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Edible Orchids in Makete district, the Southern Highlands of Tanzania:
distribution, population and status.

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Abstract

In Tanzania, "edible Orchids" are terrestrial species of the family Orchidaceae growing wildly, particularly in mountainous parts of the Southern Highlands, where their tuberous roots are dug up from the ground for human consumption. However, Orchid populations are overexploited in the Southern Highlands, due to trade with Zambia, and also other threats including changes in land use and habitat fragmentation, are prevalent. This study aimed to establish the status of edible Orchids, their diversity, abundance and habitat. Six Orchid genera and 17 species were gathered during this study, contributing 8% and 16%, respectively to the general flora of the study sites. Orchidaceae rank second position among plant families in terms of the number of species. Edible Orchid species contribute 6%, whereas for non-edible ones 10% to the total flora. Two species were found to be rare. These were *Habenaria occlusa* and *Eulophia schweinfurthii*. Orchidaceae, Asteraceae and Poaceae represent 50% of the species in the study sites. The edible Orchid species *Brachycorythis pleistophylla* and *Eulophia schweinfurthii* are reported for the first time as edible, probably their genera as well. Other edible species include *Satyrium buchananii, S. atherstonei, Disa ochrostachya, D. erubescens, D. robusta,* and *Habenaria xanthochlora*. Nine non-edible species are also listed. Having higher values of diversity indices, Kitulo portrays more diversity of Orchids and other plants species. Five species that occurred only at Kitulo were *Brachycorythis pleistophylla, Habenaria occlusa, Satyrium acutirostrum, Satyrium atherstonei* and *Satyrium buchananii.*
Grasslands account for 31% as an Orchid habitat of preference, followed by mbuga vegetation (22%) and woodland vegetation (19%).The overall Orchid population density was 37±28 individuals/10 m^2, whereas for edible and non-edible orchids it was 9±7 /10 m^2 and 28±26 /10 m^2, respectively. The population density of non-edible Orchids is thus, three times that of edible ones.

Key words; *Edible Orchids, Non-edible Orchids, Diversity, Abundance, Habitat, Tanzania, Makete, Southern Highlands,*

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Introduction

General

The family Orchidaceae comprise more than 20 000 epiphytic and terrestrial non-woody perennial species worldwide. The family is famous for its ornamental and medicinal values (Lehneback 1999; Cribb 2004) but also as a food delicacy (Davenport and Ndangalasi 2003; Bingham 2004; Cribb and Leedal 1982). In Tanzania, "edible Orchids" are terrestrial species of the family growing wildly, particularly in mountainous parts of the Southern Highlands, where their tuberous roots are dug up from the ground for human consumption (Davenport and Ndangalasi 2003; Hamisy 2005; Ruffo et al. 2002). They represent more than 80 species belonging to the genera *Disa*, *Satyrium*, *Habenaria* and *Brachycorythis* amongst others. These plants are abundant in upland or Montane grassland areas 1 200–2 700 m a.s.l. (Ruffo et al. 2002). Many rare Orchid species are found on Matamba Ridge, on the northern rim of the Kitulo Plateau.

All Orchid species are protected by the Convention on International Trade in Endangered Species (CITES), which requires certification of plants crossing international borders. However, scant knowledge of the trade's existence and a subsequent lack of enforcement of CITES rules, has led to a situation where truckloads of uncertified plants are entering Zambia each day. It is estimated that between 2.2 and 4.1 million tubers have been collected from the Tanzanian Southern Highlands region each year for consumption in Zambia (Davenport and Ndangalasi 2003).

Justification for the study

Orchid populations are overexploited in the Southern Highlands of Tanzania due to trade with Zambia. Some of the species are claimed extinct (Davenport and Ndangalasi. 2003). The growing trade between Tanzania and Zambia is an aftermath of a similar overexploitation of the species which led to extinction of the popular edible species of the genus *Disa* in northern Zambia (Bingham 2004). While trade poses a major threat, the fact remains of other threats including changes in land use pattern, expansion of agricultural land and growth of human enterprise (Cribb and Leedal 1982; Niet and Gehrke 2005; Hamisy and Millinga 2002; Gaston and Spicer 2004), all being potential competitors to Orchid habitats. Habitat loss is amongst the main threats leading to species extinction. Local people in Makete claim that Orchids do grow in areas where cultivation has been dormant for at least three years (Davenport and Ndangalasi 2003; Hamisy 2005) and in open grassland or sparse vegetation and that they occur only rarely in *Pinus* and *Eucalyptus* plantations – a growing economic activity in the area (Plates 1 and 2). This puts forth an argument that increased agricultural land and forests in the area are likely to disturb Orchid habitats. Some Orchid collectors in Kitulo indicated during this study survey that most Orchid species scantly found under forest plantation are non-edible ones.

A

B

C

Plate 1. A - Mobile saw mill at Ndulamo village forest plantation; B - New forest plantation at Ilindiwe; C - Cypress forest plantation established at the heart of a prime area for Orchids collection.

It is upon this awareness that the government of Tanzania decided to establish the Kitulo national park (275 km^2), famously known as the Garden of God by the local community because of its flowering blossoms, for conservation of its unique flora including the Orchid species endemic to the area (Davenport and Ndangalasi 2003; Bingham 2004). Apart from the richness in the Orchids there are also found a generally rich flora and fauna. Twelve globally significant bird species are found in the newly designated areas, including breeding colonies of blue swallows, Widowbird and Denholm's bustards (Cribb and Leedal.1982).

Many rare plant species are restricted to small isolated populations in which fitness may be reduced because of inbreeding, environmental and demographic stochasticity, and reduced pollination (Kéry et al. 2001). This is likely to happen in the established park, since the area turned to a national park is relatively small, implying wide exposure to local extinction due to resource competition and inbreeding pressures. For instance, spreading of forest plantations as one of the economic activities in Makete shall bring in considerable changes in land-use pattern so rapidly as the industry demands considerable amount of land for its returns to be realised. By the eighties, Cribb and Leedal (1982) noted that many of the most exciting areas were being destroyed by expanding cultivation or forestry. This is likely to bring considerable disturbances to the park and its inhabitants, as it will create habitat fragmentation and barriers to interaction between Orchid populations, including interaction between Orchid populations in the park and the surrounding areas, narrowing down the gene pool and creating small population sizes.

In light of these concerns, there is a need for studies to bring knowledge on several factors involving biodiversity conservation of Kitulo national park, including Orchids. This includes studies in the surrounding areas as well, to elucidate if they have any significant complements to the biota so as to avoid any negative impact to the conservation area. This study was therefore designed in line with the scenario above to address some of the pertinent issues regarding edible Orchids.

Objectives of the study

General objective

The overall objective of this project is to study the status and distribution of edible Orchid populations and also to discuss conservation management strategies in an area with high exploitation of the Orchid resource.

Specific objectives

1. To identify and prepare a checklist of edible Orchids of the study area in Makete District.
2. To study their population distribution among habitat types and with different disturbances.
3. To estimate their abundance.

Study area

Description of the study area

In the southern part of Tanzania lie the Southern Highlands, famous for their flora and fauna. The highlands have an altitudinal range of about 1 500 to 2 961 m above sea level (Fig. 1).They cover the Southern regions of Tanzania which include Mbeya, Iringa and Rukwa administrative regions (Davenport and Ndangalasi 2003; Cribb and Leedal 1982). Several distinct sectors in this area include Ufipa plateau, the great Rukwa escarpment, Mbozi plateau, Kitulo plateau, Kipengere range, Uporoto, Umalila and Livingstone mountain ranges, Mufindi plateau and Dabaga highlands (Davenport and Ndangalasi 2003; Cribb and Leedal 1982; Hamisy and Millinga 2002). Other important geographical features notably found in these highlands include two rift valley great lakes, i.e. Nyasa and Tanganyika. Lake Rukwa and several other small lakes like Lake Sundu, Kwela and small volcanic lakes, i.e. Ngosi and Masoko, are also found in this area. Also, there are several major rivers. These are Kalambo and Kafufu in the west, Kiwira, Mbaka and Lufirio in the central sector, and others include Lumbila, Ruhuhu, Ketewaka and the Great and Little Ruaha. Also found in this area are several mountains some of which are volcanic, like mount Rungwe (2 959 m a.s.l.) and Ngosi (2 620 m a.s.l.). It is here that the rich floras of eastern, southern and central Africa meet; above 3 000 species of flowering plants can be found, probably over one-third of the total flora of East Africa (Cribb and Leedal 1982).

The region is characterized by very unique types of vegetation, including grasslands with wild terrestrial edible Orchid species. The grasslands in this area include species of *Andropogon*, *Eragrostis*, *Hyparrhenia*, *Pennisetum* and *Setaria*, many of which are restricted to the highlands and the Nyika plateau in Malawi (Cribb and Leedal 1982).

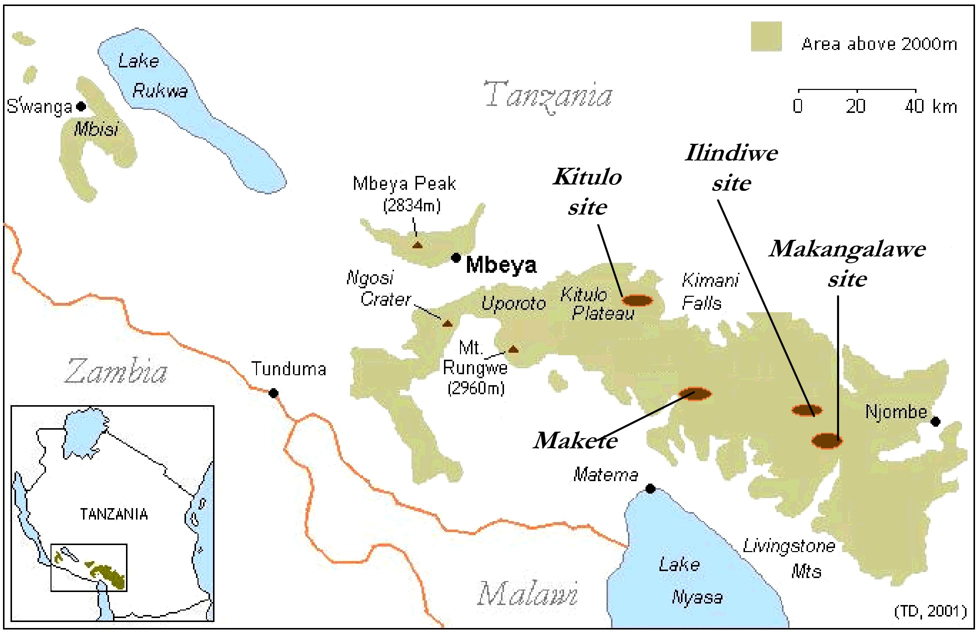


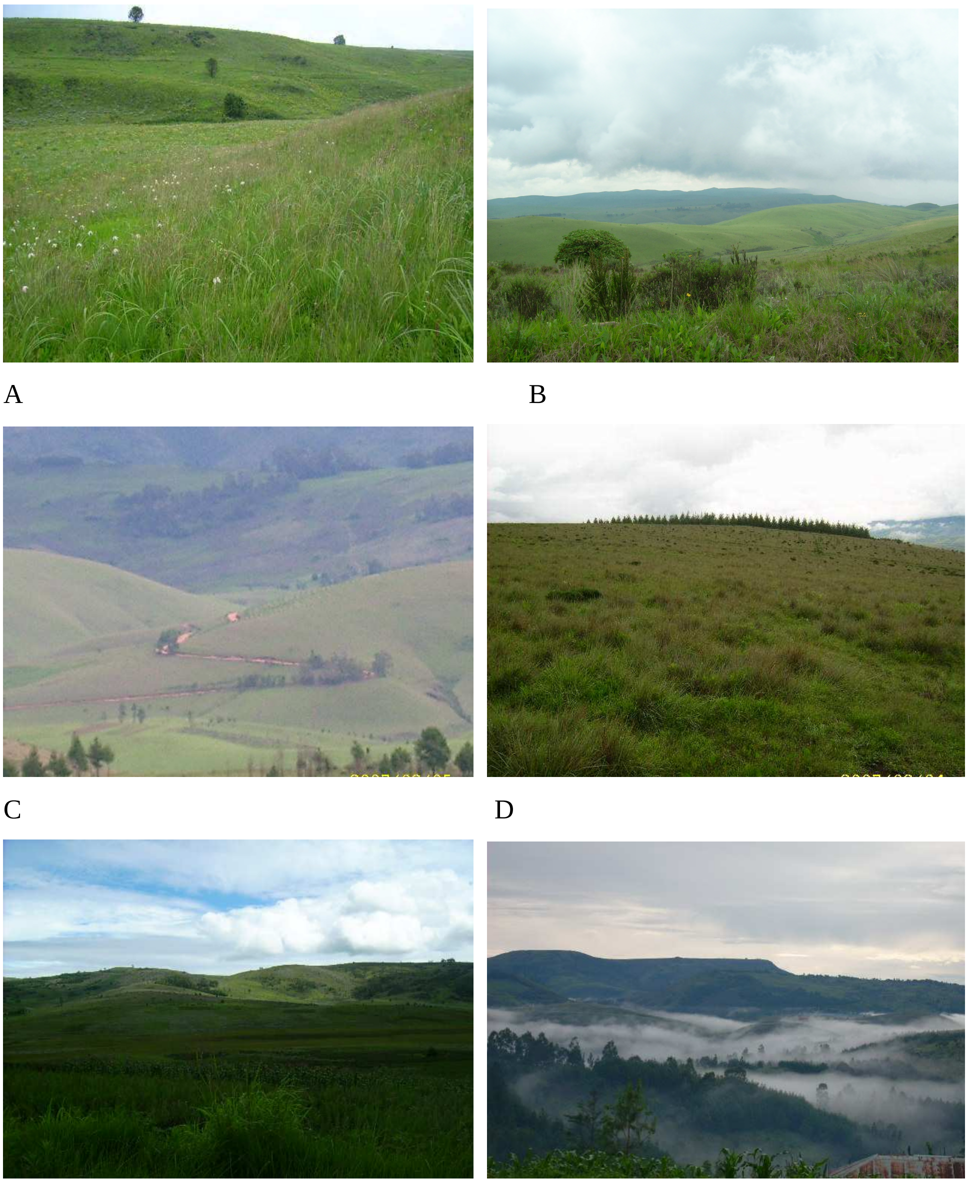
Fig. 1. Part of the Southern Highlands of Tanzania (shaded area), illustrating Orchid collecting sites in Makete district. (From Southern Highlands Conservation Programme website)

Climatic conditions in this area are characterised by high rainfall with the rainy season during November – May and the dry season during June – October. However, the rainfall is variable throughout the region with probably the wettest part of the country, Lake Nyasa averaging 2 850 mm per year. On the Kitulo plateau, a temperature of -5^{0}C has been recorded and night frosts are common. Periodically once every 25 years or so frost occurs all over the highlands with devastating consequences for the vegetation (Cribb and Leedal 1982).

The landscape of Makete

This study was conducted in upland or Montane grassland areas 1 200–2 961 m a.s.l. It is in these highlands, Makete, one of the five districts in Iringa region is located. The district covers about 5,000 km^2, located between 80 45' and 90 45' E and 330 45' and 340 50' S. The district has five divisions with fifteen wards and ninety six villages with a population of 115 480 and an average of 23 people per km^2 according to the Population census 1998 (Hamisy and Millinga 2002). The district has two agro-ecological zones, namely the Highland and Lowland zones. The villages included in this study, Kitulo, Makangalawe and Ilindiwe, belong to the highland zone at 2 310–2 800 m a.s.l. (Plate 2). It is in this zone where the key habitats for Orchids are mostly found. Topographically Makete district is predominantly a highland area and extends from the Livingstone mountain ranges (2 400 m a.s.l.) eastwards to Kipengere ranges via the Kitulo plateau. Due to high altitude, the district is characterized by cold weather with exceptions in a small area in the Northern part which is characterized by a semi-arid tropical climate (Hamisy and Millinga 2002). The Kitulo plateau is located in this district. The plateau has for a long time been advertised as a paradise, as it contains great numbers of endemic species.

The Kitulo Plateau has 350 species of vascular plants including more than 45 species of terrestrial Orchids, many of which have restricted distributions. Some 31 species of Orchids are endemic to Tanzania, out of which 16 are endemic to Kitulo/Kipengere and 10 restricted to Kitulo/ Poroto (Davenport and Ndangalasi 2003; www.southernhighlandstz.org/keysites.html viewed on 28.05.07).



A B

C D

E F

Plate 2. A and B -View of the Kitulo landscape; C and D - View of the Makangalawe landscape; E and F - View of the Ilindiwe landscape.

Study Limitations

Staggered flowering of Orchids

The Orchids show a staggered flowering. The field work for this study took place from the end of January to the mid of February, but not all Orchids flower at the same time. The flowering time ranges from November to May according to Cribb and Leedal (1982), and similar information is depicted from the studied herbarium specimens (Fig. 7), and hence, significant populations of

Orchids may not have been sampled. For instance, *Disa walteri*, *Satyrium aberrans*, *S. comptum* and *S. johnsonii* were reported flowering around the same time in southern Tanzania in March (Niet et al. 2005). Other Orchids flower as early as in October (Bingham 2004). Since flowers are important for identification of the Orchids (Davenport and Ndangalasi 2003), this may end up missing data related to such species. Observations from herbarium specimens indicated, however, a peak in flowering around February and March, i.e. during the field work period (Fig. 7) which may somehow rectify the problem. Nevertheless, this problem may lead to species identification gaps, hence underestimation of their abundances and diversity.

Short duration of the study

The field work was limited to fifteen days, and as a result the area covered was small. Only threes sites were surveyed and sampled. Therefore, general conclusions based on the quantitative sampling should be made with caution. On the other hand other information derived from this study such as the species listed as edible or non-edible is based on firm facts. Niet and Gehrke (2005) did a one day survey and could come up with very useful information on status of some rare Orchid species at Mbeya peak. Apart from that the study is exploratory and may serve as a bench mark for further studies to come. Thus the usefulness of the study depends on what information and objectives one is interested in.

Limitations related to the use of herbarium data

This study used herbarium data to affix Orchid species to habitat of preference. Data from herbarium labels have several limitations, some are very technical and difficult to handle, some may miss information, for instance on habitat and geographical coordinates and some may have wrong naming or use synonyms. Also, the information may be historic and not reflect the current situation on ground.

Methods

Data and information on edible Orchids were collected, including their abundance, species richness/diversity, habitat, plant community, and distribution over vegetation or habitat types in the landscape. An assessment of physical conditions (e.g. dry soils, wet or swampy) and disturbances (e.g. farming, forestation and Orchid collection) was also done. Modified Whittaker plots (Comiskey et al.1999; Stohlgen et al. 1995) were used for primary data collection (Fig. 2, 3). Herbarium specimens were studied and any information on vegetation types and flowering time was noted from their labels. The literature was also reviewed for secondary data.

Study site selection

A meeting with the District Natural Resources Officer in Makete was conducted to brainstorm and identify sites/villages for the study. The criteria for site selection included high diversity or richness and abundance in edible Orchid species, distance to the site and site accessibility in terms of roads. Areas identified by the district authorities possessing many edible orchids both in terms of species and quantities were preferred as the candidate study sites. A total of three sites/village were purposively selected from the list, basing on the criteria above. These were Ujuni, Makangalawe and Ilindiwe. However, due to heavy rains, hence bad roads, Ujuni village could not be reached, so instead Kitulo Livestock Multiplication Unit was selected. At the village level, discussions were conducted to find competent Orchid collectors/herbalists to participate in the field survey to identify Orchids in terms of edibility. These would specify the sites where they normally go for Orchid collections.

Vegetation sampling

During this study, modified Whittaker plots were used for the vegetation sampling. The methodology is described by Comiskey et al. (1999), and the revised sampling layout for the methodology, suggested by Stohlgren et al. (1998), was adopted. This methodology has been used in North America and yielded valuable results in a tropical lowland and montane monitoring project (Comiskey et al. 1999). This method has several advantages: The selection of sites is objective, the type of plot used is rather small but with several replicates and the vegetation types measured have included non-woody species and trees down to 1 cm dbh. The characteristic different sizes of plots in this sampling protocol allows examining species richness at local and large scales. This provides a detailed method that simply and quickly assesses the vegetation type and baseline information for monitoring (Comiskey et al. 1999).
Several scientists have testified the methodology to be very useful when it comes to vegetation sampling (Leis et al 2003; Stohlgren et. al 1998). Leis et al. (2003) compared this method against the point–intercept method and contiguous quadrants in mixed-grass prairie, and they concluded the modified

Whittaker plots to be more efficient as they produced data quality similar to contiguous quadrants but in less time. The point-intercept method was found to be quite inefficient as it produced less number of species per unit sampling effort. Yet, Modified Whittaker plots detected the greatest number of species and provided data at different spatial scales. Further, the strength of the method included detection of rare species and of spatial autocorrelation.

In a similar investigation, Stohlgren et al. (1998) compared four rangeland vegetation sampling techniques with the Modified Whittaker Plots. The four methods were superimposed in short grass steppe, mixed grass prairie, Northern mixed prairie and tall grass prairie in the Central Grassland of the United States with four replicates in each prairie. They found that the Modified Whittaker plots could catch more species than the other methods. This made the method of functional importance to my study; henceforth I used it for my vegetation sampling.

The layout of a plot is illustrated in Fig. 2. A plot of 20 by 50 m (0.1 ha) provides the framework, within which vegetation sub-sampling can take place. The sampling of vegetation at different scales (subplot sizes) allowed us to examine species richness at local and larger scales in order to estimate richness for the entire area.

Within the plot are several subplots of different sizes (Fig. 2). The largest subplot (C) is 20 by 5 m and is in the centre of the plot. Two smaller subplots (B1 and B2) are 2 by 5 m and located in two opposite corners of the plot. Finally there are ten small subplots (A1-A10) of 2 by 0.5 m placed just inside the periphery of the plot.

A total of four 0.1 ha plots were laid out per study site from which the vegetation data were collected. Random numbers were used for locating these plots so as to avoid subjective biases. This included the selection of trail to lay a plot, distance from camp to the plot, side of the trail to lay the plot, distance from trail and plot orientation. A table was constructed to record all these details from each study site for each plot to keep track of the exact location of each plot for future studies and reference. Plot locations were marked using GPS reading by recording all the four corners of the plot and the central plot. Care was taken to walk as little as possible within the site and to ensure that the vegetation in the subplots (A1-A10) was not trampled.

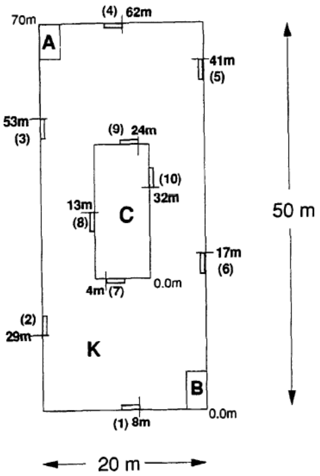


Fig. 2. Revised sampling layout for the Modified-Whittaker sampling plot. 1 m^2 subplot locations are marked along two 70-m tape from the 0.0 m point to the 70 m point of the plot (K), and clock-wise along a 50-m tape from the 0.0 m point of the I00 m^2 subplot (C).

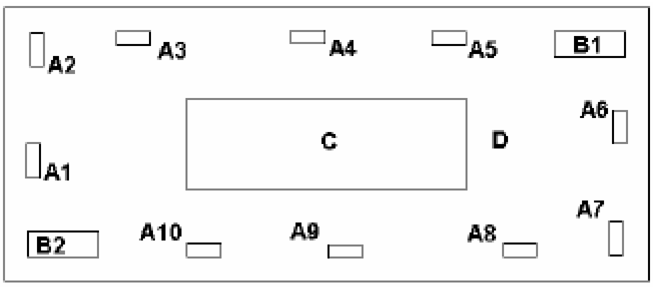


Fig. 3. Names of the subplots. Note that 'D' refers to the entire plot area that is not covered by the subplots B1, B2 and C.

Sampling procedure

For the purpose of the study, which took place in grassland only, the smallest subplots (A1 – A10) were used. In these subplots Orchids, other herbaceous plants, along with saplings, including all plants less than 50 cm in height, were searched for. By the help of Orchid collectors or herbalists all Orchids were identified by their local names, if any, counted and noted whether they were edible, non-edible or had any other functional uses. The same was done for other plant species, except that instead of counting of individuals their percentage covers were estimated. All Orchid species or other plant species that could not be identified by either local or scientific name were given annotated names.

Because all identifications of plant species could not be done in the field specimens were collected. Wherever possible, the botanist should identify morpho-species in the field in order to reduce the need for multiple collections. In addition, the botanists made general collections of species not inventoried throughout the plot. This was accomplished by surveying the entire plot for individuals of species not encountered and by examining the adjacent areas. The specimens were initially processed in the field and subsequently dried using a kerosene cooker, and pressing of the specimens took place at the camp. Specimens of plant species that could not be identified in the field were taken for herbarium identification at the National Herbarium of Tanzania.

Data collection

Sufficient reference information about the plot and its habitat was collected so that any changes in the vegetation between sites were explained. Since the sites varied in elevation and other features it was important that these were noted. The variables measured included: Latitude and longitude using GPS unit, elevation using altimeter, slope (estimated and categorised as steep, fair/gentle or flat), aspect (measured by compass as North , East ,South, etc) (Appendix 1).

Vegetation data

The survey and specimen collection took place during end of January- mid of February 2007, being the early flowering season as identified through discussions with Natural Resources officers during prior visits to the Makete district, with the help of a botanist and folklore botanists, the latter being herbalists or Orchid collectors/harvesters for trade purposes.

Observational data

At the end of every plot data collection, an assessment on physical condition of the Orchids was conducted by the whole team trying visualizing and brainstorming on what they could observe during plot laying and data collection. The information recorded included signs for predators, competitors, and prevalence of pests and diseases, phenological data and growth stage. The latter included vegetative stages given as germinating, wildling/seedling and mature plant. Reproductive stages were given as flowering, fruiting or seeding. Further stages were wilting, dormant or dead. Insect attacks/bites and also recent harvests indicated by remnant diggings were noted.

Secondary data

439 Orchid specimens from both University of Dar es salaam and National Herbarium of Tanzania were studied for their flowering period, habitat and distribution. Only the terrestrial species of Orchids and those from the southern higher lands were studied for the purpose of this study. The species were considered as the candidate species for Makete district. A literature review was done to supplement information from both herbaria and the field survey.

Data analysis

Compilation of a checklist of the flora and the family Orchidaceae

Flora data were described into families, genera and species into their percentage contribution (Changwe & Balkwill 2003). A checklist which included both edible and non-edible species of Orchids and species of other families was compiled from data collected from Modified Whittaker plots during this study, following identification of all the species at the National herbarium of Tanzania. Only plants that could be identified to species level were included in this case. It included the local names for the respective plants and where there were no local names only the scientific names were included.

Diversity estimation

The vegetative cover percentages for the other plants in the community, occurring together with the Orchids were converted to the Domin scale values. Relative to the Braun-Blanquet scale, the more detailed division in the Domin scale enables detailed assessment to be made of plant coverage (Kershaw and Looney 1985). The values were then used directly in calculating the diversity indices. All plants that could not be identified at least to family level were excluded from the calculations for the indices. The indices calculated were Shannon H', Simpson D-ln(D) and Evenness E(1/D). Shannon index emphasizes on the richness component of diversity, whereas Simpson places more weight on the evenness component of the diversity. The latter value of measure will rise as the assemblage becomes more even. The Simpson is easily interpreted and reflects underlying diversity, yet it is independent of the sample size (Magurran 2004).

Orchids' diversity indices for Kitulo, Makangalawe and Ilindiwe were calculated separately and then as a whole set of sites combined and at plot level so as to analyse diversity at different resolutions. A computer based software Diversity version 2.2 was used to calculate diversity of Orchids. Shannon H', Abundances and Heterogeneity were also calculated. MINITAB regression and correlation analysis were then used to determine if there were any relations between Orchid diversity and other plant community diversity. During regression analysis orchid diversity indices per plot were used as dependent variable.

A matrix with presence and absence data was produced to analyse endemism and rarity of Orchid species. The numbers of each species as counts per plot were entered to represent presence and at the same time the count of that species, whereas zero represented absences.

Orchid distribution among habitats

The criteria for specimens to be included in the study were that it should be from the Southern Highlands in general and be a terrestrial Orchid species.

The criteria form the taxon of interest (TI) of this study (Ponder et al. 2000). Information from the labels of 439 herbarium specimens was extracted and sorted using EXCEL into Species name, Date of collection, Date of flowering, Habitat and Altitude. The habitats were then classified into nine habitat categories:

Grassland vegetation (Gv - which included all the open grassland vegetation on dry land), **Mbuga vegetation** (Mv - which included all sorts of wet land including, Swamps, Bogs, Dambo soils and wet meadow), **Riverine vegetation** (Rv - including grassland , woodland and vegetations along the rivers), **Rocky vegetation** (Rcv - which includes vegetation mostly in shallow soils on rocky on mountains areas and lime stones), **Closed forest** (Cf - Riverine forests and "rain forest"), **Forest plantation** (Fp - Cypress and pine plantations and all man made forests), **Woodland vegetation** (Wv - all sorts of other natural open forests or woodlands, mostly Miombo woodland comprising largely of *Uapaca* and *Brachystegia* species), **Shrubby vegetation** (Sv – including grassland dominated by shrubs) and **Cultivated land** (Cl – which includes farmland, tea plantations etc).

Only those species represented by six and above herbarium specimens were considered in affixation of their habitat of preference. A matrix of species against habitat was then prepared in which specimen counts for a specific species were entered to represent presence and at the same time count value. Absences were represented by empty cells. The distribution of presence counts was then used to infer habitat preferences for a specified species.

Orchid population estimations

Orchid population densities were calculated from EXCEL descriptive statistics, both as a common group and later as edible and non-edible Orchid groups. Using MINITAB software, one-way ANOVA was done to test for significance between quantities of edible and none edible categories of Orchids and for comparison of general quantities of Orchids between sites. To see if there were any differences between edible and non-edible quantities, MINITAB Mann-Whitney test was used. Species relative abundances were estimated for the twelve plots. Abundances per species in the twelve plots were estimated to describe species abundance between the twelve plots using their total counts across the twelve plots. Counts for each species were then divided by twelve for this purpose.

Results

Checklist of Flora and the family Orchidaceae

The twelve plots from the study sites had a total of 108 species in 80 genera and 32 families (Table 1). Six of the genera are Orchids. The six Orchid genera bear 17 species gathered during this study, contributing 8% and 16% of the total number of genera and species, respectively, prevalent during the field study from the end of January up to mid February. Orchidaceae rank second position in terms of the number of species, preceded by Asteraceae bearing 22 (20%) species. Third is Poaceae with 15 (14%). Poaceae contribute 15 genera to the total flora and Asteraceae 14 (Table 2).

Table 1. Number of families, genera and species that comprise the general flora as gathered from the twelve plots of the study sites.

	Orchidaceae		Other families		
Taxonomic level	Total	%	Total	%	All Total
Family	1	3	31	97	32
Genus	6	8	74	92	80
Species	17	16	91	84	108

Among the three dominant families, Orchidaceae has the highest species to genus ratio of 2.83, indicating that its taxa are spread within few genera (Table 2). Poaceae has the highest number of taxa in the flora but a relatively low species to genus ratio of 1.0 represented by 15 taxa in 15 genera. The three dominant families contribute 50% of the species.

Edible Orchid species contribute 6%, whereas non-edible ones are left with 10% of the total flora. However, the contribution on genus level between edible and non-edible Orchids is tricky as both edible and non-edible species occur in the genera *Satyrium*, *Habenaria* and *Eulophia*. The genera *Brachycorithis* and *Disa* are represented by edible species only, whereas the genus *Roeporocharis* is represented by non-edible ones. *Disa* alone contributes three species of edible Orchids sampled during the study, *Satyrium* two, whereas *Brachycorithis*, *Habenaria* and *Eulophia* are represented by one species each (Appendix 2).

Table 2. Number of genera and species in families represented by two or more species and species: genus ratio for those families at the study sites.

	Genera		Species		
Family	Total	%total	Total	%total	Species/Genus ratio
Anthericaceae	2	3	2	2	1
Apiaceae	4	5	3	3	0.75
Asteraceae	14	18	22	20	1.57
Balsaminaceae	1	1	2	2	2
Campanulaceae	1	1	2	2	2

Cyperaceae	3	4	4	4	1.33
Poaceae	15	19	15	14	1
Iridaceae	1	1	3	3	3
Orchidaceae	6	8	17	16	2.83
Papilionaceae	7	9	9	8	1.29
Proteaceae	2	3	2	2	1
Ranunculaceae	2	3	2	2	1
Rubiaceae	2	3	2	2	1
Scrophulariaceae	2	3	3	3	1.5
Thymelaceae	1	1	3	3	3

A total of 17 Orchid species could be gathered (Appendix 2) during this study. Two of them were collected outside the surveyed area, on transect work across the plantation forest at Ndulamo village, though outside the forest on open grassland adjacent to the forest.

Data from sample plots at the three study sites show Orchid contribution to site flora to be 9, 7, and 5 species versus 40, 24 and 32 for other plant species (Kitulo, Makangalawe and Ilindiwe, respectively). Generally, edible Orchids possessed fewer species, i.e. 4, 2, and 2 contributing 8%, 16% and 5% of the total flora at each site (Appendix 4). Edible Orchids at Kitulo bear lower species to genus ratio relative to Makangalawe, which is because there are more species of Orchids in Kitulo, whereas the two sites have a similar number of genera (5).

More edible Orchid genera (3) and species (4) were found from Kitulo. Makangalawe and Ilindiwe had 1 genus and 2 species of edible Orchids each. Thus the proportion of edible Orchids in the family was 39% for species and 38% for genera (Table 3) when examined separately.

Table 3. Number of genera and species in the family Orchidaceae, comparing edible and non-edible species contribution in the family at each study sites.

		Kitulo	Makangalawe	Ilindiwe	Totals	%
Edible	Genera	3	1	1	5	39%
	Species	4	2	2	8	38%
Non-Edible	Genera	3	3	2	8	61%
	Species	5	5	3	13	62%

Makangalawe and Ilindiwe had 1 genus and 2 species of edible Orchids each. Thus the proportion of edible Orchids in the family was 39% for species and 38% for genera (Table 3) when examined separately.

Orchid diversity and rarity

Kitulo had highest diversity values, followed by Makangalawe and lastly Ilindiwe, though in the evenness index (E1/D) Makangalawe looks more even than Kitulo.

Table 4. Species diversity indices for combined study sites and as per each site.

	Shannon *H'*	Simpson-$_{ln(D)}$	Evenness $_{(E1/D)}$
Sites combined	2.264	2.028	0.380
Kitulo	1.94	1.639	0.572
Makangalawe	1.631	1.353	0.483
Ilindiwe	1.311	1.109	0.606

The Shannon diversity indices of Orchids per plot show a similar pattern. Similar observations were obtained when diversity indices for the other plants occurring together with Orchids were calculated and plotted, thus Kitulo was the most diverse site relative to the other two sites (Fig. 4).

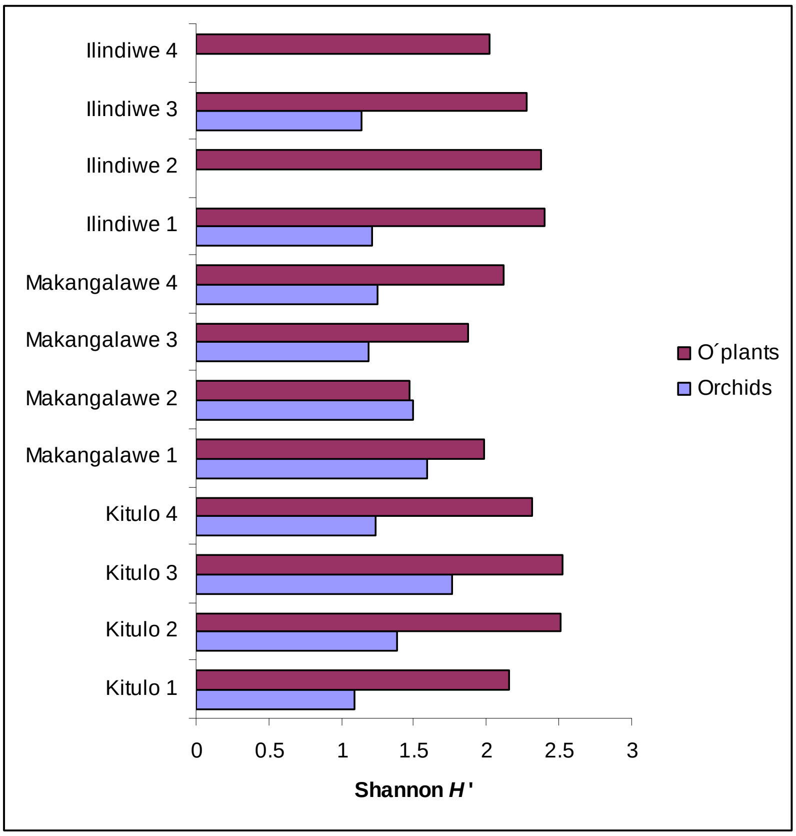


Fig. 4. Shannon index for Orchids and other plants (O' plants) in each of the twelve plots.

Species cumulative curves were plotted for each site separately to evaluate reliability on the sampling effort and Orchids diversity collection. Four sites were found to be enough to gather the diversity at a site. When the two categories of edible and non-edible Orchids combined for all sites were plotted, they indicated that different sampling efforts would be needed for the two categories. Edible Orchids demanded 5 plots and non-edible ones 9 plots to gather their diversities (Fig. 5).The cumulative curve for the plant community is on the increase. This implies that more than the twelve plots were needed for a complete species gather; thus more sampling effort would have added more species for the whole plant community and therefore more diversity.

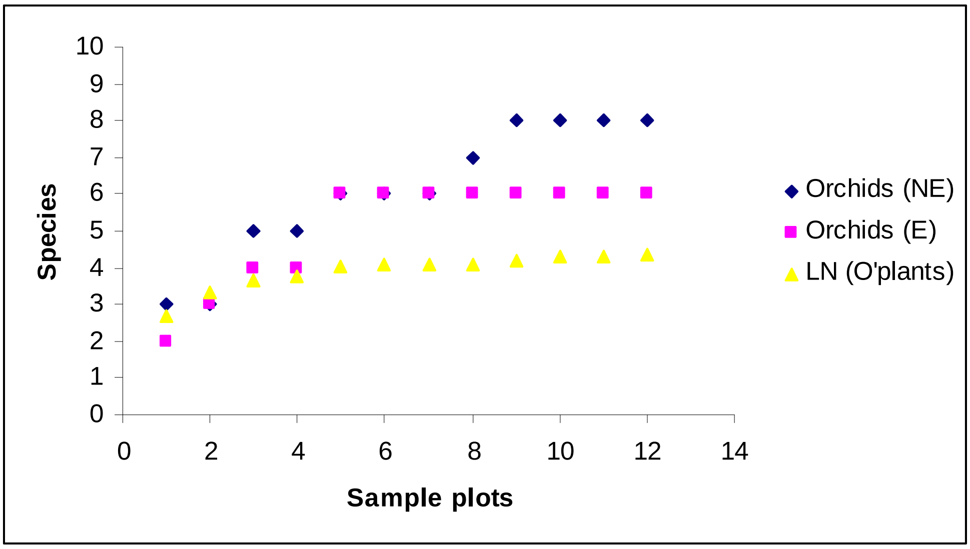


Fig. 5. Species cumulative curves for edible (E), non-edible (NE) Orchids and other plants (O'plants).

The relation between diversity indices for Orchids and those for other plants was analysed through regression analysis, but shown to be non-significant (P>0.05). Similar results were found in a regression analysis with Orchids as the response factor (P>0.05).

The species *Satyrium neglectum*, which is non-edible was observed to be the most common one and not confined to any of the three sites, though most prevalent in Makangalawe (Plots 5 to 8). *Habenaria praestans* is confined to Makangalawe and Ilindiwe (Plot 9 to 12). Three out of six edible Orchids were confined to Kitulo (Plot 1 to 4) and one to Makangalawe. Two species were found to be rare and confined to Kitulo and Makangalawe, each represented by only one individual. These were *Habenaria occlusa* and *Eulophia schweinfurthii* (Table 5).

Table 5. Orchid species and their number of individuals in the twelve sampled plots.

Species name/Plots no.	1	2	3	4	5	6	7	8	9	10	11	12
Brachycorythis pleistophylla [e]	0	**1**	**8**	**1**	0	0	0	0	0	0	0	0
Disa erubescens [e]	0	0	0	0	**9**	**13**	**5**	**11**	**5**	0	**3**	0
Disa ochrostachya [e].	0	0	0	0	**1**	**3**	0	**4**	0	0	0	0
Disa robusta [e]	0	0	**4**	**4**	0	0	0	0	0	0	**9**	0
Eulophia schweinfurthii	0	0	0	0	0	0	0	**1**	0	0	0	0
Habenaria macrura	0	0	**7**	0	2	0	1	**10**	0	0	0	0
Habenaria praestans	0	0	0	0	**10**	0	**10**	0	**35**	0	**28**	0
Habenaria occlusa	0	0	0	**1**	0	0	0	0	0	0	0	0
Roeperocharis wentzeliana	0	0	**7**	0	**6**	**7**	0	**1**	0	0	0	0
Satyrium acutirostrum	**11**	0	0	**7**	0	0	0	0	0	0	0	0
Satyrium atherstonei [e]	**3**	**1**	**6**	0	0	0	0	0	0	0	0	0
Satyrium buchananii [e]	**4**	**1**	0	**13**	0	0	0	0	0	0	0	0
Satyrium crassicaule	**42**	0	**9**	0	0	**6**	0	**6**	0	0	0	0
Satyrium neglectum	**5**	**1**	0	0	**10**	**12**	**9**	**53**	**16**	0	0	0
Satyrium princeae	0	0	0	0	0	0	0	0	**17**	0	**11**	0

e – Denotes edible Orchids

Orchid distribution among habitat and vegetation types as seen from herbarium labels.

The 439 herbarium specimens comprised of 160 species, most of them represented by a range of 1 to 3 specimens. *Disa erubescens* had a highest number of 16 specimens. There were 21 species that were represented by six or more specimens, which together make up 39% of the general collections of terrestrial Orchids found in the Southern Highlands in the two herbaria. The remaining 61% are represented by 1 to 5 specimens (Appendix 9). Of the specimens, 262 were from the University of Dar es salaam (UDSM) and 177 from the National herbarium of Tanzania (NHT) at the Tropical Pesticides Research Institute, Arusha.

Much of the specimens were collected from year 1958 to 2005 with high variability in number of specimens collected each year and with a peak during 1982–87. Thereafter there was a dramatic drop of the collection up to today (Fig. 6). Collections, done during 1985 to 1987, represent 72% of the total specimens in the two herbaria.

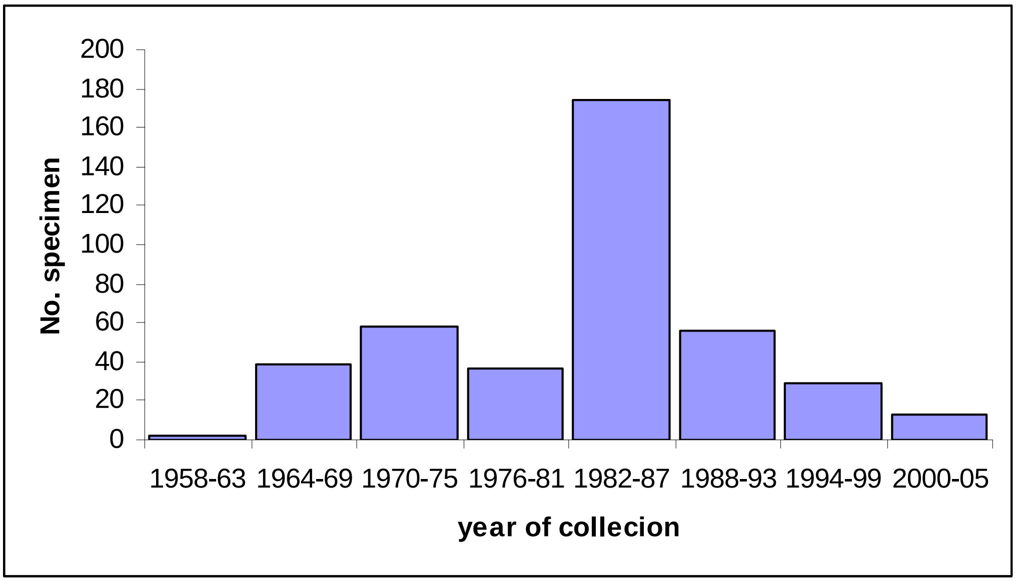


Fig. 6, Year-wise distribution of Orchids specimen collections in the UDSM and NHT herbaria.

Most of the collections indicate flowering to occur during November to May with the peak flowering in March. Surprisingly there are some species that flower in the dry season, making the flowering range for Orchids to be 12 months of the year (Fig 8).

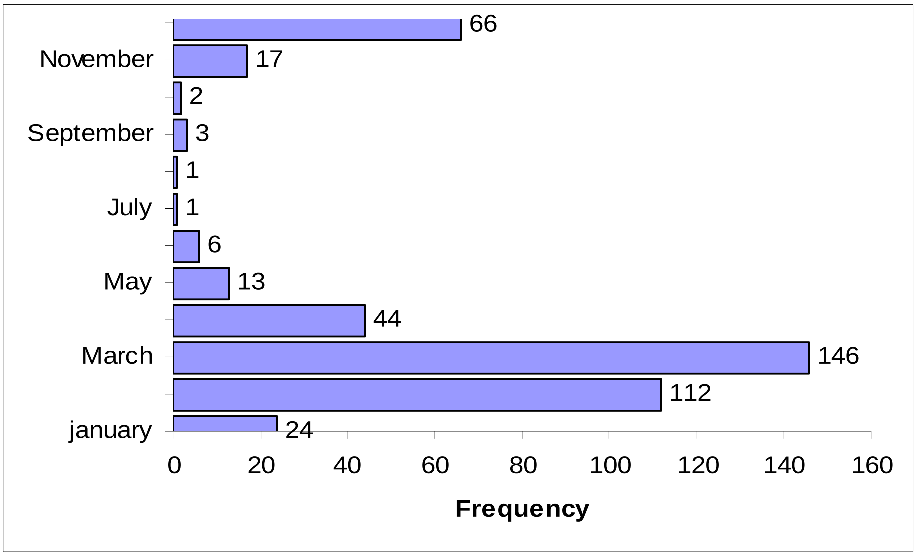


Fig. 7. Temporal flowering distribution among Orchids as depicted from specimens in the NHT and UDSM herbaria.

More than 50% of the Orchid specimens were collected at altitudes between

1 501 and 2 000 m above see level; the next significant range was 2 001–2 500 m, accounting for 20% of the total collections. Most specimens (84%) had been collected at altitudes ranging 1 501–3 000 m a.s.l. (Fig. 8).

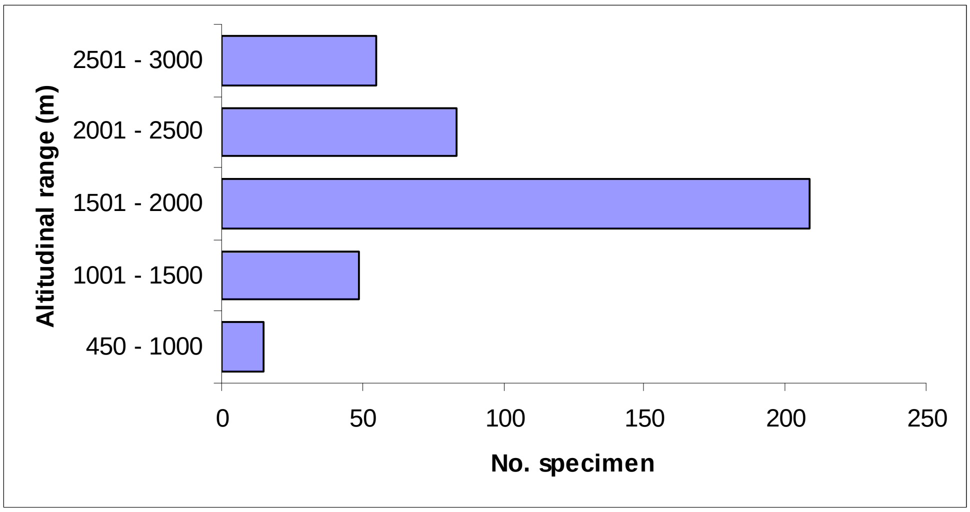


Fig. 8. Altitudinal range of Orchid distribution depicted from the herbarium specimens.

The extracted information indicates that most of the specimens were collected from grasslands, which account for 31% of the specimens, followed by mbuga vegetation 22% and woodland vegetation 19%, all together accounting for 72.3% (Table. 6).

Table 6. Orchid specimens' distribution across the nine habitat categories, as per information collected from herbarium specimens.

Habitat	No. Specimen	%
Closed forest	4	1
Cultivated land	3	1
Forest plantation	33	8
Grassland vegetation	137	31
Mbuga vegetation	97	22
Riverine vegetation	44	10
Rock vegetation	18	4
Shrubby vegetation	4	1
Woodland vegetation	84	19
Undefined*	14	3

* represent those species of which their habitat could not be described from the herbarium specimens

Results on species distribution among the nine habitat categories are presented in appendix 7.

Orchid population estimations

The average population density for all plots was 37±28 Orchid individuals/10 m2. This gives about 4 individuals of Orchids/m2

Population densities of edible and non-edible orchids were found to be 9±7 /10 m^2 and 28±26 /10 m^2, i.e. one edible Orchid individual/m^2 and 3 individuals of non-edible Orchids/m^2. The population density of non-edible Orchids is found to be three times that of edible ones. The difference was statistically significant (t-test, $P<0.05$; Table 7).

Table 7. Comparison of edible and non-edible Orchid quantities per 10 m^2 as sampled from the twelve plots of the study sites.(N=12)

Source	DF	SS	MS	F	P
Factor	1	2223	2223	6.27	0.020
Error	22	7796	354		
Total	23	10019			

Orchid population densities in the three sites (33.7/10m^2, 47.5/10m^2 and 31.0/10m^2 for Kitulo, Ilindiwe and Makangalawe, respectively) were not significantly different (one-way ANOVA, $P>0.05$).

Within site tests for edible and non-edible Orchid quantities indicate no difference between the two categories at Kitulo (Mann-Whitney test; P= 0.77) or Ilindiwe (P= 0.64). However, a significant result was found at Makangalawe site (P= 0.03) with non-edible species having a higher value. Since the combined site numbers for non-edible and edible Orchids yielded significant results, it can thus be concluded that this was because of the difference at Makangalawe.

The density range per species for non-edible Orchids were from 0.1/10m^2 (*Habenaria occlusa*) to 8.8/10m^2 (*Satyrium neglectum*). The edible species were less abundant and ranged from 0.1/10m^2 (*Eulophia schweinfurthii*) to 3.8/10m^2 (*Disa erubescens*). Four out of seven of the edible Orchids have densities below one per plot. Only one, *H. occlusa* of the non-edible Orchids has a similar value; the rest are above 1.5/10m^2 (Table 8).

Table 8. Total number of Orchid individuals in the subplots A1-10 and the average number per plot (N=12)

	Species	Specimens count	Average per plot
Edible	*Brachycorythis pleistophylla*	10	0.8
	Disa erubescens	46	3.8
	Disa ochrostachya	8	0.7
	Disa robusta	17	1.4
	Eulophia schweinfurthii	1	0.1
	Satyrium atherstonei	10	0.8
	Satyrium buchananii	18	1.5
Non-edible	*Habenaria macrura*	20	1.7
	Habenaria occlusa	1	0.1
	Habenaria praestans	83	6.9
	Roeperocharis wentzeliana	21	1.8
	Satyrium acutirostrum	18	1.5
	Satyrium crassicaule	63	5.3
	Satyrium neglectum	106	8.8
	Satyrium princeae	28	2.3

Discussion

Checklist of Flora and the family Orchidaceae

Considerable numbers of Orchid species have been reported before from Tanzania, including 21 species of the genus *Disa*, 77 of *Habenaria* and 33 of *Satyrium* found mostly in the Southern Highlands part of the country (Hamisy 2005). Davenport and Ndangalasi (2003) estimated that as many as 85 species of Orchids in the Southern Highlands may be at risk as a result of the escalating tuber trade. Niet and Gehrke (2005) think the area could be considered as the centre of diversity for *Disa*, *Habenaria* and *Satyrium*, as they are represented by large numbers of species. The observation by Davenport and Ndangalasi (2003) that the montane grassland species include a significant number of terrestrial Orchids is then confirmed as reflected from this study.

Apart from the renowned edible genera of *Disa*, *Habenaria* and *Satyrium*, quoted in most literature (Ruffo et al. 2002; Hamisy and Millinga 2002; Davenport and Ndangalasi 2003; Bingham 2004; Hamisy 2005), this is probably the first time to report edible Orchid species of the genera *Brachycorithis* and *Eulophia*. Their species are *Brachycorythis pleistophylla* and *Eulophia schweinfurthii*. Besides these a group of non-edible species were as well obtained, and also edible Orchids of the well-known genera have been identified to species level (Appendix 2). *Satyrium*, *Habenaria* and *Disa* are represented by 2, 1 and 3 edible species, respectively. As it is always claimed, *Disa* confirms to be the most edible genus as all of its species gathered from this study are edible.

The flora of the study sites is considerably rich, both for Orchids and for other plant species (Table 1). The family Orchidaceae is amongst the highly diversified ones in terms of genera and species (Table 2). Thus Orchids bear a relatively good genetic richness in this case with reference to the number of genera and species they posses (Gaston and Spicer 2004). However, edible Orchids were fewer than the non-edible ones, both overall and at each site (Table 3, Appendix 2, 4 and 6). Thus, non-edible Orchids contribute more to the diversity of the family in the study sites. Yet, it is encouraging to note that despite the desperate situation for the Orchids, the family Orchidaceae emerges second in terms of total number of species it contributes to the flora of the study sites. Even the number of edible Orchid species of 6 ranks considerably higher than many other families, like Apiaceae (Tab. 2). These findings are encouraging on realisation of the position of diversity for species that are overexploited, though more work of conservation is needed for their assured continued existence and sustainability.
This being the first hand fact drawn by my own study, I remain positively optimistic that the conservation efforts proceeding in the area, such as the established national park at Kitulo, are useful for the edible orchids, whereas the other plants found together with the Orchidaceae would also benefit. Other conservation efforts such as the Southern Highland Conservation Program are timely beneficial in this connection.

Orchid diversity and rarity

The species accumulative curves indicate that a fair proportion of the Orchid diversity was captured at the time of this field work (Fig. 5). A higher diversity of Orchids and other plants is found at Kitulo (Table 4, Fig. 4 and Appendix 5). Kitulo bears higher values for the diversity indices, though the Evenness index is higher at Makangalawe which suggests that the species at Makangalawe are generally more abundant rather than diverse (Table 4). Thus, chances are bigger that one can encounter most of the species found prevalent in Makangalawe at a lesser sampling effort than in Kitulo. In Ilindiwe two plots went nil in terms of Orchid counts which explains their generally low values of diversity across the indices (Table 4). The lower diversity in the other two sites is probably the result of Orchid overexploitation and habitat degradation.

Kitulo is famous for its floristic diversity, and the area has long ago been recognized as an area of outstanding botanical importance (Davenport & Ndangalasi 2003). The higher diversity implicated to Kitulo relative to the other two sites supports the establishment of the park in the area. The Kitulo site borders the national park and two plots at the site were sampled inside the park. The combined diversity indices (Table 4) indicate that more diversity could be contained if the whole area included in the study could be turned into a national park to accommodate the possible available diversity of Orchids outside the park. Though this is practically very difficult to implement, it could be important that the surrounding matrix to the park are also controlled in a manner deemed fit to the surrounding community on a participatory basis that will supplement the conservation efforts in the park and at the same time support rural livelihood.

The higher diversity of edible Orchids in Kitulo (Appendix 5) is attributed to presence of a control. Basically this was a government livestock multiplication farm, and on the recent development of establishment of the national park, Orchid collectors are now out of bound to the area and its surroundings, though still some encroachment can be seen and reported. A dialogue with the Orchid collectors at Makangalawe and Ilindiwe revealed that the only control prevalent in the area is to avoid collection from areas of identified ownership such on someone's farm etc. The park authority is also responsible for monitoring and restricting Orchid collection from all the surrounding areas and the District natural resource office, too. However, the control is never that effective in remote villages like Ilindiwe and Makangalawe. The kind of control at the national park will have an impact on Orchids both in terms of quantities and diversity, though for sustainable conservation participatory conservation will be more meaningful here.

There was no clear relation between diversity indices for Orchids and other plants occurring together, though in both cases there is a decrease towards Ilindiwe. However, the observations can not be conclusive at this stage since there were still chances for the diversity of other plants to increase as indicated by its species cumulative curve (Fig. 5). It may also be of interest to note a deviating type of vegetation at Ilindiwe and Makangalawe sites that is accompanied by lower Orchid diversity. The vegetation in two sites was dominated by shrubs of the family Asteraceae, a vegetation which is not preferred by many Orchids (Table 6, Appendix 7). This may partly explain the lower Orchid diversity in the two areas.

Of all the species the most common one was *Satyrium neglectum*, which occurred across all the three sites though it was noticeably prevalent in Makangalawe. Five species occurred only at Kitulo (Appendix 5). These were *Brachycorythis pleistophylla, Habenaria occlusa, Satyrium acutirostrum, Satyrium atherstonei* and *Satyrium buchananii*. Two species were confined to Makangalawe, i.e. *Disa ochrostachya* and *Eulophia schweinfurthii* while only one species, *Satyrium princeae*, appears confined to Ilindiwe. Probably Makangalawe would be the best choice if park extension or conservation were to be considered, as it actually plays a buffer role between the two sites and shares all the non-confined species with the other two sites (Table 3). Thus the idea of conserving more species would have been achieved on inclusion of the two sites, Kitulo and Makangalawe, whereas for the species *Satyrium princeae*, confined to Ilindiwe, it could be easily monitored and managed form its location.

Much more attention is needed for the confined and rare species *H. occlusa* at Kitulo and *E. schweinfurthii* at Ilindiwe. Though this study could not establish their status clearly, it sets a benchmark for more evaluation for the two species. With reference to herbarium data, *H. occlusa* has been collected during 1986, 1989 and 1991 which indicates its recent extant, while *E. schweinfurthii* was not found at all among the 439 herbarium specimens.

Cribb and Leedal (1982) describe *H. occlusa* to be mostly confined at Kitulo and Mbeya peak, and according to them, this species is only found in the Southern Highlands and was first described in 1964 from a plant collected on the Kitulo plateau. In terms of habitat preference it is a high altitude species. Their finding and the fact that only one plant could be spotted from this study demand further evaluation to establish its status. Niet and Gehrke (2005) reported nothing concerning this species though they visited Mbeya peak during March, the time the species is also recorded to flower. The same attention is needed for *E. schweinfurthii*.

Without proper conservation management, the surrounding areas of the national park will suffer more intensive collection now than before as people will tend to concentrate collections in these areas, avoiding the enforcements currently prevalent at Kitulo and its adjacent areas. On the other hand, Orchid collection is contributing to rural livelihood, and many HIV orphans depend on this trade for their income (Joyce Somba, pers. comm). Therefore there is the need for a participatory conservation programme, so that the two interests, conservation and livelihood, are met.

Orchid distribution among habitat and vegetation types

The use of herbarium and museum data in ecological and biodiversity studies is becoming increasingly important. Roberts et al. (2004) describe the use of herbarium records to infer threat and extinction, Ponder et al. (2000) use museum collection data in biodiversity assessment, Burgman et al. (1995) describe the methodology to estimate threats of extinction using the data and Niet and Gehrke (2005) use herbarium records to ascertain some Orchid species into the IUCN red list of threatened species. These collections are essentially huge databases that have accumulated over long periods and this can provide a historical perspective to complement contemporary field surveys (Ponder et al. 2000). Such methods have wide application as indicators of threat (Robets et al. 2004). As the most comprehensive, reliable source of knowledge for most described species these records are potentially available to answer a wide range of conservation and research questions (Ponder et al. 2000).

However, there are some important limitations that need be addressed: Collection effort is not a uniform process, and most collections in the herbaria and museums are opportunistic and mainly trend oriented. For instance, recent trends may well focus on rare species at the expense of common species (Burgman et al. 1995). Accurate species level identification, accuracy of specimen locality data, geographical gaps, lack of access or availability, unpublished data, lack of electronic data bases which causes inefficient manual retrieval, ad hoc nature of the collections, presence only data, biased sampling and large collection gaps, both temporal and spatial, have been short listed as discrepancies to herbarium and museum data (Burgman et al. 1995; Ponder et al. 2000). However, the extent of such gaps depends on the area and group under study and does not discriminate the use of the data (Ponder et al. 2000). During this study I used herbarium specimens to study and affix Orchid species to habitats of their preference. Most of the studied specimens were from relatively recent collections and probably reflect the reality currently on the ground; the bigger part of the collections were from 1980 to 2000 (Fig. 6). It is possible that the intensive collection of orchids during 1982 – 87 is attributed to such trends. At that time my former supervisor for this work, the late Dr. Börge Pettersson appears in the records; his collections extend for the two months of March and April. Together with his team they collected 66 Orchid specimens, all deposited at NHT in Arusha with duplicate samples at Uppsala University. His visit signals a trend though it is not clear. In the future it will be very useful, if missions are stated in brief on the label, for instance in my case "A Masters study on edible Orchids at Makete", which would associate the herbarium collection deposited at NHT with a scholarly event. This would considerably add value to the herbarium data.

Herbarium results indicate many Orchids to flower between February and March, and probably this is the time when most of the Orchid diversity can be gathered (Fig. 7). Higher altitudes between 1 500 to 3 000 m a.s.l. harbour most of the terrestrial orchids in the Southern Highlands (Fig 9) which partially confirms the result on diversity. The sites for this study were located between 2 390 and 2 735 m above sea level.

Four edible and six non-edible Orchids identified during this study, could be gathered from the herbarium specimens. Apart from these none of the rest can be grouped into the edible or non-edible categories due to lack of data.

The herbarium study showed that grassland vegetation is the key habitat for Orchids. Other important habitats are mbuga vegetation, woodland vegetation and riverine vegetation (Table 6, Appendix 7). The grassland vegetation harbours most of the species, except for *Satyrium breve, Calanthe sylvatica, Liparis nervosa* and *Satyrium atherstonei. S. breve* appears to be a habitat specialist in the mbuga vegetation only, whereas *Calanthe sylvatica* appears mostly in forest vegetation, i.e. both closed forest and woodland vegetation, though much inclined to woodland vegetation; Cribb and Leedal (1982) found a colony of this species growing in a deep forest by a mountain stream. Among the edible species, *Disa erubescens* prefers the grassland vegetation but there are also a few records in mbuga and riverine vegetation. *Satyrium atherstonei* was found to prefer wet conditions, as it was represented mainly in the mbuga and riverine vegetation. Cribb and Leedal (1982) give a similar observation on habitat for this species.

The non-edible *Roeperocharis wentzeliana* appears more prevalent in the grassland vegetation, while *Habenaria praestans* is a generalist species, as it appears across all the habitat categories, except for closed forest and rocky vegetation. Other habitat generalist species include *Habenaria cornuta* (described to be widespread in varying habitats from poorly drained grassland, marshes and woodlands, Cribb and Leedal 1982), *Liparis nervosa* (growing in a variety of habitats in woodland, forest and plantations and also in wet grassland, Cribb and Leedal 1982), *Holothrix nyasae* (growing amongst rocks and short grassland, Cribb and Leedal 1982), *Pteroglossaspis eustachya* and *Satyrium sphaeranthum*. These generalists feature in more than three habitat categories which bear considerable differences in terms of disturbances, vegetation and physical conditions.

Liparis bowkeri is almost a generalist species though mostly confined to forest plantation and woodland where a total of five out of nine of its specimens feature (commonly in cypress plantations; natural habitats are woodland and montane forest patches, Cribb and Leedal 1982). The rest are more or less inclined to grassland vegetation and include *Satyrium buchananii*, of which four out of seven counts are in mbuga and riverine vegetation with an inclination to wet vegetation. Cribb and Leedal (1982) describe this species to be eaten by Kingas in western Njombe district in times of famine, and they also describe its habitat as in wet grassland. Others that are inclined to grassland vegetation are *Roeperocharis bennettiana, Habenaria kyimbilae* and *Pteroglossaspis eustachya*.

Knowledge on species habitat preference is vital and even provide an easy link of a species to extinction threats, especially in the world where environment, hence species habitats, are under serious non-random destructions. The logic is simple: when we see certain changes related to habitat, like development of settlement, expansion of agricultural land and plantation in certain habitat types we should be able to link this with disappearance of certain species or families. Orchid collectors use a similar knowledge in locating new sites for collection, and such knowledge is also important in identifying refugia, especially at this time of rapid climatic change where conservation managers will have to assist plant movement as a rescue (Davis and Shaw 2001). Niet and Gehrke (2005) inferred a higher extinction threat to *Satyrium johnsonii* relative to *S. abberrans* and *S. comptum*, partly basing on the fact that the latter two species grow in microhabitats unsuitable for farming and not in areas which are targets for tuber collection. The phenomenon of Orchid habitat specialization as to microsites and microhabitats, can also be learnt from Bingham (2004) when he discusses some species of *Disa* and *Habenaria* which grow in wet or dry sites, e.g. *D. roeperocharoides* in mbuga vegetation.

Many terrestrial orchid species in Tanzania are under severe threat from habitat loss in general, and consumption and trade of tubers in particular (Cribb and Leedal 1982; Davenport and Ndangalasi 2003; Bingham 2004; Niet & Gehrke 2005; Hamisy 2005). Increased lands under cultivation, especially for potatoes and Pyrethrum, have been described by collectors and traders to be amongst the reasons for Orchid scarcity in Kitulo (Davenport and Ndangalasi, 2003). My own field observations in Makete show, that there is also a growing scale of forest plantations (Pines, Cypress and Eucalyptus). These need big allocations of land, yet they take long time to harvestable stage. This will bring habitat fragmentation and isolation of Orchids into smaller populations on one hand while also affecting dispersal and gene flow among the subpopulations remaining in the disjunct habitat fragments (IUCN 1996). Then the Orchid habitat, gene flow and population size will be compromised leading to extinction threats of the orchid populations.

A few species found in the forest plantation category (Appendix 7), are habitat generalists and not restricted as to habitat type. Local people in the study area claim that only non-edible species of orchids can be found in such habitats, yet very few. During the transect walk in plantation forest at Ndulamo we could not spot any Orchids in the forest but only at the adjacent open grassland area not under shade. This confirms the threat imposed by the plantations to Orchids, especially for the edible ones which according to this study prefer growing in open grasslands.

In conservation management, it will be useful to allocate time and resources to conserve the habitats that harbour many species of terrestrial Orchids. This should include grassland vegetation, mbuga vegetation and woodland vegetation. Little attention and resource allocation can be put on those species which are habitat generalists, in this case *Holothrix nyasae, Satyrium sphaeranthum, Liparis bowkeri, L nervosa Habenaria praestans* and *H. cornuta*. Much more attention will be required for habitat specialists like *S. breve* and *Calanthe sylvatica*. In this way sustainable conservation management and effective resource allocation will be easily achieved.

Orchid population estimations and species relative abundances

This would probably be the first study trying to quantify the orchid population abundance and challenges are welcome. Just as it was encouraging to note Orchids rank second in terms of species in the study sites, the figure on the family population density was considerably higher than what I could expect. A higher density value is observed for non-edible Orchids, i.e. 3 individuals/m^2, while edible ones had a density of 1 individual/m^2. The three sites had statistically equal densities for Orchids when edible and non-edible were grouped as one, similarly when categories were compared within each site except for Makangalawe where non-edible species were more numerous than edible ones.

Lack of baseline data makes it difficult to evaluate these results, even though the figure of tubers traded could partially be used to reflect the abundances of the edible species. Davenport and Ndangalasi (2003) reported on the estimated number of tubers traded from the border at Tunduma to be around 2 to 4 millions annually, and in a recent event in 2006 the park authority at Kitulo arrested several Orchid collectors and confiscated 30 bags of Orchid tubers from Ujuni (Peter Nkunga, extensionist DNRO office. pers. comm). This could be indicative that the figures represented in this study are reasonable. I made a rough calculation to estimate the quantity of tubers from the 30 bags. My estimation is based on volume of a tin (Debe) which is 20 000 cm^3 by volume and a tuber of 35 cm^3 (1.5 cm diameter, 5 cm height and $\Pi = 3.14$). The volume of the tuber is actually on the higher side to accommodate the packing in that bag which shall include some spaces. This gives about 571 tubers per tin, in a bag of 100 kg where 6 tins make up the volume 3 426 tubers are estimated, hence 102 780 tubers in 30 bags. Such a considerable quantity for a plant that yields only one tuber per plant should be supported by a base of numerous plants, though probably my estimations may be on the higher side.

In their study, Davenport and Ndangalasi (2003) estimated a maximum of 453 tubers per "Debe", hence a volume being exported to Zambia through Tunduma each year to be as high as 4 185 720 tubers. This sound of to be a lower estimation to me unless the debe they use and size of tubers are different from my perception. If the volume of the "Debe" is the same I know this estimations simply means the the volume of the Orchid tuber is 44 cm^3, which may be too big.

Further confirmation on the vulnerability of edible Orchids can be found from individual species abundances in the twelve sampled plots (Table 8). More than half of the edible ones have relative abundances between 0 and 1 with a mean of about 1.3, whereas the mean abundance for the non-edible ones is 3.6 and many of them, except for *Habenaria occlusa*, have average abundance values above 1.

While admitting that this is a short-term study, the different densities confirm that edible Orchids are being overexploited for the tuber trade. The difference in abundance between the two categories is so huge that extinction of some of the Orchid species could be assumed, probably not only of edible ones but also non-edible, especially those resembling edible tubers, as they are also collected when tubers are scarce and faked to make up a saleable volume. Recent surveys have indicated that more and more species are harvested as the supply fails to keep pace with the demand (Bingham 2004).

Therefore, it is difficult not to consider the trade as an important reason for the lower abundances across the edible Orchids. Trade is directly linked to overexploitation. Overexploitation is seen to threat the Orchid populations. Overexploitation poses second amongst causes for biodiversity reduction (Baillie et al. 2004). Commercial exploitation of wildlife can easily become overexploitation; potential market for wild products, desire for money and the fact that the market price of a wild species usually increases as it becomes rarer, precipitates exploitation and makes the wild species even rarer (Hunter 1996). Bingham (2004) attributed the disappearance of several terrestrial edible Orchid species in north-eastern Zambia and adjacent Tanzania, as well as significant reductions of some commoner species, to the Orchid tuber trade. Both Bingham (2004), Hamisy (2005) and Davenport and Ndangalasi (2003) indicate Orchid trade to have contributed significantly to the livelihood for rural and low income urban inhabitants. In Zambia a woman engaged in this trade earns a maximum of about USD 2.5 per cake daily (Bingham 2004).

In addition to the cross border trade, a local market exists in Mbinga, also in the Southern Highlands of Tanzania, where tubers are used for local consumption. Rural people trading on the tubers here get a significant income, approximately around 120 000/= Tshs (app. USD 120) for a 100 kg bag. This is considered a very profitable business for the rural people compared to other formal crops in Mbinga (Hamisy 2005).

Currently in Mbinga, the orchids have become rare and local collectors travel for two to three days to hunt for the orchids around the Mozambique border, whereas some are imported from Makete (Hamisy 2005). This urge in Orchid collection for trade is also a reason to relate its disappearance to trade.The 4.0 million tubers traded annually (Davenport and Ndangalasi 2003) and the 30 bags confiscated from Ujuni indicate a harvest of enormous numbers of individuals of edible Orchids.

However, Burgman et al. (1995) demanded precautious observations when inferring threats to species as some of them are inherently small, whereas Pupulin (2004) insisted on the need of scientific data when including Orchids under CITES as opposed to the current situation when all Orchids are considered to be under threat. While conscious of the two cautions, pending other revelations about Orchids and especially edible Orchids, such as life history, regeneration etc, I attribute the low quantities and diversity of edible Orchids to the tuber trade between Zambia and Tanzania (Makete district).

As earlier mentioned, two plots in Ilindiwe were without Orchids because of anthropogenic disturbance. One of these plots had been cultivated one year before and was now a forest plantation. Davenport and Ndangalasi (2003) found that Orchids need at least three years of fallow for re-growth to occur. This is a plot at the heart of a key area for Orchid collection turned into a plantation forest! One year old seedlings could be spotted. This puts further alerts on the possible rate of threats to extinction, where Orchid habitat is been competed by the forest plantations and agricultural land (Hamisy 2005; Niet and Gehrke 2005; Davenport and Ndangalasi 2003). The other empty plot was very close to the residential area and even very close to a primary school. On the way to this plot, I observed a few stems of edible Orchids that may have been dug from the site. Thus, collection intensity close to residential areas is indicated, which may be the reason that many of the collections were some how far from residential areas at a range of 1 km and more.

However, a few Orchid individuals could be spotted at plot 10 when the plot was randomly searched for. In my opinion the claim that Orchids do not grow in such cultivated land could be a relative quantitative perception inherent to many Orchid collectors as to what amount they consider present or absent. Since local people do not feed on the plants but trade on them, the collection effort is weighed in the amount enough to make up a sales unit which must reflect returns which is likely to be bigger, rather than for consumption where even little could suffice a demand, hence the generalized perception on Orchid availability in such sites which are actually scanty. Such perception may be harmful if it is taken for granted, that Orchids can not be produced in a farm context; this needs to be investigated and evaluated. We managed to see a few stems in the plot, as opposed to local people´s claim.

An old woman, Mechina Ilomo by name, from Ilindiwe village narrated to us her trial to grow Orchids in a field which succeeded. She collected a mature flower bunch, mixed it with soil and broadcast the mixture to a farm and they could grow. Some farmers from other villages tried to grow Orchid tubers with fertilizer and they found good response in terms of the size of the tuber which they observed to be bigger than a tuber from the forest, with the exception that you harvest only one tuber like you planted (Hamisy 2005), so the yield was a problem. This somehow indicates positive Orchid response to agronomic practices, and to me this indicates a possibility of growing Orchids in a farm, that needs be studied.

Need for conserving a bigger population size

As loss of biodiversity continues unabated, guidelines for how extinction risk is related to population size should be given high priority in conservation biology. However, estimates such as effective population size (Mark et al. 1999) or estimates on minimum viable populations (Ebenhard 2000 and Reed et al. 2002) are important to be practiced, rather than simply using population size.

Estimating the size of wild populations plays a central role in managing harvested populations and conserving rare and endangered species (Miller et al. 2005). Effective management solutions for Orchids demand further research on feasibility of introducing harvesting quotas, licenses and harvesting season (Davenport & Ndangalasi 2003).

Orchid species, though often somewhat restricted in distribution, usually form populations of thousands of individuals. While their variation in terms of genetic diversity is likely to be in good health (Pupulin 2004), a large population size may be important for the persistence of species as it serves as a buffer against demographic, genetic and environmental stochasticity as well as catastrophic events (Kéry et al. 2001). Conservation should ultimately aim at maintaining populations of several thousands individuals to ensure long term persistence of species (Reed 2005).

Comments on the Modified Whittaker Plot method

As described in the method, vegetation sampling using Modified Whittaker Plots is quite useful and especially when applied as recommended by Stohlgren et al. (1995), the methodology has been used extensively and intensely in America with good results. In most studies a range of 2 to 4 plots per site was enough to gather the prevalent diversity; similarly this is observed when edible Orchid diversity could be gathered after 5 plots (Fig. 5) and 9 plots for non-edible ones. Among the reasons for the sanction of this method involves its ability to gather rare species, and two rare Orchid species could be gathered during this study (Table 5). There may be rare species also among other groups of plants, since a multitude of them were represented by only one individual, but this is not within the interest of this study and data are not presented here.

However, some discrepancies might arise in this methodology, especially when considering quantifying plants that grow in clusters or colonies like the Orchids. The method may suit those plants which are reasonably evenly spread or scattered. For the Orchid quantification probably this method may not be the best, probably methods such as adaptive cluster sampling may be the option. This methodology is particularly advantageous for sites where the target population is rare, clustered, unpredictable, elusive or hard to detect (Silletti and Walker 2003). A combination of the two would probably yield better results, pending resources and time availability.

Some aspects on ethnobotany

During this study we worked together with Orchid collectors and could explore and conduct dialogues. Most of those we worked together with were Kingas', and hence we got many names in their language (Appendix 2), though some other languages could feature. In such instances the collectors are aware of the name of the species in other languages, or the name from another ethnic group was adopted since the Kinga did not have a name on that species. The Kinga are very famous in the region as traders. They own most business undertakings from small scale to large scale in the southern part of Tanzania, especially Mbeya and Iringa. On that ground they are probably the main traders of Orchids and thus very knowledgeable about Orchids or probably they form the most informative group when it comes to Orchids.

In many cases different species bear the same name implying poor naming as a result of a recent perceived use value, since the majority of local names apply to useful plants whereas rarely one can get a local name for a plant with no local use (Cribb and Leedal 1982); the importance of the Orchids is a recent phenomenon and the result of the tuber trade. The general name for all Orchids in this area is Visekeni and they are grouped into edible and non-edible ones. Madudu, Linu, Manu or Mandu are names for species useless in trade and non-edible. Similarly Makali or Amakhali belong to this group, and the names imply their taste as bitter.

Visekelele or Masekelele refer to all non-edible Orchids. The edible group is referred to as Manseke or Vinseke, and they include names, such as Lidala, Sidala, implying "female" plants and Ligosi, Sigosi and Likose implying "male" plants. Local people in the study sites, name Orchids, especially the edible ones, with gender reference as "male" and "female" plants. According to them the Orchid plant that flowers is responsible for seeding for the next generation and thus on their perception they refer them as "male" plants, whereas those plants which do not flower as "female" plants. Notably, the gender names were mostly applied to edible species. This can possibly be a result of a traditional harvest practice before the escalating tuber trade where "male" plants were not harvested (contrary to these days when they are harvested) for perpetuation of the species. Instead their presence was considered sending signals for the next harvest collection site and yield. Upon location of such a plant one could foresee the next harvests spatially and quantitatively, normally expectedly distributed a few metres surrounding "male" plants. In addition the "male" plant tubers were not preferred relative to "female" ones, for they were considered not to bear a sizeable tuber, mainly because they feed the inflorescence, and hence loose tuber quality.

Conclusions

Small edible Orchid population size

Populations of edible Orchids were found to be smaller than non-edible ones, both quantitatively and species wise, seemingly due to plant collection. It is therefore important that their population size is established and appropriate action taken to avoid extinction.

More diversity of Orchids were gathered with increased area

Higher diversity was observed at Kitulo. However, there was much higher diversity when study sites were combined, suggesting for increased area for conservation. The area turned into a national park is relatively small, implying wide exposure to local extinction of the species. However, expansion of the national park is likely to bring conflicts with surrounding communities, and therefore this could only be possible if efforts in conservation will involve community based conservation strategy.

There is scanty knowledge on edible Orchids.

More coverage in terms of time and space is needed to explore and identify edible species parallel to conservation. The list produced by this study marks and yet indicates the long journey ahead for identification of both edible and non-edible ones. Much knowledge currently of edible species ends up at genus level and not all genera are listed, yet some genera bear both edible and non-edible Orchids. The assertion that probably 85 species in Makete are edible (Davenport and Ndangalasi 2003) demands verification.

Importance of habitat knowledge for Orchid conservation

Habitat loss/degradation holds the first position among species extinction threats, hence the need for its attention (Baillie 2004). Upon understanding which key habitats of preference of individual Orchid species are, it will be very easy for conservation and identification of threatened species as a result of habitat loss or degradations. This will help to decide on resource allocation and make strategic conservation management easy.

Orchid species experience different exploitation gradients

Different species experience different exploitation gradients due to different market preferences and, hence demand for different conservation attention. Literature shows that there is evidence that species collected for trade experience different exploitation pressure, depending on how that species fetches a market and price in the cross border trade between Tanzania and Zambia. A most preferred species is likely to face severe extraction from its habitat, hence more extinction threats relative to one with less preference. This phenomenon already exists (Davenport & Ndangalasi. 2003 and Bingham 2004); some species of *Disa* mostly preferred in Zambia have disappeared as a result, whereas the lesser preferred species were noted to get harvested later in the season after the preferred ones are exhausted.

Herbarium and museum records of the uses of Orchids for conservation management

Much of the information in museums and herbaria is not used in conservation, although such information would presently be very useful. It is important that this information is used to complement field works. Methods for evaluating museum and herbarium data should continue to be developed and enhanced, but equally their values be more widely recognized and made more accessible through databases and improved data quality. The move towards online access to museum collection data should eventually result in a global biodiversity facility of immense importance. The provision of adequate resources is essential and taxonomic expertise and ongoing field work will be indispensable in improving and expanding these data (Ponder et al. 2000)

Need for community based conservation

It is a tendency to think that local people are not concerned about a loss of natural resources. Alas! this is not the case, as can be seen from various efforts local people in Makete have sought trying to avoid Orchids resource depletion. Examples include traditional harvesting restrictions where only non-flowering plants ("females") were allowed to be harvested and not the flowering plants, a practice which appears to me as a strategic traditional conservation management method which gives a way for Orchid perpetuation. Yet, many farmers and local collectors upon such awareness have done individual trials to grow the tubers and one at Ilindiwe has tried to grow the seeds in an effort to domesticate the plant. The district administrative secretary (DAS) in Makete, who originally comes from Mbinga where they eat the Orchids, told us that when he was young they used to dig Orchids, but instead of removing the whole plant, they just plucked the tubers and put back the soil and left the plant to continue growing.

Whatever we see happening now in the form of overexploitation is the result of a situation, where the government took control of the natural resource conservation and local people were coercively taken out. This has created a situation where a resource becomes open access to local people and everyone else, such that no one but the government is considered responsible in conserving the resource, whereas after the government has taken control of the resources any one can harvest that natural resource at his or her own risk without boundaries and the only one to fear is the government authorities. In such a situation, even if one person would be willing to leave the flowering "male" plants for conservation purposes, it would not work, since one can be sure that if he or she does not collect the plants, another person will collect it. As the result everyone picks whatever is found to make up the saleable volume. This is exemplified by situations at Makangalawe and Ilindiwe where freelance collection is prevalent.

Recommendations

Community based conservation strategy as a tool for conservation area expansion and sustainability

Conservation sustainability will be achieved upon a common understanding between the park authority, Natural resource office and the surrounding community. This makes a call for participatory, community based conservation in which the village communities in Makete would be involved in conservation, to safeguard both rural livelihood and conservation. In this way expansion of the conservation efforts to surrounding matrices of the park would increase the area under conservation hence more accommodation of Orchid diversity and other plants.

Introduction of harvesting quotas

There is an urgent need to develop more reliable methods for managing harvested populations. Three alternative policies commonly used to manage harvests of natural resources are fixed quota, fixed proportion and fixed escapement. Fixed quota harvesting policy is more likely to lead to a wide variation in population density and elevated probability of extinction than fixed proportion or fixed escapement policies. Yet, it does not provide a compensatory mechanism to accommodate environmental variation that will inevitably occur (Fryxell et al. 2005).

The use of herbarium/museum data in conservation planning and management

It is very important to collect field information and specimens, which are critically reviewed and included in electronic data bases for easy access and retrieval. Because many collections in the data bases are trend oriented, it is important that in the labels the mission for that collection is stated, and also that information on habitat be included in the data base. Institutions dealing with plants or other life forms in one way or another should be involved in documenting such information by establishing their own herbarium.

The need for more studies for effective Orchid conservation

There is generally very scanty information on Orchids in the study area. More studies are important to fill up knowledge gaps and hence a meaningful conservation management. This includes, but is not limited to, their life cycles/history, their population sizes, which species are edible and non-edible as well as habitat requirements and preferences and possibilities for their cultivation.

Need for market-oriented studies and on alternative development for edible Orchids

More studies are needed to identify edible species of Orchids prone to the trade and estimate their population for effective conservation management and monitoring. Also studies can be directed towards sourcing alternatives to edible Orchids so as to reduce their overexploitation impacts

Protection of key habitats from degradation and destruction

Grassland, mbuga and woodland vegetation as described in this study are the key habitats as they harbour relatively more Orchid species; these would conserve a considerable Orchid diversity, hence the demand to protect them.

Conservation of habitat specialists and rare species

More attention is to be allocated towards conserving the rare species *Habenaria occlusa* and *Eulophia schweinfurthii*, but also habitat specialist species (appendix 8) since habitat degradation is currently intensive.

Community based conservation must be opted

As a way to expand conservation area and at the same time support rural livelihood, yet for sustainability reasons, participatory conservation methods are of key importance

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Dedication

This work is dedicated to my former supervisor, the late Dr. Börge Petterson. It is through his keen attention to Orchids that I developed interest to study them and I look ahead to continued work on this family.

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Appendix 1. Plot reference Information

PLOT 1
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 06 206	09 06 193	09 06 183	09 06 196	09 06 195
Longitude – E	033 52 296	033 52 318	033 52 314	033 52 291	033 52 305
Altitude	2735 m				
Slope	Fairly slope area at the depression or the foot of the hill				
Aspect**	South west				

PLOT 2
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 06 202	09 06 177	09 06 178	09 06 207	09 06 195
Longitude – E	033 52 296	033 52 318	033 52 314	033 52 291	033 52 191
Altitude	2800 m				
Slope	12% Fairly steep slope area at the side of the hill				
Aspect**	South west				

PLOT 3
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 05 071	09 05 081	09 05 071	09 05 061	09 05 071
Longitude – E	033 53 489	033 53 514	3033 52 517	033 53 591	033 53 501
Altitude	2640 m				
Slope	Gently slope area at the side of the hill				
Aspect**	South-South west				

PLOT 4
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot

Latitude – S	09 05 054	09 05 047	09 05 059	09 05 065	09 05 060
Longitude – E	033 53 605	033 53 580	033 53 516	033 53 599	033 53 593
Altitude	2639 m				
Slope	Flat river plain				
Aspect**	-				

PLOT 5
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 20 979	09 20 824	09 20 825	09 20 799	09 20 810
Longitude – E	034 20 523	034 20 524	034 20 535	034 20 534	034 20 528
Altitude	2400 m				
Slope	Summit almost flat				
Aspect**	South east				

PLOT 6
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 20 809	09 20 810	09 20 836	09 20 834	09 20 8823
Longitude – E	034 20 603	034 20 611	034 20 606	034 20 596	034 20 604
Altitude	2390 m				
Slope	Summit almost flat				
Aspect**	-				

PLOT 7
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 21 530	09 21 531	09 21 509	09 21 507	09 21 520
Longitude – E	034 20 708	034 20 696	034 20 692	034 20 701	034 20 699
Altitude	2310 m				

Slope	Almost flat at summit
Aspect**	-

PLOT 8
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 21 932	09 21 480	09 21 490	09 21 482	09 21 482
Longitude – E	034 20 932	034 20 636	034 20 614	034 20 610	034 20 621
Altitude	2360 m				
Slope	Almost flat at summit				
Aspect**	-				

PLOT 9
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 14 287	09 14 269	09 14 261	09 14 271	09 14 277
Longitude – E	034 14 613	034 14 633	034 14 626	034 14 619	034 14 609
Altitude	2360 m				
Slope	Fairly slope area				
Aspect**	South east				

PLOT 10
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 14 287	09 14 269	09 14 261	09 14 271	09 14 277
Longitude – E	034 14 613	034 14 633	034 14 626	034 14 619	034 14 609
Altitude	2360 m				
Slope	Fairly slope area				
Aspect**	North – west				

PLOT 11
Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 14 499	09 14 499	09 14 508	09 14 506	09 14 502
Longitude – E	034 14 628	034 14 606	034 14 606	034 14 626	034 14 609
Altitude	2370 m				
Slope	Fairly gentle slope area				
Aspect**	-				

PLOT 12

Altimeter and GPS Readings

Item	Corner 1	Corner 2	Corner 3	Corner 4	Center plot
Latitude – S	09 16 194	09 16 185	09 16 193	09 16 203	09 16 197
Longitude – E	034 15 928	034 15 931	034 15 957	034 15 956	034 15 942
Altitude	2290 m				
Slope	Gentle slope				
Aspect**	North				

Appendix 2. Species checklist

Edible Orchids

Family	Name	Vernacular Name - Kinga	Coll No.
Orchidaceae	*Brachycorythis pleistophylla* Reichb.f.	Likose	OK 1329
Orchidaceae	*Disa erubescens* Rendle	Liseku	OK 1265
Orchidaceae	*Disa ochrostachya* Reichb.f.	Edible	OK 1347
Orchidaceae	*Disa robusta* N.E.Br.	Likose,Manseke, Liiseke	OK 1257
Orchidaceae	*Eulophia schweinfurthii* Kraenzl.	Ndulamo	
Orchidaceae	*Habenaria xanthochlora* Reichb.f.	Ndulamo	OK 1254
Orchidaceae	*Satyrium atherstonei* Reichb.f.	Lidala	OK 1327
Orchidaceae	*Satyrium buchananii* Schltr.	Likosi	OK 1330

None Edible Orchids

Family	Name	Vernacular Name - Kinga	Coll No.
Orchidaceae	*Eulophia odontoglossa* Reichb.f.		OK 1345
Orchidaceae	*Habenaria macrura* Kraenzl.	Masekelele	OK 1287
Orchidaceae	*Habenaria occlusa* Summerh.		OK 1318
Orchidaceae	*Habenaria praestans* Rendle	Dinu, Linu	OK 1352
Orchidaceae	*Roeporocharis wentzeliana* Kraenzl.	Masekele	OK 1349
Orchidaceae	*Satyrium acutirostrum* Summerh.		OK 1255
Orchidaceae	*Satyrium crassicaule* Rendle	Masekelele,	OK 1277
Orchidaceae	*Satyrium neglectum* Schltr.	Linu, Amanu /Sekelele	OK 1336
Orchidaceae	*Satyrium princeae* Kraenzl.		

Other Plant species

Family	Name	Vernacular Name - Kinga	Coll No.
Poaceae	*Acroceras attenuatum* Renvoize	Manyasi ya mkiholo, Kidilu	
Poaceae	*Acroceras attenuatum* Renvoize	Manyasi yamkihulu,Manyasi, Zwibu feki	OK 1356

Papilionaceae	*Adenocarpus mannii* (Hook.f.) Hook.f.		OK 1319
Papilionaceae	*Aeschynomene mimosifolia* Vatke	Lisonge	OK 1274
Apiaceae	*Agrocharis pedunculata* (Bak.f.) Heyw. & Jury		OK 1291
Poaceae	*Agrostis kilimandscharica* Mez	Madani	OK 1296
Anthericaceae	*Albuca abyssinica* Jacq.		
Apiaceae	*Alepidea peduncularis* Steud. ex.A.Rich.		OK 1295
Poaceae	*Andropogon amethystinus* Steud.		OK 1300
Asteraceae	*Anisopappus chinensis*Hook. & Arn.	Kalango	OK 1339
Rubiaceae	*Anthospermum usambarense* K.Sch.	Nyambasa	OK 1354
Asteraceae	*Artemisia afra* Jacq.	Manyaghe,Msumba	OK 1276
Asteraceae	*Aster tansaniensis* Lippent	Mikisilo,Malawasa,Madani	OK 1278
Papilionaceae	*Astragalus atropilosulus*(Hochst.) Bunge		OK 1302
Asteraceae	*Athrixia rosmarinifolia* (Walp) Oliv. & Hiern		
Asteraceae	*Bidens magnifolia* Sharff	Nyalaenza	OK 1341
Poaceae	*Brachiaria scalaris* Pilg	Zwibu	OK 1340
Poaceae	*Bromus leptoclados* Nees		OK 1263
Scrophulariaceae	*Buchnera capitata* Benth	Lighoba	
Cyperaceae	*Bulbostylis afrosanguinea* (Boeck.) C.B.Clarke	Kinyanya	
Cyperaceae	*Bulbostylis boeckleriana* (Schweinf.) K.Lye	Lugiliwe	OK 1284
Cyperaceae	*Carex taylorii* Nelmes		OK 1259
Dipsacaceae	*Cephalaria pungens* Szabo		OK 1279
Anthericaceae	*Chlorophytum macrophyllum* (A.Rich) Asch.		OK 1261
Anthericaceae	*Chlorophytum* sp.	Majongoingoi	OK 1336
Ranunculaceae	*Clematopsis uhehensis* (Engl.) Staner & Leonard		OK 1264
Commelinaceae	*Commelina africana* L.	Matonya,Kololo	
Asteraceae	*Conyza bonariensis* (L.) Cronquist	Ghapula	
Crassulaceae	*Crassula alba* Forsk. *x vaginata* Eckl. & Zeyh.		OK 1314
Asteraceae	*Crepis newii* Oliv. & Hiern	Sugulya	OK 1344

Thelypteridaceae	*Cyclosorus tottus* (Thunb.) Pic.Serm.	Likete	
Boraginaceae	*Cynoglossum johnstonii* Bak.	Dekenyi,Mandadela,Manghapoli	OK 1308
Cyperaceae	*Cyperus tenax* Boeck	Iniekele	OK 1353
Ranunculaceae	*Delphinium leroyi* Franch. ex Huth		OK 1259
Asteraceae	*Dicoma anomala* Sond.	Linyenye	OK 1282
Papilionaceae	*Dolichos kilimandscharicus* Taub	Liholi, Ngwida	OK 1333
Aspidiaceae	*Dryopteris athamantica* (Kunze) O.Kunze	ILing'eteng'ete.	
Poaceae	*Echinochloa colona* Link.		OK 1307
Asteraceae	*Echinops lanatus* C.Jeffrey & Mesfin		OK 1315
Poaceae	*Eragrostis canescens* C.E.Hubb.	Dinu	OK 1266
Poaceae	*Eragrostis hispida* K.Schum.		OK 1280
Papilionaceae	*Eriosema nutans* Schinz.	Ndago,Singhogwo	OK 1288
Papilionaceae	*Eriosema ukingense* Harms	Lichobolo	OK 1334
Poaceae	*Festuca caprina* Nees	Kinyanya	OK 1270
Geraniaceae	*Geranium incanum* Burm .f.	Mandododo	OK 1258
Asteraceae	*Gerbera viridifolia* Sch.Bip.	Sunzi	
Iridaceae	*Gladiolus dalenii* van Geel.	Machaichai	OK 1294
Iridaceae	*Gladiolus gregorius* Baker	Makilisi	OK 1293
Iridaceae	*Gladiolus rupicolus* Vanpel	Matsi	
Thymelaceae	*Gnidia fastigiata* Rendle		OK 1331
Thymelaceae	*Gnidia fastigiata* Rendle		OK 1281
Thymelaceae	*Gnidia mollis* C.H.Wright	Nyamahala	
Asteraceae	*Haplocarpha thunbergii* Less		OK 1303
Asteraceae	*Helichrysum abietinum* O.Hoffm.	Nyamahala,Nyalukenge	OK 1343
Asteraceae	*Helichrysum foetidum* (L.) Moench	Lisumba	OK 1325
Asteraceae	*Helichrysum forskahlii* (G.F.Gmel.) Hilliard & B.L.Burtt	Maluhala,Masumbi	OK 1313
Asteraceae	*Helichrysum forskahlii* (G.F.Gmel.) Hilliard & B.L.Burtt		OK 1322
Asteraceae	*Helichrysum nudifolium* Less. var. *nudifolium*		OK 1271

Asteraceae	*Helichrysum nudifolium* Less. var. *pilosellum*		OK 1286
Asteraceae	*Helichrysum odoratissimum* (L.) Sweet	Usunda	OK 1268
Asteraceae	*Helichrysum splendidum* (Thunb.) Less.	Msumba	OK 1283
Apiaceae	*Heteromorpha trifoliata* (Wendli) Eckl. & Zeyh.		OK 1321
Poaceae	*Hyparrhenia filipendula* Stapf	Masoli, Kinyabina,Nyanyonga	OK 1320
Poaceae	*Hyparrhenia rudis* Stapf	Imapelegu,Mapelegu	
Balsaminaceae	*Impatiens cribbii* (Grey-Wilson) Grey-Wilson	Heleni,Bongubongu	OK 1316
Balsaminaceae	*Impatiens rosulata* Grey-Wilson		OK 1271
Papilionaceae	*Indigofera antunesiana* Harms		OK 1348
Asteraceae	*Inula chilensis* Oliv.		OK 1301
Acanthaceae	*Justicia matammensis* (Schweinf.) Oliv.	Mwisobolo,Manokolya	OK 1311
Aloaceae	*Kniphofia grantii* Baker	Mapinzakokolo,Masusukanyandeka	OK 1292
Labiatae	*Leucas menthifolia* Baker	Manindandalis	OK 1342
Lobeliaceae	*Lobelia gibberoa* Hemsley		
Lycopodiaceae	*Lycopodium clavatum* L.		OK 1337
Oxalidaceae	*Oxalis obliquifolia* A.Rich.	Tamtam,Vinono	OK 1309
Poaceae	*Panicum lukwangulense* Pilger		OK 1269
Geraniaceae	*Pelargonium luridum* (Andr.) Sweet.	Lungulila,Dwa jino	OK 1310
Rubiaceae	*Pentas decora* S.Moore	Simimi	OK 1317
Poaceae	*Pentaschistis natalensis* Stapf	Murkas	
Apiaceae	*Peucedanum dispersum* C.C.Townsend		OK 1305
Proteaceae	*Protea heckmanniana* Engl.	Sirumenye	OK 1328
Poaceae	*Rendlia altera* (Rendle) Chiov.	Nyekele	
Rosaceae	*Rubus iringanus* Gust.		OK 1332
Polygonaceae	*Rumex abyssinica* Jacq.	Liputi, Madoda	OK 1306
Dipsalicaceae	*Scabiosa columbaria* L.	Matandala	OK 1304
Asteraceae	*Senecio* cf. *semiamplexifolius* De Wild.		OK 1285
Asteraceae	*Senecio erubescens* Aiton	Lisumba	OK 1324

Asteraceae	*Senecio inornatus* DC.		OK 1275
Asteraceae	*Senecio karaguensis* O.Hoffm.		OK 1299
Scrophulariaceae	*Sopubia comfeta* S.Moore	Kidia	OK 1289
Poaceae	*Sporobolus pyramidalis* P.Beauv.	Zwibu original	
Menispermaceae	*Stephania abyssinica* Walp.		OK 1355
Asteraceae	*Stoebe kilimandscharica* O. Hoffm.	Nyalukenge	
Scrophulariaceae	*Supubia manii* Skan		
Papilionaceae	*Trifolium simense* Fresen		
Papilionaceae	*Trifolium wentzelianum* Harms		OK 1272
Papilionaceae	*Trifolium wentzelianum* Harms		OK 1272
Campanulaceae	*Wahlenbergia abyssinica* (A.Rich) Thulin		OK 1312
Campanulaceae	*Wahlenbergia polycephala* (Mildbr.) Thulin	Mandondo	

Appendix 3. Number of genera and species in all families and their species/genus ratio

	Genera		Species		
Family	Total	%total	Total	%total	Specie/Genus ratio
Acanthaceae	1	1	1	1	1
Aloaceae	1	1	1	1	1
Anthericaceae	2	3	2	2	1
Apiaceae	4	5	3	3	0.75
Asteraceae	14	18	22	20	1.57
Balsaminaceae	1	1	2	2	2
Boraginaceae	1	1	1	1	1
Campanulaceae	1	1	2	2	2
Commelinaceae	1	1	1	1	1
Asteraceae	1	1	1	1	1
Crassulaceae	1	1	1	1	1
Cyperaceae	3	4	4	4	1.33
Dipsacaceae	1	1	1	1	1
Dipsalicaceae	1	1	1	1	1
Geraniaceae	1	1	1	1	1
Poaceae	15	19	15	14	1
Iridaceae	1	1	3	3	3
Labiatae	1	1	1	1	1
Lobeliaceae	1	1	1	1	1
Lycopodiaceae	1	1	1	1	1
Menispermaceae	1	1	1	1	1
Orchidaceae	6	8	17	16	2.83
Oxalidaceae	1	1	1	1	1
Papilionaceae	7	9	9	8	1.29
Polygonaceae	1	1	1	1	1
Proteaceae	2	3	2	2	1
Ranunculaceae	2	3	2	2	1
Rosaceae	1	1	1	1	1
Rubiaceae	2	3	2	2	1
Scrophulariaceae	2	3	3	3	1.5
Thelypteridaceae	1	1	1	1	1
Thymelaceae	1	1	3	3	3

Appendix 4. Contribution of the Orchids to the flora of the study sites

Kitulo

	Orchidaceae*		Other families		
Taxanomic level	Total	%	Total	%	All Total
Family	1	5.56	17	94.44	18
Genus	5	13.16	33	86.84	38
Species	9	18.37	40	81.63	49

* Edible Orchids % contribution; Genera 3 (2.63%) & Species 4 (8.16%)

Makangalawe

	Orchidaceae*		Other families		
Taxanomic level	Total	%	Total	%	All Total
Family	1	6.25	15	93.75	16
Genus	5	17.24	24	82.76	29
Species	7	238	24	77.22	31

* Edible Orchids % contribution; Genera 2 (6.70%) & Species 2 (16.12%)

Ilindiwe

	Orchidaceae*		Other families		
Taxanomic level	Total	%	Total	%	All Total
Family	1	5.56	17	19.44	18
Genus	3	9.38	29	90.62	32
Species	5	13.16	32	86.84	38

* Edible Orchids % contribution; Genus 1 (3.13%) & Species 2 (5.26%)

Appendix 5. Orchid presence by site

Edible	**Kitulo**	**Makangalawe**	**Ilindiwe**	**Ndulamo**
Brachycorythis pleistophylla Reichb.f.	x			
Disa erubescens Rendle		x	x	
Disa ochrostachya Reichb.f.		x		
Disa robusta N.E.Br	x		x	
Eulophia schweinfurthii Kraenzl.				x
Habenaria xanthochlora Reichb.f.				x
Satyrium atherstonei Reichb.f.	x			
Satyrium buchananii Schltr.	x			
None Edible				
Eulophia odontoglossa Reichb.f.				x
Habenaria macrura Kraenzl.		x		
Habenaria praestans Rendle		x	x	
Habenaria occlusa Summerh.	x			
Roeporocharis wentzeliana Kraenzl.	x	x		
Satyrium acutirostrum Summerh.	x			
Satyrium crassicaule Rendle	x	x		
Satyrium neglectum Schltr.	x	x	x	
Satyrium princeae Kraenzl.			x	

Appendix 6. Proportion of edible Orchids per site in the family Orchidaceae

Kitulo

	Orchidaceae				
	Edible		**None edible**		
Taxonomic level	Total	%	Total	%	All Total
Family	1		0		1
Genus	3	50	3	50	6
Species	4	44.44	5	55.56	9

Makangalawe

	Orchidaceae				
	Edible		**None edible**		
Taxonomic level	Total	%	Total	%	All Total
Family	1		0		1
Genus	1	25	3	75	4
Species	2	28.57	5	71.43	7

Ilindiwe

	Orchidaceae				
	Edible		**None edible**		
Taxonomic level	Total	%	Total	%	All Total
Family	1		0		1
Genus	1	33.33	66.67		3
Species	2	40	3	60	5

Ndulamo

	Orchidaceae				
	Edible		**None edible**		
Taxonomic level	Total	%	Total	%	All Total
Family	1	100	0		1
Genus	2	66.67	1	33.33	3
Species	2	66.67	1	33.33	3

Appendix 7.Number of herbarium specimens from different habitats for species with at least 2 records.

Cl –Cultivated land **Gv** – Grassland vegetation **Mv** - Mbuga vegetation **Rv** – Riverine vegetation **Rcv** – Rocky vegetation **Cf** – Closed forest **Fp** –Forest plantation **Wv** – Woodland vegetation **Sv** – Shruby vegetation

	Habitat categories									No.
Species name	**Cl**	**Cf**	**Sv**	**Rcv**	**Fp**	**Rv**	**Wv**	**Mv**	**Gv**	**individuals**
Calanthe sylvatica (Thou.) Lindl		2					9			11
Cynorkis anacamptoides Kraenzl.								2	3	5
Cynorkis kaessneriana Kraenzl.					2	1	2			5
Disa concinna N.E.Br.					1	1	1	1		4
Disa erubescens Rendle[1]						2		3	10	15
Disa robusta N.E. Br.[1]							3		3	6
Disa welwitschii Rchb.f.								3	1	4
Disperis anthoceros Rchb.f.					2				1	3
Disperis dicerochila Summerh.					2		2			4
Disperis johnstonii Rchb.f. ex Rolfe							4			4
Disperis reichenbachiana Welw. ex Rchb.f.					3		1			4
Eulophia euantha Schltr.							2		1	3
Habenaria cornuta Lindl.					2	1		2	1	6
Habenaria kyimbilae Schltr.						1		1	6	8
Habenaria malacophylla Reichb.f.							5			5
Habenaria occlusa Summerh.[2]						3	1			4
Habenaria praestans Rendle[2]	1		1		4	2	1		2	11
Habenaria retinervis Summerh.					1		1	1	2	5
Habenaria schimperiana Hochst. ex A. Rich.			1				1	3		5
Habenaria trachypetala Kraenzl.									4	4
Habenaria welwitschii Rchb.f.						2		2		4
Habenaria xanthochlora Schltr.[1]						1			3	4
Holothrix nyasae Rolfe				1		3	1		2	7
Liparis bowkeri Harv.				2	2	1	3		1	9
Liparis nervosa (Thunb.) Lindl.		1					3	2		6
Platycoryne buchananiana (Kraenzl.) Rolfe				1				3		4
Pteroglossaspis eustachya Reichb.f.			1				1	3	2	7
Roeperocharis bennettiana Reichb.f.							2	3	5	10
Roeperocharis wentzeliana Kraenzl.[2]						3		2	7	12
Satyrium acutirostrum Summerh.[2]						2				2
Satyrium atherstonei Reichb.f.[1]						2	1	3		6
Satyrium breve Rolfe								6		6
Satyrium buchananii Schltr.						1		3	3	7
Satyrium crassicaule Rendle[2]						2		3		5
Satyrium monadenum Schltr.								1	4	5
Satyrium neglectum Schltr.[2]						3			3	6

Satyrium sphaeranthum Schltr.					1		2	2	5	10
Satyrium volkensii Schltr.							2	1	1	4
No. individuals per habitat	**1**	**3**	**3**	**4**	**20**	**31**	**48**	**50**	**70**	**230**
No species per habitat	**1**	**2**	**3**	**3**	**10**	**17**	**21**	**21**	**22**	

1- Edible species encountered during field survey of this study; 2 – None edible species encountered during this study field survey.

Appendix 8 Habitat preferences as recorded from herbarium specimens

Habitat specialists

- *Calanthe sylvatica* - woodland vegetation,
- *Disa erubescens*- grassland vegetation
- *Roeperocharis wentzeliana* - grassland vegetation
- *Satyrium atherstonei* and *Satyrium buchananii* – Mbuga vegetation
- *Satyrium breve* - mbuga vegetation

Habitat generalists

- *Habenaria cornuta*
- *Habenaria praestans*
- *Holothrix nyasae*
- *Liparis bowkeri*
- *Liparis nervosa*
- *Pteroglossaspis eustachya*
- *Satyrium sphaeranthum*

Appendix 9. A list of specimens of Orchid species in the two studied herbaria.

Species name	No. Specimen
Brachycorythis buchananii (Schltr.) Rolfe	1
Brachycorythis friesii (Schltr) Summerh.	1
Brachycorythis rhodostachys (Schltr.) Summerh.	1
Brachycorythis tenuior Rchb.f.	1
Brownleea parviflora Harv. ex Lindl.	3
Calanthe sylvatica (Thou.) Lindl.	11
Calanthe volkensii Rolfe	1
Cynorkis anacamptoides Kraenzl.	6
Cynorkis hanningtonii Rolfe	2
*Cynorkis kaessneriana*Kraenzl.	6
Disa aequiloba Summerh.	2
Disa celata Summerh.	1
Disa concinna N.E.Br	4
Disa engleriana Kraenzl.	1
Disa equestris Reichb. f.	1
Disa erubescens Rendle	16
Disa fragrans Schltr.	1
Disa hamatopetala Rendle	3
Disa leucostachys Kraenzl.	2
Disa longilabris Schltr.	1
Disa miniata Summerh.	2
Disa ochrostachya Reichb.f.	2
Disa ornithantha Schltr.	2
Disa robusta N.E. Br.	7
Disa satyriopsis Kraenzl.	1
Disa saxicola Schltr.	2
Disa stairsii Kraenzl.	1
Disa stolzii Schltr.	3
Disa ukingensis Schltr.	1
Disa walteri Schltr.	4
Disa welwitschii Reichb.f.	4
Disa zombica N.E.Br.	3
Disperis anthoceros Reichb.f.	4

Disperis anthoceros Reichb.f. var *anthoceros*	2
Disperis dicerochila Summerh.	4
Disperis johnstonii Reichb.f. ex Rolfe	4
Disperis leuconeura Schltr.	2
Disperis reichenbachiana Welw. ex Reichb.f.	4
Disperis sp.	1
Eulophia angolensis (Reichb.f.) Summerh.	2
Eulophia clavicornis Lindl.	1
Eulophia cucullata Lindl.	1
Eulophia euantha Schltr.	5
Eulophia horsfallii (Bateman) Summerh.	1
Eulophia ischna Summerh.	1
Eulophia kyimbilae Schltr.	1
Eulophia latilabris Summerh.	1
Eulophia lindiana Kraenzl.	1
Eulophia livingstoniana (Reichb.f.) Summerh.	1
Eulophia malangana (Reichb .f.) Summerh.	2
Eulophia milnei Reichb.f.	1
Eulophia odontoglossa Reichb. f.	2
Eulophia paivaeana (Reichb.f.) Summerh. subsp. *borealis* Summerh.	2
Eulophia rara Schltr.	1
Eulophia shupangae (Reichb.f.) Kraenzl..	1
Eulophia sp.	4
Eulophia speciosa (R. Br. ex Lindl.) Bolus	1
Eulophia streptopetala Lindl.	2
Eulophia thomsonii Rolfe	1
Eulophia warneckeana Kraenzl.	1
Eulophia zeyheri Hook.f.	2
Habenaria adolphi Schltr.	2
Habenaria altior Rendle	1
Habenaria clavata (Lindl.) Reichb.f.	1
Habenaria cornuta Lindl.	6
Habenaria filicornis Lindl.	1
Habenaria galactantha Kraenzl.	1
Habenaria genuflexa Rendle	2
Habenaria goetzeana Kraenzl.	3
Habenaria gonatosiphon Summerh..	2
Habenaria holubii Rolfe	1

Habenaria humilior Reichb.f.	3
Habenaria isoantha Schltr.	2
Habenaria kilimanjari Reichb.f.	3
Habenaria kyimbilae Schltr.	8
Habenaria leucotricha Schltr.	1
Habenaria macrura Kraenzl.	1
Habenaria malacophylla Reichb.f.	5
Habenaria occlusa Summerh.	5
Habenaria papyracea Schltr.	3
Habenaria petitiana (A.Rich.) T. Durand & Schinz	2
Habenaria praestans Rendle	11
Habenaria retinervis Summerh.	6
Habenaria richardsiae Summerh.	1
Habenaria schimperiana Hochst. ex A. Rich.	5
Habenaria silvatica Schltr.	3
Habenaria sp.	1
Habenaria sp.	3
Habenaria splendens Rendle	1
Habenaria stolzii Schltr.	1
Habenaria tentaculigera Reichb.f.	2
Habenaria tenuifolia Summerh.	2
Habenaria trachypetala Kraenzl.	4
Habenaria trilobulata Schltr.	3
Habenaria uhehensis Schltr.	1
Habenaria walleri Reichb.f.	1
Habenaria welwitschii Reichb.f.	4
Habenaria xanthochlora Schltr.	4
Habenaria zambesina Reichb.f.	2
Holothrix longiflora Rolfe	2
Holothrix nyasae Rolfe	8
Holothrix puberula Rendle	2
Liparia mulindana Schltr.	3
Liparia rungweensis Schltr.	1
Liparia sp.	1
Liparis bowkeri Harv.	9
Liparis deistelii Schltr.	1
Liparis nervosa (Thunb.) Lindl.	6
Malaxis katangensis Summerh.	1

Malaxis weberbaueriana (Kraenzl.) Summerh.	1
Neobolusia stolzii Schltr.	1
Neobolusia stolzii Schltr. var. *bombyliiflora* P.J.Cribb	2
Nervilia crociformis (Zoll. & Mor) Seidenf.	1
Nervilia humilis Schltr.	1
Nervilia kotschyi (Reichb.f.) Schltr.	1
Nervilia shirensis (Rolfe) Schltr.	1
Platycoryne buchananiana (Kraenzl.) Rolfe	4
Platycoryne crocea (Schweinf. ex Reichb.f.) Rolfe ssp. *ochrantha* (Schltr.) Summerh.	1
Platylepis glandulosa (Lindley) Reichb. f.	1
Polystachya bennettiana Reichb.f.	1
Polystachya sp.	1
Pteroglossaspis eustachya Reichb.f.	7
Roeperocharis bennettiana Reichb.f.	10
Roeperocharis wentzeliana Kraenzl.	12
Satyrium acutirostrum Summerh.	4
Satyrium anomalum Schltr.	2
Satyrium atherstonei Reichb.f.	6
Satyrium breve Rolfe	7
Satyrium buchananii Schltr.	8
Satyrium cheirophorum Rolfe	1
Satyrium chlorocorys Reichb.f. ex Rolfe	7
Satyrium comptum Summerh.	1
Satyrium crassicaule Rendle	5
Satyrium elongatum Rolfe	2
Satyrium kitimboense Kraenzl.	1
Satyrium longicauda Lindl.	2
Satyrium microcorys Schltr.	2
Satyrium monadenum Schltr.	5
Satyrium neglectum Schltr.	6
Satyrium neglectum Schltr. subsp. *woodii* (Schltr.) A.V. Hall	2
Satyrium neglectum Schltr. var. *neglectum*	1
Satyrium princeae Kraenzl.	2
Satyrium rhynchantoides Schltr.	1
Satyrium riparium Reichb.f.	1
Satyrium robustum Schltr.	1
Satyrium sacculatum (Rendle) Rolfe	3
Satyrium sceptrum Schltr.	3

Satyrium shirense Rolfe	1
Satyrium sp.	2
Satyrium sphaeranthum Schltr.	10
Satyrium trinerve Lindl.	1
Satyrium volkensii Schltr.	4
Schizochilus sulphureus Schltr.	2
Schwartzkopffia lastii (Rolfe) Schltr.	1
Stolzia nyassana Schltr.	2