemism and diversity of biological species and are globally recognized among areas of great biological importance and diversity [25].

Two plots, each sized 140mX140m (4.8 Acres) were identified for the study. One plot was in re-vegetated area and another in un-quarried area. The re-vegetated areas are ones that were previously quarried and then replanted with trees and grasses. Two types of Butterfly traps were used, that is the sweep nets and Butterfly traps. Two people were used in capturing the Butterflies randomly in each plot using sweep nets. The activity involved walking slowly along the plots and capture Butterflies that were immobilised and preserved. Two hours were spent in each plots searching for the Butterflies. At the same plots also Butterfly traps baited with rotting banana and banana mixed with wine were used to capture Butterflies, where two traps were run for sixteen Butterfly day traps from both two sites. The capturing of Butterflies using sweep net and traps was done once per month for four months (from April to August, 2012) extending from wet to dry seasons.

The same plots were used for the assessment of the vegetation where two transects were set in each of the plot. In each transect, the quadrate of 5mx5m were set at an interval of 25m for sampling vegetations. Five groups were identified that are grasses, trees, climbers, herbs and shrubs. Assessment of the vegetation was done once during the study.

Raw data were recorded in prepared sheets in the field then entered into the computer using Microsoft office excel spreadsheet 2007. Species diversity in each plot was determined by using species indices like Shannon Weiner and Margalef indices [10] using The Species Diversity and Richness program, Version 2.65[11]. Special t-test was used to determine the difference in Species diversity between the two sites. Kruskal-Wallis Test Statistic and Mann-Whitney U test statistic were used to determine the difference in abundance of butterflies between the two sites and among the habitat types at α=0.05 using SYSTAT version 10 computer software [12] to determine the difference in Butterfly abundances in the two study sites.

3. Results

3.1 Abundances

Butterfly traps and sweep net gave the total sample of 83 yielded the abundance of 188 individuals (2.265±0.2860 with standard deviation of 2.604 at maximum and minimum of 1 and 14 respectively. 98% of samples (equivalent to 81 samples) collected were obtained through sweep net while only 2% of samples were obtained through butterfly traps.

Different species of butterflies showed variation in abundance in different type of habitat. For instance 64% and 36% *Colotis*

vestaliscastalis were observed to occur in shrub land and shrub-grass land while none was observed in grassland. The abundance of butterflies was observed to be low in grassland than either shrub land or shrub-grassland (Figure 1).The difference in abundance between the three types of habitats were statistically insignificant (Kruskal-Wallis Test Statistic = 0.874, *P*>0.05). When abundance was compared in among habitats, no significant difference was observed (Table 1).

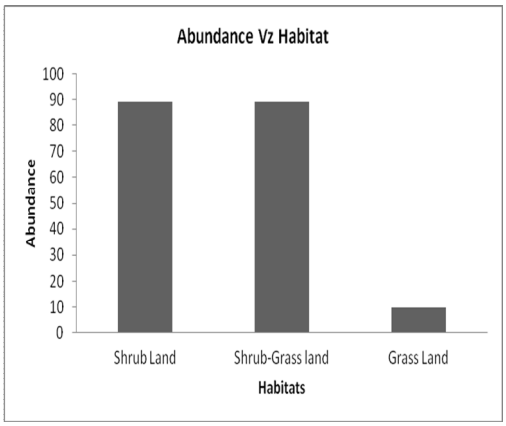

Fig 1: The abundance of butterflies in different types of habitats

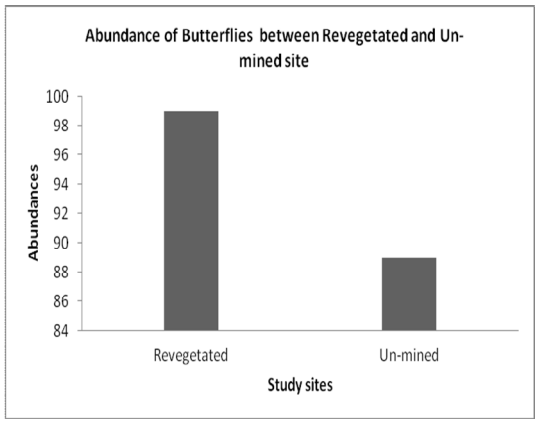

Fig 2: Abundance of butterflies in Revegetated site and un-mined site in Wazo hill

Table 1: Comaparison of butterflies abundances in different tpes of habitats.were U= Mann-Whitney U test statistic, P=Probability value, ShG=Shrub Grassland, G=Grassland, Shrubland

• Comparison between	• U	• P	• Chi-Square	• Comment
• G vz ShG	• 123.500	• >0.05	• 0.367	• Not Significant
• Sh vz G	• 73.500	• >0.05	• 0.549	• Not Significant
• ShG vz	• 658.500	• >0.05	• 0.342	• Not Significant

In comparison between the revegetated site and un-mined sites, Different species showed some variation in the two study sites, *Eurema senegalensis* was observed to be high in un-mined site (80% equivalent to 12 individuals) while being low in revegetated site (20%). Opposite scenario was observed for species like *Catopsilia florella* were high abundance was observed to occur in revegetated area (78.94% equivalent to 15 individuals) while being low in un-mined site (21.06%). Species like *Gegenes nisobrevicornis*, *Cacyeus Sp*, *Cacyreus lingeus*, *Freyeria trochylus trochylus* were observed to occur as singletons. Generally the revegetated (Mean=2.750±0.534, S.D=3.202) were observed to harbour high abundance of butterfly than the Un-mined site (Mean=2.472±0.627, S.D=3.761), however the difference was statistically insignificant (Mann-Whitney U test statistic =732.000, *P*>0.05).

3.2 Diversity

Thirty six species of Butterflies were identified in which 75% of species were observed to occur in re-vegetated site while 25% equivalent to 19 species was observed to occur in un-quarried site.Occurance of different species of butterflies in these two sites varied. For instance species like *Eurema brigitta brigitta*, *Colotis euppe omphale and Colotis euppe complexivus* occurred in both revegetated and un-mined sites. Species like *Colotis ione*, *Anthene ligures and Eurema regularis regularis* occurred only in revegetated site while species such as *Desmolycaena rogersi, Gegenes nisobrevicornis* and *Bicyclus safitze safitze* were observed n Un-mined site only.

Simpson index showed high diversity in the revegetated site (D=17.086) than in un-mined site (D=12.511). Similar trends were observed when different diversity indices like The Shannon-Weiner index and Margalef's diversity index while species evenness being high in un-mined site (Table 2).

The un-mined site was dominated by shrubs followed by grasses while the revegetated site was dominated by herbs and trees followed by grasses (Table 4). High number of plant species was observed in revegetated site (Mean=3.600±0.678, S.D=1.517) than in un-mined site (Mean=3.200±0.800, S.D=1.789) and the difference in number of plant species was insignificant (Kruskal-Wallis Test Statistic = 1.333, *P*>0.05).

4. Discussion

4.1 Abundance of butterflies

Generally the abundance of butterflies collected in Wazo hill was low if were to be compared with are ecosystem in Tanzania. For instance, in study done in Katavi, 2707 individual were caught which about 10times more of the individuals we caught in this Wazo hill [13]. This can be explained by the fact that, the area sampled in wazo hill was small due to large area being mined for cement. Also habitat alteration by the factory, sampling efforts and ecosystem heterogeneity can be among of the factors

The abundance of butterflies in Wazo hill for different habitat was less similar. That is no difference in abundance was observed. This can be due to habitat similarity between the revegetated and un-mined caused by revegetation efforts which lead to insignificant different in number of plant species. Findings from Selous Game reserve showed that, the abundance of insects are affected by the habitat heterogeneity which can be caused by variation of plant species [14]. Another finding in Kibaha Pwani in assessing the impact of urbanization on biodiversity showed that, unless the quarrying are accompanied with restoration, the impact in biodiversity including butterflies are inevitable [15].

When the abundance were compared between the un-mined and mined site, the difference was not significant. This can be

attributed to the migration of species between the mined and un-mined sites, similarity in habitats and favourable microclimate disturbance. During the study we noted some species migrating from one locality to another. Large butterfly like *Papilio sp* were observed to migrate over long distance than small sized species. Some studies have shown that, certain level of disturbance can be beneficial to butterflies, thus increasing the abundance of butterflies. This suggests that, the revegetated area upgraded the quarried area to favourable microclimate disturbance for butterflies [17].

Table 2: The different diversity indices (Shannon-Weiner index, Margalef's diversity index and Evenness index Fisher Alpha, Equitability, Berger Parker), abundance, mean and number of Butterfly species in the two study sites.

Diversity Indices	Re-vegetated Site	Un-quarried Site
• Shannon-Weiner index(H')	• 2.9546	• 2.60812
• Margalef's diversity index(D)	• 5.722719	• 4.010127
• Fisher Alpha (F)	• 12.87	• 7.4025
• Equitability (J)	• 0.8310	• 0.73358
• Berger Parker (B)	• 0.16304	• 0.1573
• Evenness (E)	• 0.031004	• 0.58105
• Mean µ	• 4.158	• 4.684

Table 3: Special t-test to compare the diversity of butterflies using different indices between the revegetated and un-mimed sites. Were t=t-value, P= probability

Diversity Indices	t	p	comments
• Shannon-Weiner index(H')	• 0.346528	• <0.05	• Significant
• Margalef's diversity index(D)	• 1.73981	• <0.05	• Significant
• Fisher Alpha (F)	• 5.47103	• >0.05	• Not Significant
• Equitability (J)	• 0.0975	• <0.05	• Significant
• Berger Parker (B)	• 0.00574	• >0.005	• Significant
• Simpson index (D)	• 4.57453	• >0.05	• Significant

Table 4: Number of plant species in the re-vegetated and un-quarried sites

Plant Group	Species in Revegetated	Species in Un-quarried
• Trees	• 5	• 2
• Shrubs	• 2	• 6
• Grasses	• 4	• 4
• Herbs	• 5	• 2
• Climbers	• 2	• 2
• **Total Number of Plant Species**	• 18	• 16

4.2 Diversity

The re-vegetation programme of the quarry has attracted 27 species of Butterfly in the re-vegetated site, a number that was higher than 19 Butterflies species that was found in the un-quarried site.

And the species diversity of butterflies between the revegetated and un-mined site was significant different. The higher diversity of butterflies in the revegetated site can be explained by the high number of plant species in the revegetated area which lead to habitat heterogeneity, different in succession level between the two sites and predation in the un-mined area. Also improved biotic and abiotic factors for Butterflies in the re-vegetated.

The finding in Selous Game Reserve showed that, the habitat heterogeneity has great impacts on insect diversity including butterflies [13]. Similar finding was observed in Udzungwa were habitat heterogeneity was observed to affect the diversity of *Beetle* [18].

The re-vegetated sites had several tree, shrub, herb and grass species replanted for the re-vegetation programme while the un-mined site had fewer plant species due to dominant plant species. The introduced plant species in the revegetated site attracted more species of butterflies than un-mined site. This agrees with the study which was done in the restored quarry site of Bamburi which attracted more than 180 species of birds, 15 species of larger mammals, 93 species of Butterflies, and 8 species of amphibians after active introduction of 430 indigenous plant species [19].

In un-quarried site, Butterflies were observed be preyed by Bird species such as little bee-eaters and Dragonflies, the observation thought to have influence on their diversity. In Costa Rica the major predators for Butterflies were identified

to be ants, spiders, wasps, parasitic wasps, parasitic flies, birds, rats, toads, lizards, praying mantis, snakes and monkeys [4, 5]. This provides profound information for those who want to engage in Butterfly farming to think about controlling the Butterflies predators for maximum business profit.

However some studies have showed different cases on the variation of butterfly's diversity for disturbed area. For instance, the study done by [16] revealed that different disturbance did not cause difference in species diversity due to understory vegetation cover. Butterflies play a keystone species role in the ecosystems by pollination and completion of food chain [20]

4.3 Conclusion and Recommendations

From this study, it is concluded that, revegetation had positive effects on the diversity of butterflies but not on their abundance. The introduced plant species exotic plus natives have attracted more butterflies species in the revegetated site. For instance *Acraea solinkensis, Deodorix dinochares and Eurema mandarinula* were observed to occur in revegetated site only.

In this case, the re-vegetation programme implemented by the TPCC has the potential for restoring the quarried areas. Butterfly as indicator species have demonstrated this through this study. The focus of the study was on the Butterflies, but other fauna species were seen in the re-vegetated area for example other insects, various bird species, small mammals such as hares and rats and large mammal like Vervet monkey are present too in the re-vegetated areas. Because of the positive indication of the re-vegetation programme it is recommended for restoring the quarried areas in the Wazo Hill and other mining sites in Tanzania.

In addition, is recommended to carry other studies which covers other group of fauna resources in relation to the re-vegetation of the quarried areas be carried out. Due to scarcity of resources the study could not sample in un-restored quarried areas.

Also, it is suggested that the adjacent community be involved in conservation of biodiversity in the quarry areas. The feasibility study on Butterfly farming in the area should be carried to assess its possibility and eventually the community participates in the Butterfly farming, the activity that will increase the house hold income and improve the relationship between local community and the factory and win their support in conservation of the biodiversity in the quarry.

There is a need for giving conservation education to the local communities on the importance of conserving biodiversity resource. The re-vegetated areas can be used for study and training for students in terms of attachments, internships and research projects.

The re-vegetated areas have the potential for tourism activities because of the restored biodiversity and the landscape. The potential tourist attractions and activities in the rehabilitated areas include Bird watching, Butterfly viewing, Landscape hiking and Swimming in constructed swimming pools. If the tourism will be developed it will create employments, increase income, and improve the relation with adjacent community as well. It is known that while humans are involved in economic venture from Butterflies, the conservation of the Butterflies and other biodiversity resources are enhanced [21].

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