Final Report

On the

Diversity and Population Density Endangered Epiphytic Orchids in the Mau Forest, Kenya

By

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PROJECT SUMMARY

This project aimed at improving the conservation of endangered epiphytic orchids in disturbed forest regimes by understanding their diversity and population density using demographic variables. The work was carried out in the Mau forest, Kenya. The forest is located within Kenya's Rift Valley and is the largest indigenous closed canopy montane forest in East Africa. Mau has a rich diversity of fauna and flora and serves as a critical water catchment and source to numerous rivers, providing lifelines to Kenya's wildlife, people and neighbouring Tanzania. The forest provides ecosystem services such as river flow regulation, flood mitigation, water storage, reduced soil erosion, biodiversity, carbon sequestration, and carbon reservoir and microclimate regulation. However, Mau is continuously being exploited for other alternative land uses including settlement and private agriculture. Deforestation, encroachment, charcoal production and logging of indigenous trees have negatively impacted on water resources, drying out boreholes and some rivers. Our findings show a clear evidence that orchids are threatened by loss and fragmentation of their habitats particularly the destruction of the moist forest habitats and indigenous host plants. Consequently, conservation efforts should take into account the associated plants which could serve as indicators for the ecological status of native orchids. Therefore, deliberate effort should be taken to sensitize relevant stakeholders including communities living around the forests on importance of conserving the primary indigenous forests for the benefit of all. The findings further indicate that forest degradation reduces orchid species diversity in the forest. In addition, they show that orchids are bioindicators of forest degradation status.

1. Project Results

1.1 Orchid Species Richness and Abundance

A total of five orchid species were recorded across the three forest disturbance regimes. These were *Aerangis* sp*, Bulbophyllum* sp*, Chamaeangis* sp*, Polystachya confusa* and *Tridactyle* sp. Of the five species, *Polystachya confusa* had the highest population (600.0±227.9 clumps per ha) compared to *Tridactyle* sp that had the lowest (100.0±0.0 clumps per ha) as shown in Figure 1.

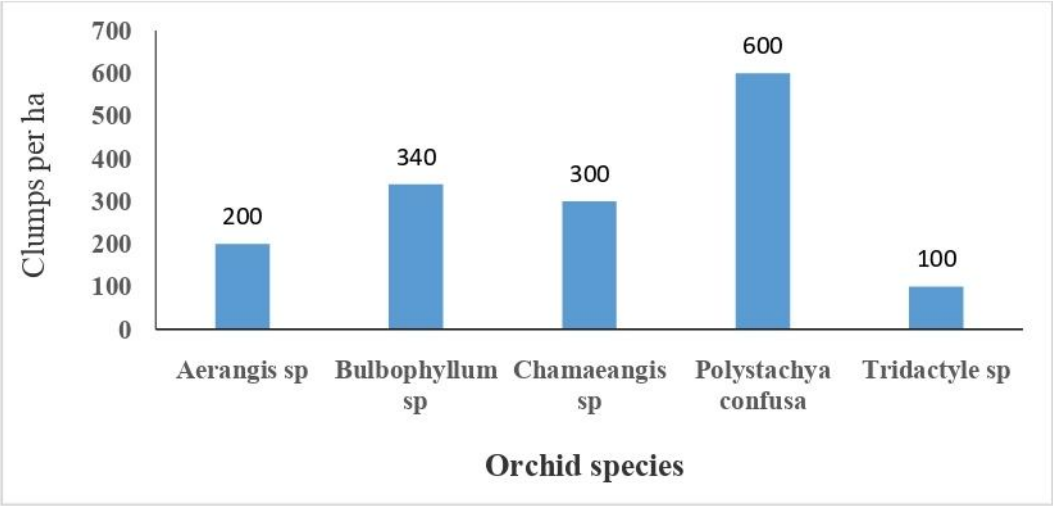

Figure 1: Orchid species richness and respective population abundance in West Mau Forest, Kenya

All the five orchid species were present in the intact forest. The moderately disturbed forest had only *Aerangis* sp and *Polystachya confusa*, while the highly degraded forest did not have any orchids (Table 1). The moderately disturbed forest had a higher orchid population density (422.2±195.6 clumps per ha) than the intact forest (390±133.8 clumps per ha), but the different was not statistically significant ($F_{(1,2)} = 0.01$; $p =$

0.933). Similarly, the population density of *Aerangis* sp was relatively higher (233.3±66.7 clumps per ha) in the moderately disturbed forest than in the intact forest (100.0 ±0.0 clumps per ha).

Table 1: Orchid species richness and abundance across a forest degradation gradient in West Mau Forest Block, Kenya

Vegetation type	Orchid species	Abundance (clumps ha^{-1})
Intact forest	*Aerangis sp*	100.0 ±0.0
	Bulbophyllum sp	340.0 ±112.2
	Chamaeangis sp	300.0 ±115.5
	Polystachya confusa	671.4±360.4
	Tridactyle sp	100.0 ±0.0
Moderately disturbed forest	*Aerangis sp*	233.3±66.7
	Polystachya confusa	516.7±292.6
Degraded forest	-	-

1.2 Orchid Species Diversity

Shannon-Weiner Diversity Index (H) was used to measure the diversity of orchid species. The results in Table 2 were obtained from the sampled population of host-trees across both intact and moderate disturbed forest regimes. The results reveal that the forest has more than one species of orchids. By Shannon Index (H=0.552) being greater than zero, it indicates that the different orchid species are found in the different forest disturbance regimes. However, the *Polystachya confusa* accounts for the largest share of orchid species. To measure the evenness of the orchid species across the entire forest, the Shannon Equitability Index (E_H) was calculated.

$$E_H = \frac{0.551904098}{\ln(5)} = 0.3429172966 \approx 0.343$$

Based on this result, since the E_H is lower and far from 1, it indicates that there is partial evenness of orchid species in the forest. Ideally, the species do not have complete even distribution across the Mau forest.

Table 2: Shannon Diversity Index

Species	**Frequency**	**pi**	**Ln(pi)**	**pi*Ln(pi)**
Aerangis sp	4	0.04925776	-3.268060682	-0.138117951
Bulbophyllum sp	8	0.02724359	-3.808955497	-0.092466497
Chamaengis sp	3	0.03846154	-3.454025426	-0.119091252
Polystachya confusa	24	0.05909807	-3.226479139	-0.146373156
Tridactyle sp	4	0.01282051	-4.356708827	-0.055855241
			H	**0.551904098**

1.3 Variation of richness and abundance across forest regimes

As shown in table 3, the richness and abundance of orchids across different forest regimes. The average number of clump per host tree in the intact (*M*=2.78, *SD*=3.215) and moderate disturbed (M=2.56, SD= 1.672) forest were slightly different.

A similar trend was also observed on the number of clumps per Ha with intact forest averaging 277.78 clumps with a stand deviation of 321.455 while the moderate disturbed forest averaged 2.56.25 orchid clumps and a standard deviation of 167.207.The statistical significance of the variations across the forest regimes was carried out using independent samples t-test with the following results obtained.

Table 3: Orchid Richness and Abundance across forest regimes

	Disturbance Regime	Mean	Std. Deviation
No. of Clumps	Intact	2.78	3.215
	Moderate Disturbed	2.56	1.672
Clumps Per Ha	Intact	277.78	321.455
	Moderate Disturbed	256.25	167.207

From the analysis and based on the data generated by the study indicated in table 4, there is no significant variation in the number of clumps across forest regimes ($t_{(41)}$ =0.248, p=0.805) since the p-value is greater than 0.05 at 95% confidence level. Similarly, there was no statistically significant variation in the number of orchid clumps on host trees per hectare across the two forest regimes. With 95% confidence, the research found that the difference in the mean number of clumps per hectare between intact and moderate disturbed forest in SWM was insignificant ($t_{41)}$ =0.248, p=0.805).

Table 4: Test for variation of orchid richness & abundance across forest regimes

		Levene's Test for Equality of Variances		t-test for Equality of Means					
						Significance		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Two-Sided p	Mean Difference	Lower	Upper
No. of Clumps	Equal variances assumed	2.130	.152	.248	41	.805	.215	-1.538	1.969
	Equal variances not assumed			.288	40.521	.775	.215	-1.293	1.724
Clumps/ha	Equal variances assumed	2.130	.152	.248	41	.805	21.528	-153.843	196.898
	Equal variances not assumed			.288	40.521	.775	21.528	-129.311	172.367

1.4 Host Tree Structural Characteristics and Orchid Clump Population

Nine out of the 32 tree species recorded in Mau Forest hosted orchid species. These were *Albizia gummifera, Dovyalis macrocalyx, Macaranga kilimandscharica, Neoboutonia macrocalyx, Parvetta grandifolia, Podocarpus sp, Schefflera abyssinica, Syzygium guineense* and *Tabernaemontana stapfiana*. Seven host tree species were in the intact forest while four were recorded in the moderately disturbed forest. Of the overall stem density of 472 woody stems ha^{-1} in Mau Forest, orchid host tree species accounted for 198 stems ha^{-1} (41.9 % of the woody plants population). Host tree species in the intact forest were generally taller ($F_{(1,2)} = 6.57$; $p = 0.062$) and larger in diameter ($F_{(1,2)} = 3.14$; $p = 0.151$) compared to those in the moderately disturbed forest (Table 5).

Table 5: Variation in structural attributes of orchid host trees across a forest degradation gradient in Mau Forest, Kenya

Vegetation type	**Host trees**		**No. of orchid species**	**Orchid clumps ha^{-1}**
	Stem DBH (cm)	**Tree height (m)**		
Intact forest	46.6	24.6	5	390±133.8
Moderately disturbed forest	26.2	13.3	2	422.2±195.6
Highly degraded forest	-	-	-	-
	$p = 0.151$	$p = 0.062$		$p = 0.933$

None of the five orchid species had a single host tree species. *Polystachya confusa* was present on eight different host tree species while the rest were recorded in three host trees each (Table 4). Of the nine host tree species, seven shared between two and four orchid species, while two had single orchid species. The number of orchid clumps per

host tree ranged between 1 and 5.2 while the clump height on host trees ranged between 1 m and 25 m.

Table 6: Orchid host tree species and their respective clump densities in West Mau Forest, Kenya

Host tree species	Orchid species	Orchid clumps per host tree
Albizia gummifera	*Chamaeangis sp*	1
	Polystachya confusa	1
	Tridactyle sp	1
Dovyalis macrocalyx	*Polystachya confusa*	3.8
Macaranga kilimandscharica	*Aerangis sp*	1
	Chamaeangis sp	5
	Polystachya confusa	1
	Tridactyle sp	1
Neoboutonia macrocalyx	*Aerangis sp*	3
	Bulbophyllum sp	1
	Polystachya confusa	5.2
Parvetta grandifolia	*Aerangis sp*	2
	Polystachya confusa	2.7
Podocarpus sp	*Bulbophyllum sp*	2
Schefflera abyssinica	*Polystachya confusa*	2
Syzygium guineense	*Chamaeangis sp*	3
	Polystachya confusa	1
	Tridactyle sp	1
Tabernaemontana stapfiana	*Bulbophyllum sp*	3
	Polystachya confusa	4

2 Discussion

The stand structure and tree composition is a key element in determining the distribution, diversity and abundance of orchids in Mau forest. Forest degradation damages forest canopy cover, which destroys not only orchids but also their habitat leading to the decline in their diversity and abundance. Orchids are host specific, host tree bark texture of is a critical determinant of the orchid species abundance and

richness. Host tree species tend to have rough or fissured barks, particularly when mature. Most non-host trees, on the other hand, tend to have smooth barks. Rough or fissured barks of host-trees support the establishment of mycorrhizal fungi, which orchids depended on for vital nutrients. In this regard, orchid species-host tree-specificity will vary with the mycorrhizal relationship preferred by an orchid species, and therefore, this explains why host species with rough or fissured barks has more orchid species and populations in relation to those with smooth bark, thus influencing the distribution of Orchids, their diversity and abundance. Equally host trees that exhibit some features such as large trees, for instance, *Macaranga kilimandscharica* is a large tree, often with a pyramidal crown and hence the high number of orchids as compared to *Schefflera abyssinica* which is a small to medium-sized tree that hosts the list number of orchids. Again host tress display a gradient in bark age from the youngest branches to the basal trunk, and this is reflected in physico-chemical features such as the thickness, water-holding capacity and acidity of bark, in regard to this most orchid clumps above the main the trunk where the conditions for orchids survival are more conducive since water-holding capacity affects habitat condition for survival of orchids. Considering the degradation regimes, Intact forest had a greater abundance of orchid clumps ha^{-1} hosting all the 5 orchid species, while moderately disturbed forest hosted only 2 of the 5 orchids identified in Mau forest with fewer abundance of orchid clumps ha^{-1}.

For the highly degraded forest regime there were no orchids since the host trees were destroyed. Results from this study indicated that orchid species richness, abundance, and diversity decreased with an increase in the severity of forest degradation.

Therefore, examining the efficacy of existing conservation strategies is necessary in order to reverse the decline in orchid populations in disturbed tropical montane forests. In addition, the conservation of orchid host-tree species should be given priority in order to secure orchid habitats through reforestation of the most preferred host tree species in protected and unprotected forest ecosystems and regulating through licensing extraction of wild orchids for medicinal purposes and other economic uses, and bring in the aspect of *in-situ* and *ex-situ* conservation of orchids.

Acknowledgement

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Financial expenditure:

Item	Description	Total (USD)
Minor equipment	1. Laptop (HP Probook 450)	520.00
Minor equipment	Garmin GPS	350.00
Minor equipment	Bushnell 8MP Trophy Cam HD Hybrid Trail/ Trigger Camera	360.00
Subsistence/ accommodation	Scientists, students, field assistants and KFS warders	930.00
Laboratory reagents	Consumables/ Expendable supplies for molecular analysis	0.00
Local transportation	4-Wheel drive car hire and fuel for the field	550.00
Documentation	Printing, photocopying, library access/software/Publications	420.00
Research Authorization	Research permits for the scientists	50.00
Other costs	Data analysis, coordination, postage, courier services	320.00
Total		**3500**

Attachments:

Figure 1: Research team displaying orchids found on logged host trees

Figure 2: Researchers observing epiphytic orchids on a host tree

Figure 3: Scientist measuring the diameter of orchid host tree

Figure 4: The research team holding a field discussion

Figure 5: The research team using the Orchids of Kenya guide book to identify orchids

Figure 6: Researchers assessing damage on orchids and their host trees

Figure 7: Researchers confirming the identity of a terrestrial orchid

Figure 8: Researchers rescuing damaged epiphytic orchids