Effects of Anthropogenic Activities on Distribution and Abundance of the Epiphytic Orchid, *Polystachya fusiformis* (Thou.) Lindl. in the Manga Range Ecosystem, Kisii, Kenya

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Abstract: ***It has been observed that anthropogenic activities namely, farming, tree harvesting, seasonal fire regimes, introduction of exotic tree species like Eucalyptus and Greviella, and collection of herbs for medicinal use are going on and form a major threat for the orchid Polystachya fusiformis (Thou.) Lindl. This study determined the relative abundance and distribution of the species Polystachya fusiformis (Thou.) Lindl. in the Manga range ecosystem of Kisii, Western Kenya during two flowering seasons. Other results of the present study were analyzed with SPSS version 17 for paired sample correlations, OriginPro7 t-Test and ANOVA, Minitab 16 chi-square test. From the analysis there is a significant correlation between altitude and number of orchid population clusters with a p-value of 0.008 in the distribution of Polystachya fusiformis (Thou.) Lindl. which led to rejection of the null hypothesis. The Levene's test for equal variance shows that at α 0.05 there is a significant difference between altitude and number of clusters as indicated by the P value of 0.00004. Of the 88 sites sampled, only 41sites had orchid clusters. Principal component analysis using Unscrambler 9.7 indicated that many of the orchid population clusters fell within the range of one or two orchid population clusters. The score plots from the two Hoteling's outputs show how well data is distributed including sample patterns, groupings, similarities and differences during the study. The two analyses illustrated how fire affects the orchid population on fire prone sites of the range. Orchid population clusters progressively increased with increase with altitude range (from 1800m to 1850m) above sea level, but number of orchid population clusters decreased towards 1950m. Sites with minimal anthropogenic disturbances (1796m, 1830m, 1854m, 1886m, and 1890m) had a higher number of orchid population clusters.***

Keywords: Orchidaceae, *Polystachya fusiformis*, mycorrhiza, pollinia, herbivory.

1. Introduction and Literature Review

1.1 Introduction

Orchids are nonvascular perennial plants having simple leaves, parallel venation with flowers which display a variety of colours and fragrances. Leaves may be ovate lanceolate or orbiculate with varying sizes. Leaves are normally alternately positioned while the structure of the leaf depends on habitat conditions. Orchids have complex life cycles often involving a fungal partner in mycorrhiza and seed germination, and specific pollinators. Some have single bilaterally symmetrical flowers but most including *Polystachya fusiformis* (**Thou.**) **Lindl.** have a racemose inflorescence with a large number of flowers. Pollen is released in the form of pollinia which is a waxy mass of pollen grains held together by a glue-like viscin. Orchids tend to have highly specialized pollination systems which reduces chances of being pollinated and as such, orchid flowers remain receptive for 2-3 weeks before shriveling. The possible pollinators are lured by shape, fragrance, nectar and colour of labellum. Orchids are cosmopolitan plants which occur in all habitats except glaciers, with the highest concentration being found in the tropics especially in Asia, South America, Central America, and Africa. Terrestrial orchids form rhizomes, corms or tubers used as food reserves and as perenating organs. Epiphytic orchids have modified aerial roots made up of spongy velamen which absorbs humidity. A majority of orchids are perennial epiphytes or lithophytes which grow anchored on trees, shrubs or on rocks. They are very sensitive to environmental change and are a subject of great concern at present. Threats facing orchids can be narrowed down to human activities including land clearance for agriculture, mining and urban development, weed invasion, introduction of exotic plant species, grazing, altered environmental conditions and collection of plants for horticulture and ethnobotanical uses. The family (orchidaceae) has a considerable economic value in horticulture, floristry, pharmaceutical and fragrance industries becoming a major source of income in some countries in Asia. All types of orchids are being sought by collectors such as Sutherlandshire orchid society and the American orchid society who encourage cultivation, collection of orchids, conservation and research. Orchids offer alot in the study of interaction of plants, fungi and animals (pollinators).

1.2 Orchidaceae

Orchidaceae is an insect pollinated plant family composed of five monophyletic clades, which correspond with the currently recognized Subfamilies: Apostasioideae, Cypripedioideae, Orchidoideae, Epidendroideae, Vanilloideae[1]- [2]. *Polystachya fusiformis* **(Thou.) Lindl.**

belong to epidendroid orchids which are classified into "lower" and "higher" Epidendroids. The lower tribes comprise Neottieae, Parmorchideae, Triphoreae and Neurileae while higher Epidendroid tribes comprise Coelogyneae, Arethusae, Malaxideae, Podochileae, Dendrobieae and part of Epidendreae and Arpophyllinae Polystachyinae clade of Epidendreae [3]. Most orchids are photosynthetic at maturity but some 100 species are achlorophyllous [4]. Orchids are a diverse family of plants with about 1,000 genera and over 25,000 species [5]- [6]. Orchids usually grow on strata with sufficient moisture and shade. Most orchids emerge during the rainy season when the conditions are favourable [7].

Diversity in orchid taxonomy is attributed to specialization of two requirements which may occur independently or in combination; specific pollinators and mycorrhizal associations. Orchid distribution and abundance is more inclined towards the tropics with variations between continents and within regions [8]. Two thirds of orchids are epiphytes while one third comprise the terrestrial species. Terrestrial orchids face a greater extinction risk due to a series of threats especially under current global climatic change. Such orchid species are locally endemic and are vulnerable to threatening processes [9] such as cyclic events like drought or fire. The rare orchid species have low fruit and seed set as observed by [10] in the temperate regions.

1.3 *Polystachya fusiformis* (Epidendroid orchid)

The epidendroid orchids including *Polystachya fusiformis* **(Thou.) Lindl.** comprise the largest and most diverse subfamily, which has been the most difficult to interpret and classify phylogenetically and hence has attracted much research. The orchid *Polystachya fusiformis* **(Thou.) Lindl.** can be recognized by fully incumbent anthers, hard pollinia, thickened stems and a typical epiphytic nature. [11]- [12] tried to subdivide Epidendroideae into more natural subgroups which include those with erect anthers and soft pollinia to a distinct subfamily, Neottioideae and those with stipes and superposed pollinia into Vandoideae. However, [2] decided to retain Neottioideae and Vandoideae within Epidendroideae. Epidendroideae are characterized by reed stems, eight pollinia [13].

Plate 1: A population of *Polystachya fusiformis* (**Thou.) Lindl**. cluster growing on an old tree stump at Manga range.

The subfamily Epidendroideae is a polyphyletic clade which has not been easy to be subdivided into old world or new world clades. *Polystachya fusiformis* **(Thou.) Lindl.** belongs to the sub-tribe Polystachyineae. The degree of biotic interdependency between a given plant or animal species and other organisms increases the risk of extinction of rare species [14]. The range and abundance of terrestrial orchids may be influenced by the underground phase and above ground life history [15]- [16]- [17]. Underground phase is dependent on orchid-fungal association [18- [19]- [20]. Above ground phase is dependent on effective transfer of pollinia, fertilization and subsequently proper fruit and seed set [21] - [22]. [23] have elaborately discussed pollination of orchid flower that it does not only depend on intrinsic factors such as the types of pollinator species, but also on extrinsic factors such as habitat characteristics [24], flower and foliar herbivory [25]- [26], and ecological relationships provided by the floral community in the habitat [27]- [28].

1.4 Anthropogenic activities affecting the distribution and abundance of *P. fusiformis*

Anthropogenic activities such as tree harvesting and agricultural activities may have resulted in severe damage at the Manga range ecosystem, change of vegetation structure, ecosystem function and loss of biodiversity. Such changes have long lasting consequences which have a long term effect on the vegetation structure recovery. Loss of natural habitats as a result of land use changes and activities such as tree harvesting, fire wood collection, introduction of exotic tree species such as *eucalyptus*, collection of wild herbs for medicinal use may contribute to the reduction in the population of *P. fusiformis* (**Thou.**) **Lindl.** [29].

Modification of forested land to agricultural land occurs at a rate of about 13 million hectares per year [30]. Fire is considered as a potent force in environmental modification and also as an important management tool. Human-ignited fires include both intentional fires that are part of land management and unwanted wildfires. Fires tend to increase in intensity and extent as the dry season progresses, though later fires may be controlled by networks of earlier burns. Fire plays an important role in redistribution of nutrients in the environment. An animal's ability to find food, shelter and breeding habitat and to survive predation and competition is affected by fire incidence [31].

1.5 Conservation considerations

Manga range was once a rich biodiverse ecosystem with a large number of floral species (Append. 8). The ecosystem continues to change as a result of partial or complete degradation, resulting from the conversion of the Manga ecosystem into new land use. Critical decisions should be made to manage the diminishing flora and fauna in the region. Important considerations should be taken care of in the developing of conservation considerations and policies which include the recognition of the existing and future environmental threats; developing taxonomic distinctions for flora and fauna; identify the geographic distributions of keystone species using a GPS; characterize organisms in relation to habitat specialization; study and document their reproductive biology; identify evolutionary processes influencing population structure, and wherever appropriate adopt *ex situ* conservation technology.

Resource and time limitation may not allow threatened biodiversity to be saved, which requires the setting of conservation priorities for selecting species, habitat or ecosystem at the greatest risk. Conservation biologists must ensure that technological capacity for conservation is not used to intervene directly against effective conservation *in situ*. [32] notes that "the big question at the end is not whether science can help; rather it is whether scientific evidence can successfully overcome social, economic and political resistance for the protection of natural resources".

2. Materials and Methods

2.1 Study site

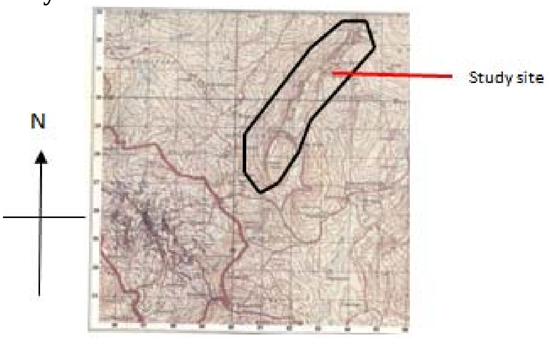

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Figure 2: A topographic map of the study site at Manga Range.

Manga range has an approximate area of 20 km^2 and is situated 5 km to the North-east of Kisii town between 00^{o}33' South and 34^{o}57' East in Kenya (fig.4). The Range is a natural montane rocky area owned by the local community in which there are schools, a Catholic mission, tea plantations and *Eucalyptus* plantations but much of the plateau is grassland. Manga range is a habitat to a variety of unique flora and fauna which are endemic to the range. Although the vegetation varies considerably with altitude these unique species include orchids. Many bird species are endemic at the range especially at the slopes nesting on thickets and the *Eucalyptus* trees. It is an important site which should be used for conservation of flora and fauna, some of which are both locally and globally threatened. The climate is influenced by the bimodal rain pattern with long rains starting from March to May followed by short rains which start from August to September. The climate of Manga is cool and wet with rainfall averaging 2000mm per annum. Temperature varies in relation to topography with an annual average of 22^{o}C.

The natural boundaries of Manga range are the rocky cliffs on the North as well as the North-east facing slopes and the fairly steep slopes on the eastern side having tea plantations and grasslands (plate 4). The rocky cliffs serve as a natural barrier to the farming activities and to the community living along the range. However, increased anthropogenic activities such as agroforestry and grass harvesting are a threat to the natural vegetation at the Range. These activities have raised great conservation issues for the range and its flora and fauna species which include *Spathodea campanulata*, *Protea sp*., ferns, several varieties of herbs including aloe and the epiphyte *Polystachya fusiformis* **(Thou) Lindl.** The animals found in this ecosystem are as follows: wild rabbits, aves, reptiles, arachnids, butterflies, lepidopterans, parasitoid wasps and bees.

2.2 Sampling design

The sampling plan was designed to fit the study site as the heights of the cliffs from the foot of the range to the top are averagely 30 meters.

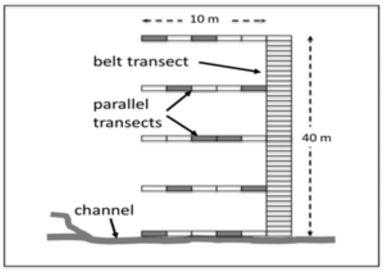

Figure 4: The gradient directed transects ("gradsects")

The sampling design was adopted and modified from the *Gradient directed transects* ("gradsects")(fig. 4); [32] which is fairly adaptable to different kinds of environments. In the modified design 1m^2 quadrats placed at 4m interval from the baseline along the parallel transects replaced the 1x2m randomly placed plots in the original design. The baseline ran at the foot of the range while transects were drawn from the base to the top of the range along the rocky surface.

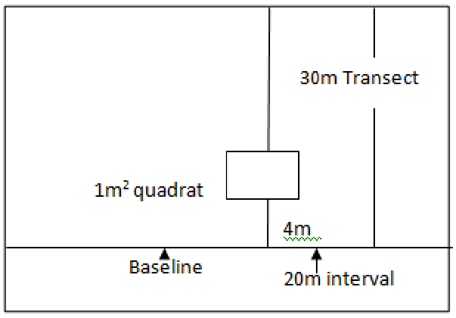

Figure 5: The modified sampling plan consisting of a baseline at the base of the range; a 30 metre long transect drawn from the base to the top of the cliff at a regular interval of 20 meters

Sampling plots were established by drawing 30 transects along the steep North and North-West facing slopes of the Manga range where there are sites with indigenous vegetation and minimal disturbance. A total of 87 quadrats each measuring 1m^2 were laid at a 4m interval along a 20 m long belt transect as this was the average height of the cliffs along the range. The belt transect was laid using a 30 m tape measure. The interval between one transect and another was 20 metres to reduce sampling bias. A pair of binoculars was used to count population clusters of *Polystachya fusiformis* **(Thou) Lindl.** on the parts of the range which are very steep and inaccessible. The number of orchid population clusters was determined in each sampling site to establish their distribution and abundance. The GPS location of the orchid population was recorded using a Garmin GPS with the exception of the very steep sites, and digital photographs were taken using an Olympus D-340L/C-840 digital camera.

2.3 Sampling

The necessary sample size was determined using the formula:

$$n = \frac{n}{1+\frac{n-1}{N}} \quad [34]$$

Where:
n = number of sampling units (quadrats)
N = size of population

$$n = \frac{88}{1+\frac{88-1}{1279}}$$

n = 82 (quadrats)

Purposeful sampling was done at sites with the highest orchid abundance based on a previous study done by [35]. Various parameters were measured and recorded during the study which included altitude, plant height, number of orchid clusters and number of orchid plants in a population cluster.

2.4 Distribution and abundance of the orchid

Sampling of the epiphytic orchid was done in the months of September, October and November 2011. A total of 30 transects were drawn at a regular interval of 20 metres. The transect had a width of 1 metre and a length of 20 metres. Quadrats were laid at a 4 metre interval along each 20 metre long belt transect in the accessible parts of the range. Distribution of *Polystachya fusiformis* **(Thou) Lindl.** was patchy with scattered population clusters across the range. Quadrats were used to determine the orchid population in each cluster. Heights of the tallest orchids in the clusters were measured using a 3 metre oxford tape measure to establish variation in rate of growth of the epiphytic orchid in relation to change in altitude.

Data was collected using a 1m^{2}quadrat, a 3metre long oxford tape measure for measuring plant height, an Olympus digital camera for taking photographs, red cloth ribbons to act as markers at the sampling sites and a Garmin GPS for determining geographical location. The process of data collection started at 8.00am each daily comprising of myself and three assistants and continued until 3.00pm especially on sunny days. All data collected in the sampling plots was recorded in data sheets. Later the data was entered into a Microsoft excel spreadsheet to analyze the distribution and abundance of the orchid population across the range.

Density of the orchid species was calculated using:

$$D = \frac{4(4n-1)}{\pi \sum (d^2)}$$

Where:
D = density
n = number of quadrats
d = number of individuals per quadrat
$\sum$ = sum

$$D = \frac{4(4X88-1)}{3.14159X1279}$$

$$D = 0.322$$

Frequency of *Polystachya fusiformis* was calculated using:

$$\text{Frequency} = \frac{\text{No.of quadrats in which a species is present}}{\text{Total number of quadrats}} X100$$

$$\text{Frequency} = \frac{41}{88} X\ 100$$

Frequency = 46.59

Frequency is a measure of the degree of uniformity with which individuals of a species are distributed in an area. The percentage of samples is in which at least one individual of the species occurs. Percentage cover was calculated using the formula:

% cover = % of quadrat which a species represents
% cover = 46.59

$$\text{Average cover} = \frac{\text{Sum of cover values for a particular species}}{\text{No.of quadrats in which a species is present}}$$

$$\text{Average cover} = \frac{46.59}{41} = 1.136$$

Index of commonness was calculated using the formula:
Index of commonness = frequency X average cover
= 46.59 X 1.136
= 52.92

2.5 Anthropogenic activities

Data was collected through photographs at the site before disturbance and after disturbance. The disturbances included tree harvesting, firewood collection, collection of herbs for medicinal use and grass harvesting for construction of traditional grass thatched houses. The disturbances were surveyed in relation to altitudinal variation. Photographs of the sampling sites were taken before a disturbance and after a disturbance especially firewood collection, tree harvesting, collection of herbs and cutting of grass for thatching houses. The photographic data collected was used in the quantification of habitat structure and complexity in order to assess the ecological impact of firewood collection on the epiphytic orchid *P. fusiformis* (**Thou.**) **Lindl.**

3. Results and Data Analysis

3.1 Abundance and distribution of orchids

The sampling results of abundance and distribution of the orchid *Polystachya fusiformis* (**Thou.) Lindl.** were analyzed using SPSS version 17 software for paired sample correlations. The paired sample correlation analysis compared the different sampling parameters and their levels of significance. Altitude and plant height had no significant correlation as their p- value was 0.937. The other sampling parameters had significant correlations. Correlation coefficient tells us how much two variables are correlated. Correlation coefficient standardizes the magnitude of the covariance to values between -1 and 1.

Table 3: Paired Sample Correlations

	N	Correlation	Sig.
Altitude (m) & Plant height (cm)	87	-.009	.937
Altitude (m) & Plants in a cluster	87	-.283	.008
Plant height (cm) & Number of clusters	87	.572	.000
Plant height (cm) & Plants in a cluster	87	.350	.001

The results in the table indicate that there is a significant correlation between altitude and number of orchid population clusters; therefore the null hypothesis was rejected. It is statistically significant at α .05 as the second box indicates the significance to be 0.008 (p-value). Therefore it will be summarized as r (87) = 0.283, p < .05. The number of clusters in relation to change in altitude indicates that the orchid species are sparsely populated on the western and north facing slopes of the range. Plant height is directly related to the size and population in a *P. fusiformis* (**Thou.**) **Lindl.** cluster, hence the strong significance value, (p = 0.000). Wherever *P. fusiformis* occurs in a large population cluster, cluster heights also indicated a high significance.

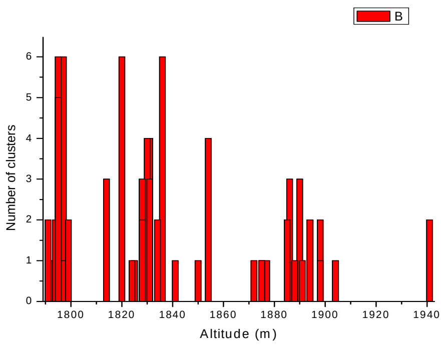

Figure 6: Bar graph of number of clusters against altitude

The bar graph above (fig.6) shows that the orchid *Polystachya fusiformis* (**Thou.**) **Lindl.** is patchily distributed across the range. The peaks of the histogram correspond with sites with minimal anthropogenic disturbance such as firewood collection, tree harvesting for timber and firewood, collection of herbs for medicinal use and cutting grass for thatching traditional grass roofed houses. These are the patches on the rocky outcrops of the range where human activities are minimal. Studies done on the western Kenya ecological zone indicate that Manga range was previously richly endowed with several plant species some of which are extinct, endemic or threatened. Part of the vegetation composition included the following:

Table 4: Part of the vegetation of Manga Range

Species name	*Habit*
Capparis fascicularis (**DC.**)	Climber /shrub
Juniperus procera (**Engl.**)	Tree
Protea madiensis (**Oliv.**)	Tree
Ricinus commmunis (**L.**)	Herb
Caesalpinia volkensii (**Harms.**)	Climber
Colutea abyssinica (**Kunth. & Bouche.**)	Herb
Dalbergia lutea (**Vatke.**)	Shrub
Tamarindus indica (**L.**)	Tree
Acacia abyssinica (**Benth.**)	Tree
Acacia brevispica (**Harms.**)	Tree
Acacia drepananolobium (**Sjostedt.**)	Tree
Acacia macrothyrsa (**Harms.**)	Tree
Albizia amara (**Roxb.**) **Boiv.**	Tree
Albizia coriaria (**Oliv.**)	Tree
Sesbania sesban (**L.**) **Merill.**	Tree
Grevia microcarpa (**K. Schum.**)	Shrub
Hibiscus calyphyllus (**Cav.**)	Herb
Clutia abyssinica (**Taub. & Spach**)	Shrub
Clutia robusta (**Pax.**)	Shrub
Croton dichogamous (**Pax.**)	Shrub
Euphorbia engleri (**Pax.**)	Herb
Croton alienas (**Pax.**)	Tree
Croton macrostachyus (**Del.**)	Tree
Croton megalocarpus (**Hutch.**)	Tree
Euphorpia tirucallii (**L.**)	Tree
Indigofera swaziensis (**Bolus**)	Shrub
Zizphus abyssinica (**A. Rich.**)	Tree
Ziziphus mucronata (**Willd.**)	Tree
Aloe dawei (**Berger**)	Herb

(Source: Kenya trees, shrubs and lianas, Beentje, 1994)

Table 5: Two Sample Paired t-Test summary statistics

Sample	*N*	*Mean*	*SD*	*SE*	*T*	*DoF*	*P-value*
Altitude	87	1850.38	47.06	5.05	363.48	86	0.0000
No. of Clusters	87	1.126	1.63	0.17			
Difference of Means: 1849.25287							

At the 0.05 level, the difference of the population means is significantly different than the test difference (0). The paired sample t-Test (table 5) shows that there is a variation in the distribution of orchid clusters with change in altitude across the Manga range. At this point the null hypothesis is rejected as the $p<\alpha$.

Table 6: One-Way ANOVA (Levene's Test for Equal Variance)

Source	*DoF*	*Sum of Squares*	*Mean Square*	*F Value*	*P Value*
Model	2	53950773.9	26975386.9	10.98400	0.00004
Error	120	294705593	2455879.95		

At the 0.05 level, the population variations are significantly different. The Levene's test for equal variance (table 6) shows that at α 0.05 there is a significant difference between altitude and number of clusters as indicated by the P value of 0.00004.

Analysis of number of clusters in relation to change in altitude was done with *Unscrambler 9.7* as shown in the scatter plot as shown below:

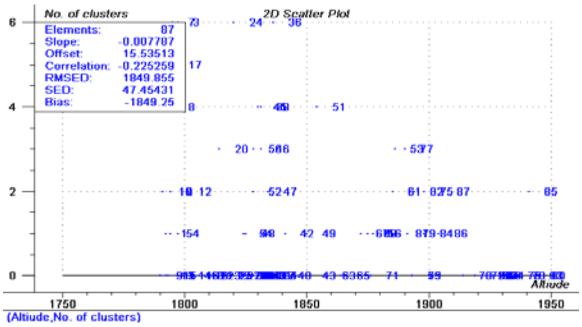

Figure 7: 2D scatter plot on distribution of orchid cluster population on the Range.

The analysis was done in line with the objective on the distribution and abundance of the epiphytic orchid. The analysis indicates that much of the orchid cluster population falls in the range of one or two clusters. A few samples have a large residual which may not be well described by the PCA model (fig.7). Fourteen sites had the orchid population with more than two clusters. Several quadrat sites had no orchid clusters. The results indicate that the number of orchid clusters progressively increased with increase in altitude from 1800m to 1850m above sea level and decreased towards 1950m. Location of most clusters corresponds with parts of the Manga range with minimal anthropogenic disturbances such as tree harvesting for timber and firewood, firewood collection seasonal fire regimens, plantation farming such as *Eucalyptus and Greviella* and collection of herbs for medicinal use, in the altitudes of 1796m, 1830m, 1854m, 1886m, and 1890m above sea level.

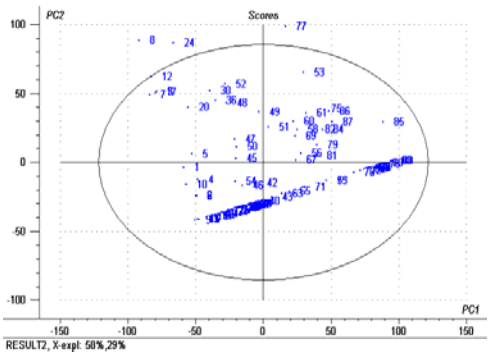

Figure 8: Hoteling's elipse on orchid population cluster showing distribution before a fire regime on the range.

Three components used in the scatter plot are altitude, number of clusters and plant heights.

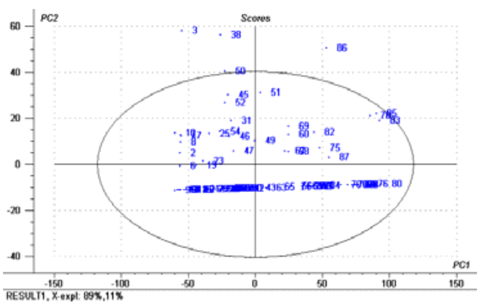

Figure 9: Hoteling's elipse on orchid population cluster distribution after a fire regime on the range.

The score plots show how sample data is distributed (fig.8) including sample patterns, groupings, influence of fire, similarities and differences during the study. Sample data lying to the right of the score plot have higher values for those two variables. Therefore, the more you move up on the score plot, the higher the density of orchid population clusters. There are a few outliers in the two plots which could be as a result of an interesting sample. Strongest outliers are placed in the upper right side of the plot and have a large leverage and high residual variance. In the normal situation 5% of the samples are expected to lie outside the ellipse.

Cluster analysis for February 2012 (fig.9) indicates that:

- Altitude has a limited influence on orchid cluster size
- Height of orchids is largely influenced by the size of a cluster
- The loadings help to illustrate the correlation between variables

The two analyses illustrated how fire affects the orchid population on fire prone sites of the range.

3.2 Anthropogenic activities

Plate 10 a: A population of *P. fusiformis* (Thou.)

Lindl. cluster growing on an old tree stump at Manga range. **b:** effect of firewood collection at the site where *P. fusiformis* (Thou.) Lindl. Was previously attached. Fires are mostly lit late in the dry season (plates 11 a and b) almost towards the start of the rainy season when moisture levels are low. Grasses form the main under storey plants in the range [36]- [37] and they readily burn once they begin to brown off at the start of the dry season. Grass fuels become more flammable as the dry season progresses and moisture levels decline [38]- [39]. Fuel loads of woodland and forest areas also increase towards the end of the dry season with the shedding of leaves by water stressed plants [39]. The size of the area burnt by a fire tends to increase as the dry season progresses. Early season fires frequently leave unburnt patches because of variation in quantity of dry leaves [40]. Response to fire varies between species and a diversity of fire regimes, from fire exclusion through to regular and irregular burning patterns, are likely to be required to maintain animal diversity.

(a) (b)

Figure : Plates 11 a and **b**: Destruction of orchid population: (a) after a cool fire; (b) after an intense fire.

4. Discussion

4.1 Distribution and abundance of the orchid *Polystachya fusiformis*

The epiphytic orchid, *Polystachya fusiformis* (**Thou.**) **Lindl.** is found at the Manga range in Kisii, Western Kenya as previously noted by [35]. The study has tried to address the ecological knowledge gap through the examination of the impact of fire disturbance and moisture availability, on the rocky cliffs of Manga range. Orchids serve as indicator species of habitat due to complexity of their ecological relationships and increasing levels of endemism [41]- [42]- [43]- [44]- [45]. In the range it was observed that the orchid species *Polystachya fusiformis* (**Thou.**) **Lindl.** is sparsely distributed on the North and North-west facing rocky slopes of the Manga range. Large areas of the original vegetation in the range have been cleared for timber, firewood, grass for thatching traditional grass roofed houses and grazing over a long period of time and resulted in a significant loss of habitat and a negative impact on wildlife. Only small remnant patches of some woody trees remain.

The distribution of the epiphytic orchid species is greatly affected by the frequent fires which have decimated the indigenous tree species which serve as hosts for the orchid *Markhamia lutea*, and *Spathodea campanulata*. Presently the orchid species are patchily distributed on the rocky outcrops which are not easily affected by the seasonal fires on the Northern slopes of the Manga range.

The analysis done using SPSS version 17 on altitude against the number of clusters indicated that a large number of clusters are found on the altitudes 1796 m, 1830 m, 1854 m, 1886 m, 1890 m and 1894 m. The altitude at the range was measured using Garmin eTrex vistaHCx global positioning system (GPS). The population of the orchid species *Polystachya fusiformis* (**Thou.**) **Lindl.** fluctuates due to sporadic or cyclic events such as drought or fire [9]. The fluctuation of orchid population is dependent on some specific ecotypes which prevail at the ecological frontiers of a species.

Anthropogenic activities such as logging and seasonal fires have greatly damaged the Manga range ecosystem function and biodiversity. Loss of natural habitats due to tree felling, fires, introduction of exotic tree species have contributed to decline in the species population in the Manga range. Some sites especially those with higher number of clusters exhibited different characteristics as compared to those with a low number of clusters. Such sites have vegetation which is dense with less exposure to sunlight and wind and a relatively high humidity.

5. Conclusion

Human poverty and environmental degradation are interrelated; we should pledge ourselves to improve the quality of life for all people. Our key goal in Conservation Biology is a sustainable utilization of resources while meeting human needs. It is therefore necessary for Conservation Biologists to raise the level of understanding and commitment to individuals, organizations, businesses and institutes to pay attention in areas with high population to ensure that there is food security, minimize loss of species and genetic resources and formulate strategies for environmental conservation. Manga range ecosystem requires such kind of efforts

6. Recommendations

For future studies it would be useful to gain a wider and long term (multigenerational) understanding of metapopulation dynamics of *P. fusiformis* (**Thou.**) **Lindl.** in order to establish a stronger estimate of recovery time after disturbance.

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