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A Catalog of Orchid Species and Their Distribution in Mazumbai Forest Reserve, Tanga Region, Tanzania

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SIT Study Abroad

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SIT Tanzania Fall

Acknowledgements

First, I would like to thank my guide Imamu for running down the mountain with me, rolling up my measuring tape, and repeating many, many times how to spell tree names in Kisambaa. I would also like to thank Oscar and Felicity who, by guiding me through the ISP selection process, enabled me to study something I didn't even know I was interested in. I want to thank the experts for teaching me the data collection techniques that I later used in my ISP. I want to thank Mama Juni for all she does behind the scenes for SIT, and for always asking how we were during our weekly phone calls. I would like to thank Mr. Kiparu, my advisor and the head forester at Mazumbai Forest Reserve for helping me construct my ISP report and hosting us at the Mazumbai Chalet. I would like to thank Beatrice and David for cooking three delicious meals a day for us and letting us take over the kitchen on Thanksgiving. I want to thank the staff of Mazumbai for helping us get hot water and playing Frisbee with us in the evenings. Lastly, I would like to thank my 5 wonderful Mazumbai companions for teaching me how to headstand and distracting me from orchid identification with too many games of rummy.

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Abstract

Although orchids are common in Mazumbai Forest Reserve (MFR), there are limited resources on where they grow and how to identify them. The primary objective of this study is to create an updated catalog of orchids in MFR, using species abundance, richness and diversity of the orchids as indicators of where orchids prefer to grow in MFR. Orchid species vary greatly as altitude changes, making it important to survey orchids across different altitudes. Therefore, Mazumbai Forest was split into five different altitudinal bands spanning 1400 – 1900m and six 100 x 20m plots in each band were surveyed for both epiphytic and terrestrial orchids. All orchid species recorded was also photographed: both as a means of identification, and as a future reference for orchid species determination. In total, 337 individual orchids, and 15 different orchid species were cataloged. The catalog pictures all 15 species of orchids and gives a short description on the morphological characteristics, and habitat of each species (Appendix III). A one-way ANOVA showed that orchid abundance was significantly different across altitudes, F (4, 25) = 3.23, p = 0.03), but orchid richness was not F (4,25) = 1.82, p > 0.05. Orchid abundance was greatest from 1400 – 1500m elevation (n = 141), and species richness was greatest from 1500 – 1600m elevation (n = 7). Diversity, calculated using Simpson's Index of Diversity was highest between 1600 – 1700m (D = 0.615), and lowest between 1400 – 1500m (D = 0.372). Terrestrial orchids were only found from 1700 – 1900m elevation, while epiphytic orchids were found in all elevation bands. Epiphytic orchids had a variety of tree hosts (n = 23) and did not appear to strongly prefer one tree species.

Introduction

The Eastern Arc Mountains, located in the northeast corner of Tanzania are composed of thirteen mountains and 3300km^2 of forested area. These mountains are biologically important and a conservation priority. Climate in the Eastern Arc Mountains has remained relatively stable for millions of years, and as a result, the mountains contain a number of both ancient and more recent endemic species. They are also important for their water catchment capabilities, supplying water to the surrounding local populations, and even to major cities such as Dar es Salaam (WWF, 2013). Recent deforestation in the Eastern Arc Mountains has contributed to a loss in biodiversity and threatens endemic species to extinction (Hall, 2009). Protected areas are crucial to maintaining biodiversity and preserving endemic species in the Eastern Arc Mountains. Mazumbai Forest Reserve (MFR), located in the West Usambara Mountains of the Eastern Arc Mountains, is one such protected area. Mazumbai Forest Reserve (MFR) is a tropical forest that ranges from 1300 m to 1900 m in altitude and is known as a biodiversity hotspot. Part of the reason for MFR's great biodiversity is the elevation range that it covers. Elevation plays a large role in species diversity, because environmental factors change more drastically with differing altitudes than with constant altitudes. This means that larger changes in elevation will be accompanied by greater species diversity (Zhang, 2015). Elevation is also important when considering which species will be affected by habitat degradation. Species growing at one elevation may be subject to different habitat pressures than those growing at another elevation. This makes it crucial for conservationists to focus on an entire elevation gradient when preserving an area (Hall, 2009).

The *Orchidaceae* family comprises one of the largest and most diverse families of flowering plants in the world, containing over 25,000 known species. Orchids have high rates of speciation, so different species are specialized to reside only in very specific habitats (Zhang, 2015). They grow mainly as epiphytes (non-parasitically on trees), but they can also grow terrestrially. Epiphytic orchids tend to grow in warmer, moist climates, and anchor themselves to tree canopies where they can receive more light. Terrestrial orchids tend to grow in more temperate regions and can withstand lower light conditions as they grow on forest floors. Characteristically, orchids are bilaterally symmetrical, with the bottom petal extending further than the rest in order to attract pollinators (Chadwick, 2017). Orchids, particularly terrestrial orchids, are endangered because of increasing pressures of climate change and habitat fragmentation (Wang et al., 2015).

The great diversity and exotic beauty of orchids makes them a target of observation and admiration worldwide. The orchids in MFR are no exception. Lucie Tanner, one of the founders of MFR, documented the orchids of the Usambara Mountains between 1946 and 1982. This resource pictures and identifies over 60 orchids that she found in the Usambara Mountains. However, the reference is outdated, and does not contain information on where to find the orchids in MFR. This poses a problem to visitors of Mazumbai Forest who are interested in the endemic orchids there, making it difficult to direct the visitors where to look for the orchids. A more cohesive and recent catalog of orchids in MFR could be used as a resource to identify orchids commonly found in Mazumbai Forest. Orchids grow both epiphytically and terrestrially in MFR. In dense parts of the forest, epiphytic orchids grow mainly on the crowns of trees, while in parts of the forest that receive more sunlight, epiphytic orchids can be found closer to the ground. Epiphytic orchids in the Usambara mountains grow on a variety of tree species, but there is evidence that they prefer hosts with rougher bark (Moreau W., 1939). A combination of the elevation changes in MFR and the fact that orchids grow in very specific habitats makes is likely that one species of orchid will not be found at every elevation. A study from the mid 1900s of orchids in east Africa found that orchid species diversity in the Usambara Mountains is highest below 1530m in elevation and then declines as elevation increases, while a more recent study of orchids in China shows that orchid diversity peaks between 1400m and 1700m (Moreau W.; Wang et al., 2015). However, a study on epiphytic orchids in Mazumbai Forest from 2013 found the highest abundance of orchids between 1400 – 1500m and 1700 - 1910m (Patterson, 2013). Therefore, is necessary to look at different elevations in the reserve in order to get a more complete picture of the orchids in MFR. Differences in orchids abundance, richness, and diversity between elevations could also increase the information on the biodiversity of different elevations in MFR since orchids are a marker of biodiversity. This study will focus on how the abundance, richness, and diversity of orchid species varies across different elevations in MFR. I predict that the abundance, richness, and diversity will differ across elevations, peaking between 1400 and 1500m, because evidence suggests that orchid abundance and richness are greatest in this elevation range. The goal of this study is to add to the limited current documentation on where different orchids species reside in Mazumbai Forest. I hope that by answering the question above, this study will: 1) help visitors looking for orchids find and identify them, and 2) add to the information on biodiversity in MFR based on elevation.

Study Site Description

The entirety of this study was conducted in Mazumbai Forest Reserve. MFR is a 320 ha area of protected forest in the West Usambara Mountains, which are part of the greater Eastern Arc Mountains. Mazumbai Forest used to be a tea plantation owned by John Tanner, but in 1984, ownership of MFR was transferred to Sokoine University. The forest is now protected full time, and is one of the last remaining pristine forests in the Eastern Arc Mountains (Redhead, 1981). Winds from the Indian Ocean have kept temperatures in MFR relatively constant, and have provided the forest with consistent rainfall. The forest also functions as a water catchment area for the surrounding human populations (Patterson, 2013). While the Mazumbai Forest is protected, it also suffers biodiversity loss. Bordered by the Sagara Community Forest on the north, and agricultural land on the east, MFR has experienced increasing human pressures as surrounding populations illegally use the forest as a resource for food and firewood. In addition, changes in Indian Ocean temperatures as a result of climate change have affected, and will continue to affect, rainfall in Mazumbai Forest (Burgess et al., 2007).

Vegetation in MFR varies considerably based on elevation. A study from 2001 found four major elevation bands in Mazumbai Forest, each with a distinct plant community (Pantaleo, 2001). The lower montane community extends from 1300 – 1500m elevation, the intermediate montane from 1500 – 1600m, the upper montane from 1600 – 1700m and the heath from 1700 – 1900m elevation. The unique nature of each plant community makes it important to look at orchids in all elevation bands.

Methods and Ethics

This study was conducted in Mazumbai Forest Reserve from November 3^{3d} to November 20^{th}, 2018. The catalog surveyed both terrestrial and epiphytic orchids in MFR. Data collection took place in the mornings from 8am – 1pm, and orchid identification took place in the afternoons. The survey of orchids spanned 1400 – 1900m in elevation, covering the majority of the elevation gradient of Mazumbai Forest. The elevation range was sectioned into five altitudinal bands to organize data collection and data analysis. Band 1 ranged from 1400 – 1500m, band 2 from 1500 – 1600m, Band 3 from 1600 – 1700m, Band 4 from 1700 – 1800m and band 5 from 1800 – 1900m. Altitude was measured using the phone application Altimeter, (Hearn, 2018).

In each band, orchids were surveyed in six 100m x 20m plots, so each plot covered $2000m^2$. The plots were constructed using two 50m measuring tapes aligned head to foot, so that the 100m side of the plot ran parallel to the slope. The measuring tapes bisected each plot and all orchids within 10m to either side of the tapes were surveyed. Epiphytic orchids growing more than 25m high on a tree were not included in the survey because they could not be identified accurately. Plot locations were determined systematically in each altitudinal band by going to the highest elevation of each band and subsequently surveying plots 15m apart in elevation. For example, in band 1 plots were surveyed at 1500m, 1485m, 1470m, 1455m, 1440m, and 1425m (Figure 1). This was done because not all locations in Mazumbai Forest are accessible, and systematic sampling maximized the span of elevations surveyed in each band.

A trained Mazumbai forest guide aided in determining plot locations, measuring out plots and identifying host tree species. Importantly, the guide was also helpful in minimizing impact on the forest. He enabled the use of forest paths whenever possible, and appeared to only cut down branches and vines when necessary. No orchids or other plants were removed from the forest during this study.

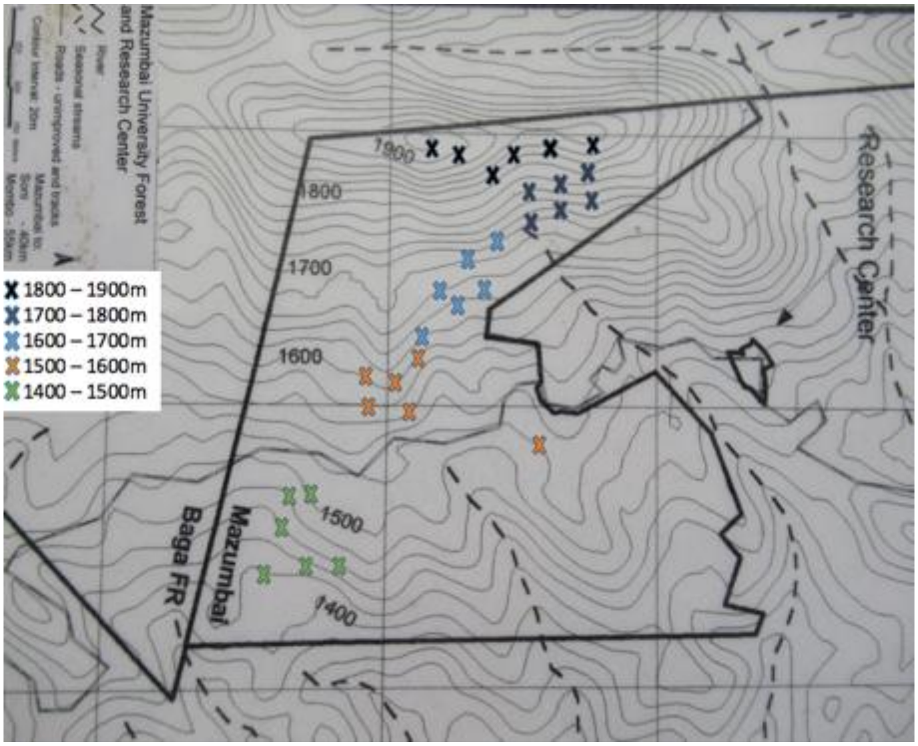


Figure 1. A map of Mazumbai Forest Reserve with X's marking approximate plot locations (see key).

Every day, pictures were taken of each species suspected to be an orchid and the photo number, number of orchids per species, growth form (epiphyte or terrestrial) and host tree species were recorded. Pictures of orchids on tree canopies were taken with a camera, which was capable of zooming clearly to 25x. As the guide identified all tree species, tree names were recorded in Kisambaa and later translated into Latin. The guide also gave the orchid species names in Kisambaa, but these were not used in the identification process as there is no available translation of orchid species from Kisambaa to Latin. To identify orchids, the pictures were compared to Lucie Tanner's guide of orchid in the West Usambara Mountains, as well as online guides of orchids in East Africa (Ballings, 2018; Pfhal, 2018; Tanner, 1946 – 1982; Wurston, 2018).

Diversity was measured at each altitude using Simpsons Index of Diversity (SID). Values calculated using SID that are closer to one indicate greater diversity. SID is a commonly used measure of diversity, thus diversity measured by this index is comparable across studies. A one-way ANOVA measured differences in species abundance and richness over the 5 altitudinal bands surveyed. Abundance, richness, and diversity were correlated using a Pearson's correlation.

Results

In total over all of the elevations surveyed in MFR, 15 species, and 337 orchids were cataloged. Of all the orchids recorded, 8% were terrestrial and 92% were epiphytic. *Cyrtorchis praetermissa* was the most abundant species, making up 42% of the recorded orchids (n = 143). *Angraecum Minus*, *Bulbophyllum Maximum*, *Polystacya Eurygnatha,* and *Polystachya Isochiloides* were the least abundant species, each with only one orchid cataloged (Figure 2).

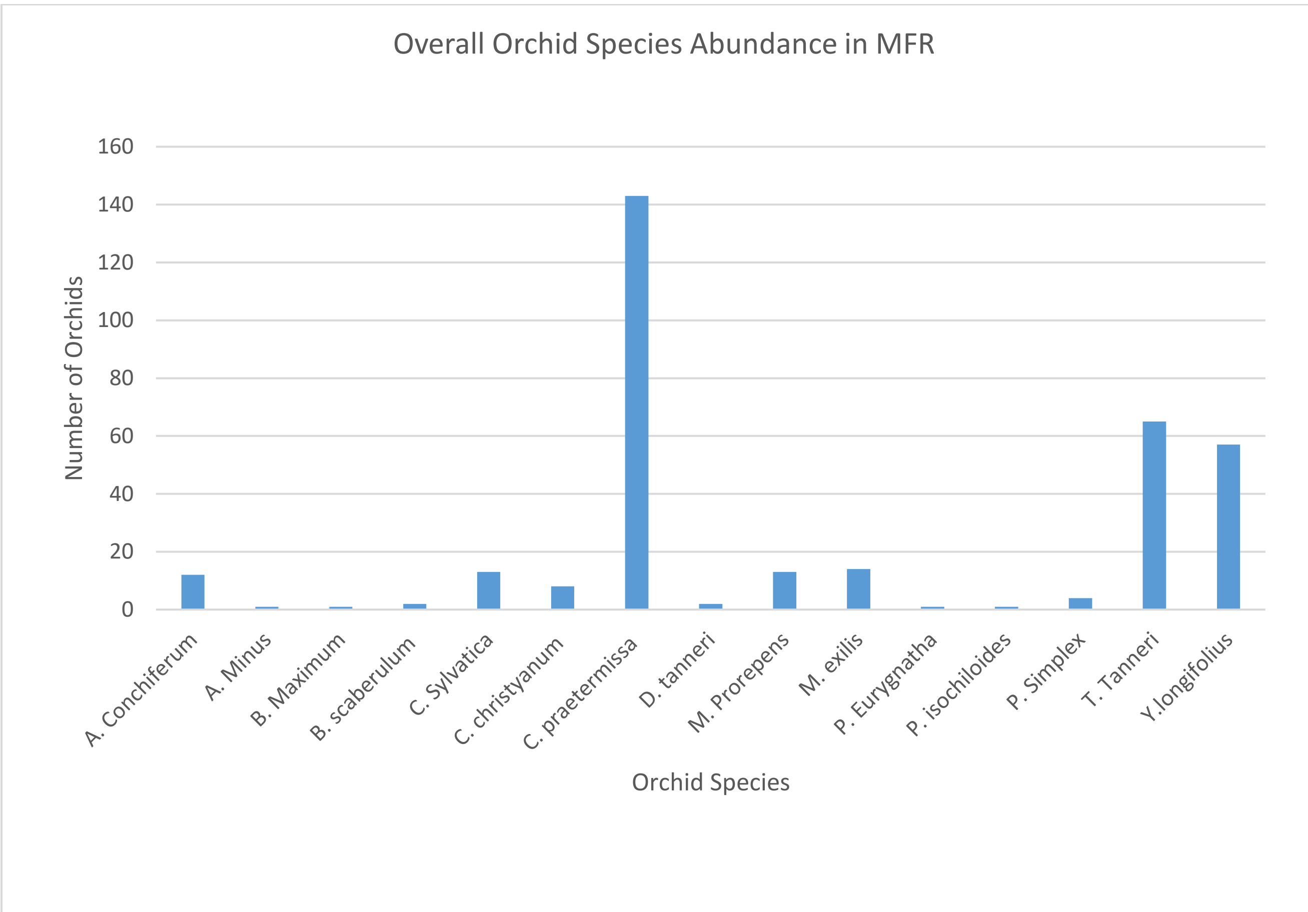


Figure 2. Overall abundance of all orchid species cataloged in MFR from 1400 - 1900m elevation (n = 337).

No species were present in every elevation band, although *Ypsilopus longifolius* was observed in every band except for band 4. Two species, *Malaxis Prorepens* and *Calanthe Sylvatica*, out of the 15 recorded were terrestrial orchids. All other orchid species observed were epiphytes. Terrestrial orchids were only found in the two highest elevation bands, while epiphytic orchids were observed in every elevation band (Table 1).

Table 1: Observed elevations and growth form of each orchid species found in MFR along with their scientific and Kisambaa names. Band 1 spans 1400 – 1500m, band 2 1500 – 1600m, band 3 1600 – 1700m, band 4 1700 – 1800m and band 5 1800 – 1900m.

Scientific Name	Kisambaa Name	E/T	Band 1	Band 2	Band 3	Band 4	Band 5
Angraecum Conchiferum	Mnavo	E	x	x			x
Angraecum Minus	Mnavo	E		x			
Bulbophyllum platyrhachis	Kidadaishe	E				x	
Bulbophyllum scaberulum	Shungamzinga	E			x		
Calantha Sylvatica	Kogho	T				x	x
Calyptrochilum christyanum	Kiandama	E		x			x
Cyrtorchis praetermissa	Onge	E	x	x	x		
Diaphananthe tanneri[1]		E	x				
Malaxis Prorepens	Nkoko	T				x	x
Microcoelia exilis	Ushwe	E	x	x			
Polystachya Eurygnatha	Kngwee	E		x			
Polystachya Isochiloides	Kngwee	E			x		
Polystachya Simplex[1]		E	x				
Tridactye Tanneri	Ndeema	E					x
Ypsilopus longifolius	Owenge	E	x	x	x		x

A one-way ANOVA of orchid abundance based on elevation band showed that orchid abundance varied by elevation F (4, 25) = 3.23, p = 0.03; Figure 3).

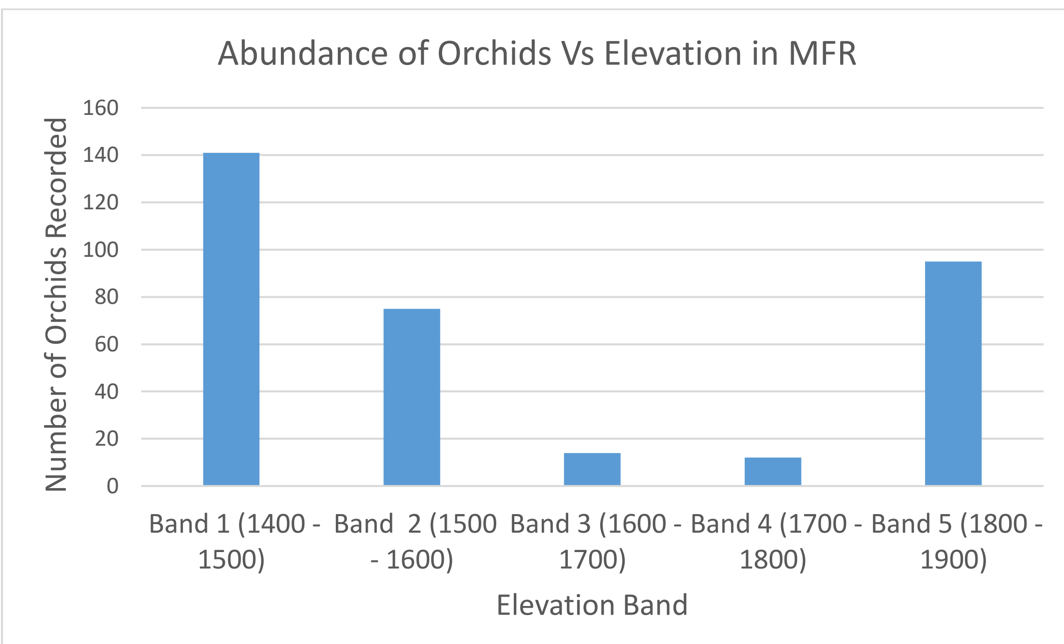
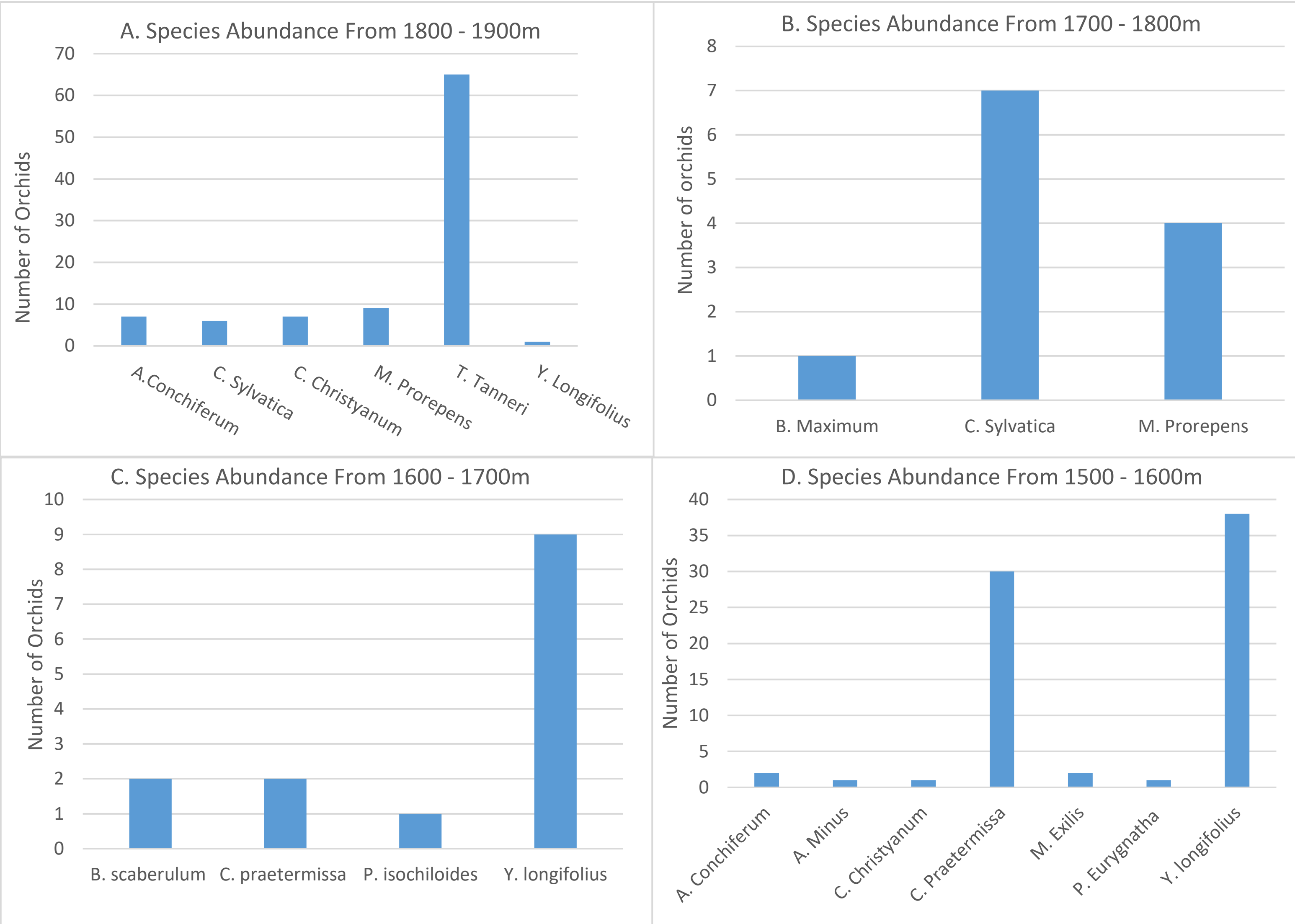


Figure 3. Abundance of individual orchids based on elevation in MFR.

[1] Kisambaa Species name unknown

Ypsilopus longifolius was the most abundant species in both bands 2 and 3, from 1500 – 1700m. *Tridactlye Tanneri* was the most abundant species found at 1800 – 1900m (n = 65), and it was not found in any other elevation band (Figure 4, Table 1). Similarly, *Calanthe Sylvatica* was found only from 1700 – 1800m and was the most abundant species present at that elevation. *Cyrtorchis praetermissa* was by far the most abundant species in band 1, containing 111 out of 141 species cataloged between 1400 – 1500m (Figure 4).



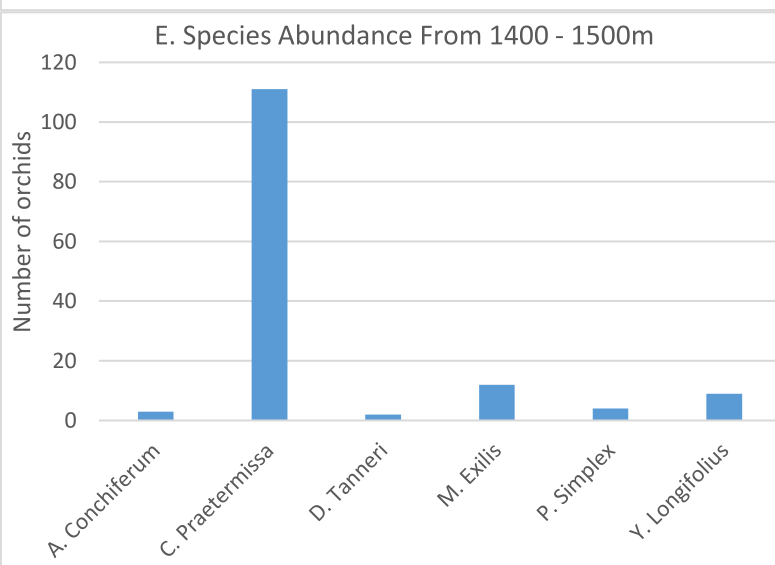


Figure 4. Species abundance by elevation for **A.** band 5 (top left), **B.** band 4 (top right), **C.** band 3 (middle left), **D.** band 2 (middle right) and **E.** band 1 (bottom left).

Species richness was not significantly different based on elevation $F\ (4,25) = 1.82$, $p > 0.05$. The highest observed species richness was in band 2 (1500 – 1600m), with 7 species cataloged, while band 4 (1700 – 1800m) had the lowest richness with 3 species cataloged (Figure 5).

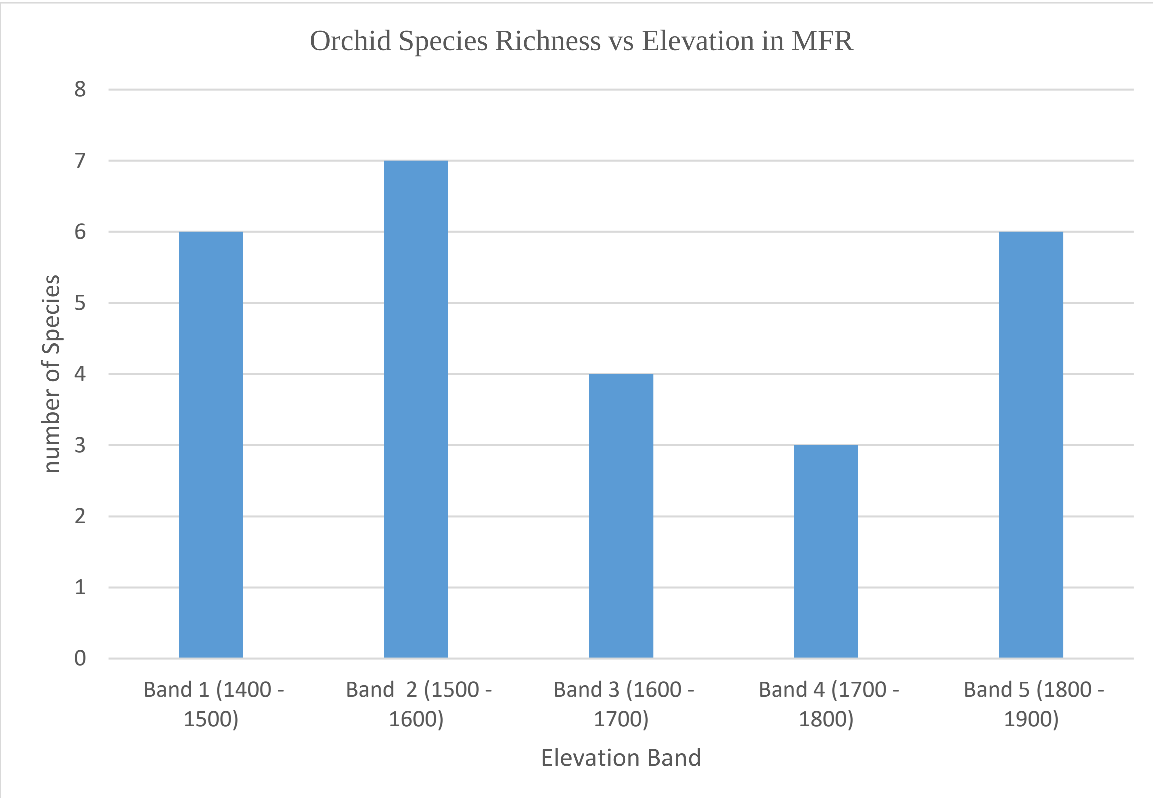


Figure 5. Orchid species richness in each of the five elevation bands surveyed.

Calculations of species diversity using Simpson's Index of Diversity show an inverted U-shaped curve of orchid diversity, where diversity is highest in the intermediate elevations and declines at the exterior elevations of MFR. Diversity peaked from 1600 – 1700m elevation (D = 0.615), and was the lowest from 1400 – 1500m in elevation (D = 0.372, Figure 6). All diversity values calculated based on elevation bands were lower than the overall value of orchid diversity in MFR of 0.75.

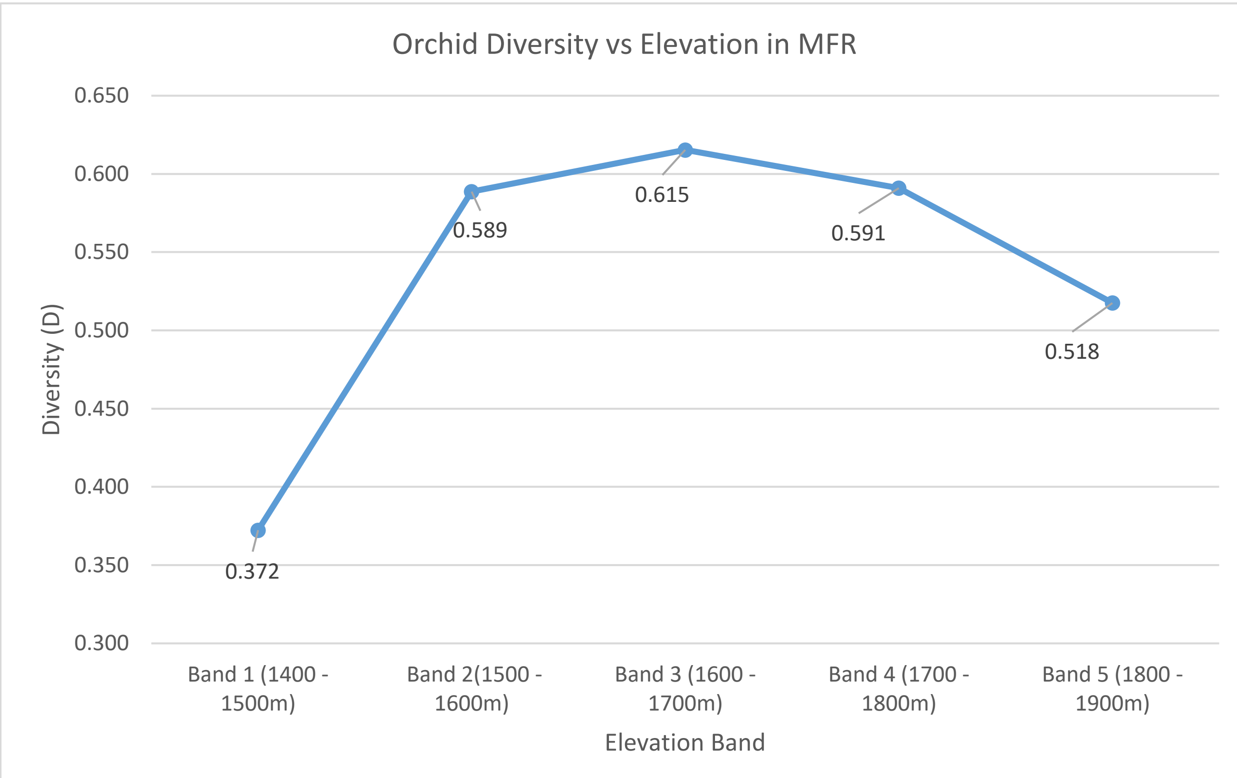


Figure 6. Orchid diversity in each elevation band surveyed. Diversity was calculated using Simpson's Index of Diversity.

Species abundance, diversity, and richness all peaked at different elevations. Elevation bands 3 and 4 had the lowest species abundance and the greatest species diversity, while band 1 had the highest species abundance and the lowest species diversity (Figure 7). There was a significant negative correlation between species abundance and diversity (r = -0.89, p = 0.043 < 0.05), so as abundance decreased, diversity increased. In addition, there was a positive correlation between species richness and species abundance, but this relationship was not significant (r = 0.77, p >

0.05). The correlation between species diversity and species richness was not significant ($r = -0.41$, $p > 0.05$).

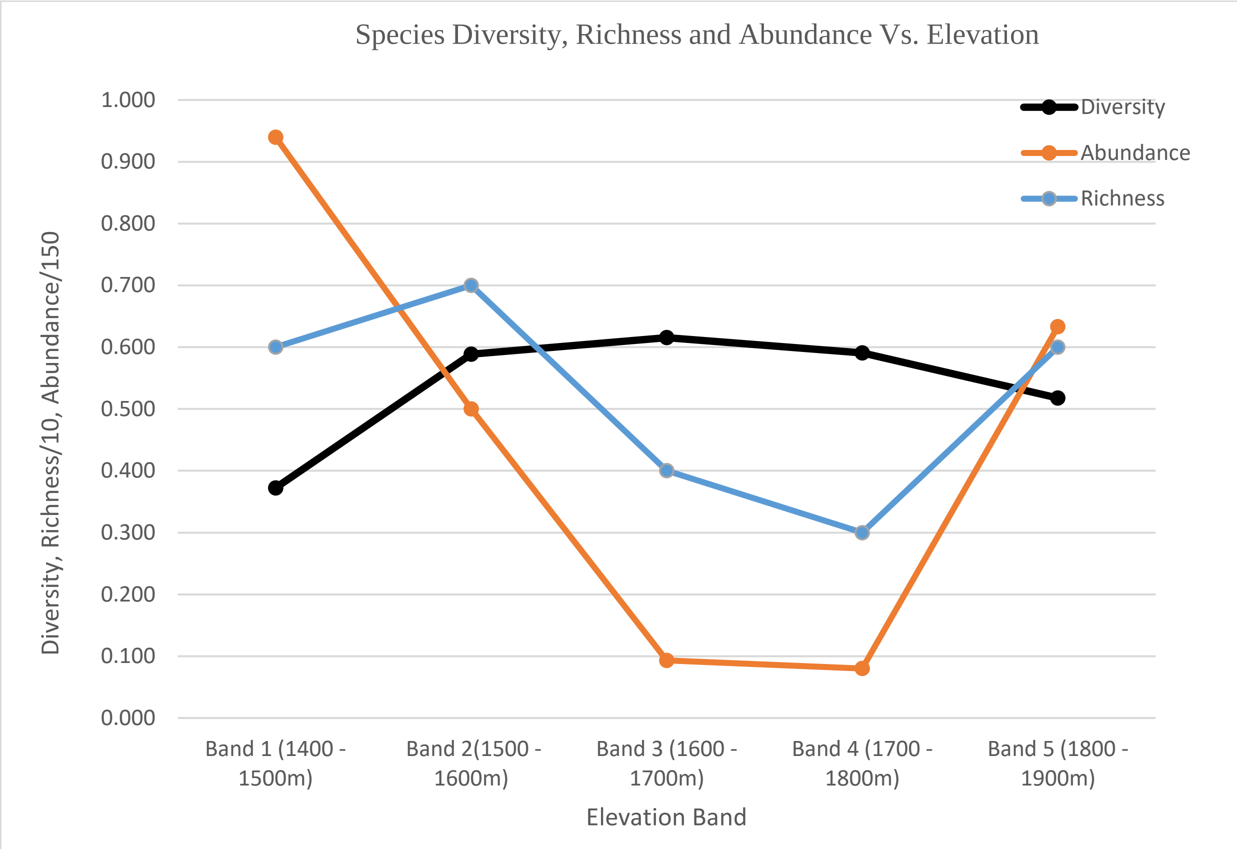


Figure 7. Species diversity, richness and abundance over 5 elevations in MFR. Species richness was divided by 10 and species abundance was divided by 150 to scale them to species diversity.

Epiphytic orchids were found on 23 different host tree species (Appendix II). In general, host trees were large with rough bark, and were also hosts to multiple species of mosses and ferns. Orchids were found growing on small branches in tree canopies, in nodes where the host tree trunk split, or on fallen branches of host trees. *Maesa lanceolate* and *Sorindeia usambarensis* were the most common host species, each carrying 39 individual orchids. *Parinary excels* was host to the greatest variety of orchids, hosting 7 different orchid species (Appendix II).

Discussion

As hypothesized, orchid species abundance varied with elevation, peaking between 1400 – 1500m. However, this mainly because so many individual *Cyrtorchis Praetermissa* were found in band 1. Orchids at this elevation were concentrated in one dominant species rather than spread evenly among many species. The domination of one species in an area is related to species competition. When competition is high, only species most fit for the environment will thrive. On the flip side, when competition is low, it leaves more room for more species to grow. In band 1, *Cyrtorchis Praetermissa* is likely dominant because it has out-competed other species for the resources, in that elevation band.

Contrary to the hypothesis, species richness was not significantly different over elevations, however, no species were found at every elevation. This indicates that different orchid species may be specialized to very specific niches in MFR. One species may only grow within a narrow elevational range, causing different species to be found in different altitudinal bands. *Ypsilopus longifolius*, is probably the most generalist species observed, as it was found in all but one elevation band and thus can survive in a greater range of elevations.

Previous research on orchids in MFR found the greatest number of orchids in the lower montane region (1400 – 1500), but said nothing about the diversity of orchids at this elevation (Patterson, 2013). While orchid species diversity changed based on elevation, species diversity was the lowest between 1400 – 1500m in elevation, which goes against the initial prediction that diversity would peak between 1400 – 1500m. Simpson's Index of Diversity takes into account both the species richness and the evenness of a species within an area (Simpson's Diversity Index, 2000). Species richness was fairly high between 1400 – 1500m, but the abundance of orchids per species was not evenly distributed. Diversity was low in band 1 because the probability of observing *Cyrtorchis Praetermissa*, was much greater than the probability of observing a different species in this elevation band.

In general, orchid abundance impacted diversity more than richness impacted diversity. There was a significant negative correlation between abundance and diversity, while there was no significant correlation between richness and diversity. A greater abundance only increases diversity if abundance is spread evenly among many species, which was not the case in this study. While high species richness is usually an indicator of high species diversity, in this study, elevations that had the most species also tended to have a higher abundance of orchids. As abundance was correlated with lower diversity, species richness was also inversely related with diversity, although this relationship was not significant. A third variable, such as species competition, may have affected abundance and diversity, driving the significant negative relationship observed.

Movement away from the equator is accompanied by a decrease in species richness and diversity because climatic conditions become less favorable for biodiversity. It is often believed that increases in elevation resemble this effect, because of similar temperature changes at higher elevations (Rahbek, 1995). However, a number of studies have found a hump-shaped curve, rather than a steady decline, of species richness and diversity moving up an elevation gradient (Kluge, 2006; Rahbek, 1995; Zhang, 2015). Particularly in tropical forests, water supply is the most stable in the cloud zone, which tends to fall at more intermediate elevations. For species such as epiphytes, this peak in moisture also coincides with a peak in species diversity (Rahbek, 1995). This may have contributed to the inverted U-shaped curve of diversity observed in this study. Environmental factors such as high moisture levels could be greater in MFR at elevations of 1500 – 1800m than at lower or higher elevation, making this elevation range more favorable for a diversity of orchid species. The mid-domain effect (MDE) could also explain why diversity was highest in the intermediate elevations. The MDE predicts that species diversity will be higher at middle elevations, because species growing only in specific habitats are most likely to overlap in the middle of an elevation gradient (Zhang, 2015).

Orchids did not appear to have a strong affinity for one tree species. Often, many orchids of the same species were found on a single host tree. This was the case for *Maesa lanceolate* and *Sorindeia usambarensis,* which were the tree hosts with the highest abundance of orchids. Factors such as tree size and bark composition seemed to play a larger role in epiphytic orchid abundance than tree species. Orchids preferred host trees with rougher bark, as this helps them obtain nutrients and attach to the host tree (Patterson, 2013). Orchids were also less prevalent on tree hosts that carried other epiphytes such as *Elaphoglossum Lastii,* but were often accompanied by lichens or ferns.

It is also important to note that terrestrial orchids were only found in the two highest elevation bands, indicating that they may prefer different climatic conditions than epiphytic orchids. Previous research has found that species richness for terrestrial orchids peaks at a higher elevation than species richness for epiphytic orchids (Zhang et al., 2015). This is likely due to a combination of differences in the ways terrestrial and epiphytic orchids are affected by temperature and access nutrients. While this study focused on all orchids, a further study could look at epiphytic and terrestrial orchids separately, as there is evidence that the two types of orchid are impacted by altitude-related factors differently. In addition, a study looking at the orchid species diversity in Sagara Community Forest compared with the species diversity in Mazumbai Forest could be interesting and informative. This comparison would illuminate to what extent conservation efforts in MFR are maintaining orchid diversity, and even overall biodiversity.

Biases and Limitations

There are limitations to this study that should be taken into account when considering the results. First and foremost, not all orchids could be identified with 100% confidence. Orchid species can be nearly indistinguishable when flowers are not observed, which was often the case in this study. Species determination utilized both pictures and habitat information to pair a known scientific name to each observed orchid species, however, there was still some subjectivity in species determination.

The epiphytic nature of orchids also created an issue of visibility, as many orchids grow high in the tree crowns. Orchids growing more than 25m high were not recorded as they were out of range of the camera and thus could not be identified accurately. Although the methodology remained consistent in each plot, orchids growing from 1700 – 1900m are on average 11m lower than orchids growing in the rest of MFR (Patterson, 2013). As a result, orchid abundance, richness, and diversity in the highest two elevation bands may have appeared greater compared to the rest of MFR than they actually are.

Conclusion

Orchids were found at every elevation in Mazumbai, although species abundance varied significantly with elevation. Orchids were most abundant between 1400 – 1500m, and least abundant between 1600 – 1700m. Species richness was statistically the same at every elevation in MFR, but different species were found in different elevation bands. Diversity peaked from 1600 – 1700m, and was the lowest between 1400 – 1500m which contradicted the hypothesis that diversity would be greatest between 1400 – 1500m. Terrestrial orchids were observed much less frequently than epiphytic orchids, and were only found at the two highest elevation bands.

Information may be extracted from this study on the general biodiversity of MFR at different elevations. First, the high species abundance from 1400 – 1500m suggests that species competition in MFR is higher in this elevation range. Second, the elevation gradient of Mazumbai likely contributes to the biodiversity of the protected area, since each elevation band contained a unique combination of orchid species. Third, climatic conditions at middle elevations in MFR may be the most favorable for biodiversity, as mid elevations optimize factors such as rainfall and overlapping habitats. The protection of Mazumbai Forests is increasingly important as climate change and human pressures continue to decrease similar tropical forests in the Eastern Arc Mountains.

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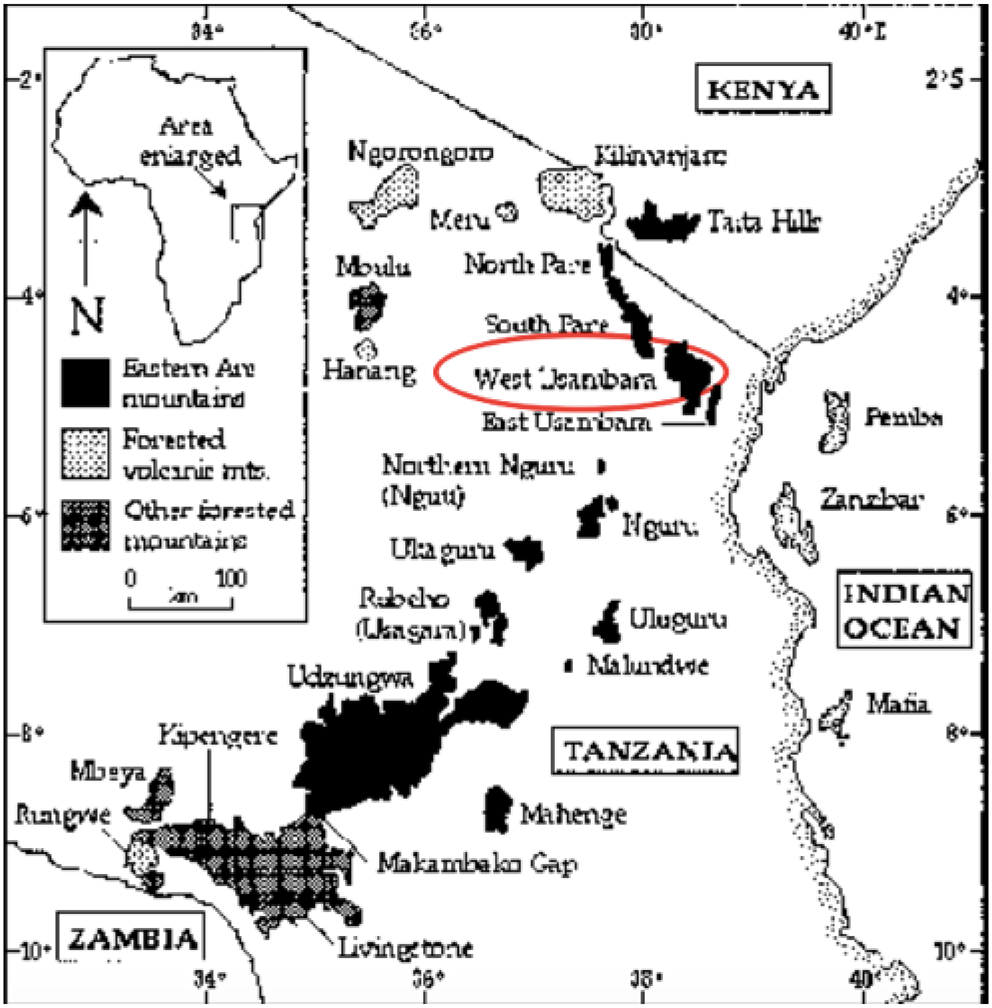
Appendix I

A map of the Eastern Arc Mountains with the West Usambara Mountain circled in red.



Appendix II

Epiphytic orchids with their tree species hosts. Epiphytic orchids are listed in the rightmost column and tree species are listed as numbers in the top row, (key indicates tree species). The table shows the number of each orchid species on each tree host.

	Tree Species																						
Orchid Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**Total**
A. Conchiferum			2			3														7				12
A. Minus																		1						1
B. platyrhachis																			1					1
B. scaberulum																		2						2
C. christyanum																	1			7				8
C. praetermissa	2	8			14	2	5	2			5			38	1		15	2	21		15	11	2	143
D. tanneri						1										1								2
M. exilis					1	1	1	2	3					1		1			3				1	14
P. Eurygnatha																			1					1
P. isochiloides																		1						1
P. Simplex	4																							4
T. Tanneri			5	26			1			7		5	10			3			1	7				65
Y.longifolius			1		2	2	1								1		6	8	5		24	7		57
Total	6	8	8	26	17	9	8	4	3	7	5	5	10	39	2	5	22	14	32	21	39	18	3	

Tree Species	Number	Tree Species	Number
Albizia schimperiana	1	*Macaranga kilimandscharica*	13
Allanblankia stuhlmanii	2	*Maesa lanceolata*	14
Aphloia theaeformis	3	Mhoshwe[2]	15
Bersama abyssinica	4	*Myrianthus arboreus*	16
Casearia engleri	5	*Newtonia buchanani*	17
Craibia brevicaudata	6	*Ocotea usambarensis*	18
Dicranolepis usambarica	7	*Parinary excels*	19
Entandrophragma deiningeri	8	*Podocarpus usambarensis*	20
Ficus thoningii	9	*Sorindeia usambarensis*	21
Ficus valis-choudae	10	*Syzygium guineense*	22
Hombo[2]	11	*Vernonia iodocalyx*	23
Kikusu[2]	12		

[2] Scientific names not found

Appendix III

A picture catalog of all orchid species observed from this survey of Mazumbai Forest. The catalog also contains a short description of the morphological characteristics of each species as well as the growth form of the species and where it might be located in MFR.

Angraecum Conchiferum: Linear, thick, somewhat pointed leaves emerging opposite each other from a central stem. 1 – 2 white, jasmine scented flowers bloom in the spring. Found as an epiphyte from 800 – 2400m elevation (Pfhal, 2018).

Angraecum Minus Summerh: Up to 4 linear green leaves emerging from a small stem. 1 – 6 small white flowers bloom from the stem in March. Grows epiphytically in high rainfall forests from 1000 – 1800m elevation (Ballings, 2018).

Bulbophyllum Maximum: Up to 3 thick leathery leaves emerging from oblong to ovoid pseudobulbs. Blooms in the fall on a 50cm stem carrying up to 50 small flowers. Grows epiphytically in riverine forests from 600 – 2100m elevation (Pfhal, 2018).

Bulbophyllum scaberulum: Two ovular fleshy leaves growing from pseudobulbs spaced along the rhizome. Flowers are purple, bloom in the fall and arise from a 5 – 55cm stem. Grows as an epiphyte or occasional lithophyte from 100 to 2300m in elevation (Pfahl, 2018).

Calanthe Sylvatica: Dark green elliptical leaves emerging from psudobulbs enveloped by the leaf sheath. Leaves are ridged and taper at the ends. Blooms in the spring and summer with many flowers on a 50 – 70cm stem. Found from 400 – 2700m elevation growing terrestrially on forest floors (Pfahl, 2018).

Calyptrochilum christyanum: Many apical, fleshy, oblong-shaped leaves protruding from a horizontal stem. White, lemon-scented flowers bloom in the late spring or summer. Grows epiphytically or lithophytically on rocks in riverine forest, from 900 – 1900m (Pfahl, 2018).

Cyrtorchis praetermissa: Erect stem with 4 – 6 pairs of distichous (opposite) linear, thick leaves. 2 sets of twelve white, waxy, sweet smelling flowers (2cm) bloom in the fall. Grows epiphyticaly in woodlands from 450 – 2200m in elevation (Pfahl, 2018).

Diaphananthe Tanneri: Numerous fleshy, snaking roots arising from a central stem. Produces multiple small yellow flowers growing close to the stem. Grows epiphytically in Mazumbai forest around 1400m in elevation (Tanner, 1946 – 1982).

Malaxis Prorepens: Multiple psudobulbs enveloped by a leaf sheath carrying 2 – 4 ovate, thin leaves. Blooms in the winter carrying 30 – 50 flowers. Found terrestrially from 550 – 1850m elevation (Pfahl, 2018).

Microcoelia exilis: Leafless epiphyte with grey-green roots emerging from a short stem. White/yellow inflorescence bloom in the fall and spring on a 2 – 13cm racemose. Found in riverine forests from 500 – 2000m elevation (Pfahl, 2018).

Polystachya eurygnatha Summerh: Cylyndrical psudobulb arising from the previous growth carrying 3 – 5 linulate-oblong leaves. Many green flowers (1cm) bloom in the spring Grows epiphytically from 1000 – 2350m elevation. (Pfhal, 2018).

Polystachya isochiloides: 3 to 5 linear, almost erect, apical leaves blooming on an unbranched stem up to 17cm. Four or more white flowers bloom on an upright stem. Grows epiphytically from 800 – 1700m (Pfahl, 2018).

Polystachya Simplex Rendle: 3-4 Glossy, green, elliptical leaves about 10cm long emerge from the cylindrical psudobulbs. Up to 15 green and yellow flowers bloom in December or January. Grows as an epiphyte or sometimes lithophyte from 900 – 1900m elevation in evergreen forests (Wurston, 2018).

Tridactyle Tanneri: Linear, bilobed leaves emerging from a central stem. Leaves are light green with dark green splotches. Blooms in the winter producing 2 – 8 green flowers. Grows Epiphytically from 1450 – 1900m elevation in shaded areas (Pfahl, 2018).

Ypsilopus longifolius: Five or six linear leaves of about 5-25cm long emerging from a central stem. Inflorescence 2 – 10 white flowers generally observable in March and April. Grows epiphytically between 1450 and 2400 m in elevation on branches of rougher trees (Pfahl, 2018).