The impact on orchid species abundance of gathering their edible tubers by HIV/AIDS orphans: a case of three villages in the Southern Highlands of Tanzania

J.F.X. Challe[1, 2] and P.C. Struik[2, *]

[1] Ministry of Agriculture, Food Security and Co-operatives, Department of Research and Training, Mikocheni Agricultural Research Institute, P.O. Box 6226, Dar es Salaam, Tanzania

[2] Centre for Crop Systems Analysis, Wageningen University, P.O. Box 430, NL-6700 AK Wageningen, The Netherlands

[*] Corresponding author (e-mail: paul.struik@wur.nl)

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Abstract

This paper examines the gathering of wild orchids and its effect on orchid species diversity and abundance in rural communities with high prevalence of HIV/AIDS and high numbers of orphans. The study was conducted in three villages in the Makete District of Tanzania. The study used a triangulation of ethnobotanical, anthropological and sociological methodologies. On the three gathering sites, we found a total of 12 different orchid species (7 edible and 5 non-edible ones) confirmed by an expert botanist, although local gatherers identified many more species. The Shannon–Wiener diversity index significantly differed among the three gathering sites. Analyses of focus group discussions and household surveys revealed that HIV/AIDS orphans and non-orphan children were the main gatherers of wild orchids. HIV/AIDS orphans (n = 55) gathered significantly more frequently (4.1 ± 1.8 times per week) than non-orphan children (n = 49; 1.9 ± 1.3 times per week) ($P < 0.01$). There was a statistically significant interaction between village and type of gatherer ($P < 0.05$). Scattered observations of changes in orchid species abundance over time were done using gatherers' indigenous knowledge and opinions. Orchid abundance peaked during May 2006. The study showed increasing abundance of non-edible orchid species and decreasing abundance of edible ones. There were highly significant, linear negative relationships between gathering pressure on the one hand and total number of orchid plants, total number of orchid species, number of edible orchid plants and number of edible orchid species on the other. These relationships were not statistically significant for non-edible orchids. We surmise that gathering edible orchid tubers is likely to become unsustainable, because once its tuber is harvested the plant does not recover or survive.

Additional keywords: chikanda, edible orchids, gathering pressure, Orchidaceae, species diversity, survival strategies

Introduction

Orchids are categorized by their way of growing into epiphytic, terrestrial and litophytic species (Axelsson, 2005). About 70% of the world's orchids are epiphytic and/or litophytic, 25% are terrestrial and 5% grow as litophytic, epiphytic and terrestrial (Arditti, 2007). Most terrestrial species are deciduous with subterranean storage organs in the form of fleshy tuberous roots that are replaced annually or persist for a few growing seasons. Orchids vary in flowering time (Wells *et al.*, 1998; Kindlmann & Balounova, 1999), depending on many population characteristics, including sensitivity of flower induction and flower growth to environmental factors, persistence and dormancy (e.g., Pfeifer *et al.*, 2006). In the Southern Highlands of Tanzania orchids produce spectacular flowers from April to October each year (Anon., 2006), thus attracting many tourists.

We focused our study on the Makete District located in the Southern Highlands. Some species of terrestrial orchids in this district are edible (Bingham, 2000; 2004; Davenport & Ndangalasi, 2003; Challe, 2005). These edible orchids mainly occur in the plateau grassland vegetations and grow with their roots anchored in the soil (Woodrich, 2007). For decades, the use of edible orchid tubers in Makete was limited to their roasted form known as *midday snacks*, consumed by the youth and elderly children while grazing livestock and to making recreational balls for playing (Challe, 2005). However, these orchids form part of the Zambian rural and urban diets, which has resulted in the expansion of their exploitation into the study area. Tubers of some edible orchid species are now being gathered commercially for export to Zambia by the villagers living nearby the Kitulo National Park and other gathering sites (Bingham, 2000; Davenport & Ndangalasi, 2003; Challe, 2005). In Zambia, processed orchid tubers form the main ingredient of the favourite local dish *chikanda*. Gathering orchids involves their complete uprooting, using various tools. However, no matter what kind of tool is used to dig up the orchids, the plant does not recover once the tuber has been removed. This causes a major threat to the survival of some of the orchid species bearing edible tubers. Davenport & Ndangalasi (2003) reported that more than 85 edible orchid species of the genera *Disa*, *Habenaria* and *Satyrium* are found in the wild in the Southern Highlands of Tanzania. They estimated that between 2.2 and 4.1 million orchid tubers are gathered *per year* and indicated that the species are under a threat of extinction due to their overexploitation. Bingham (2000) reported that in Zambia the orchid genera *Disa, Habenaria* and *Satyrium* are considered *upper grade* and excellent for preparing *chikanda*. However, due to the overexploitation of these species in Zambia, other *inferior* ones are currently being harvested in Zambia and there is a high demand for the better orchids from the Southern Highlands of Tanzania.

Whereas nature conservation societies are interested in conserving the terrestrial orchids, some of which are endemic in the area, collecting their tubers is a 'reliable' surviving strategy by the district's rural communities (O. Kapinga; personal communication) with low or no resources for agriculture production. The introduction of orchid tubers as a booming business by Zambia's middlemen came as a rescue to HIV/AIDS-affected households too. All orchids are protected by the International Union for Conservation of Nature (IUCN) and listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (Anon., 2008). Due to this, all orchids are on the Red List (i.e., the list of endangered species), explaining the establishment of

Kitulo Plateau National Park (Anon., 2006). This national park harbours diverse species of rare fauna and flora. Among the enormous variety of rare and spectacular flowers are 45 species of terrestrial orchids (Anon., 2006). Despite this unfortunate conflict of interests between the need to conserve threatened terrestrial wild orchid species and the need for the increasing number of local HIV/AIDS orphans to make a living by gathering wild orchids, there is scant knowledge on the impact of HIV/AIDS prevalence on gathering activity and species abundance and biodiversity of these orchids.

From the first AIDS patient in the late 1980s, Makete District has experienced and continues to experience a big impact of the pandemic as there is an increasing number of HIV/AIDS orphans (O. Kapinga; personal communication) like elsewhere in Sub-Saharan Africa (Monasch & Boerma, 2004). The increase in number of orphans is not only caused by deaths in district households, but also by deaths among people returning to the district, who left the district as emigrating workers, only to come back when they became too ill from a HIV/AIDS-related illness. Orphans are left uncared after the death of one or both of their parents. The death of the male adult "might leave the surviving widow in a precarious situation" (Muller, 2004) while leaving the orphans at the mercy of finding any means of surviving. Gathering orchid tubers is one of the very few ways to realize some level of food security and to provide resources to cover other basic needs for themselves and their siblings. However, the premature death of the parents prevents the passing of gathering knowledge to the children (Loevinsohn & Gillespie, 2003; Turner, 2003).

The objective of this study was to assess whether HIV/AIDS is a driving force behind orchid species exploitation and behind reduction in abundance of specific (edible) orchid species. Therefore, this study quantified gathering activity and pressure as well as species availability over time, and tried to link gathering pressure to species richness and species abundance.

Materials and methods

Some definitions

UNESCO defines a child as "...a person under 18, unless natural laws recognize the age of maturity earlier..." (Anon., 2004).

An orphan is a child of whom at least one parent has passed away. MacLellan (2005) discriminates between a single orphan, when one parent has deceased and a double orphan when both parents have deceased. A child who has lost one or both parents due to HIV/AIDS illness is called an HIV/AIDS orphan (HO). An HO has to provide for his/her own basic needs.

Non-orphan children are children under 18 of whom both parents are still alive and are not suffering from HIV/AIDS.

Secondary data and literature review

Prior to the study, relevant documents, written reports and other types of secondary information and records relevant to the history, demography, environmental characterization and natural resources of the study area were sought from relevant offices and organizations,

including the Tanzanian Ministry of Natural Resources and Environment, to articulate the gap this study intended to fill. Other secondary information from relevant bodies included the status of HIV/AIDS and its impact in the district. In none of the secondary sources, studies were described that linked the HIV/AIDS impact to wild plants and hence the Ministry of Natural Resources and Environment supported our study in the area.

Furthermore, a literature review was carried out on the potential orchid species that could be expected in the area.

Description of Makete District and selection of the study sites

The study was carried out in Makete District in the Southern Highlands of Tanzania. Makete village is located at about 332 km from the Iringa municipality. Undulating plains characterize the landscape. The district occupies a large and sparsely populated area (Table 1). About 72% of the land is suitable for agriculture. Game reserves occupy 9000 ha, natural forests 11,821 ha and plantation forests 7313 ha. The area under cultivation is 24,459 ha representing 20.3% of the total arable land area (O. Kapinga, personal communication). The whole district lies between 33°85' and 34°30' E and between 8°45' and 9°40' S.

The district of Makete consists of 56 villages. The study was conducted in three villages and their three gathering sites: Ujuni (with the Kitulo National Park as its nearby gathering site), Makangalawe and Ilindiwe. The study villages were selected by district officials on the basis of high numbers of HIV/AIDS orphans active in gathering orchid tubers.

Ethnobotanical study

Study site selection, plot identification and marking observational plots

The initial idea to analyse species abundance along a transect from the villages outwards into the pristine land proved impractical as there were no orchids close to the villages. Conversant orchid gatherers were selected and joined the research team for a brief inventory of gathering sites before the observation areas were selected. By involving indigenous gatherers in the transect walk and site selection, description, location and knowledge on the rules that govern the gathering of orchids were narrated. Furthermore, researchers gained information on precise sites where and in what habitats the orchids prevailed in the study area (Doble & Emery, 2001). It should be noted that gathering of orchids is illegal as the orchid plants are protected. Gathering in the Kitulo National Park is even less acceptable since no removal of plant material from that site is allowed.

Three gathering sites were selected: A, B, and C. Selection was based on actual sites where orchids were found and gathered, ecological conditions and nature of the sites. Gathering site A was selected because the gatherers believed it to be the only site with high abundance of marketable orchids; it is a conserved part of the Kitulo National Park. Gathering site B was selected because it was remote and had a low density of human population; the nearest village was Makangalawe. Gathering site C was selected as a wetland habitat frequented by Ilindiwe gatherers.

Within each of the three sites four permanent plots were selected using the random trail method (see Whittaker's plant diversity sampling method as described by Shmida, 1984). These plots were 20 m × 50 m; they were marked and a Global Positioning System

Table 1. Population, number and types of households and number of orphans in Makete District and the three orchid-gathering villages studied.

Makete District			
Total population	106,061		
Total area (km²)	5800		
Number of villages	98		
Total number of households	27,672		
No. (%) of HIV/AIDS-affected households	6925 (25)		
No. (% of population) of orphans	13,864 (13)		
Orchid-gathering villages	Ujuni	Makangalawe	Ilindiwe
No. of inhabitants per village	1521	655	487
No. of households per village	299	172	113
No. (%) of HIV/AIDS-affected households	240 (80)	75 (44)	80 (71)
No. (%) of female-headed households per village	32 (11)	25 (14)	27 (24)
No. (%) of orphan-headed households per village	63 (21)	8 (5)	13 (12)
No. (%) of guardian (of orphans) headed households	145 (48)	42 (24)	40 (35)
No. (% of population) of orphans per village	298 (20)	68 (11)	77 (16)

Sources: Makete District Commissioner Report (Anon., 2005) and Ujuni, Makangalawe, Ilindiwe village meetings with key informants, village and district reports (Anon., 2006; this study).

device was used to locate them accurately. In each plot, 10 quadrants of 1 m × 1 m were demarcated along the diagonal for sampling.

The three villages (Ujuni, Makangalawe and Ilindiwe) were at close distance from the study area. Numbers of inhabitants per village were recorded as well as the walking distance (in hours) from the villages to the orchid gathering sites. We also collected data on the social structure of households in these three villages (see below).

Species identification and assessment of species diversity and abundance

Name of orchid species and number of individuals per orchid species found in the 1 m × 1 m quadrants of all 12 plots were recorded in May 2006, October 2006 and January/February 2007. In the first two months, code names plus local names as identified by the knowledgeable gatherers from each village were temporarily assigned. In the period January/February, a botanist was present to identify the orchids by family, genus and species, if needed based on voucher specimens. The code names were then replaced by the correct scientific species names. Voucher specimens were collected and kept in the National Herbarium of the Plant Genetic Resource Institute in Arusha, Tanzania. Also photographs were taken to capture (flowering) species for identification and to support the description of ecotypes.

Anthropological approach

Being a very sensitive topic, studying the impact of HIV/AIDS in many African societies needs a careful approach of the society in question. For this study, tactics used by anthropologists were necessary. Bernard (2002) states that most anthropological data collection is done by field workers who go out and stay out and listen, take notes and bring it all home. It enables the researcher to have both emic (insider) and etic (outsider) perspectives of the study in question (Pelto & Pelto, 1978). However, data analysis in anthropology is done in an interpretivist tradition, and some empirical anthropologists reject the positivist epistemological tradition, whereas other empirical anthropologists (such as Bernard) identify with the tradition.

Since terrestrial wild orchids are 'forbidden' (O. Kapinga; personal communication) and gathering is prohibited by the Tanzania National Park Authority and the District Natural Resource Officers, gathering was also found to be a very sensitive issue to study and hence needed a tactful approach. Elsewhere, indigenous gatherers have sometimes been perceived as an invisible group, and are often difficult to locate (Doane, 1999), based on the common fear of being caught by legal authorities. This fear makes gatherers reluctant to talk about their gathering experience. Wanzala (O. Wanzala; personal communication) designed the tactic of using primary school children to prepare the ground in their respective households. Similarly, we used primary school children to fill census forms (with crucial and relevant open-ended questions) with their parents or guardians in their own language to gain trust.

Prior to the census, primary school children of grades 5 to 7 were given a short seminar on the importance of non-timber forest products to ecosystem services and the importance of sustainability for their livelihoods.

Social study: Participatory Rural Appraisal

Preparation

The social study started with meetings with key informants at national, district and village levels. Meetings with relevant Makete District officials facilitated the researcher to get insight into the situation of HIV/AIDS affliction and the increasing number of orphans. The group of officials pointed out the relevant villages with a high number of HIV/AIDS cases and orphans who practised gathering orchid tubers.

At the village level a meeting with village elders, women, youth and children was set up prior to the onset of the actual fieldwork, to design and initiate the study. The points of discussion included awareness of orchid species, how many types were known (and which are edible and non-edible) with their respective differences; the area where orchids were likely to be found; any associated plant species; indigenous knowledge on the orchids' growth habit and life cycle; and harvesting season (whether there were seasons of high and low availability). Other points of discussion were cultural significance of orchids; the main gathering categories; harvesting tools; who sets the price; where do buyers come from; storage of the tubers; change in vegetation; activities performed at the gathering sites; and benefit they derive from the orchid business. Finally, key informants were asked for their own, general comments on orchids.

Focus group discussions

Focus group discussions were a powerful exploratory tool used in this study, facilitating revived thinking, expressing feelings and allowing using detailed information about various topics relevant to this study. In each village, key informants were purposely divided into four groups: women, youth, children and elderly, with between 7 to 10 participants per group. Participants managed to explore different points of view and hence formulated their own perspective and understanding. This kind of dialogue yielded a lot of information on and insight into issues relevant for the study.

Case studies / in-depth interviews

Case studies included in-depth interviews with individuals selected randomly and with HIV/AIDS-affected individuals such as orphans, individuals from orphan-headed or female-headed households, and guardians. Case studies were crucial to gain additional information on the informant's social, economical and cultural issues and triangulate the information if the issues were driving forces behind the threat of species biodiversity. Patton (2002) noted that in-depth interviews are best suited for acquiring perceptions, motivations and feelings. A further advantage was the confidentiality between the researcher and the respondent.

Household surveys

Household surveys were necessary to collect empirical data on relevant variables of the sample population. Two kinds of purposeful sampling were applied to obtain a sufficient number of households affected by HIV/AIDS for comparison with non-HIV/AIDS households. The first purposeful sample included different types of orchid tuber gatherers, including widows (n = 120). The second purposeful sample was of orphan gatherers (n = 55) and non-orphan gatherers (n = 49) as control.

Calculations and data processing

Gathering pressure (GP) was estimated as

$$GP = \sum Pop_i / Wt_i$$

where

Pop_i = population of people in village i, (i = 1, ..., 3);

Wt_i = walking time from village i to the orchid gathering site.

Note that the gathering pressure was not corrected for differences between villages in proportion of HIV/AIDS orphans or for differences in gathering frequency between HIV/AIDS-affected orphans and other members of the population. A sensitivity analysis had shown that such corrections would not improve the correlations to be reported below.

The Shannon–Wiener diversity index (H) was calculated as

$$H = -\sum (p_k \ln p_k)$$

where
p_k = the (number of individuals of a certain species) / (total number of all species in the plot).

Statistical Package for Social Sciences (SPSS, Version 15) and Microsoft Excel computer programmes were used for regression analysis.

Results

Species identified and their diversity

The respondents to the survey indicated that they based identification of orchid species on the way the leaves emerged (40%), on the colour of the inflorescences (15%), the taste and texture of the tuber (10%), the shape of the tuber (5%), and/or the appearance of the stem (30%). For example, a gatherer explained that one could always identify a *Habenaria* plant (and distinguish it from for example *Satyrium*) in the vegetative stage based on the emerging leaves and the leaf arrangement just above soil level.

The botanical research showed that several different vernacular names could be given to the same botanical species whereas the locals also sometimes used the same vernacular name for different botanical species (Table 2). Vernacular names for the same botanical species often differed between the different villages.

As mentioned above, the study area is not representative for the entire Southern Highlands of Tanzania. The diversity in ecological niche included in the sampling is limited, and the time horizon is restricted. Nevertheless, we present precise data from a total area of 12,000 m² repeatedly sampled and are able to indicate some trends in numbers of individuals of different orchid species over time. In the study plots, 12 botanical species of

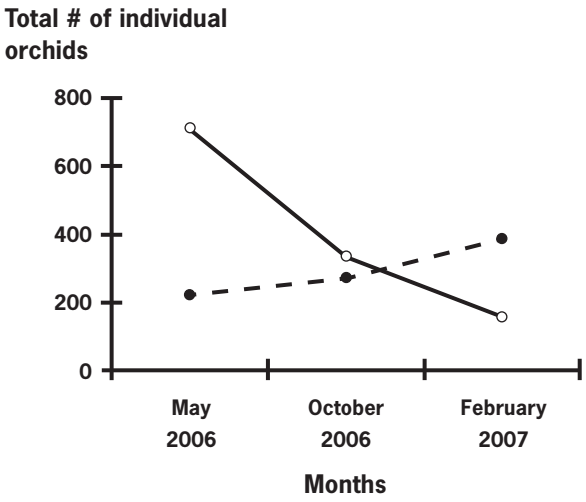

Figure 1. Changes in total number of edible (○) and non-edible (●) orchids per plot (10 m²) over the period May 2006 – February 2007.

Table 2. Names, numbers and use of the orchid species found at gathering sites A, B and C.

Botanical name	Local name	Total number encountered [1]	Use [2]
Disa erubescens Rendle	Masekele, Masekeni, Makaha ga mlutu.	321	E
D. robusta N.E. Br.	Liseku, Mekundu, Vikubwa, Vyekundu, Manene, Masekeniyakizungu.	150	E
Satyrium atherstonei Rchb. f.	Lidala, Jike, Sidala, Visekenividala, Vijike, Madala, Lisekejike, Numbunumbu, Ingingi, Masekenimadala, Lisekenilidala, Lisekeni.	94	E
S. buchananii Schltr.	Ligosi, Likosi, Masekeni dume, Visekenivikhosi, Dochamua, Visekenivigosi, Titisigosi, Lisekedochamua, Lisekekiume, Magosi, Lisekedume, Masekeni magosi, Sisekeni sigosi.	45	E
Habenaria xanthochlora Schltr.	Manseke, Mamkumungu, Liseke, Likose, Mviringo, Mansekemakubwa.	57	E
Eulophia schweinfurthii Kraenzl.	Lisesa	44	E
Roeperocharis wentzelania Kraenzl.	Masekele	0	E
Habenaria praestans Rendle var. *praestans*	Makeju, Mandutu, Makali, Masekeni ya mvidunda.	74	NE
Satyrium crassicaule Rendle	Masekelele, Lisekelele.	62	NE
S. acutirostrum Summerh.	Linu, Amanu, Dinu.	42	NE
S. neglectum Schltr. var. *neglectum*	Mansekerere, Mandutu, Isititu.	37	NE
S. princeae Kraenzl.	Lindu, Madudu	5	NE

[1] Reference time: May 2006.

[2] E = edible; NE = non-edible.

wild orchids were identified by indigenous orchid tuber gatherers. Among the 12 species, seven were categorized as edible (marketable ones) and five as non-edible ones (Table 2). For the 12 orchid species identified, 56 vernacular names were counted in the three villages investigated.

The most abundant species at the onset of the study were the edible ones *Disa erubesence* Rendle, *Disa robusta* N.E. Br. and *Satyrium atherstonei* Rchb. f. (together 79.5% of the total

number of edible orchid plants gathered). These three species also showed the strongest decline over time, accounting together for 82.7% of the total decline in number of edible orchids (Figure 1). The most abundant non-edible species at the beginning were *Satyrium crassicaule* Rendle and *Habenaria praestans* Rendle var. *praestans*, together accounting for 61.8% of the original number of non-edible orchid individuals and for 79.0% of the increase in non-edible individuals (Table 2; Figure 1).

However, the edible species *Satyrium atherstonei* Rchb. f. was found on four different plots, whereas the *Disa* species were only found on three plots. The non-edible species *Satyrium crassicaule* Rendle was even found on seven plots surveyed. Three plots had the highest orchid richness and these plots had especially large numbers of *Disa erubescens* Rendle (at least 54% of total count). In the second category were two plots: there *Disa robusta* N.E. Br. was most abundant (at least 72% of total count).

Among the three gathering sites, site B had the highest diversity index ($H = 1.092$), followed by site A (0.776) and site C (0.746). The survey in October 2006 gave the highest number of individual orchids over all sites (n = 931). February 2007 had the lowest (n = 544), but this difference was associated with a strong decline in the number of edible orchids (from 711 to 157) and an increase in the number of non-edible ones (from 220 to 387), suggesting that there was significant gathering pressure on the edible orchid species (Figure 1).

Census survey and information from key informants

Census

Simple statistics revealed that of all primary school children from the three villages (n = 400) 93% were aware of edible wild orchids species. About 75% of census respondents revealed to have orphans in their households (n = 400). When asked to identify the main categories of gatherers in their respective villages, all key informants mentioned children as the main gathering category followed by women.

Distinguishing factors between edible and non-edible orchid species

In all three villages key informants could easily distinguish between edible and non-edible orchids, using taste and other characteristics: edible orchids are sweet, have sugar crystals, are considered 'female orchids', and are highly marketable; non-edible orchids are bitter, have watery tubers, are considered 'male', and are non-marketable.

Potential area where orchid species were found

There was consensus amongst informants that orchids could be found in diverse areas, including mountainous areas, wetlands, non-fertile lands and fertile lands. However, key informants identified grasslands as the main biotope where orchids could be found. Gatherers indicated that they collected from no-man's land except, since recently, the Kitulo National Park demarcation. They explained they continued gathering in the park be it cautiously in order not to get caught.

Indigenous knowledge of orchid species, growth habit and life cycle

Key informants' consensus was that the orchids do not flower at the same time, that

the species are present at different (partly overlapping) periods, and that the gathering seasons for the different species are also spread over the entire year. Informants observed that once an orchid tuber was harvested at a particular spot, there would be no tuber found on the same spot the following year. Explaining this, they stated that orchid species grew 1 to 1.5 m from the hole where gathering had taken place and often in colonies (5 to more than 150 orchid plants). However, they noted most of these would be non-edible species.

Harvesting season

Gathering of tubers was done in the months of April, May, June and July (high season) and September, October, November (low season). In our study we recorded abundance in May, October and February. As some orchid species start sprouting in October, they can easily be distinguished in November.

Household survey

Household structure

The population and household structures with the number and proportions of orphans, HIV/AIDS-affected, female-head managed, orphan-head managed and orphan–guardian managed households are given in Table 1. The study areas show a high proportion of orphans and a high number of HIV/AIDS-affected or female-headed households.

Frequency of gathering (HIV/AIDS orphans and non-orphans) in the three villages

We found statistically significant main effects of village [$F(2, 98) = 34.658$, $P < 0.05$] and type of gatherers [$F(1, 98) = 58.812$, $P < 0.05$] on gathering frequency. Orphans gathered much more often than non-orphans. Finally, there was an interaction between village and type of gatherer [$F(2, 98) = 3.506$, $P < 0.05$]. Table 3 summarizes the effect of type of gatherer on gathering frequency in Ujuni, Ilindiwe and Makangalawe villages.

Impressions of gatherers on changes in orchid population density

The gatherers were very much aware of the impact of the high gathering pressure on the

Table 3. Mean frequency of gathering by HIV/AIDS orphans (n = 55) and non-orphan children (n = 49) in the three villages where orchids were gathered.

Village	Type of gatherer	Mean times per week orchids were gathered
Ujuni	HIV/AIDS orphans	4.1 ± 1.80
	Non-orphan children	2.8 ± 1.48
Makangalawe	HIV/AIDS orphans	2.2 ± 0.87
	Non-orphan children	1.2 ± 0.56
Ilindiwe	HIV/AIDS orphans	3.6 ± 1.17
	Non-orphan children	1.5 ± 0.74

abundance of edible species. About 65% of the respondents (n = 120) had the impression that too much gathering of the marketable orchid species would result in the species not having enough time to regenerate. One gatherer formulated it this way: "*The edible ones are 'the gold', that is, the highly marketable ones. We are not giving enough rest for the orchid plant to complete its life journey, that is, we harvest before they produce seeds for potential and future 'gold'.*"

Gatherers were also very aware of the fact that the edible orchid plants they harvested only produce one tuber. Only 6 respondents (n = 120) tried several times to propagate the edible orchid tuber through tubers, with discouraging results.

Non-edible orchids are not gathered since they have no commercial use. Orchid gatherers also noticed that non-edible orchids have enough time to "*continue with seeding and hence complete the reproduction and propagation cycle*".

Orchid tuber brokers/middlemen counterchecked all orchid tubers collected. This step, as explained by respondents, was very important for making sure all collected orchid tubers were marketable/edible. In this counterchecking exercise, between 25 and 50% of the orchid tubers gathered by orphans were rejected by the brokers/middlemen as *madudu*, non marketable and non-edible compared with only 10% of the tubers gathered by non-orphans.

Relationship between gathering pressure and species diversity and abundance

Figure 2 shows that there was a statistically significant, non-linear and negative relationship between gathering pressure and the Shannon–Wiener index ($P = 0.021$), confirming the general notion that gathering indeed reduced the diversity of orchids in the region. We therefore analysed this relationship in detail. Figure 3 provides information on the relationship between gathering pressure and the total number of orchid plants per plot, the number of edible orchids, and the number of non-edible orchids. These relationships were linear and highly significant for the total number of orchids ($P < 0.001$) and the number of edible orchids ($P < 0.001$), but not for the number of non-edible orchids ($P > 0.05$). Figure 4 shows the relation between gathering pressure and the total number of orchid species, the number of edible orchid species (Figure 4) and the number of non-edible orchid species found per plot. The results were very similar to those presented in Figure 3, with highly significant negative linear relationships for the total number of orchid species ($P < 0.001$) and the number of edible orchid species ($P < 0.001$), but not for the number of non-edible species ($P > 0.05$).

Discussion

The sites for the collection of the data on species abundance and diversity cannot be considered representative for the entire Southern Highlands. In order to be representative, our study should have been continued for much longer and should have included many more and more diverse sites. However, in combination with the social aspects of our study, several interesting aspects can be inferred.

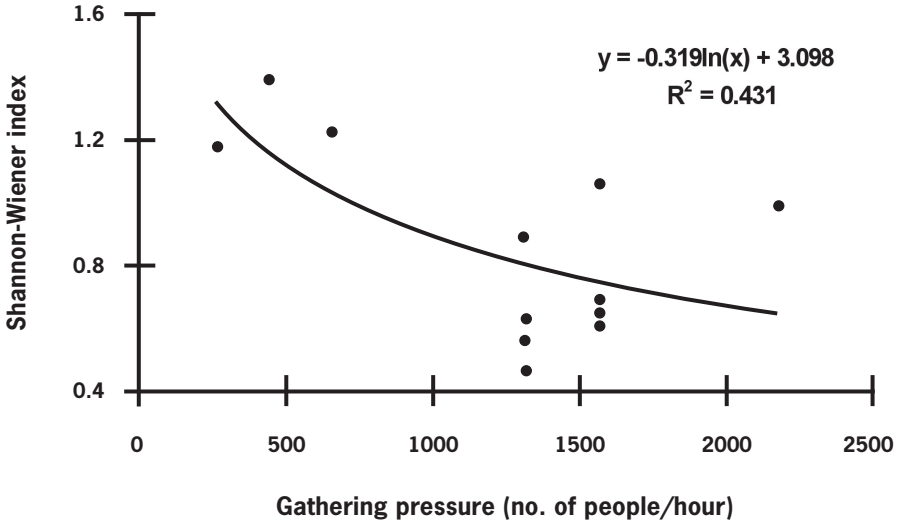

Figure 2. Effect of gathering pressure on the Shannon-Wiener Index.

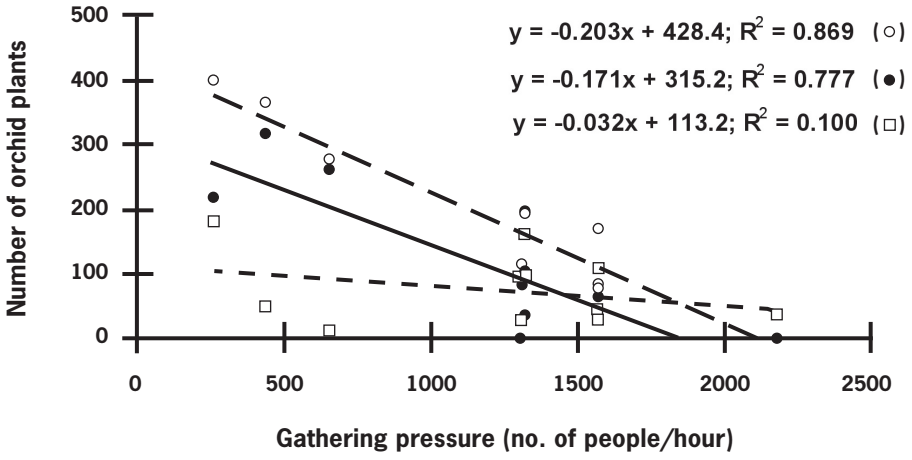

Figure 3. Effect of gathering pressure on total number (– – – ; ○), number of edible (▬ ; ●) and number of non-edible (- - - ; □) orchid plants per plot (10 m²).

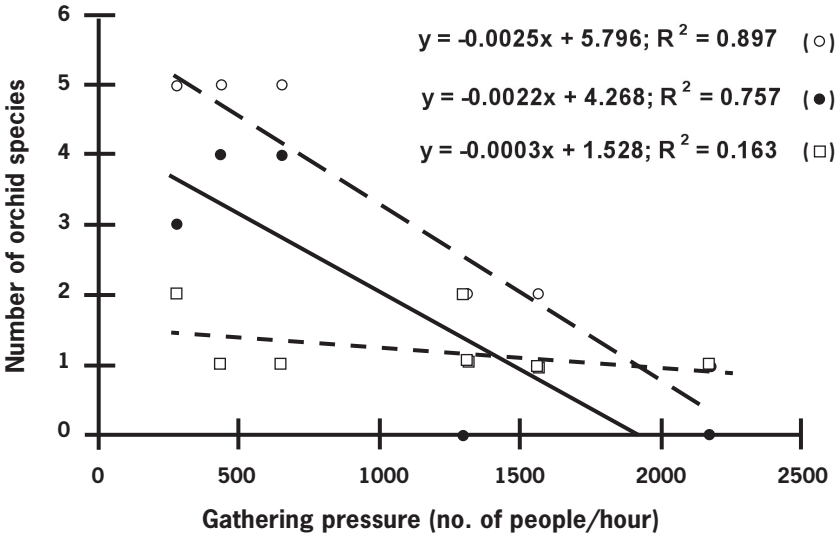

Figure 4. Effect of gathering pressure on number of all orchid species (– – –;○), edible orchid species (▬ ;●) and non-edible orchid species (- - -;□) per plot (10 m²).

Local versus botanical identification of orchid species

Local or indigenous identification of edible and non-edible orchid species was a challenge in this study. The indigenous gatherers managed to identify the species in the observational plots relatively correctly, based on their botanical knowledge, as observed elsewhere (Doane, 1999). However, identification was mainly correct at the genus level. The identification strategies were consistent with botanical keys (e.g., Cribb & Leedal, 1982; Stewart, 1996).

Differences in HIV/AIDS prevalence amongst villages

Makete District shows a relatively high proportion of orphan- and female-headed households (Table 1) as has been noted earlier (Dwasi, 2002; Daley, 2004). As orphans and female-headed households are the most vulnerable, the district as a whole is among the poorest areas in Tanzania.

This study also shows a very high proportion of households being in some way affected by HIV/AIDS (Table 1). Although all three villages were severely affected, the HIV/AIDS prevalence varied among them: Ujuni had the highest overall proportion of affected households (80%), Makangalawe the lowest (44%). The Ujuni village, being close to a through road from Makete town to Mbeya, is a busy village with an influx of business people from urban towns. Ilindiwe does not have a through road but is nearby the main road from Njombe to Makete. Makangalawe was located in a remote area where there was no road and no influx of people.

Frequency of gathering

HIV/AIDS orphans depended almost entirely on cash generated by selling edible orchid tubers for purchasing food, school items and refreshments according to all orphan gatherers interviewed (n = 55), much more so than non-orphan gatherers (n = 49). This dependency on gathering and selling non-timber forest products for cash income was anticipated by the Africa Biodiversity Collaborative Group (Anon., 2002) in high HIV/AIDS prevalence communities. In such societies, affected households tend to depend increasingly on natural resources and there is an increase in use intensity as a survival strategy, especially when the breadwinner becomes sick or has deceased.

Gathering frequency effect on orchid's species abundance

The possible extinction of orchids was confirmed by further analysis and by the impressions of the gatherers. Only the edible species suffered under the gathering pressure. Whenever there is a huge gathering pressure, the population of edible orchids tends to decline (Figure 3). All orchid gatherers interviewed admitted that the tuber removal involved total orchid plant uprooting resulting in plant death. Rock *et al.* (2004) and Ghimire *et al.* (2008) observed the same negative effect of harvesting the underground parts of other plant species.

Further social analysis in each village revealed that whenever there is an increase in HIV/AIDS orphans, there is an increase in gathering pressure. The increase in gathering frequency is based on a new-found coping strategy from HIV/AIDS-affected households. However, the new strategy and demand from the affected communities threaten to deplete the natural resources and reduce biological diversity (Dwasi, 2002).

Link between gathering frequency, HIV/AIDS orphans and decline in orchid species abundance

The increase in number of orphans in the study area has been explained by a long-term shockwave impact of HIV/AIDS (Rugalema, 1999). Other scholars (Dwasi, 2002) also noted that

> *"The number of AIDS orphan-headed or grandparent-run households increases. Many AIDS orphans are forced to fend for themselves and many grandparents have had to take responsibilities for raising their grandchildren directly when their children die. This has huge impacts on the social structure of communities. It also impacts how people use natural resources, as orphans and grandparents may not be able to do the labour-intensive farming typically performed by healthy adults."*

According to Rugalema (1999), the HIV/AIDS pandemic differs from other epidemics that have occurred in Africa. Non-timber forest products play a crucial role in rural households' coping strategies, especially when households experience a loss of breadwinner (Shackleton & Shackleton, 2005). Other scholars (Dwasi, 2002) have gone as far as to acknowledge the existence of linkages between the impacts of the HIV/AIDS pandemic and the use and management of natural resources in various ways. Dwasi (2002) pointed to the impact of HIV/AIDS on the use and management of natural resources, although

he admitted having little empirical data to illustrate the mechanism. Our study, although limited in size, has shown (indirect) linkages between the number of orphans, gathering frequency and decline in orchid abundance.

Indigenous knowledge and gathering

Gathering knowledge is present in local communities (Santasombat, 2003) and is transmitted from one generation to the next through parents to children (Turner, 2003) or through folk stories in gatherer–hunter societies. Elders/parents have to be accompanied by their children for letting the children gain the gathering knowledge. In the study area, the indigenous knowledge on the use of edible wild orchids has been transferred in the same way for more than three decades for two purposes mainly. The knowledge about one of the traditional uses of the edible orchids was transferred through youth and elderly children while grazing livestock. The knowledge involved digging up the edible orchids with either a machete or a stick to gather their tubers (this study). These tubers were then washed, peeled and roasted as *midday snack*. They could also be used to make balls for playing.

The new introduction of booming business of the same edible orchids for the Zambian market was, as argued (Bingham, 2000; 2004; Davenport & Ndangalasi, 2003), the beginning of unsustainable gathering leading to a decrease in abundance of edible and marketable species. This study has shown that about the same edible orchids were collected in massive quantities, orchids that before were used traditionally at small scale. Whereas the transfer of knowledge is supposed to be from parents to children from generation to generation, this study showed that those who used to do small-scale gathering are from a generation different from those doing the extensive gathering.

Also in other areas of high HIV/AIDS prevalence (Dwasi, 2002), traditional knowledge of the management and conservation of natural resources that tended to be passed from one generation to the next was being lost. For example, knowledge on medicinal plants, which ensures conservation of the plants, is passed from one generation to another. Children in a non-HIV/AIDS community acquire such kind of knowledge from their parents. However, because many people in rural communities are dying prematurely of HIV/AIDS and leaving many orphans behind, the knowledge is assumed to die with the deceased (Dwasi, 2002).

Knowledge gap or utilization gap?

Could this study imply that there was a knowledge gap between the traditional use of edible wild orchid tubers (*midday snacks* and *recreational balls*) and the booming *chikanda* Zambian market? The first case of HIV/AIDS in Makete District was recorded a few years before the introduction of the more commercial gathering of edible wild orchid tubers. The level of local or indigenous knowledge tends to disappear when there is a disruption of knowledge transfer and such a disruption may occur when parents die prematurely (Saelemyr, 2004). Also others argue that in areas where there is large-scale commercialization, indigenous social values of gathering might be displaced (Emery, 1998).

Since most orchid tuber gatherers in the study area were orphans, receiving little

training from their caretakers, many of the gatherers were probably not capable of accurately identifying edible orchid species and therefore also gathered many non-edible orchid tubers. This type of gathering is of no benefit to anyone involved but is much to the detriment of the orchid populations.

Protection, conservation or domestication?

This study also suggests that protection is not effective. The Shannon–Wiener index of the protected area (gathering site A) was lower than that of the sites with free access (sites B and C). Dwasi (2002) reported that even in very strictly guarded National Parks in Caprivi, Namibia, they could not rule out the possibility of encroachment.

Conservation strategies can come from various angles ranging from tissue culture for propagation to complete domestication. This implies that for conservation purposes a lot of detailed research is needed to understand the reproductive biology of the precious orchids (Zots & Schmidt, 2006). The importance of understanding more of the reproductive biology of the orchids has been emphasized earlier (Stewart, 1996).

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