Ethnobotanical Study of Hyacinthaceae and Non-hyacinthaceous Geophytes in Selected Districts of Malawi

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Research

Abstract

This paper reports on the findings of an ethnobotanical survey of geophytes used in 15 selected districts of Malawi. The survey was initially driven by the need to assess the conservation status and use of Lilioid monocots of the family Hyacinthaceae. Altogether, 49 geophytes were documented as useful for food (24%), medicine (58%) and other purposes (18%). The most commonly reported species was *Dioscorea odoratissima* Pax. (Dioscoreaceae). Monocots represented 45% of the total. Members of the family Hyacinthaceae were only represented by 3 (6%) species *Albuca abyssinica* Jacq., *Ledebouria cordifolia* (Baker) Stedje & Thulin and *Ledebouria revoluta* (L.f.) Jessop. The study has further explored six alternative methods of evaluating sampling effort and estimating species richness. Michaelis-Menten Means estimator appeared to be the best estimator of species richness but was not able to accurately predict species richness for all the data combined. A bootstrap estimator was found to be more accurate. It was also apparent from the survey of geophytes that species in the Asteraceae and Fabaceae are more sought after for food and medicine than hyacinthoide monocots evidenced by fewer representatives mentioned by respondents.

Introduction

The family Hyacinthaceae

The family Hyacinthaceae formerly part of the monocotyledonous Liliaceae *sensu lato* (Engler & Prantl 1930) was not accepted as a separate family until the work of Dahlgren (Dahlgren *et al*. 1985, Dahlgren & Rasmussen 1983) and continues to be recognized as a distinct family (Angiosperm Phylogeny Group 2003, Stevens 2001). The family comprises ± 40 genera and some 900 species widely distributed in temperate to tropical regions, with the highest diversity in southern Africa and in the region from the Mediterranean to South-West Asia. (Stedje 1996a). Members of Hyacinthaceae occur in a great variety of habitats. Most species are adapted to seasonal climates that have a pronounced dry or cold period unfavorable for plant growth and during which the plants are dormant. Evergreen species are restricted to subtropical forests or savannah, temperate grasslands and perennially moist fynbos (Manning 2004). A few species grow in marshes or along streams and some even grow only in the spray of seasonal waterfalls. The above ground parts (leaves and stems) of deciduous species die down when the plant enters dormancy. The plants thus survive periods that are unfavorable for growth by retreating underground (Manning 2004).

Some members of the family Hyacinthaceae for example *Drimia maritima* (L.) Stern (synonym *Urginea maritima* (L.) Baker), the sea onion, has been in medicinal use since earliest times and was mentioned as early as 1554 B.C. in the Papyrus Ebers of the Middle Empire of Egypt as a cure for dropsy (Manning 2004). Bufadienolides isolated from *D. maritima* and *Drimia indica* (Roxb.) Jessop are cardioactive steroids that have digoxin-like effects

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(Manning *et al*. 2004). In South Africa, several species such as *Ledebouria cooperi* Jessop, *Ledebouria inquinata* Jessop, *Ledebouria ovatifolia* (Baker) Jessop, *Ledebouria revoluta* (L.f.) Jessop, *Ornithogalum saundersiae* Baker, *Ornithogalum thyrsoides* Jacq., and several members of subfamily Urgineoideae are poisonous to grazing animals (Manning 2004). The toxic compound (scilliroside, a bufadienolide) is used for poisoning rats (Pohl *et al*. 2000). In Malawi ethnobotanical uses are known for some members of the family, e.g., *Albuca* sp. from which an infusion is made of the roots that is drunk as a remedy for chest ailments (pneumonia) (Morris & Msonthi 1991)

Hyacinthaceae are only occasionally used for human consumption. In Greece, the bulbs of *Muscari comosum* (L.) Mill. are eaten pickled, and in France, the inflorescences of *Ornithogalum pyrenaicum* L. are eaten as a vegetable (Pohl *et al*. 2000). In Africa, bushmen eat the bulbs of *Ledebouria apertiflora Jessop* and *L. revoluta* (Pohl *et al*. 2000). Hyacinthaceae are broadly employed for purposes ranging from the treatment of hangovers, rheumatic fever, sprains, syphilis and cancer, to the bewitchment of neighbors and securing of good fortune (Pohl *et al*. 2000). Many species feature prominently in the top ten regional medicinal plants in trade, the most important being *Bowiea volubilis* Harv. ex Hook.f. *Eucomis autumnalis* (Mill.) Chitt., and *Scilla natalensis* Planch. (Pohl *et al*. 2000). With 13 hyacinthaceous species identified from a total of 198 taxa catalogued in their medicinal plant survey, this family was second only to the Aloaceae in popularity in Southern Africa (Pohl *et al*. 2000).

More important is the use of various species of Hyacinthaceae as ornamentals and cut flowers. Species of *Chouardia*, *Hyacinthoides*, *Hyacinthus*, *Muscari*, *Othocallis*, *Puschkinia*, and *Scilla* are spring flowers of Northern Hemisphere parks and gardens. In southern Africa, species of *Eucomis*, *Galtonia*, *Veltheimia* and others are cultivated as ornamentals. *Ornithogalum thyrsoides* and related species are important as cut flowers (Manning 2004). In Malawi, some species of *Ledebouria* and *Scilla* are also used as ornamentals (personal observation).

Geographical, Botanical and Demographic aspects

Malawi (Figure 1) is situated in Central Africa between 9° 22' and 17° 01'S and 32° 43' and 35° 55' E (Mwanyambo & Nihero 1998). It is divided into three administrative regions; Northern, Central and Southern. There are 26 districts. The Great Rift Valley traverses the country from north to south, and in this deep trough lie Lake Malawi, the third-largest lake in Africa, comprising about 20% of Malawi's area.

Malawi is a landlocked, densely populated country. Its economy is heavily dependent on agriculture which, represents 34.7% of the gross domestic product and represents about 80% of all exports. Nearly 90% of the population engages in subsistence farming (BAA 2008). The

Figure 1. Malawi and the districts visited during the geophyte survey: 1A. Balaka, 1B. Mangochi ; 2A. Dedza, 2B. Lilongwe, 2C. Mchinji, 2D. Mzimba, 2E. Nkhata bay, 2F. Ntcheu, 2G. Ntchisi, 2H. Rumphi; 3A. Chikwawa, 3B. Mulanje, 3C. Mwanza, 3D. Nsanje, 3E. Thyolo.

agricultural sector contributes about 63.7% of total income for the rural population, 65% of manufacturing sector's raw materials, and approximately 87% of total employment (reviewed in Mwanyambo & Nihero 1998). The population is presently estimated at 12 million of which 90% live in rural areas. Agricultural products account for 90%

of Malawi's exports; tobacco, tea and cotton are the major export commodities (NSO 1992).

White (1976) proposed a chorological classification of African vegetation and Malawi falls within the Zambezian region. Floristically, Malawi is included in the Flora Zambesiaca region together with the following countries; Mozambique, Zambia, Zimbabwe, Botswana, and the Caprivi Strip of Namibia. It is known to be one of the richest in its specific diversity, and the main vegetation which characterizes this region is different forms of woodland and thicket lacking evergreen rain forests (White *et al*. 2001). Zambezian woodlands comprise three major types: 1. **miombo** (dominated by *Brachystegia* spp.), 2. **mopane** (dominated by *Colophospermum mopane* (J. Kirk ex Benth.) J. Léonard), and 3. undifferentiated woodland. The total number of plant species in Malawi is estimated at between 5500-6000 (Msekandiana & Mlangeni 2002). Malawi presents a rich mosaic of different habitats brought about by its varied topography and altitudinal ranges (37-3002 m) and rainfall regimes with the average rainfall ranging from 700 to 3000 mm (White *et al*. 2001). From May to August, the climate is cool and dry. Average temperatures rise from September to November and the rainy season begins towards the end of November and extends to April or May (NSO 1992).

The populations of developing countries worldwide continue to rely on the use of wild plants as a source of food and traditional medicine as their primary source of health care. This has created a demand for forest products, which cannot be met from rapidly dwindling indigenous forests (Hardcastle 1977). Ethnobotanical surveys conducted throughout Africa confirm that native plants are the main constituent of traditional African medicines (reviewed in Cunningham 1993). With 70-80% of Africa's population relying on traditional medicines, the importance of the role of medicinal plants in the health care system is enormous (Cunningham 1993). Mwanyambo & Nihero (1998) noted that, in Malawi, modern health care provided principally by Ministry of Health and Population (MOHP) is highly complemented by services from herbalists especially in the rural areas where 90% of the population lives. Herbalists are the people, who handle most local health problems. On a national scale, there is one herbalist to every 138 persons. This is in contrast to a doctor to population ratio of 1:27,000 and a nurse to population ratio of 1:14,000 for the period 1985-1990 (Anon. 1997).

Interest in ethnobotany of Malawian plants dates back to the 1970s with a benchmark study by Williamson (1974). In his book, he documented useful plants of Malawi. This was the first comprehensive study of all useful plants of Malawi as a nation, and in her book she listed 122 plant species. Other notable investigations are generally on the use of medicinal plants in Malawi (Hagreaves 1994, Maliwichi 1997, Morris & Msonthi 1996, Msonthi 1994, Msonthi & Seyani 1994, Mwanyambo & Nihero 1998, Ndibwami *et al*. 1998) as well as non-medicinal plant uses of the other tribes of Malawi (Mwanyambo 1994). The study by Mwanyambo & Kananji (2001) on edible tubers lists some of the species that are edible especially during famine and some eaten in the form of relish. The list includes the orchids *Satyrium buchananii* Schltr. and *Satyrium* sp. (both locally known as **mbuyeuye**, a Nyanja term which refers to a type of vegetation with *Brachystegia* and *Jubernadia*), *Satyrium carsonii* Rolfe, *Disa robusta* N.E.Br. and *Disa ukingensis* Schltr.

The urgent need to carry out ethnobotanical surveys in Malawi has been expressed by several workers (reviewed in Mwanyambo 1994) because of concern about steady loss of plants and tribal traditions through decline in natural vegetation and urbanization. The present study, therefore, addresses this issue by focusing on the geophytic flora, with particular emphasis on Hyacinthaceae.

Geophytes are plants which posses underground resting buds attached to storage organs such as rhizomes, tubers, bulbs or corms (Esler *et al*. 1999) but in this study, only bulbs and tubers are considered. A tuber is a thickened underground stem, and the stem tissue serves as the primary storage tissue; but unlike a corm, it has no basal plate. Meristems occur on the tuber and are commonly called "eyes" on a potato. A true bulb is comprised of a compressed stem, or basal plate, and modified leaves called scales serve as the primary storage tissue. Examples include tulip, lily, allium (e.g., onion). In the present study the collective term 'underground parts' will be used to refer to both bulbs and tubers

Although some geophytes are known to be evergreen, many of them survive periods of environmental stress such as summer drought or winter cold by dying back to these underground storage organs (Dafni *et al*. 1981). When the conditions are favorable, they resprout new foliage with inflorescences imaging before, during or at the end of the vegetative growing season. Geophytes are generally targeted by people for food, medicine and ornamentals. This act causes serious damage to the targeted plants and in most cases the whole plant is uprooted and dies back. Although few data are available on the impact of harvesting underground organs, i.e., whole plants, local depletion of plants targeted has been recorded elsewhere (reviewed in Cunningham 1994). The present investigation sought to document ethnobotanical uses of geophytes of the family Hyacinthaceae but since no previous ethnobotanical work has been done exclusively on geophytes of Malawi, this also included non-Lilioid plants to gain an overview of their use and to assess their conservation status. Furthermore, the study explored methods of measuring sampling effort and species richness among the 15 selected districts using non-parametric methods adapted from mark-recapture applications for estimating population size (reviewed in Williams *et al*. 2007). These methods require no assumptions about community structure (Colwell & Coddington 1995). The estimators are also known to be homologous in that richness is estimated from the preponderance of

rare species (Colwell & Coddington 1994), i.e., the higher the proportional abundance of rare species, the greater the probability of encountering more new species with increased sampling effort (Williams *et al*. 2007).

Methodology

An understanding of geophyte use in Malawi and their conservation status required the administration of group and household interviews through the administration of a structured questionnaire. The survey was conducted from the period January to March 2007 in three phases; Phase 1 (Mangochi and Balaka Districts); Phase 2 (Rumphi, Mzimba, Nkhatabay, Ntchisi, Mchinji, Lilongwe, Dedza, Ntcheu Districts) and Phase 3 (Nsanje Chikwawa, Mwanza, Mulanje and Thyolo Districts). See Figure 1 for list of the districts numbered in phase order. Phase 1 was conducted to pretest the designed questionnaire and adjustments were made to some of the questions before going into the second phase. All in all, 87 questionnaires were administered in the 15 selected districts mostly to individuals and in some cases to groups. The districts were selected to include different tribes represented in Malawi. Data collected included personal particulars, knowledge of geophytes and uses. To asses the economic significance and conservation status of geophytes data on cost and availability was also collected. Plants names were recorded on site and both scientific and vernacular names recorded. All names were verified at National Herbarium in Zomba by technicians.

Data analysis was achieved by using three programs; Microsoft Excel 2003, PAST (Hammer & Harper 2004) and EstimateSWin800 (Colwell 2006). Microsoft Excel was used for univariate analysis whereas PAST was employed for cluster analysis. Cluster analysis is a family of multivariate statistics which attempts to subdivide or partition a set of heterogeneous objects into relatively homogenous groups (Höft *et al*. 1999). Dice similarity index, also known as Sorensen Index, was used in the clustering analysis. This index is useful for calculating the similarity index of presence/absence or positive/negative reply data (qualitative) (Höft *et al*. 1999). The mathematical algorithm calculates the degree of similarity or dissimilarity and clusters the objects according to their overall most similar attributes, i.e., it projects clusters of objects that are more similar to each other than any other specimen (Sneath & Sokal 1973). Data on presence/absence of species collected from all the districts were used in the cluster analysis and the resultant table of similarity indexes were projected as a dendrogram.

EstimateS (Colwell 2006) was used to plot a species accumulation curve/collectors curve, which is a plot of cumulative number of species discovered within a defined area as a function of some measure of the effort expended to find them (Colwell & Coddington 1994). According to Williams *et al*. (2007), if sampling is incomplete, the curve will show an upward trend illustrating the extent to which sampling effort might have to be increased to accumulate more species. Six non-parametric species richness estimators, namely: ICE, Chao 2, first order and second-order Jackknife, bootstrap and Michaelis–Menten Means, appropriate for incidence-based data (observed species) were run to evaluate their performance in estimating species richness. The sample order was randomized 100 times to compute the mean estimator and expected species richness for each sample accumulation level the end result of which was a smooth curve. The 15 districts visited are here treated as samples. A thorough description and formulae of the species richness estimators used in the present are well documented in Colwell & Coddington (1994).

Results

Fifty nine percent of people interviewed in the survey were female. Most respondents were from the Sena tribe (30%), and the least proportion from Yao tribe (4%) (Figure 2). Regarding age groups of respondents, 18**%** were over 50 years old, over half of them, 52% were 35-49 years old, 26**%** were 21-34 years old, and the least proportion, 2% were less than 20 years old.

Table 1 summarizes the results of interviews about plants. When asked if they were familiar with geophytes around them, the majority (88%) indicated that they were familiar

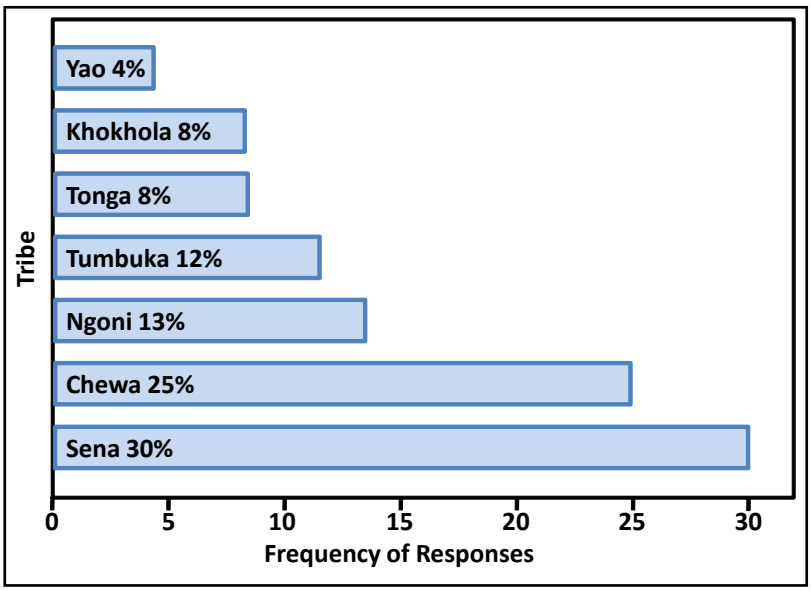

Figure 2. Percentage of respondents based on tribe as interviewed in Malawi about familiarity with geophytes.

Table 1. Geophyte plants identified by informants in Malawi and their respective uses. Local languages (Ch=Chichewa, Kho=Khokhola, Lo=Lomwe, Man=Mang'anja, Se=Sena, To=Tonga, Tu=Tumbuka). Use (F=Food, M=Medicine, O=Ornamental). Part used (L=Leaves, U=Underground part)

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Amaryllidaceae							
Boophone disticha (L.f.) Herb	**Chimbozya** (Tu)		X		U	Pound, soak and administer to patient three times a day.	Rheumatism, Venereal diseases
Crinum macowanii Baker	**Nkali** (Kho), **Anyezi wa mthengo** (Man), **Chimemene** (To)		X	X[1]	U	Pound underground parts, soak, and take three times a day. For sore skin, pound underground parts and add to bath water.	Stomachache, fertility, sore skin, cleaning the birth canal of a woman, Aphrodisiac, diarrhoea
Apocynaceae							
Raphionacme welwitschii Schltr. & Rendle	**Kangale** (Lo)	X	X		U	The underground part is peeled, boiled and eaten like any other potato.	Aphrodisiac
Araceae							
Colocasia esculenta (L.) Schott	**Madumbe** (Lo)	X			U	Eaten after boiling.	
Gonatopus boivinii (Decne.) Engl.			X		U	Sliced, dried and processed into powder and added to porridge or tea.	Headache
Stylochiton puberulus N.E.Br.			X		U	Cut into smaller pieces and added to drinking water.	New Castle disease in chickens
Asteraceae							
Dicoma anomala Sond.	**Palibekanthu** (Ch) (Lo), **Palijekanthu** (Tu)		X		U	Burn and add salt. For stomach pains, sore throat and rheumatism roots are dried and pounded into powder and a teaspoon is added to tea or porridge.	Protection from thugs, headache, cough, rheumatism, stomach pains, sore throat, attract members of the opposite sex, **liwombo**, abortion, Wounds, aphrodisiac
Capparaceae							
Boscia salicifolia Oliv.	**Nyenze** (Sen)	X[2]	X[3]		U/L	Pound leaves and rub where the rash is. The underground part is eaten after boiling.	Skin rash
Colchiaceae							
Gloriosa superba L.	**Thengeza** (Ch)			X[4]	U	Keep underground part in pocket.	

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Cucurbitaceae							
Cucumis hirsutus Sond.	**Nkhakathengo** (Se)		X		U	Pound underground part, soak in water and give to patient three time a day.	Swollen body
Momordica foetida Schumach & Thonn.	**Nyamandwa** (Ch)	X			U	Peel underground part and eat raw.	
Dioscoreaceae							
Dioscorea bulbifera L.	**Chilazi** (Ch)		X		U	Pound underground parts, soak and take three time a day. To treat skin rash, rub leaves on affected area after taking a bath.	Immunity booster, treat skin rash
Dioscorea dumetorum (Kunth) Pax	**Nyanya**, **Zinyanya** (Lo)	X			U	Cooked in water for several hours and served with fish, meat or vegetables.	
Dioscorea esculenta (Lour.) Burkill	**Chilazi** (Ch), **Viyawu** (To)	X	X		U/L	Underground part washed and cooked for long hours decanting the water in the process. To treat skin rash underground part rubbed on affected area.	Skin rash
Dioscorea odoratissima Pax	**Makhuthi** (Man), **Ndiya**, **Mtama** (To)	X			U	Cooked in water for several hours and served with fish, meat or vegetables.	
Dioscorea sansibarensis Pax	**Miole** (Lo)	X			U	Cooked in water for several hours. However, in this case water is decanted several times to remove poisonous chemicals. Most of the times it is cooked over night and eaten the following day.	
Dioscorea sansibarensis Pax	**Chidya Nkhumba** (Sena)	X	X		U	Underground part pounded and rubbed on the affected area.	Snake bites, Headache, skin rash
Tacca leontopetaloides (L.) Kuntze	**Mwinimunda** (guardian of the garden) (Ch), **Dinde** (Sen), **Dinda**, **Khazikhazi**, **Madinda** (To)	X	X		U	The underground part is cut into pieces, dried and made into flour which is then used to make porridge. As a medicine the underground part is soaked and taken three times a day. To treat a child's swollen spleen the underground part is cut into two and rubbed on a child's belly.	Stomachache, yellow fever, improve fertility in women, spleen enlargement, anal prolapse, appetizer, porridge for kids, rheumatism, love potion, diarrhoea in children
Euphorbiaceae							
Manihot glaziovii Müll. Arg.	**Mpira** (Ch)	X			L	Cooked and eaten as a vegetable.	

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Fabaceae							
[*Dolichos* sp.]	**Namandephule** (Kho),			X[5]	U	Pound the underground part, add water and soak clothes. Wash them as with any detergent.	
Dolichos kilimandscharicus Taub.	**Nthupa** (Ch), **Ngunga** (Lo), **Dema** (Tu)		X		U	Pound underground parts, boil and give to patient.	New Castle in chickens, dysentery, rheumatism, scabies, shingles
Dolichos trinervatus Baker	**Chamkhwere** (Tu),		X	X[6]	U	Cut underground parts into pieces, soak and drink 3-4 times a day.	Stomachache
Elephantorrhiza goetzei (Harms) Harms	**Chateta** (Ngoni), **Thetha** (Sen)		X		U	Washed, cut into smaller pieces and soaked in water. The patient is given three times a day.	Bloody diarrhoea, boils, stomachache
Eminia antennulifera (Baker) Taub.	**Suzya** (Tu)	X			U	Peel and eat raw.	
Mucuna poggei Taub.	**Nkhunga** (Tu)		X		U	Cut into small pieces, boil, add eggs and honey and administer to patient three times a day.	Cough, asthma
Neorautanenia mitis (A.Rich.) Verdc.	**Katupe** (Ch), **Chibata** (Lo), **Ombwe** (Sen), **Njowera** (Tu)		X	X[7]	U	Pound underground parts and sprinkle in water and the fish will float to the surface. To treat New Castle disease the pounded roots are added to drinking water. As a pesticide pound the underground part, soak and spray the infected plants.	New Castle in chickens, fish poison, pesticide, used to strengthen clay pots
Tylosema fassoglensis (Kotschy ex Schweinf.) Torre & Hillc.	**Chikwakwa** (Ch)		X		U	Cut into smaller pieces, soaked in water, and take three times a day.	Rheumatism, fertility in women
Hyacinthaceae							
Albuca abyssinica Jacq.	**Nkhonkho** (Ch)		X		U	Pound underground part and add to bath water.	Protect new born babies from diseases
Ledebouria cordifolia (Baker) Stedje & Thulin	**Nkhonkho** (Ch)	X			U	Cook together with an orchid and used as a relish.	
Ledebouria revoluta (L.f.) Jessop	Chikolanyenje, Chibato (Ch), Chimati (Tu),			X[8]	U	Pound underground part and smear product on bird trap.	Venereal diseases with *Aloe* sp.

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Hypoxidaceae							
Hypoxis villosa L.f.	**Ekhwiya** (Lo)		X		U	Cut roots into pieces, boil and give to patient.	Immunity booster, aphrodisiac, yellow fever, stomach pains, Trichomonas vaginalis (Libale)
Icacinaceae							
Pyrenacantha kaurabassana Baill.	**Njovu yayenda** (Man), **Chikhazika**, **Chikhaziko**, **Mchende**, **Phavuwa**, (Ch), **Mambo** (Se), **Mlozi wanalume**, **Vindindi** (Tu)		X	X[9]	U	Washed and boil underground parts then add to bath water to treat swellings. Squeeze and drink to treat stomachache. For high blood pressure powdered underground part is added to porridge.	Stomachache, swellings, stomach ulcers, rheumatism, skin rash, high blood pressure, heart palpitations, fever
Iridaceae							
Gladiolus dalenii Van Geel	**Bwantete** (Ch), **Bwangulu** (To), **Jangulu** (Tu)	X		X[10]	U	Pierce middle of underground part and insert a string made of sisal.	
Lamiaceae							
Plectranthus esculentus N.E. Br	**Buye** (Kho)	X			U	Peel and eat raw or boiled.	
Nymphacaceae							
Nymphaea caerulea Savigny	**Nyika** (Sen)	X			U	Cook and eat during famine.	
Orchidaceae							
Disa sp.	**Chikande** (Ch), **Chinaka** (Tu)	X			U	Wash, dry and pound underground part. Then, sieve to get fine powder. The powder is cooked in water together with Sodium bicarbonate or pot ashes.	
Habenaria sp.	**Chikande**(Ch)	X			U	Wash and boil part in water then eat.	
Passifloraceae							
Adenia gummifera (Harv.) Harms	**Thobodimbo** (Ch), **Mwanamphepo** (Ch, Lo)		X		U	Pound part and rub on the affected area.	Gonorrhoea

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Portulaceae							
Portulaca oleracea L.	**Nyamgogwa** (Man)	X	X		U/L	Boil and season leaves and eat as relish. Pound underground part and use to treat oral sores in children.	Oral sores
Ruscaceae							
Eriospermum abyssinicum Baker	**Mtimaumodzi** (Ch), **Bwangulu** (To), **Jangulu** (Tu)	X		X[11]	U	Dry underground part, grind into powder and add a teaspoon to porridge. As a love potion, dry and burn the underground part into ashes together with hearts of a male and female pigeon and add to relish which your husband will eat. This will trigger him into showering you with all his love. The herbalist also said that instead of pigeon hearts, one can use hearts of a male and female sheep. This mixture is more powerful than the former because it is believed that the man will be acting like a sheep in the relationship, i.e., the wife will be in charge.	Appetizer, cure swollen spleen, heart palpitations, love portion
Vitaceae							
Ampelocissus africana (Lour.) Merr.	**Mwanamphepo** (Ch, Lo)		X		U	Pound underground part, soak and administer to patient. For wounds clean the affected area with the solvent.	Wounds, stomachache
Ampelocissus obtusata (Welw. ex Baker) Planch.	**Mwanamphepo** (Ch, Lo)		X		U	Pound underground part and smear product on wound/swollen area.	Wounds
Cissus aristolochiifolia Planch.	**Mwanamphepo wa ntawaleza** (Lo)		X		U	Pound, boil and drunk three times a day.	Diarrhoea
Cissus cornifolia (Baker) Planch.	**Mwanamphepo** (Ch, Lo), **Mbumbu** (Tu)		X		U	Cut into small pieces, soak and administer on expectant woman.	Easy delivery
Cissus integrifolia (Baker) Planch.	**Mwanamphepo** (Ch, Lo)		X		U	Pound, boil and take three times a day.	Headache, skin rash (**mwanamphepo**)
Cissus rubiginosa (Welw. ex Baker) Planch.	**Nyakatambe**(Se)	X	X		U	Pound, boil and drink. Powder in tea or porridge.	Rheumatism
Cissus zombensis (Baker) Gilg & M. Brandt	**Kanamwalicheche** (Ch)	X			U	Eat after boiling.	

Plant species	Local names	Use			Part used	Preparation (note that the dosage per treatment is 100ml unless indicated otherwise)	Disease treated
		Food	Medicine	Other			
Cyphostemma junceum (Webb) Desc. ex Wild & R.B. Drumm.	**Mwanamphepo** (Lo), **Mbumbu** (Tu)		X		U	Pound, boil and taken three times a day. For swellings, cut underground part and rub on affected area.	Diarrhoea, rheumatism, swellings, blood booster, given to weak babies to make them strong again
Zingiberaceae							
Kaempferia rosea Schweinf. ex Baker	**Chikasu** (Ch)		X		U	Wash, dry and pound. Pounded underground parts are then sieved to a fine powder. The powder is then cooked in water together with Sodium bicarbonate or pot ashes.	Sore throat, yellow fever, cleaning the uterus and birth canal

Other uses: 1. Used as an ornamental. 2. Underground part used as a food. 3. Leaves used medicinally. 4. Underground part kept in pocket as a lucky charm. 5. Used for laundry. 6. Used as soap. 7. Used as a pesticide. 8. Used for catching insects known as **nyenje**. 9. Used as a pesticide. 10. The underground part is used as a toy. 11. Children make a playing wheel out of the underground part. This is also used as a love potion.

with the plants. Those who were not familiar (12%) were all between age 21 and 49. A total of 49 species were recorded in the survey as being used by the respondents either for food (24%), medicine (18%), or other uses (58%) including as ornamentals, pesticides, for child's play and laundry. Figure 3 illustrates the eight most commonly reported or popular geophytes reported with other species mentioned fewer times. Plant parts used were reported as either leaves only (4%), leaves and underground parts (6%) or underground parts (90%). Prescriptions for preparation of remedies and diseases treated were also recorded (Table 1). The 49 species listed were lumped into three major use categories (food, medicinal and other) and then further grouped into 16 use categories (Table 2).

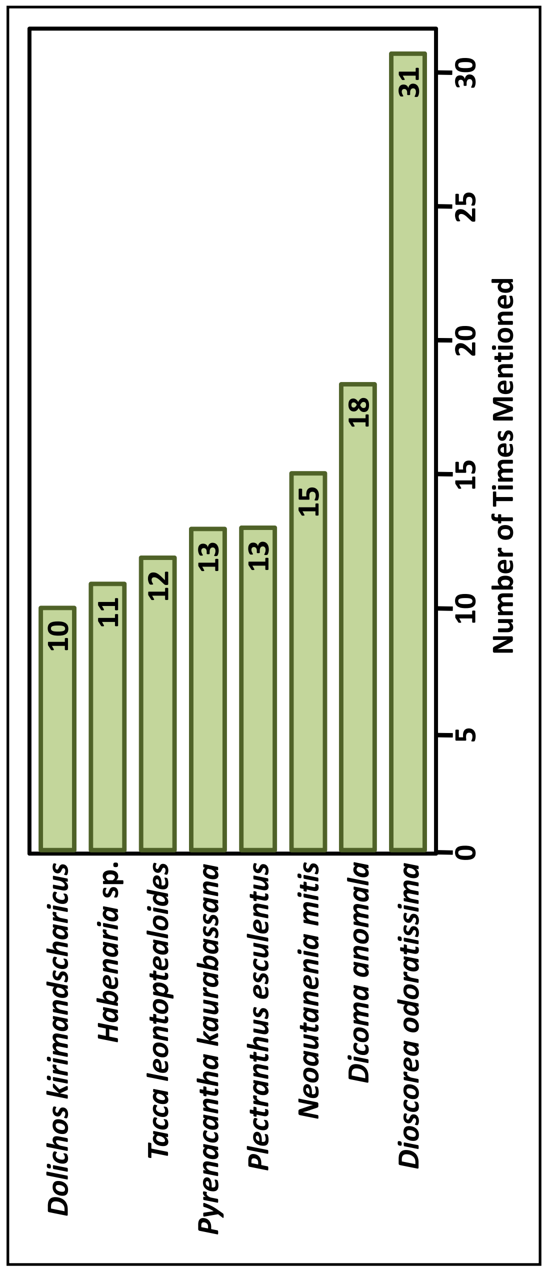

Figure 3. Most popular geophytes reported from a survey in Malawi. Species that were mentioned less than eight times were excluded.

Table 2. Medicinal geophytes identified by informants in Malawi and sorted into major use categories. (See Figure 5.)

Species	Medicinal Use Categories															
	Food	Digestive System Problems	Wounds, Sores, Skin Rashes	Gynecological	Headaches	Respiratory System Problems	Circulatory System Problems	Blood Booster	Snake Bite	Immunity Booster	Infant/ Newborn Care	Aphrodisiac, Love Potion	Protection from Thugs	Abortion	Poultry Diseases	Fish Poison, Pesticides
Adenia gummifera				X												
Albuca abyssinica											X					
Ampelocissus africana		X	X													
Ampelocissus obtusata			X													
Boophane disticha				X			X									
Boscia salicifolia			X													
Cissus aristolochiifolia		X														
Cissus comifolia				X												
Cissus integrifolia			X		X											
Cissus rubiginosa	X						X									
Cissus zombensis	X															
Colocasia esculenta	X															
Crinum macowanii		X	X	X			X					X				
Cucumis hirsutus							X									
Cyphostemma junceum		X					X	X			X					
Dicoma anomala		X	X		X	X	X					X	X	X		
Dioscorea bulbifera			X							X						
Dioscorea dumetorum	X															
Dioscorea esculenta	X															
Dioscorea odoratissima	X															
Dioscorea sansibarensis	X		X		X				X							
Disa sp.	X															
Dolichos sp.		X														
Dolichos kilimandscharicus		X	X				X								X	
Dolichos trinervatus		X														
Elephantorrhiza goetzei		X	X				X									
Eminia antennulifera	X															
Eriospermum abyssinicum		X										X				
Gladiolus dalenii	X															
Gloriosa superba	X															
Gonatopus boivinii					X											
Habenaria sp.	X															
Hypoxis villosa		X		X			X			X						
Kaempferia rosea				X		X	X									
Ledebouria cordifolia	X															

Species	Medicinal Use Categories															
	Food	Digestive System Problems	Wounds, Sores, Skin Rashes	Gynecological	Headaches	Respiratory System Problems	Circulatory System Problems	Blood Booster	Snake Bite	Immunity Booster	Infant/ Newborn Care	Aphrodisiac, Love Potion	Protection from Thugs	Abortion	Poultry Diseases	Fish Poison, Pesticides
Ledebouria revoluta				X												
Manihot glaziovii	X															
Momordica foetida	X															
Mucuna poggei						X										
Neorautanenia mitis															X	X
Nymphaea caerulea	X															
Plectranthus esculentus	X															
Portulaca oleracea	X		X													
Pyrenacantha kaurabassana		X	X				X									
Raphionacme welwitschii	X											X				
Stylochiton puperulus															X	
Tacca leontopetaloides	X			X			X	X			X	X				
Tylosema fassoglensis				X												

Food Plants

A number of geophyte species are used for food (24%) being consumed raw or boiled in water. The only member of the family Hyacinthaceae which falls into this category is *L. cordifolia*. This bulb is mixed together with orchid tubers to make cakes that are used as relish. Five species of yams (*Dioscorea*) are however the mostly targeted for their tubers especially during periods of famine. *Dioscorea odoratissima* was frequently mentioned by respondents as being the most important tuber species (Figure 3), meaning that it was preferred over the other tuber species. *Dioscorea* species are known to have varying proportions of an alkaloid dioscorine that is bitter and toxic (Mwanyambo & Kananji 2001). This is why some species known to be poisonous are cooked for long hours mostly overnight to remove toxicity. Water is decanted several times in the process of cooking. Another popular famine tuber is *Nymphaea caerulea*, locally known as **nyika** (Sena). The underground part is yam-like and the most popular famine food amongst the Sena people in Nsanje district. This species is very scarce such that men must travel by boat for six hours across the Shire River to harvest it because it has been over-exploited and hence scarce (Mpaka 2008). It is harvested underwater by diving. It is peeled and boiled before consuming. It is served together with vegetables. However, people complain that the underground part is bitter. Other tubers are eaten raw. These include *Eminia antennulifera*, *Momordica foetida* and *Plectranthus esculentus*.

Medicinal plants

The 29 geophyte species identified as medicinal are mostly used in preparations which are powders, decoctions and ashes (Figure 4). In this category, the only members of the family Hyacinthaceae mentioned were *Albuca abyssinica* and *L. revoluta*. *Dicoma anomala* was mentioned as the most popular medicinal plant (Figure 3) by respondents because of its diverse uses. Figure 5 sorts the diseases treated by the underground parts of the plants reported into major use categories. Interestingly, half of the uses account for the three largest categories with 17% each.

Some members of the genus *Hypoxis*, commercially known as “African potato,” are taken to boost the immune system especially by people infected with HIV **(**Ncube 1998). In the category of boosting the immunity of human beings, especially those infected with AIDS, the geophytes involved are used in combination with other tubers and the end product of this is administered in powder form. One of the respondents, a traditional healer claimed that the drug (Figure 4A), which is a combination of several tuber species “has been proven to purify blood and raise the CD4 cell count of patients suffering from AIDS” and further claimed that “most patients had gained weight after taking the drug.” The vast number of medicinal plant species as opposed to food species is an indication of the important role played by geophytes in the health care system of Malawi.

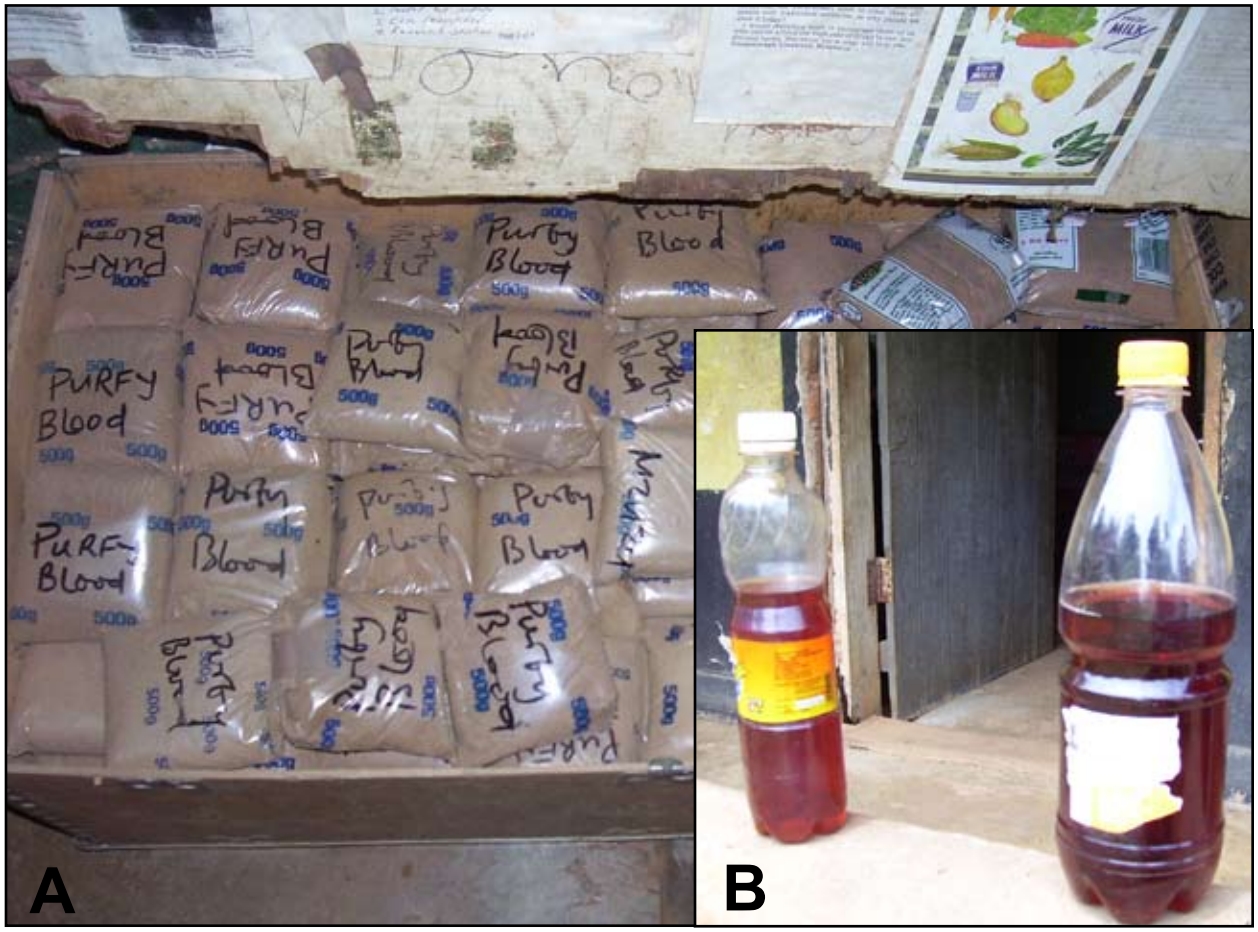

Figure 4. Geophyte-based remedies documented in Malawi are usually prepared in the form of (A) powders and (B) decoctions. (Photos by D. Mpalika)

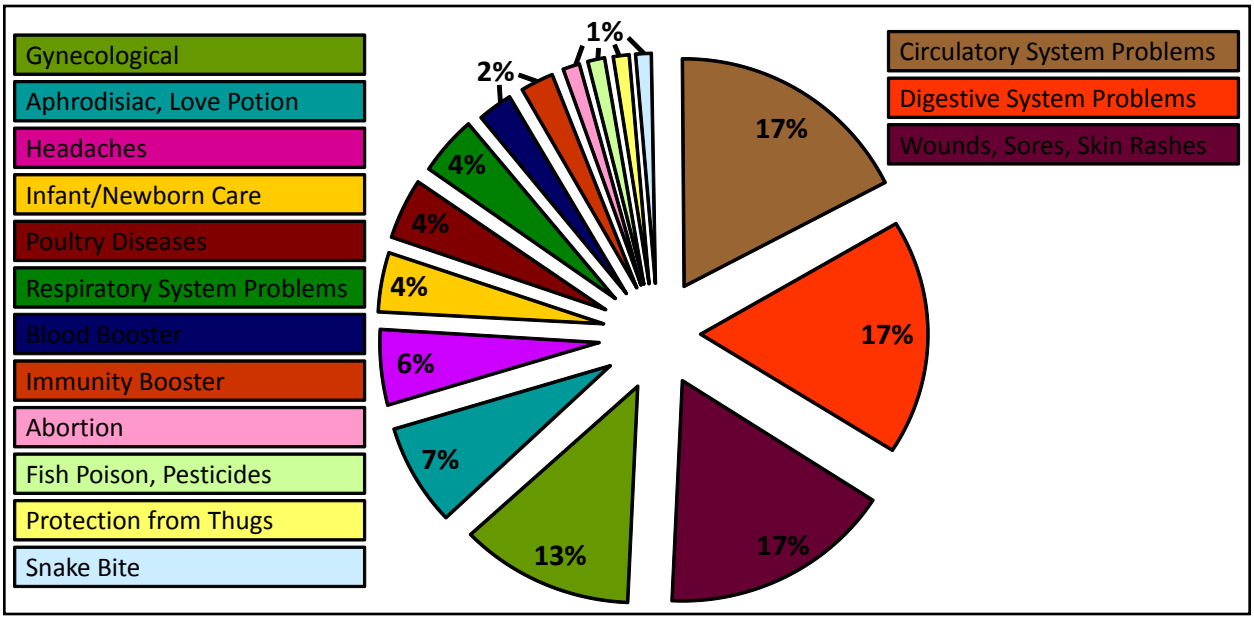

Figure 5. Medicinal geophytes identified by informants in Malawi sorted into major use categories. n=71 total uses. See Tables 1&2 for details of plants and uses.

The local term **mwana wa mphepo** (Chichewa) which means "Child of the wind" is the common name referring to plant species and the diseases that they treat. In this study, the term was allocated to seven species, all vines, one, *Adenia gummifera*, in the Passifloraceae is introduced to Africa from South America. The other six are native African members of the Vitaceae family: *Ampelocissus africana*, *Ampelocissus obtusata*, *Cissus aristolochiifolia*, *Cissus cornifolia*, *Cissus integrifolia*, and *Cyphostemma junceum*. The traditional category of plant species is also known to treat different types of ailments as well (Tables 1 & 2). As a condition in the body, **mwana-mphepo** (Chichewa, Lomwe), which is an abbreviation for **mwana wa mphepo** (Chichewa) refers to an upset stomach, stomach pains or sore skin.

Other Uses

Young boys used *L. revoluta* to catch insects. The bulb is ground and smeared close to where insects are flying and they get caught in the process. *Dolichos kirimandscharicus* and *Neorautanenia mitis* are used to treat poultry diseases such as Newcastle. Newcastle disease is a highly contagious zoonotic bird disease affecting many domestic and wild avian species. The disease is endemic in many countries including Malawi. In some parts of Malawi, *N. mitis* is also used as a fish poison and is known to kill a lot of fish when sprinkled in water.

Trading of geophytes

Half of the respondents also said that they sold the underground parts especially *D. odoratissima* which is an important famine food and *D. anomala* which is popular amongst herbalists and is sold as a single tuber or as a pile. In most cases these tubers are mixed with roots belonging to different species and processed into powder. These are then sold at a price of US$7 (2006) per packet locally but the price varies when the powder is sold to foreigners (Dr. Kaunda personal communication).

Method of harvesting and availability

All respondents indicated that they harvested the tubers by digging with hoes Figure 6) or just uprooting (Figure 7). Geophyte digging is the most destructive kind of harvesting because it kills the whole plant. Most respondents indicated that in most cases the plant died after harvesting the tubers. 72% also indicated that tuber plant species have decreased if they compare with their availability now to five to ten years ago. Despite the apparent decrease in populations of geophytes, their domestication is not popular among the public because most believe that they grow naturally in forests and that they are difficult to cultivate. During the survey, most people said that they have seen some people, especially traditional healers, grow them around their yards; the major reason being easy access for their medicinal value.

Figure 6. A respondent using a hoe to dig a tuber in Malawi. (Photo by D. Mpalika)

Figure 7. A respondent holding a *Hypoxis* species after uprooting it by hand in Malawi. (Photo by D. Mpalika)

Cluster analysis

Figure 8 illustrates similarities of responses about geophyte species recorded in the 15 districts surveyed and reveals the existence of two groups (one consisting of Chikwawa district, the other of the remaining 14 districts) that are largely different, separating early in the dendrogram. Based on this cluster analysis, no districts are highly similar with each other and at most they form into seven groups with one, two or three districts each that are somewhat similar but each other still showing much distinctiveness. The division into groups is however not consistent with geography except in one instance: Thyolo and Mulanje are both from southern Malawi and are adjacent to each other.

Species accumulation curve as a measure of sampling effort

Figure 9 presents a species accumulation curve from the geophyte study of the 15 selected districts of Malawi. The curve concludes with an upward trend indicating that sampling effort might have to be increased to accumulate more species (see Heck *et al*. 1975) in order to approach an asymptote.

Estimating species richness from samples

Figure 10 presents the performance of six non-parametric estimators of species richness compared with the species accumulation curve from the research. Since a good estimator of species richness is supposed to reach, or closely approach a stable horizontal asymptote sooner, i.e., with fewer samples, for this data set, Michaelis–Menten Means (MM Means) provided the least biased estimates based on small number of samples (ca. 2 samples) with Chao 2 a close second and ICE third. The rest of the estimators are rising parallel with the accumulation curve and seem to reach a horizontal asymptote after 15 samples. The MMMeans estimates generate the highest estimate (54 species) of species richness and Chao 2 the lowest estimate for the samples with 47 species. The bootstrap

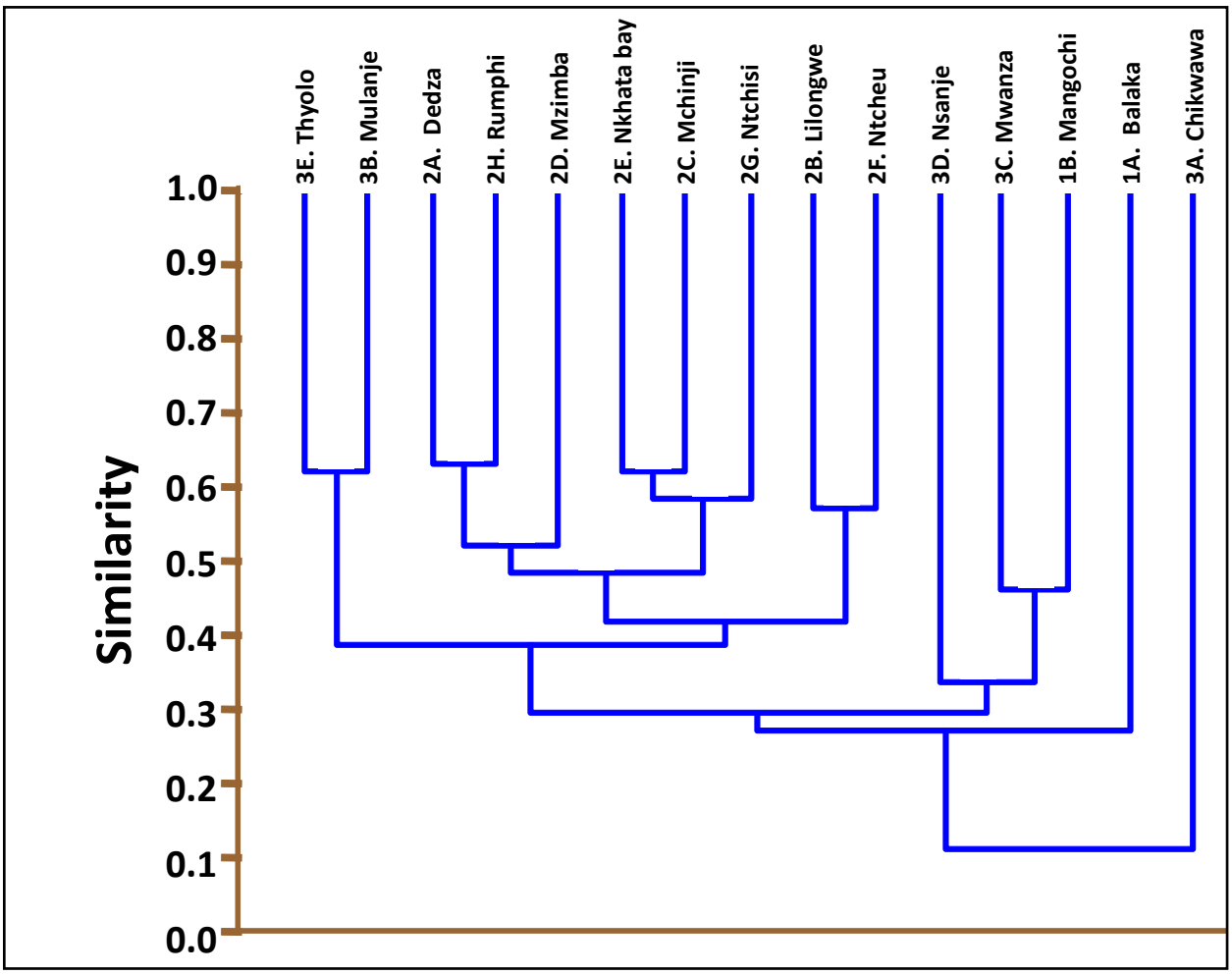

Figure 8. Phenogram cluster analysis with Sorensen Index based on presence/absence of geophyte species used in 15 districts surveyed in Malawi using PAST (Hammer & Harper 2004).

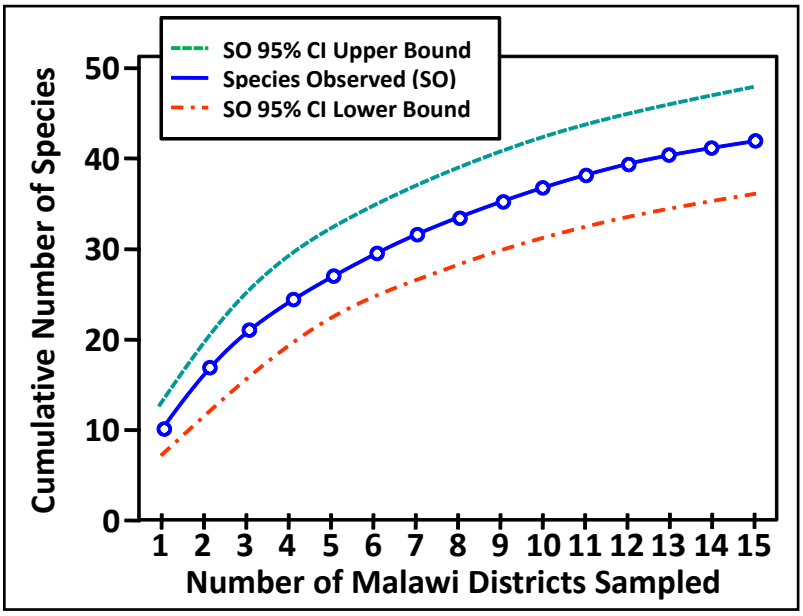

Figure 9. Species accumulation curve (middle curve) from a study of traditional use of geophytes in 15 selected districts of Malawi. Plotted with 95% confidence intervals (upper and lower curves). Analysis conducted using EstimateS (Colwell 2006).

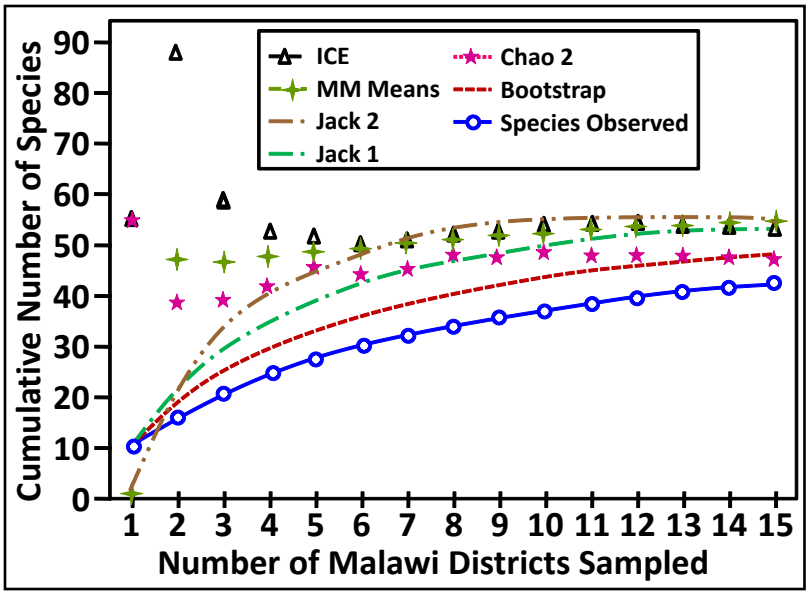

Figure 10. Species accumulation curve (species observed) from a study of traditional use of geophytes in 15 selected districts of Malawi compared with six non-parametric estimators of species richness (ICE, Chao 2, first order and second-order Jackknife, bootstrap and Michaelis–Menten Means) for the same data set. Descriptions and formulas of the species richness estimators used may be found in Colwell & Coddington (1994). The sample order was randomized 100 times to compute the mean estimator and expected species richness for each sample accumulation level the end result of which was a smooth curve. Analysis conducted using EstimateS (Colwell 2006) and following the protocol of Williams *et al*. (2007). Estimators of species richness-non-parametric estimates were used since these require no assumptions of plant community structure.

estimator however best approximated the known species richness followed by Chao 2.

Discussion and Conclusions

In the present study, members of the family Hyacinthaceae were less popular with only 3 species (6% of the 49) probably because people are spoilt with choices from other plants, both geophytes and non-geophytes, with which they could treat various diseases. In addition to this, we noticed that plants in the Hyacinthaceae were scarce in the field. This could be because most are low lying species growing in grasslands, hence they can be very cryptic. Although Hyacinthaceae were less popular in this study, members of the family have been documented elsewhere (Arnold *et al*. 2002) as being used for medicinal purposes ranging from the treatment of hangovers, rheumatic fever, sprains, syphilis, cancer, pneumonia the current study documented only 3 species of the family as being used as food and medicine Although the family is quite prominent in ethnomedicine, a few species have been chemically investigated so far (Louw *et al*. 2002). In addition to this, the family suffers from serious taxonomic problems and is in need of revision (Manning 2004, Stedje 1996).

This research has indicated that people use more underground parts that above ground parts of geophytes. The reason people say that they use more underground parts than leaves (90%) is the fact that leaves are less bitter than tubers hence they believe that the concentration of the compounds is more in the tubers than in leaves.

Bulbous plants, though studied less intensively than herbs and trees regarding their medicinal potential, have proven to contain a range of unique biologically active compounds. The presence of steroids, cardiac glycosides and alkaloids in some species can often indicate toxicity. Several studies have documented poisoning with symptoms such as diarrhoea, abdominal pain, emphysema and increased pulse rate, which can be fatal (Louw *et al*. 2002, Van Wyk *et al*.1997).

The present study similarly reports that bitter tubers used as food such as *Dioscorea* are boiled for long periods decanting water in the process of cooking to reduce the amount of poison. Similarly, species used as medicines are also diluted in water and taken in low doses because the respondents indicated that decoctions could prove to be fatal if taken in highly concentrated doses. The amount of poison is determined by tongue testing.

Dioscorea odoratissima is a famous famine food plant in most districts of Malawi and is also known to be rare. Members of this genus are also widely used around the world for both food and medicine. Wild yam species (e.g., *Dioscorea villosa* L. and *Dioscorea batatas* Decne.) have for centuries been used as sources of medicine and food by the Aztec and Mayan peoples for a wide range of ailments including many female problems and to relieve the pain of child birth (Bergeron 1997). The other famine food which is said to be rare is *Nymphaea caerulea*. Its tubers are known to have a higher calcium, phosphorus, and fatty acids (Chawanje 1998).

In this study, boiling of tubers used as food sources was very common and respondents said this act has a double function; enhancing the flavour of the tubers and reducing the poison which they contain. [This method is universally used around the world (Arnold *et al*. 2002, Banguar 1993).

Morris (1989) and Hargreaves (1994) identified 50 kinds of **mwana wa mphepo** and saw this category as not specific but referring to plants which store water and are able to produce flowers and leaves during the windy season. The problem with this definition is that not all such plants are **mwana wa mphepo**. This is probably why folk taxonomy is very difficult to adopt because it may represent different behavioral responses of people related to the salience of each organism (Hays 1982). Furthermore, Brown (1985) pointed out that people's vocabulary is related to their long-term interests. There is need to further research this term and see if indeed it is related to plant form and function or behavior of the people using the species included in this phenomenon. The term also contains unresolved species and hence more research into species delimitation and taxonomy is needed since certainty in species identification is a precondition for access to published species information related to, e.g., botany, ethnopharmacology, conservation and propagation (Krog *et al*. 2006). Proper species identification is also important in relation to consumer safety.

Species accumulation curves are known to enhance the value of ethnobotanical studies and create an opportunity for cogent arguments that advance scientific and practical knowledge (Williams *et al*. 2007). A comparative test of species estimators in the present study raises a question of survey sampling sufficiency because of failure of 4 out of 6 estimators to approach a horizontal asymptote. It is clear from these curves that more sampling was required and would have increased the species inventory.

The geophyte survey was driven by the need to document the use of Liliopsid monocots of family Hyacinthaceae and assess their conservation status. It is apparent from the survey that members of the Fabaceae and Asteraceae are more sought after for food and medicine than Lilioid monocots evidenced by fewer hyacinthoide representatives mentioned by respondents.

The most common anthropogenic pressure to all geophytes is tuber digging and clearing of woodlands for farming. The survey listed about 49 plant species that are most utilized. This number only represents a small proportion of all geophytes in Malawi. Some species were not reported here because they could not be spotted during field searches. Future work is therefore needed especially to go through the existing literature which will help generate new research ideas. Although this study has identified 49 geophytes from Malawi the actual number is not known. This problem is compounded by lack of a national checklist which usually acts as a guideline for such surveys. Support should also be provided for more taxonomic work in problematic genera, more ethnobotanical surveys and research towards sustainable use and conservation of these plants.

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