Plant Diversity in Western Ethiopia: Ecology, Ethnobotany and Conservation

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Abstract

The aim of this thesis is to investigate the ecology and ethnobotany of vegetation in Benishangul Gumuz Regional State (BGRS), western Ethiopia. The studies reported in this thesis have confirmed the existence of 1102 vascular plant species in BGRS. The region has, therefore, comparable vascular plant diversity to other floristic regions in Ethiopia. The study, which was carried out using classification and ordination techniques, revealed the existence of five plant comminutes and enabled to identify environmental variables that are structuring the plant composition. These plant communities could be used in conservation planning in BGRS. Potential threats to the vegetation were identified and found to increase with altitude. The study on *Tgetes patula* has revealed that the species has several characters that might facilitate invasiveness and may be considered as a threat to the natural landscapes in the absence of woodland fire to which the vegetation in the region is adapted. The result of the ethnobotanical study revealed that the people in BGRS and Kafa depend on diverse plant species which are mainly collected from wild population (ca. 70%). Over harvesting of wild plants that give immediate economic return, may increase the burden on wild plant populations. Such findings give hints for prioritization of plant species for *in-situ* and *ex-situ* conservation. In conclusion, this thesis has improved to the understanding of the imperfectly known vegetation in BGRS and medicinal plants used by Kafficho people.

List of papers

This thesis is based on the following papers which will be referred to in the text by their Roman numerals.

I. Sebsebe Demissew, Nordal, I., Herrmann, C., Friis, I., Tesfaye Awas & Stabbetorp, O. 2005. Diversity and endemism of the western Ethiopian escarpment – a preliminary comparison with other areas of the Horn of Africa. *Biol. Skr.* 55: 315-330.

II. Tesfaye Awas, Inger Nordal and Sebsebe Demissew. 2007. Plant communities in woodland vegetation of Benishangul Gumuz Region, western Ethiopia. Submitted.

III. Tesfaye Awas & Inger Nordal. 2007. Benishangul Gumuz Region in Ethiopia: A center of endemicity for *Chlorophytum* – with the description of *C. pseudocaule* sp. nov. (*Anthericaceae). Kew Bulletin.* 62(2): in press.

IV. Tesfaye Awas, Sebsebe Demissew, Inger Nordal and Ib Friis. 2007. New plant records for the Ethiopian flora from Benishangul Gumuz Region, western Ethiopia. Submitted.

V. Agnethe B. Salvesen, Tesfaye Awas and Inger Nordal. 2007. Escape of introduced ornamentals in Asteraceae - with main focus on *Tagetes patula* L. in western Ethiopia. Submitted.

VI. Tesfaye Awas, Zemede Asfaw, Inger Nordal and Sebsebe Demisew. 2007. Ethnobotany of Berta and Gumuz People in western Ethiopia. Submitted.

VII. Tesfaye Awas and Sebsebe Demissew. 2007. Ethnobotanical study of medicinal plants in Kafficho people, southwestern Ethiopia. Submitted.

Introduction

Ethiopia's boundaries encompass the major part of the eastern African highland massif. On the northern and western boundaries lie the foothills of the main massif. The Great Rift Valley cuts diagonally across the country from north east to south, creating a vast depression. The dry areas have isolated the highlands. Thus, there is great variation of altitude from 116 meters below sea level to 4620 meters above sea level. Rainfall also varies widely in amount and distribution. These factors strongly influence Ethiopia's extraordinary range of terrestrial and aquatic ecosystems, and have contributed to a high diversity and rate of endemism (Tesfaye Awas et al. 2003). The existence of such diverse ecosystems has endowed Ethiopia with diverse vegetation types.

Ethiopia being the land where the first humans have evolved, its vegetation has been exposed to various human induced impacts that have diminished its diversity for a longer period than anywhere else. The attention given to vegetation conservation and sustainable use has so far been inadequate. Some of the current contributory factors to accelerated decline of vegetation are: the size and pattern of the distribution of human and domestic animal populations, the level of resource consumption, market factors and policies. Under-valuation of vegetation conservation due to low-level of awareness about the rate at which it is deteriorated or lost and poor regard to the conservation problems have also contributed to under-investment in proper vegetation management.

The present vegetation of Ethiopia is physiognomically divided in to nine major vegetation types: 1) Desert and semi-desert scrubland; 2) Lowland (semi-) evergreen forest; 3) *Acacia-Commiphora* small- leaved, deciduous woodland; 4) *Combretum-Terminalia* broad-leaved deciduous woodland and savanna; 5) Evergreen scrub; 6) Moist evergreen montane forest / Afromontane rainforest; 7) Dry evergreen and montane forest and grassland; 8) Afro-alpine and subafroalpine zone; and 9. Riparian/riverine and swamp vegetation (Friis, 1992; Sebsebe Demissew et al. 1996; Conservation Strategy of Ethiopia, 1997; Friis and Sebsebe Demissew, 2001). This thesis focuses on the aspects of plant diversity, ecology and ethnobotany of vegetation type 4 and 9, particularly its part in Benishangul Regional State (BGRS), western Ethiopia. In addition, the study on the ethnobotany of medicinal plants of Kafficho, who are the dwellers of vegetation type 6, is included. Vegetation type 6 was also originally found in BGRS in areas above 1900m, though it is now completely lost and is represented only by remnant trees that indicate that the area was once covered by Moist evergreen montane forest.

Vegetation type 9 consists of at least two physiognomically different vegetation types, riverine/riparian forest, and open, almost treeless vegetation. The riverine and riparian forest and *Combretum-Terminalia* broad-leaved deciduous woodland and savanna in western Ethiopian were named by White (1983) as *undifferentiated woodlands (Ethiopian type).* Based on the floristic study made on the part of this woodland vegetation that occurs in Gambella Regional State in southwestern Ethiopia, five plant communities were recognized (Tesfaye Awas et al. 2001). They are *Commelina zambesica-Hygrophila auriculata*, *Sorghum purpureo-sericeum-Pennisetum thunbergii*, *Loudetia arundinacea-Hyparrhenia pilgeriana*, *Combretum adenogonium-Anogeissus leiocarpa* and *Tamarindus indica-Anogeissus leiocarpa* communities. The plant communities of the woodland vegetation in BGRS were not studied and there is a gap of information.

The woodland vegetation in western Ethiopia provides many resources to the inhabitants. Mengistu Wube (1995), Tesfaye Awas et al. (1997a), had studied and compiled information on the indigenous plant uses by Anywaa, Majangir and Nuer people in Gambella Regional State. Berta and Gumuz inhabited areas in the BGRS has never been studied. These studies had indicated the dependence of the people on this vegetation type for food, medicine and other uses.

Objectives

Recent botanical expeditions to the woodland vegetation in BGRS have come up with several new plant records that are either new to science (Nordal and Sebsebe Demissew 2002) or new for the Ethiopian flora (Edwards et al. 2000; Cribb et al. 2002). The Ethiopian Government has recognized this area as suitable for both rain fed and irrigated agriculture, which should be urgently developed through implementation of integrated development plans (Ministry of Information 2001). So far there is no area designated for any kind of conservation in BGRS. Conservationists are concerned that the new development plans may disrupt the ecosystem in general and the interaction of local people with indigenous plants in particular. Thus, there is an urgent need for information for conservation planning, sustainable biodiversity utilization and environmentally sound decision-making as part of integrated economic development program in the region. This study was, therefore, initiated to generate data for plant diversity conservation planning and sustainable development of Benishangul Gumuz Regional State in western Ethiopia. Some specific objectives include:

- To identify the plant communities that could be used as biodiversity surrogates for conservation of woodland vegetation in BGRS.
- To identify the most important environmental gradients structuring the plant communities in the region.
- To document ethnobotanical knowledge of Berta and Gumuz, the two dominant socio-cultural groups in BGRS.
- To compile a checklist of all plants in BGRS.
- To investigate ecological and biological factors that facilitated the invasion of woodland vegetation in BGRS by *Tgetes patula*
- To document medicinal plants used by Kafficho people, southwestern Ethiopia

Materials and methods

Vascular plant diversity

The number of vascular plant species in BGRS reported in **Paper I** was based on the list compiled from Cribb et al. (2002), Nordal and Sebsebe Demissew (2002), Sebsebe Demissew et al. (2003) and published Flora of Ethiopia and Eritrea (Hedberg and Edwards (1989), Phillips (1995), Edwards et al. (1995, 1997 and 2000), Hedberg et al. (2003 and (2006) and Mesfin Tadesse (2004). The list was further updated in this thesis based on recent studies (**Paper II, III, IV, V** and **VI;** Chance 2006; Friis and Vollesen 2007).

Vegetation classification and ordination (Paper II)

A systematic sampling method was used to select homogenous vegetation stands along an altitudinal gradient on both sides of Blue Nile River. In all stands, the cover/abundance data of all flowering plants in relevés were recorded following the Braun-Blanquet approach (Braun-Blanquet 1965; Muller-Dombois and Ellenberg 1974). A total of 61 relevés were sampled using a square plot of 400 m^2 (20 m by 20 m). The percentage cover/abundance values were transformed to a scale of ordinal transform values from 1 to 9 (van der Maarel 2005). Human impacts on the vegetation were also estimated subjectively on ordinal scales from zero to three. Environmental data on topographic and soil factors were gathered for each relevé. GPS was used to record the position (latitude and longitude) of each relevé. Everest Altimeter and GPS were used to measure altitude. Soil samples were collected from each relevé and analyzed by the National Soil Research Laboratory in Ethiopia.

Escape of introduced ornamentals (Paper V)

Vegetation stands that have been invaded by *T. patula* were found in Bulen, Dibatie and Mandura districts of BGRS. In each district, one site was selected and people were interviewed about the positive and negative impacts of *T. patula* on their life, when it arrived, if it was of any use, if it was eaten by animals, if it was actively or passively spread. The percentage cover of all plants associated with *T. patula* in 2m X 2m quadrat was recorded to investigate ecological preference of the species. The number of seed produced by *T. patula* was counted. The diaspores of *T. patula,* another escaped ornamental - *Zinnia elegans* and indigenous species - *Bidens prestinaria* were collected from ripe inflorescences for fire treatment experiments which was carried out at the University of Oslo. The later two species were included for comparison. Soils samples were collected to investigate weather *T. patula* and *B. prestinaria* survive in the soil seed bank.

Ethnobotanical data collection (Paper VI and VII)

The data collections have been conducted in two phases. In the first phase, pre-prepared semi-structured interview items were administered with extended discussion with informants. The local names of plants and use were recorded on the spot when informants reach to consensus. In the second phase, the plants were identified and their botanical names were listed along their respective local names. This list was used in preparing format for structured interview. The houses in each village were numbered starting from one corner and selected using random numbers for interview.

Data analysis

The cover/abundance data was analyzed using a FORTRAN Computer Program TWINSPAN, TWo-way INdicator SPecies ANalysis, Version 1.0 (Hill 1994). Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) were run to analyze patterns of variation in the species composition by using the computer program data package CANOCO version 4.5 (ter Braak and Smilauer 2002). One Way ANOVA statistics was used to find out if there were significant differences in seed germination fractions in the heat treatments. Ethnobotanic data was analyzed using multivariate computer program PAST (Ryan *et al.,* 1995).

Results and Discussion

Vascular plant diversity

The occurrence of 956 vascular plant species in BGRS was reported in **Paper I**. Based on this figure, the total number of vascular plants in BGRS was estimated to be between 1040 and 1180 species. Subsequent studies in BGRS have come up with verification of the occurrence of additional 147 plant species (**Paper II, III, IV, V** and **VI;** Chance 2006; Friis and Vollesen 2007). Among these, seven species were new to the Flora of Ethiopia (**Paper IV** and Friis and Vollesen 2007) while one species was new to science (**Paper III**). These studies have increased the total number vascular plants known in the woodland vegetation of western Ethiopia to 1102 species. The number of endemic species reported in **Paper I** was also increased by one, i.e. from 27 to 28 (**Paper III**).

The vascular plants in BGRS are mainly flowering plants where dicots and monocots accounted for about 70% and 29%, respectively (Table 1). The lower vascular plants (lycopodiophyta) were represented by one species - *Selaginella kraussiana* (Kze.) A. Br. (Selaginellaceae). Ferns (Polypodiophyta) were also represented by one species - *Nephrolepis undulata* (Sw.) J. Sm. (Oleandraceae).

The vascular plant species in the woodland vegetation of western Ethiopia were represented by about 117 families. About 10 families that contain more than 20 species and their ratio to the Flora of Ethiopia and Eritrea were given in Table 2. About 13 families contain 10 to 19 species, 65 families with two to nine species and 24 families were with one species each. Family Poaceae and Fabaceae were with the highest number of genera, 46 and 44, respectively (Table 2). About 10 families contain more than 11 genera, 57 families from two to 10 genera and 50 families were represented by a single genus. Thus, a total of 474 genera were represented where 10 genera contain more than 10 species (Table 3), 177 genera containing two to nine species and 287 genera were represented by one species each.

The woodland vegetation of western Ethiopia is characterized by small to moderately sized trees, herbs, grasses and sedges (Figure 1). The ground cover is dominated by herbaceous geophytes at the beginning of rainy season (May and June). Toward the end of the rainy season (September to November) tall strata of perennial grasses become dominant.

Table 1. Taxonomic diversity of vascular plants in BGRS, western Ethiopia.

Class	**Family**	**Genera**	**Species**
Dicots	92	363	776
Monocots	23	109	324
Ferns	1	1	1
Lycopods	1	1	1
Total	117	474	1102

Table 2. Families of flowering plants with more than 20 plant species in BGRS, western Ethiopia.

S. No.	**Family**	**No. of genera in BGRS**	**No. of species in BGRS**	**No. of species in Flora of Ethiopia & Eritrea**	**%**
1	Asteraceae	27	48	440	10.91
2	Convolvulaceae	10	32	132	24.24
3	Cyperaceae	12	75	185	40.54
4	Euphorbiaceae	17	39	209	18.66
5	Fabaceae	44	159	607	26.19
6	Malvaceae	9	30	139	21.58
7	Orchidaceae	14	50	154	32.47
8	Poaceae	46	117	580	20.17
9	Rubiaceae	30	49	101	48.51
10	Tiliaceae	3	21	47	44.68

Table 3. Genera of flowering plants containing more than 10 species in BGRS, western Ethiopia.

S. No.	Genera	Family	No. of Species
1	*Cyperus*	Cyperaceae	46
2	*Crotalaria*	Fabaceae	26
3	*Indigofera*	Fabaceae	21
4	*Habenaria*	Orchidaceae	16
5	*Ipomoea*	Convolvulaceae	16
6	*Acacia*	Fabaceae	14
7	*Chlorophytum*	Anthericaceae	13
8	*Eulophia*	Orchidaceae	13
9	*Hibiscus*	Malvaceae	12
10	*Hyparrhenia*	Poaceae	11

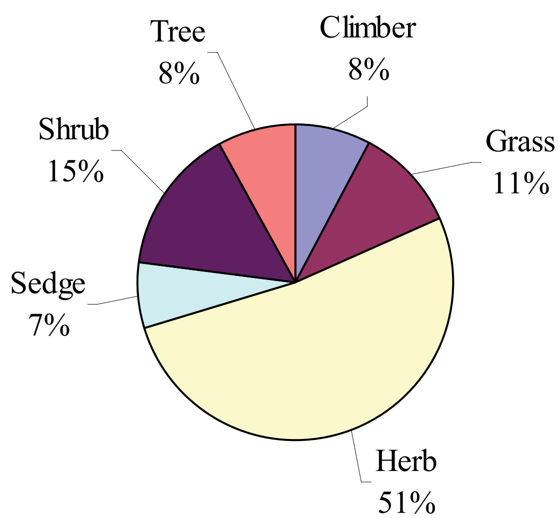

Figure 1. Proportion of life form classes of vascular plants in BGRS, western Ethiopia.

Vegetation classification and ordination (Paper II)

The woodland vegetation in BGRS was classified into five plant communities: (1) *Hyphaene thebaica-Pterocarpus lucens,* (2) *Boswellia papyrifera-Pterocarpus lucens* (Figure 2), (3) *Securidaca longepedunculata-Albizia malacophylla* (Figure 3), (4) *Croton macrostachyus-Albizia malacophylla* and (5) *Breonadia salicina-Phoenix reclinata.* The distribution of plants recorded in this study extends from Ethiopia to Senegal in the western Africa and to

Mozambique in the southeastern and Angola in the southwestern Africa. Of 232 species sampled in this study, 19% were shared with flora of Zambeziaca in southern Africa, 18% with flora of Tropical West Africa and 37% with both. The rest 26% of the species were restricted to Eastern African Flora, of which 13 species are endemic. Thus, the plant comminutes in BGRS are composed of plant species assemblages that have been formed by overlap of three phytogeographical regions in Africa; Afromontane, Sudanian and Zambezian regions.

Ordination identified two main gradients that are structuring the woodland vegetation in BGRS. The first gradient is long (4.235 S.D. units) and separated the dry woodland at lower altitude in one end and the riparian woodlands at higher altitudes in the other end. Among 26 environmental variables measured, five of them were significant (at $P<0.05$) in explaining variation in the species composition along the first gradient. The second gradient separated the plant communities at higher altitudes, where the *Securidaca longepedunculata* dominated woodland was in one end and *Croton macrostachyus* dominated woodland in the other end. Potassium was the only environmental variable which was found significant (at $P<0.05$) in explaining variation in the species composition along the second gradient. In general, altitude was found to be the most important environmental gradient to which other variables were correlated either positively or negatively.

Escape of introduced ornamentals (Paper V)

Discussion made with local people in areas where *T. patula* was found as escape revealed that so far there is no negative impact on their daily life, except for a minimum of weeding in farm lands. In the species association analysis, *T. patula* was mainly found in semi-natural woodland vegetation (Figure 4) which was characterized by trees and also species that demands some shade and moisture (Edwards et al. 1995, 1997 and 2000; Hedberg and Edwards 1989; Phillips 1995; Hedberg et al. 2003 and 2006; Mesfin Tadesse 2004). It was less frequent in open and drier habitat types.

Figure 2. *Boswellia papyrifera-Pterocarpus lucens* community in woodland vegetation of BGRS, western Ethiopia (Photo: Tesfaye Awas July 2004, 83 km along the road from Asosa to Kurmuk).

Figure 3. *Securidaca longepedunculata-Albizia malacophylla* community in woodland vegetation of BGRS, western Ethiopia (Photo: Tesfaye Awas July 2004, 22 km along the road from Asosa to Kurmuk).

The study on some biological characters of *T. patula* revealed that the species has several characters that might facilitate invasiveness. It produces a large number of relatively small diaspores, has a seed bank and grazing/trampling stimulates growth of side shoots. It is well known that most invasive plants turning weedy, share these characters (Grime 1979).

The result of fire treatment experiment revealed that the diaspores of *Bidens prestinaria* were not affected by the different heat treatments. Being an indigenous species in fire prone area, *B. prestinaria* might have been adapted to woodland fire regimes through evolution. *Zinnia elegans* showed a higher germination frequency except the highest temperature treatment. This suggests that *Z. elegans* diaspores have a higher fire resistance, which might be connected to the fact that it has thick cypsela wall. The diaspores of *T. patula* were not affected by fire, unless the heat becomes excessive. Based on these findings, the pristine woodlands, which are adapted to fire, may not be at risk of invasion.

Figure 4. Escape population of *Tagetes patula* in semi-natural woodland vegetation of BGRS, western Ethiopia (Photo: Agnethe B. Salvesen October 2005, 82 km along the rod from Chagni to Wembera).

Ethnobotany of Berta and Gumuz People (Paper VI)

A total of 185 plant species that are used in the daily life of Berta and Gumuz people have been recorded. About 30% of these plants are cultivated while 70% were collected from the wild. Two species *(Dioscorea bulbifera* and *Ricinus communis)* were found both in cultivation and in the wild. There are also three more plants, *Abelmoschus ficulneus* (Figure 5), *Hibiscus cannabinus* and *Corchorus olitorius,* which are very common in the wild stand but also tolerated in farmlands and homegardens. These plant species represent the wild-semi-wild-domesticated continuum of wild edibles of Ethiopia as described by Zemede Asfaw and Mesfin Tadesse (2001).

Berta and Gumuz have very few plant names in common (see appendix I, which is extracted from **Paper VI** to make easy identification of plants while working with Berta and Gumuz people). They share the local name of very few introduced plants and only one indigenous tree – *Boswellia papyrifera.* Both Berta and Gumuz follow similar pattern of plant naming, where they refer to color, habitat, origin of germplasm in the case of cultivated plants and relationship among plants. Plant naming and use were found to be more localized to districts among Gumuz than Berta people. Both among Berta and Gumuz the elderly person knows a higher number of plants used for commercial purpose, construction, fuel wood and medicine. Youngsters know more food plants. There is a negative relationship between the educational level of informants and their ethnobotanic knowledge, where those people who go to school know less number of useful plants.

Ethnobotany of medicinal plants of Kafficho people (Paper VII)

Ethnobotanical study of medicinal plants used by Kafficho people was carried out in Kafa zone, Southern Nations, Nationalities and People's Regional States in Southwestern Ethiopia. Informants were asked to rank medicinal plants used to cure a specific disease. A total of 124 medicinal plants were identified. Medicinal plant use among Kafficho is localized and dependent on plants that are found around them. The ethnobotanical knowledge on medicinal plants also varies among various social groups. Kafficho people obtain a significant proportion of their medicinal plants from the wild (about 74%) and only cultivate a few selected species (about 26%) in the *Ensete ventricosum* dominated homegarden (Figure 6).

Figure 5. *Abelmoschus ficulneus* under domestication in BGRS, western Ethiopia (Photo: Tesfaye Awas October 2005, Guba).

The medicinal plants are always cultivated on the upper slope of the homegarden, specifically behind the house. Kafficho people give four reasons for this: to prevent contamination by discharge of animal waste in the lower slope of their house, protection from livestock and to grow them out of human sight. The latter is related to traditional belief. The fourth reason is related to plant nutrition and the consequent plant performance. If medicinal plants are grown in homegarden quarters with high soil nutrient, they grow faster, complete their life cycle within a relatively shorter period and then die – a situation not appreciated by farmers. Instead, the farmers want the medicinal plants to remain longer in their gardens so as to ensure a prolonged harvest, and they achieve this by maintaining the plants under stressed conditions that subdue plant growth.

Kafficho people name medicinal plants by using the disease treated followed by '*ato'*. The plant naming system is mainly at species level. Medicinal plant use among Kafficho is site specific where people living close to forest depend on trees. There was also difference in medicinal plant knowledge between women and men of Kafficho people where, women know more about medicinal plants cultivated in homegarden. The older person knows high number of medicinal plants than youngsters.

The forest vegetation in Kafa zone was relatively intact a few decades ago, but recently faced heavy pressure from human activities (Kumelachew Yeshitela and Tamrat Bekele 2002; Kumelachew Yeshitela and Taye Bekele 2003). With the present ecological and socio-economical changes, medicinal plants together with the associated ethnobotanical knowledge of Kafficho are under serious threat and may be lost faster than imagined. Under such circumstances the use of plants for medicinal purposes will also decline and consequently the once effective traditional health care system will also be lost. Some ways to conserve the medicinal plants and associated knowledge were recommended in **Paper VII**.

Figure 6. *Ensete ventricosum* dominated homegarden of Kafficho people in southwestern Ethiopia (Photo: Tesfaye Awas June 2004, 8 km along the rod from Wacha to Bonga).

Conclusions and Implications for Conservation

Relatively, the woodland vegetation in western Ethiopia is still perhaps the least affected of all vegetation types in Ethiopia. However, the increasing population pressure leads to an increasing demand for agricultural land and plant products, thus forcing the people to clear woodlands for settlement and expansion of farmlands. In particular, the resettlement program that was undertaken in 1984 and the influx of refugees from Southern Sudan have lead to the sharp increase in human population, thus triggering the encroachment pressure on vegetation in BGRS. In general the threat on woodland vegetation in BGRS was found to increase with altitude, which was the most important environmental gradient in structuring vegetation in the region. Beside the existing pressure, implementation of other new development activities (Ministry of Information 2001), without conservation will lead to significant loss of vegetation. Establishment of conservation sites in the region is necessary to mitigate developments that may disrupt plant assemblage formed by the overlap of three big phytogeographical regions in Africa. Assemblage of sessile biota like the plant communities reflect the patterns in the underlying ecological process that are very important for management, and they are therefore, very important for prioritizing conservation activities. In areas like BGRS where the ecological processes are complex and poorly understood, conservation targeted to plant communities is the most recommended option. Under such situation, the findings reported in this thesis are very important basis for initiation of conservation in BGRS. The plant communities identified in **Paper II** could be used as biodiversity surrogates for conservation planning. In such process the involvement of local people is curial as they are the key generators, custodians and promoters of local biodiversity. The findings reported in **Paper VI** showed the dependence of indigenous people on diverse plants around them. In this regard, the list of plant local names along with the corresponding Latin is valuable tool for professionals to communicate with local people about the plants in BGRS. Similarly, the findings reported in **Paper III** along with the list of medicinal plants are valuable for communication with Kafficho people. It is hoped that this thesis will contribute to the efforts towards biodiversity conservation and sustainable development in the study sites in particular and Ethiopia in general.

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Appendix I.Local names of plants used by Berta and Gumuz people in Benishangul Gumuz Regional State, western Ethiopia.

Local Name§	**Botanical Name (Family)**
Abanga (Berta)	*Cordia africana* Lam. (Boraginaceae)
Abegeru (Berta; B,H,S)	*Colocasia esculenta* (L.) Schott. (Araceae)*
Abegeru (Berta; B,H,S)	*Xanthosoma sagittifolium* (L.) Schott (Araceae)*
Abendu (Berta)	*Andropogon schirensis* Hochst. ex A. Rich. (Poaceae)
Abershewa (Gumuz; K)	*Celosia trigyna* L. (Amaranthaceae)
Abombuqo (Berta)	*Strychnos innocua* Del. (Loganiaceae)
Aburmereree (Berta; S)	*Bidens prestinaria* (Sch. Bip.) Cufod. (Asteraceae)
Achegua (Gumuz; D,G,M)	*Ensete ventricosum* (Welw.) Cheesman (Musaceae)**
Achiquwa (Gumuz; G)	*Leonotis nepetifolia* (L.) R. Br. (Lamiaceae)
Adegella (Berta)	*Annona senegalensis* Pers. (Annonaceae)
Ades (Berta)	*Cajanus cajan* (L.) Millsp. (Fabaceae)*
Adihun (Berta)	*Pennisetum glaucum* (L.) R. Br. (Poaceae)*
Adimish (Berta)	*Lagenaria* sp. (Cucurbitaceae)*
Adundurutse (Berta)	*Solanum dasyphyllum* Schum. & Thonn. (Solanaceae)
Adundurutse (Berta)	*Solanum incanum* L. (Solanaceae)
Aebosiya (Gumuz; K)	*Solanum alatum* Moench. (Solanaceae)
Afud (Berta)	*Lonchocarpus laxiflorus* Guill. & Perr. (Fabaceae)
Agamo (Berta; B,H,S)	*Phragmites karka* (Retz.) Steud. (Poaceae)
Agembang (Berta)	*Corchorus olitorius* L. (Tiliaceae)**
Ageraa (Berta)	*Combretum molle* R. Br. ex G. Don (Combretaceae)
Agero (Berta)	*Maytenus senegalensis* (Lam.) Exell (Celastraceae)
Agnagnsheqe (Berta; B,H,S)	*Flacourtia indica* (Burm.f.) Merr. (Flacourtiaceae)
Agolgolo (Berta)	*Boswellia papyrifera* (Del.) Hochst. (Burseraceae)
Agu (Berta; B,H,S)	*Cucurbita pepo* L. (Cucurbitaceae)*
Agungulees (Berta)	*Adansonia digitata* L. (Bombacaceae)
Aguqasi (Berta)	*Lagenaria siceraria (Molina) Standl. (Cucurbitaceae)**
Ajenzebil (Berta)	*Zingiber officinale Roscoe (Zingiberaceae)**
Akala (Gumuz; K)	*Vigna subterranea (L.) Verdc. (Fabaceae)**

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Akomkom (Berta; H)	*Indigofera garckeana Vatake. (Fabaceae)*
Albabaya (Berta)	*Carica papaya L. (Caricacae)**
Albafra (Berta; K,S)	*Manihot esculenta* Crantz (Euphorbiaceae)*
Albun (Berta)	*Coffea arabica* L. (Rubiaceae)*
Alful (Berta)	*Arachis hypogaea* L. (Fabaceae)*
Alilintsewa (Berta; H)	*Aframomum alboviolaceum* (Ridl.) K. Schum. (Zingiberaceae)
Alkola (Gumuz; G)	*Senna obtusifolia* (L.) Irwin & Barneby (Fabaceae)
Almoz (Berta)	*Musa x paradisiaca* L. (Musaceae)*
Ambenattur (Berta)	*Lycopersicum esculentum* Mill. (Solanaceae)*
Amberta (Gumuz; G)	*Andropogon schirensis* Hochst. ex A. Rich. (Poaceae)
Amblish (Berta; B,H,S)	*Erythrina abyssinica* Schweinf. (Fabaceae)
Amhorson (Berta)	*Ziziphus mauritiana* Lam. (Rhamnacae)
Amhulee (Berta)	*Zea mays* L. (Poaceae)*
Amroro (Berta)	*Pterocarpus lucens* Guill. & Perr. (Fabaceae)
Andamenu (Berta; B,H,S)	*Ficus ovata* Vahl (Moraceae)
Andegila (Gumuz; D,G,K)	*Stereospermum kunthianum* Cham. (Bignoniaceae)
Andeha (Gumuz)	*Abelmoschus esculentus* (L.) Moench. (Malvaceae)*
Andeha Yiza (Gumuz; D,G,M)	*Abelmoschus ficulneus* (L.) Wight & Arn. (Malvaceae)**
Anderkukuwa (Gumuz; G)	*Strychnos spinosa* Lam. (Loganiaceae)
Andidekuwa (Gumuz; M)	*Hyparrhenia anthistirioides*(Hochst. ex A. Rich.) Stapf (Poaceae)
Andidiha (Gumuz; K,M)	*Ochna leucophloeos* Hochst. ex A. Rich. (Ochnaceae)
Andowa (Gumuz; D,M)	*Sarcocephalus latifolius* (J. E. Smith) E. A. Bruce. (Rubiaceae)
Andukhabiya (Gumuz; M)	*Strychnos spinosa* Lam. (Loganiaceae)
Angeled (Berta; B)	*Clerodendrum alatum* Güerke (Verbenaceae)
Angesho (Berta; B,H,S)	*Leonotis nepetifolia* (L.) R. Br. (Lamiaceae)
Anguga (Gumuz; D,G,M)	*Ziziphus abyssinica* Hochst. ex A. Rich. (Rhamnacae)
Ankerphapha (Gumuz; M)	*Hibiscus cannabinus* L. (Malvaceae)**
Ansisiwa (Gumuz; D,M)	*Albizia malacophylla (A. Rich.) Walp. (Fabaceae)*
Antsiqina (Gumuz)	*Ampelocissus schimperiana (Hochst. ex A. Rich.) Planch. (Vitaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Antsiqina Guanja (Gumuz; D,G)	*Cissus cornifolia (Bak.) Planch. (Vitaceae)*
Antutiya (Gumuz; G)	*Solanum alatum* Moench. (Solanaceae)
Anzum (Berta)	*Syzygium guineense* (Willd.) DC. subsp macrocarpa (Myrtaceae)
Aqenda (Berta)	*Gardenia ternifolia* Schum. & Thonn. (Rubiaceae)
Aqulqa (Berta; B,H)	*Stereospermum kunthianum* Cham. (Bignoniaceae)
Aranguawaya (Gumuz; D,M)	*Phaseolus vulgaris* L. (Fabaceae)*
Arenguya (Gumuz; G)	*Phaseolus vulgaris* L. (Fabaceae)*
Arezruzu (Berta; H,S)	*Cleome gynandra* L. (Capparidaceae)
Asandiya (Gumuz; D)	*Acacia seyal* Del. (Fabaceae)
Ashada Bugudo (Berta)	*Dioscorea dumetorum* (Kunth) Pax (Dioscoreaceae)
Ashetta (Berta)	*Capsicum annuum* L. (Solanaceae)*
Ashihur (Berta)	*Terminalia laxiflora* Engl. & Diels (Combretaceae)
Ashumshumar (Berta)	*Anethum graveolens* L. (Apiaceae)*
Aterash (Berta; S)	*Cassia arereh* Del. (Fabaceae)
Athehol (Berta; B,H,S)	*Coriandrum sativum* L. (Apiaceae)*
Atsegeda (Berta; S)	*Tamarix nilotica* (Ehrenb.) Bunge (Tamaricaceae)
Atsisa (Gumuz)	*Oncoba spinosa* Forssk. (Flacourtiaceae)
Atsoda (Berta)	*Vitex doniana* Sweet. (Verbenaceae)
Atteettee (Berta; B,H,K)	*Faurea speciosa* Welw. (Proteaceae)
Attettashza (D,M)	*Vernonia hochstetteri* Sch.-Bip. (Asteraceae)
Awushenshe (Berta; B)	*Bidens prestinaria* (Sch. Bip.) Cufod. (Asteraceae)
Babegoha (Gumuz; G)	*Terminalia macroptera* Guill. & Perr. (Combretaceae)
Babenga (Gumuz; G)	*Hyphaene thebaica* (L.) Mart. (Arecaceae)
Bafuchochuwa (Gumuz; K)	*Luffa cylindrica* (L.) M. J. Roem. (Cucurbitaceae)*
Bafukacha (Gumuz; K)	*Zea mays* L. (Poaceae)*
Baga (Gumuz; G,K)	*Brassica carinata* A. Br. (Brassicaceae)*
Bambaya (Gumuz; G,M)	*Ipomoea batatas* L. (Convolvulaceae)*
Bambee (Berta)	*Ipomoea batatas* L. (Convolvulaceae)*
Bambeluwa (G)	*Entada africana Guill. & Perr. (Fabaceae)*
Bambutta (Gumuz)	*Annona senegalensis Pers. (Annonaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Banja (Gumuz)	*Cordia africana Lam. (Boraginaceae)*
Banjazaka (Gumuz; M)	*Syzygium guineense* (Willd.) DC. subsp guineense (Myrtaceae)
Banshzegona (Gumuz; G)	*Wissadula rostrata* (Schum. & Thonn.) Hook.f. (Malvaceae)
Bebdaja (Gumuz; G)	*Tragia doryodes* M. Gilbert (Euphorbiaceae)
Beda (Gumuz)	*Momordica foetida* Schum. (Cucurbitaceae)
Bedanjila (Gumuz; M)	*Lycopersicum esculentum* Mill. (Solanaceae)*
Beella (Gumuz; K)	*Portulaca* sp. (Portulacaceae)*
Beewa (Gumuz)	*Lonchocarpus laxiflorus* Guill. & Perr. (Fabaceae)
Begene (Berta; S)	*Pennisetum unisetum* (Nees) Benth. (Poaceae)
Begiya (Gumuz; D,G,M)	*Strychnos innocua* Del. (Loganiaceae)
Begngira (Gumuz; G)	*Pennisetum schweinfurthii* Pilg. (Poaceae)
Beguha (Gumuz; M)	*Terminalia laxiflora* Engl. & Diels (Combretaceae)
Beguha (Gumuz; M)	*Terminalia macroptera* Guill. & Perr. (Combretaceae)
Beguwa (Gumuz; K)	*Terminalia laxiflora* Engl. & Diels (Combretaceae)
Bekiya (Gumuz; K)	*Sarcocephalus latifolius* (J. E. Smith) E. A. Bruce. (Rubiaceae)
Bembeda (Gumuz; G)	*Maytenus senegalensis* (Lam.) Exell (Celastraceae)
Benjer (Berta; B,H,S)	*Beta vulgaris* L. (Chenopodiaceae)*
Berantutia (Gumuz; K)	*Physalis peruviana* L. (Solanaceae)
Berendula (Gumuz; G,K)	*Lycopersicum esculentum* Mill. (Solanaceae)*
Besheella (Gumuz; K)	*Anethum graveolens* L. (Apiaceae)*
Beshuwe (Berta; B,H)	*Ocimum basilicum* L. (Lamiaceae)*
Betita (Gumuz; G)	*Portulaca* sp. (Portulacaceae)*
Bibi (Berta)	*Ximenia americana* L. (Olacaceae)
Bidigua (Gumuz; G)	*Hyparrhenia anthistirioides*(Hochst. ex A. Rich.) Stapf (Poaceae)
Biilga (Gumuz)	*Lannea welwitschii* (Hiern) Engl. (Anacardiaceae)
Bilga (Gumuz; G)	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl. (Anacardiaceae)
Bilia Beegneni (Berta)	*Allium cepa* L. (Alliaceae)*
Bilia Fudi (Berta)	*Allium sativum* L. (Alliaceae)*
Bilza (Gumuz; G)	*Guizotia abyssinica (L.f.) Cass (Asteraceae)**
Birbira (Gumuz; D)	*Capsicum frutescens L. (Solanaceae)**
Bisa (Gumuz; D,M)	*Cymbopogon caesius (Hook. & Arn.) Stapf. (Poaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Bishqor (Berta)	*Saba comorensis* (Boj.) Pichon (Apocynaceae)
Biyangua (Gumuz)	*Ocimum canum* Sims. (Lamiaceae)
Bogonda (Gumuz; G)	*Jatropha curcas* L. (Euphorbiaceae)*
Bogonda (Gumuz; G)	*Ricinus communis* L. (Euphorbiaceae)**
Bohzikuna (Gumuz; D,M)	*Wissadula rostrata* (Schum. & Thonn.) Hook.f. (Malvaceae)
Boqa (Gumuz; D,G,M)	*Dioscorea cayenensis* Lam. (Dioscoreaceae)*
Bora (Gumuz; G)	*Terminalia laxiflora* Engl. & Diels (Combretaceae)
Bosiya (Gumuz; D,M)	*Solanum alatum* Moench. (Solanaceae)
Bululitu (Berta; B,H)	*Linum usitatissimum* L. (Linaceae)*
Bulummtsee (Berta; B,H,S)	*Syzygium guineense* (Willd.) DC. subsp guineense (Myrtaceae)
Chaya (Gumuz; D,G,M)	*Pterocarpus lucens* Guill. & Perr. (Fabaceae)
Chelatiya (Gumuz; D,M)	*Ruta chalepensis* L. (Rutaceae)*
Chicha (Gumuz; K)	*Strychnos spinosa* Lam. (Loganiaceae)
Chicha (Gumuz; K)	*Acacia hecatophylla* Steud. ex A. Rich. (Fabaceae)
Chicha (Gumuz; K)	*Acacia polyacantha* Willd. (Fabaceae)
Chicha (Gumuz; K)	*Acacia seyal* Del. (Fabaceae)
Chichariya (Gumuz; K)	*Amaranthus spinosus* L. (Amaranthaceae)
Chintta (Gumuz; D,K,M)	*Linum usitatissimum* L. (Linaceae)*
Dadiha (Gumuz; D,M)	*Acanthus polystachyus* Del. (Acanthaceae)
Degig (Berta; B,H)	*Manihot esculenta* Crantz (Euphorbiaceae)*
Derguya (Gumuz; K,M)	*Asystasia gangetica* (L.) T. Andress. (Acanthaceae)
Dhafa (Gumuz; D,K,M)	*Eragrostis tef* (Zucc.) Trotter (Poaceae)*
Dheberi (Berta)	*Phaseolus vulgaris* L. (Fabaceae)*
Dheberimugu (Berta; H,S)	*Vigna membranacea* A. Rich. (Fabaceae)
Digle (Berta)	*Breonadia salicina* (Vahl) Heppehr & Wood (Rubiaceae)
Dijiha (Gumuz; D,G,K)	*Breonadia salicina* (Vahl) Heppehr & Wood (Rubiaceae)
Dirtsegn (Berta)	*Entada africana* Guill. & Perr. (Fabaceae)
Diwa (Gumuz; D,G,K)	*Syzygium guineense (Willd.) DC. subsp guineense (Myrtaceae)*
Dhoga (Gumuz; G,M)	*Tamarindus indica L. (Fabaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Donga (Gumuz; D)	*Piliostigma thonningii* (Schum.) Milne-Redh. (Fabaceae)
Dur (Berta; B,H,S)	*Borassus aethiopum* Mart. (Arecaceae)
Ebeya (Gumuz; D,M)	*Ficus sur* Forssk. (Moraceae)
Ebicha (K)	*Vernonia hochstetteri* Sch.-Bip. (Asteraceae)
Eboba (Gumuz; D,G,M)	*Rottboellia cochinchinensis* (Lour.) Clayton (Poaceae)
Echa (Gumuz)	*Dioscorea praehensilis* Benth. (Dioscoreaceae)
Edeeduwa (Gumuz; K)	*Protea gaguedi* J. F. Gmel. (Proteaceae)
Edimba (Gumuz; K)	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl. (Anacardiaceae)
Egaguwa (Gumuz; D)	*Phaseolus vulgaris* L. (Fabaceae)*
Egidima (Gumuz; D,K,M)	*Vernonia theophrastifolia* Schweinf. ex Oliv. & Hiern (Asteraceae)
Egile (Gumuz; M)	*Bidens prestinaria* (Sch. Bip.) Cufod. (Asteraceae)
Eimplametsumu (Berta; B)	*Aframomum alboviolaceum* (Ridl.) K. Schum. (Zingiberaceae)
Ejegaha (Gumuz; D)	*Hibiscus corymbosus* A. Rich. (Malvaceae)
Ejekuya (Gumuz; D,M)	*Physalis peruviana* L. (Solanaceae)
Ejesiya (Gumuz)	*Dombeya torrida* (J. F. Gmel.) P. Bamps (Sterculiaceae)
Ejisiya (Gumuz; G)	*Physalis peruviana* L. (Solanaceae)
Ejimbaya (Gumuz; D,K,M)	*Ozoroa pulcherrima* (Schweinf.) R. & A. Fernand. (Anacardiaceae)
Ejjiga (Gumuz; D,K,M)	*Bridelia scleroneura* Muell. Arg. (Euphorbiaceae)
Elangiya (Gumuz; D,G, K)	*Justicia ladanoides* Lam. (Acanthaceae)
Eliya (Gumuz)	*Asparagus flagellaris* (Kunth) Baker (Asparagaceae)
Emandeela (Gumuz; D,K)	*Ipomoea batatas* L. (Convolvulaceae)*
Embawuza (Gumuz; M)	*Capsicum frutescens* L. (Solanaceae)*
Engifa (Gumuz; G)	*Combretum collinum* Fresen. (Combretaceae)
Enquha (Gumuz; M)	*Combretum hartmannianum* Schweinf. (Combretaceae)
Enquha (Gumuz; M)	*Combretum molle* R. Br. ex G. Don (Combretaceae)
Enta (Gumuz)	*Oxytenanthera abyssinica* (A. Rich.) Munro (Poaceae)
Ephegaha (Gumuz; M)	*Hibiscus corymbosus* A. Rich. (Malvaceae)
Ephtseya (Gumuz; M)	*Combretum collinum* Fresen. (Combretaceae)

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Ephuwa (Gumuz; D,G,M)	*Sterculia africana* (Lour.) Fiori (Sterculiaceae)
Eqephaqiwa (Gumuz; D,M)	*Triumfetta annua* L. (Tiliaceae)
Eskophinja (Gumuz; M)	*Acacia seyal* Del. (Fabaceae)
Etissayaqua (Gumuz)	*Pennisetum thunbergii* Kunth (Poaceae)
Etsebulandi (Berta; B)	*Clerodendrum alatum* Güerke (Verbenaceae)
Ewuya (M)	*Entada africana* Guill. & Perr. (Fabaceae)
Eyampisah (Gumuz; M)	*Rumex abyssinicus* Jacq. (Polygonaceae)
Eyguyeguya (D)	*Entada africana* Guill. & Perr. (Fabaceae)
Ezerticha (Gumuz; D,M)	*Corchorus olitorius* L. (Tiliaceae)**
Ezeshiga (Gumuz; K)	*Ziziphus abyssinica* Hochst. ex A. Rich. (Rhamnacae)
Ferenji Bilza (Gumuz; G)	*Helianthus annuus* L. (Asteraceae)*
Ferentseon (Berta; H)	*Tacca leontopetaloides* (L.) O. Ktze. (Taccaceae)
Feeferentseon (Berta; S)	*Tacca leontopetaloides* (L.) O. Ktze. (Taccaceae)
Fesh (Berta; B,H,S)	*Momordica foetida* Schum. (Cucurbitaceae)
Feya (Gumuz; D,M)	*Ximenia americana* L. (Olacaceae)
Fidhenzsia (Gumuz; K)	*Capsicum annuum* L. (Solanaceae)*
Fikahanshza (Gumuz; M)	*Capsicum annuum* L. (Solanaceae)*
Firzsha (Gumuz; D)	*Capsicum annuum* L. (Solanaceae)*
Fitiya (Gumuz; K)	*Clematis hirsuta* Perr. & Guill. (Ranunculaceae)
Fodog (Berta)	*Dombeya torrida* (J. F. Gmel.) P. Bamps (Sterculiaceae)
Funishza (Gumuz; G)	*Capsicum frutescens* L. (Solanaceae)*
Fuqa (Gumuz; D,G,M)	*Ficus sycomorus* L (Moraceae)
Gagojia (Gumuz; K)	*Phaseolus vulgaris* L. (Fabaceae)*
Gagu (Berta)	*Oxytenanthera abyssinica* (A. Rich.) Munro (Poaceae)
Gaguwa (Gumuz; G)	*Phaseolus vulgaris* L. (Fabaceae)*
Gasha (Berta; B,H,S)	*Eragrostis tef* (Zucc.) Trotter (Poaceae)*
Gaze (Berta; S)	*Ensete ventricosum* (Welw.) Cheesman (Musaceae)**
Gebeba (Gumuz)	*Gossypium arboreum* L. (Malvaceae)*
Gebugur (Berta)	*Terminalia macroptera* Guill. & Perr. (Combretaceae)
Gediya (Gumuz)	*Grewia mollis* A.Juss. (Tiliaceae)

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Gendher (Berta)	*Albizia malacophylla* (A. Rich.) Walp. (Fabaceae)
Gesebe Sukar (Berta; S)	*Saccharum officinarum* L. (Poaceae)*
Gideya (Gumuz; D,G,M)	*Grewia velutina* (Forssk.) Vahl (Tiliaceae)
Gilu (Berta; H,S)	*Cissus populnea* Guill. & Perr. (Vitaceae)
Gira (Gumuz; D)	*Trigonella foenum-graecum* L. (Fabaceae)*
Gisa (Gumuz; G)	*Sorghum bicolor* (L.) Moench (Poaceae)*
Gisinaba (Gumuz; G)	*Zea mays* L. (Poaceae)*
Gisiraba (Gumuz; M)	*Zea mays* L. (Poaceae)*
Gizimpha (Gumuz; D,M)	*Andropogon schirensis* Hochst. ex A. Rich. (Poaceae)
Giziqua Eimpuchichima (Gumuz; K)	*Sesamum indicum* L. (Pedaliaceae)*
Giziqua Hoha (Gumuz; M)	*Senna obtusifolia* (L.) Irwin & Barneby (Fabaceae)
Giziqua Kifa (Gumuz; D)	*Sesamum indicum* L. (Pedaliaceae)*
Giziqua Mehichima (Gumuz; K)	*Guizotia abyssinica* (L.f.) Cass (Asteraceae)*
Gnera Woni (Berta)	*Cymbopogon caesius* (Hook. & Arn.) Stapf. (Poaceae)
Gnera Mekosh (Berta; B,H)	*Pennisetum thunbergii* Kunth (Poaceae)
Goha (Gumuz; D,G,M)	*Phoenix reclinata* Jacq. (Arecaceae)
Gohigmenza (Gumuz; M)	*Vitex doniana* Sweet. (Verbenaceae)
Gokhen (Gumuz; D,M)	*Hyphaene thebaica* (L.) Mart. (Arecaceae)
Golgola (Gumuz; D,G,M)	*Boswellia papyrifera* (Del.) Hochst. (Burseraceae)
Golgolofale (Berta; H,K,S)	*Commiphora pedunculata* (Kotschy & Peyr.) Engl. (Burseraceae)
Gora (Berta; H,S)	*Hyphaene thebaica* (L.) Mart. (Arecaceae)
Gushel (Berta)	*Combretum collinum* Fresen. (Combretaceae)
Gzimisse (Gumuz; D,M)	*Pennisetum schweinfurthii* Pilg. (Poaceae)
Gziquwa Raba (Gumuz; M)	*Helianthus annuus* L. (Asteraceae)*
Hadhigni (Berta; S)	*Crossopteryx febrifuga* (Afzel. ex G. Don) Benth. (Rubiaceae)
Hafa (Gumuz; K)	*Combretum collinum* Fresen. (Combretaceae)
Hafa (Gumuz; K)	*Combretum molle* R. Br. ex G. Don (Combretaceae)
Halale (Berta; B,H,S)	*Clerodendrum cordifolium* (Hochst.) A. Rich. (Verbenaceae)
Haphani (Berta)	*Gossypium arboreum* L. (Malvaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Harangafinasignee (Berta; B,H)	*Triumfetta annua* L. (Tiliaceae)
Hargjelo (Berta; B,H,K)	*Bridelia scleroneura* Muell. Arg. (Euphorbiaceae)
Hattab (Berta; B,H,S)	*Grewia flavescens* Juss. (Tiliaceae)
Hazra Mili (Berta; K)	*Guizotia abyssinica* (L.f.) Cass (Asteraceae)*
Heeneshemish (Berta; S)	*Helianthus annuus* L. (Asteraceae)*
Heephuya (Gumuz; K)	*Sterculia africana* (Lour.) Fiori (Sterculiaceae)
Heeraba (Gumuz; D)	*Lycopersicum esculentum* Mill. (Solanaceae)*
Heesha Mili (Berta; B,H,S)	*Guizotia abyssinica* (L.f.) Cass (Asteraceae)*
Heeshansaaro (Berta; B,H)	*Helianthus annuus* L. (Asteraceae)*
Heshe Fudi (Berta)	*Sesamum indicum* L. (Pedaliaceae)*
Hesiniya (Gumuz; G)	*Hyparrhenia filipendula* (Hochst.) Stapf. (Poaceae)
Heya (Gumuz; G,K)	*Ximenia americana* L. (Olacaceae)
Hiji Seteena (Gumuz; K)	*Clerodendrum alatum* Güerke (Verbenaceae)
Hinush (Berta; S)	*Cadaba farinosa* Forssk. (Capparidaceae)
Hoqosha (Gumuz; G)	*Sesamum indicum* L. (Pedaliaceae)*
Hornotse (Berta)	*Grewia mollis* A.Juss. (Tiliaceae)
Hornotse Gelu (Berta)	*Grewia velutina* (Forssk.) Vahl (Tiliaceae)
Ibeshanta (Gumuz; M)	*Commelina imberbis* Ehrenb. ex Hassk. (Commelinacae)
Iwe (Gumuz)	*Cissus populnea* Guill. & Perr. (Vitaceae)
Iyang (Berta)	*Carissa spinarum* L. (Apocynaceae)
Janjibil (Gumuz)	*Zingiber officinale* Roscoe (Zingiberaceae)*
Jigawuha (Gumuz; K)	*Cucumis pustulatus* Naud ex Hook.f. (Cucurbitaceae)
Jiggnewiya (Gumuz; G,M)	*Clerodendrum alatum* Güerke (Verbenaceae)
Jipiwa (Gumuz; G)	*Combretum hartmannianum* Schweinf. (Combretaceae)
Kafee (Berta; H)	*Ensete ventricosum* (Welw.) Cheesman (Musaceae)**
Kakime (Gumuz; D,G,M)	*Justicia ladanoides* Lam. (Acanthaceae)
Kaze (Berta; B)	*Ensete ventricosum* (Welw.) Cheesman (Musaceae)**
Kebanit (Berta)	*Capsicum frutescens* L. (Solanaceae)*
Kerkedee (Berta)	*Hibiscus sabdariffa* L. (Malvaceae)*
Kibuwa (Gumuz; M)	*Lagenaria siceraria* (Molina) Standl. (Cucurbitaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Kifa (Gumuz; D)	*Cynodon nlemfuensis* Vanderyst (Poaceae)
Kima (Gumuz; D,M,K)	*Portulaca* sp. (Portulacaceae)*
Kompha (Gumuz)	*Xanthosoma sagittifolium* (L.) Schott (Araceae)*
Kompha (Gumuz)	*Colocasia esculenta* (L.) Schott. (Araceae)*
Kota (Gumuz)	*Gardenia ternifolia* Schum. & Thonn. (Rubiaceae)
Kuancha (Gumuz; D,K,M)	*Sorghum bicolor* (L.) Moench (Poaceae)*
Laliqa (Gumuz; G)	*Corchorus olitorius* L. (Tiliaceae)**
Lefura (Gumuz)	*Arachis hypogaea* L. (Fabaceae)*
Lelentsewa (Berta; B)	*Aframomum alboviolaceum* (Ridl.) K. Schum. (Zingiberaceae)
Lemuna (Gumuz)	*Citrus aurantifolia* Swingle (Rutaceae)*
Lifa (Berta, Gumuz; G)	*Luffa cylindrica* (L.) M. J. Roem. (Cucurbitaceae)*
Machanchiga (Gumuz; G,K)	*Lagenaria siceraria* (Molina) Standl. (Cucurbitaceae)*
Mamusa (Gumuz; G)	*Cymbopogon caesius* (Hook. & Arn.) Stapf. (Poaceae)
Manchiga (Gumuz; D)	*Lagenaria siceraria* (Molina) Standl. (Cucurbitaceae)*
Mangal Hindi (Berta)	*Mangifera indica* L. (Anacardiaceae)*
Mangal Mesri (Berta)	*Mangifera indica* L. (Anacardiaceae)*
Mangu (Berta)	*Ampelocissus schimperiana* (Hochst. ex A. Rich.) Planch. (Vitaceae)
Mecha (Gumuz; G,M)	*Piliostigma thonningii* (Schum.) Milne-Redh. (Fabaceae)
Meela (Gumuz; G)	*Acacia seyal* Del. (Fabaceae)
Megel (Berta)	*Piliostigma thonningii* (Schum.) Milne-Redh. (Fabaceae)
Mejira (Gumuz; G,M)	*Trigonella foenum-graecum* L. (Fabaceae)*
Mejiru Gneero (Berta)	*Dioscorea bulbifera* L. (Dioscoreaceae)**
Mejiru Tayo (Berta)	*Dioscorea bulbifera* L. (Dioscoreaceae)**
Mekhima Giziqua (Gumuz; D)	*Guizotia abyssinica* (L.f.) Cass (Asteraceae)*
Mela (Berta)	*Tamarindus indica* L. (Fabaceae)
Meme (Berta; B,H,S)	*Cissus cornifolia* (Bak.) Planch. (Vitaceae)
Menga (Berta)	*Mangifera indica* L. (Anacardiaceae)*
Menzimiyo (Berta; S)	*Feretia apodanthera* Del. (Rubiaceae)
Metiya (Gumuz; K)	*Phoenix reclinata* Jacq. (Arecaceae)
Metseeya (G,K)	*Tristemma mauritianum* J.F. Gmel. (Melastomataceae)

Appendix I. Continued…

Local Name§	**Botanical Name (Family)**
Mim (Berta)	*Melia azedarach* L. (Meliaceae)*
Miwa (Gumuz; K)	*Pterocarpus lucens* Guill. & Perr. (Fabaceae)
Moro (B,S)	*Asparagus flagellaris* (Kunth) Baker (Asparagaceae)
Morqoqo (Berta)	*Ziziphus abyssinica* Hochst. ex A. Rich. (Rhamnacae)
Murqe (Berta)	*Diospyros mespiliformis* A. DC. (Ebenaceae)
Muza (Gumuz)	*Musa x paradisiaca* L. (Musaceae)*
Neyisha (Berta)	*Ficus sycomorus* L (Moraceae)
Obdaja (Gumuz; D,M)	*Tragia doryodes* M. Gilbert (Euphorbiaceae)
Odanjuwa (Gumuz; M)	*Stereospermum kunthianum* Cham. (Bignoniaceae)
Offee (Berta)	*Lablab purpureus* (L.) Sw. (Fabaceae)*
Ola (Gumuz; K)	*Aframomum alboviolaceum* (Ridl.) K. Schum. (Zingiberaceae)
Opa (Gumuz)	*Lablab purpureus* (L.) Sw. (Fabaceae)*
Papaya (Gumuz)	*Carica papaya* L. (Caricacae)*
Patuwa (Gumuz; D,K,M)	*Cucurbita pepo* L. (Cucurbitaceae)*
Pepe (Gumuz; D,M)	*Leonotis nepetifolia* (L.) R. Br. (Lamiaceae)
Phiriwa (Gumuz; D)	*Capsicum frutescens* L. (Solanaceae)*
Pille (Gumuz; D,M)	*Pennisetum unisetum* (Nees) Benth. (Poaceae)
Piwe (Gumuz; G,K,M)	*Crossopteryx febrifuga* (Afzel. ex G. Don) Benth. (Rubiaceae)
Qaha (Berta)	*Balanites aegyptiaca* (L.) Del. (Balanitaceae)
Qashi (S)	*Acacia seyal* Del. (Fabaceae)
Qashi Fudi (B,K)	*Acacia seyal* Del. (Fabaceae)
Qedeber (B,H)	*Protea gaguedi* J. F. Gmel. (Proteaceae)
Qenqetse (Berta)	*Abelmoschus esculentus* (L.) Moench. (Malvaceae)*
Qenqetse Melejida (Berta)	*Abelmoschus ficulneus* (L.) Wight & Arn. (Malvaceae)**
Qeqelo (Berta; B,H,S)	*Costus spectabilis* (Fenzl) K. Schum. (Zingiberaceae)
Qey (Berta)	*Anogeissus leiocarpa* (A. DC.) Guill. & Perr. (Combretaceae)
Qeyeda Gneero (Berta)	*Dioscorea praehensilis* Benth. (Dioscoreaceae)
Qokora (Gumuz; K)	*Vitex doniana* Sweet. (Verbenaceae)
Qombo (Berta)	*Sterculia africana* (Lour.) Fiori (Sterculiaceae)
Qosha (Gumuz; D,K,M)	*Ricinus communis* L. (Euphorbiaceae)**

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Qoshish Sudana (Gumuz; D,K)	*Jatropha curcas* L. (Euphorbiaceae)*
Qoshish Turka (Gumuz; M)	*Jatropha curcas* L. (Euphorbiaceae)*
Qota (Gumuz; D,G,M)	*Balanites aegyptiaca* (L.) Del. (Balanitaceae)
Qota (Gumuz; M)	*Ziziphus mauritiana* Lam. (Rhamnacae)
Quatsirqa (Gumuz; D,G,M)	*Acacia hecatophylla* Steud. ex A. Rich. (Fabaceae)
Qudu (Berta)	*Acacia hecatophylla* Steud. ex A. Rich. (Fabaceae)
Quwa (Berta)	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl. (Anacardiaceae)
Quwa hurhodu (Berta)	*Lannea welwitschii* (Hiern) Engl. (Anacardiaceae)
Qeyeda Tayo (Berta)	*Dioscorea alata* L. (Dioscoreaceae)*
Reba (Berta; B,H,S)	*Pavetta gardeniifolia* A. Rich. (Rubiaceae)
Sambila (Gumuz; D,M)	*Lepidium sativum* L. (Brassicaceae)*
Sanemerta (Berta; S)	*Stereospermum kunthianum* Cham. (Bignoniaceae)
Sasiqida (Gumuz; G)	*Cynodon nlemfuensis* Vanderyst (Poaceae)
Shala (Gumuz; D,M)	*Anethum graveolens* L. (Apiaceae)*
Shanduka (Gumuz; D)	*Terminalia laxiflora* Engl. & Diels (Combretaceae)
Shanduka (Gumuz; D)	*Terminalia macroptera* Guill. & Perr. (Combretaceae)
Shangur (Berta)	*Dalbergia melanoxylon* Guill. & Perr. (Fabaceae)
Shaqadona (B,H,S)	*Crassocephalum rubens* (Jacq.) S. Moore. (Asteraceae)
Shasha (Berta)	*Brassica carinata* A. Br. (Brassicaceae)*
Shawa (Gumuz)	*Syzygium guineense* (Willd.) DC. subsp macrocarpa (Myrtaceae)
Sheegee (Berta; H)	*Saccharum officinarum* L. (Poaceae)*
Shenafich (Gumuz; K,M)	*Brassica nigra* (L.) Koch (Brassicaceae)*
Shenshemuq (Berta)	*Ricinus communis* L. (Euphorbiaceae)**
Sheqee (Berta; B)	*Saccharum officinarum* L. (Poaceae)*
Sheqet (Berta)	*Securidaca longepedunculata* Fresen. (Polygalaceae)
Shibee (Berta; B,H,S)	*Phoenix reclinata* Jacq. (Arecaceae)
Shimbira (Gumuz; D,G,M)	*Cicer arietinum* L. (Fabaceae)*
Shininchawa (Gumuz; K)	*Capsicum frutescens* L. (Solanaceae)*
Shiqi (Berta; B,H)	*Kotschya africana* Endl. (Fabaceae)
Shittetta (Gumuz; G)	*Capsicum annuum* L. (Solanaceae)*

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Shuri (Berta)	*Hibiscus cannabinus* L. (Malvaceae)**
Sigah (Gumuz)	*Anogeissus leiocarpa* (A. DC.) Guill. & Perr. (Combretaceae)
Sikwaha (Gumuz; D, M)	*Carissa spinarum* L. (Apocynaceae)
Silbilo (Berta; S)	*Sorghum bicolor* (L.) Moench (Poaceae)*
Silgalo (Berta; B,S)	*Rhus ruspolii* Engl. (Anacardiaceae)
Sili (Berta; H)	*Sorghum bicolor* (L.) Moench (Poaceae)*
Silmitso (Berta; H)	*Rhus ruspolii* Engl. (Anacardiaceae)
Simah (Gumuz; G)	*Carissa spinarum* L. (Apocynaceae)
Sipe (Gumuz; D,G,M)	*Acacia polyacantha* Willd. (Fabaceae)
Siqida (Gumuz)	*Securidaca longepedunculata* Fresen. (Polygalaceae)
Sirah (Gumuz; D)	*Ziziphus mauritiana* Lam. (Rhamnacae)
Siyamuduqa (Gumuz; D,K)	*Hibiscus cannabinus* L. (Malvaceae)**
Songah (Gumuz; G)	*Ziziphus mauritiana* Lam. (Rhamnacae)
Suwiyah (Gumuz; K)	*Carissa spinarum* L. (Apocynaceae)
Tanga (Gumuz; M)	*Cynodon nlemfuensis* Vanderyst (Poaceae)
Tanqa (Gumuz)	*Eleusine coracana* (L.) Gaertn. (Poaceae)*
Tari (Berta; S)	*Dichrostachys cinerea* (L.) Wight & Arn. (Fabaceae)
Teja (Gumuz; D)	*Vitex doniana* Sweet. (Verbenaceae)
Tekihinenuwa (Gumuz; D,M)	*Amaranthus spinosus* L. (Amaranthaceae)
Tiba (Gumuz; D,M)	*Brassica carinata* A. Br. (Brassicaceae)*
Timbaq (Berta)	*Nicotiana tabacum* L. (Solanaceae)*
Timbaqa (Gumuz)	*Nicotiana tabacum* L. (Solanaceae)*
Tinkosa (Gumuz)	*Coriandrum sativum* L. (Apiaceae)*
Tirmenzuwa (Gumuz; D)	*Clematis hirsuta* Perr. & Guill. (Ranunculaceae)
Tisha (Gumuz; D,K,M)	*Maytenus senegalensis* (Lam.) Exell (Celastraceae)
Tisha (Gumuz; G)	*Hibiscus cannabinus* L. (Malvaceae)**
Tisheza (Gumuz; G)	*Vitex doniana* Sweet. (Verbenaceae)
Tiweega (Gumuz; M)	*Phaseolus vulgaris* L. (Fabaceae)*
Tiyoka (K)	*Albizia malacophylla* (A. Rich.) Walp. (Fabaceae)
Tiyoka (K)	*Entada africana* Guill. & Perr. (Fabaceae)

Appendix I. Continued…

Local Name§	Botanical Name (Family)
Tongo (Gumuz; M)	*Breonadia salicina* (Vahl) Heppehr & Wood (Rubiaceae)
Tsaba (Berta)	*Dalbergia boehmii*Taub. (Fabaceae)
Tsabi (K)	*Cucurbita pepo* L. (Cucurbitaceae)*
Tseera (Berta)	*Ficus thonningii* Blume (Moraceae)
Tseign (Berta; B,H,S)	*Tephrosia interrupta* Hochst. & Steud. ex Engl. (Fabaceae)
Tseiya Fudi (Berta; H,K,S)	*Sapium ellipticum* (Krauss) Pax (Euphorbiaceae)
Tsetsaqa (Gumuz; M)	*Bidens pilosa* L. (Asteraceae)
Tsunta (Berta)	*Amaranthus hybridus* L. (Amaranthaceae)
Tufa (Gumuz; D)	*Helianthus annuus* L. (Asteraceae)*
Ufiwacha (Gumuz; D)	*Zea mays* L. (Poaceae)*
Ugutsey (Berta; S)	*Flueggea virosa* (Willd.) Voigt. (Euphorbiaceae)
Una (Gumuz)	*Dioscorea alata* L. (Dioscoreaceae)*
Waga (Gumuz; K)	*Piliostigma thonningii* (Schum.) Milne-Redh. (Fabaceae)
Wasqenda (Gumuz; D)	*Bidens pilosa* L. (Asteraceae)
Weele (Gumuz)	*Flueggea virosa* (Willd.) Voigt. (Euphorbiaceae)
Weqneniwa (Gumuz; G,M)	*Cucumis pustulatus* Naud ex Hook.f. (Cucurbitaceae)
Wequsha (Gumuz; M)	*Sesamum indicum* L. (Pedaliaceae)*
Werekiya (Gumuz; K)	*Terminalia macroptera* Guill. & Perr. (Combretaceae)
Wobilza (Gumuz; M)	*Guizotia abyssinica* (L.f.) Cass (Asteraceae)*
Wobiza (Gumuz; M)	*Clematis hirsuta* Perr. & Guill. (Ranunculaceae)
Wofchacha (Gumuz; D,M)	*Luffa cylindrica* (L.) M. J. Roem. (Cucurbitaceae)*
Wublanda (Gumuz; D,M)	*Celosia trigyna* L. (Amaranthaceae)
Yecha (Gumuz; K)	*Ficus sycomorus* L (Moraceae)
Yedinkuwa (Gumuz; G)	*Celosia trigyna* L. (Amaranthaceae)
Yehoba (Gumuz; D,M)	*Hyparrhenia filipendula* (Hochst.) Stapf. (Poaceae)
Yempedema (Gumuz; G,K,M)	*Costus spectabilis* (Fenzl) K. Schum. (Zingiberaceae)
Yempite (Gumuz; G,M)	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl. (Anacardiaceae)
Yenegasha (Gumuz; D)	*Rumex abyssinicus* Jacq. (Polygonaceae)
Yetsegeda (Gumuz; D)	*Ochna leucophloeos* Hochst. ex A. Rich. (Ochnaceae)
Zazuqambiya (Gumuz; G)	*Ocimum basilicum* L. (Lamiaceae)*
Zeshima (Gumuz; D,K,M)	*Ocimum basilicum* L. (Lamiaceae)*
Zilbabenee (Berta; B)	*Sorghum bicolor* (L.) Moench (Poaceae)*
Zilqilign (Berta; K)	*Sorghum bicolor* (L.) Moench (Poaceae)*

§When local name is specific to certain district(s), the district name(s) was/were indicated in parenthesis, where for:

Berta names: B = Bambasi, H = Homosha, K = Kumruk and S = Sherkole.

Gumuz names: D = Dibate, G = Guba, K = Kemashi and M = Mandura.

*Cultivated plants

**Plants found both under cultivation and in the wild stand

I

Diversity and endemism of the western Ethiopian escarpment – a preliminary comparison with other areas of the Horn of Africa

SEBSEBE DEMISSEW, INGER NORDAL, CHRISTOF HERRMANN, IB FRIIS, TESFAYE AWAS AND ODD STABBETORP

SEBSEBE DEMISSEW, NORDAL, I., HERRMANN, C., FRIIS, I., TESFAYE AWAS & STABBETORP, O. 2005. Diversity and endemism of the western Ethiopian escarpment – a preliminary comparison with other areas of the Horn of Africa. *Biol. Skr.* **55**: 315-330. ISSN 0366-3612. ISBN 87-7304-304-4.

The vegetation on the western Ethiopian escarpment is still fairly intact, but imperfectly known. The escarpment-area agrees with the area of White's *Undifferentiated woodlands (Ethiopian type)*. It has characteristic vegetation, which consists mainly of deciduous woodland, with combretaceous trees, *e.g. Anogeissus leiocarpus*, *Combretum hartmannianum,* or the frankincense tree, *Boswellia papyrifera,* and dense thickets of the lowland bamboo *Oxytenanthera abyssinica*. Other vegetation types are wooded grassland, riverine forest and swamps. Potential threats to the vegetation and flora of the western escarpment are mentioned. The flora of the western escarpment consists of at least 950 species, of which at least 27 are endemic or near-endemic. Most of these occur in the Benshangul Gumuz National Regional State, a core area of the western Ethiopian escarpment. A number of new endemic species have been discovered in Benshangul Gumuz in recent years, especially petaloid monocots. Genera with western escarpment endemics include *Ceropegia* (Asclepiadaceae), *Vernonia, Bidens* and *Laggera* (Asteraceae), *Combretum* (Combretaceae), *Crinum* (Amaryllidaceae), *Chlorophytum* (Anthericaceae) and *Aloe* (Aloaceae). With regard to diversity the western escarpment ranks at a low position when compared with Ethiopian and Eritrean Flora regions, while with regard to number of local endemics it ranks higher than most Ethiopian and Eritrean Flora regions, but lower than Flora regions in Somalia. With regard to the relative number of local endemics the western escarpment ranks lower than nearly all Flora regions in Somalia, but higher than nearly all Ethiopian and Eritrean Flora regions. Possible reasons for the development of the endemism in a transition zone between the Nile Valley and the Ethiopian highlands are discussed. The new endemic species *Chlorophytum herrmannii* Nordal & Sebsebe and *Chlorophytum serpens* Sebsebe & Nordal from the region are described in an appendix, and the new combination *Drimiopsis spicata* (Baker) Sebsebe & Stedje for an endemic species is made.

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Introduction

The study of the Ethiopian flora of vascular plants has intensified since the beginning of the Ethiopian Flora project in 1980 and much new herbarium material has accumulated (Friis 2001). Yet, the gathering of information and the scientific investigations in the different parts of Ethiopia have not been evenly distributed. Accessible regions with passable roads and other infrastructure have been better investigated than those without these facilities. The construction of new roads, particularly in the southern regions of Ethiopia, has resulted in records of species that are either new to science or new for the Ethiopian flora. However, many other areas remain poorly collected (Friis 2001).

The western escarpment of the Ethiopian highlands is one of the areas that have had little attention before 1980. The flora around the twin towns of Gallabat and Metemma on the Sudan-Ethiopian border was studied in 1865 (Fig. 1 and the section *Exploration of the flora* in this paper) and this and a few other areas of the western escarpment, especially in the Gambella National Regional State (Fig. 1), have been visited by a number of botanists since.

The vegetation of the western Ethiopian escarpment has been characterised as a separate vegetation unit by White (1983) on his vegetation map of Africa, where it is mapped as unit no. 29b (Fig. 1) and named *Undifferentiated woodlands (Ethiopian type)*. To the east, this particular vegetation type is bordered by the extremely mixed and complex vegetation mosaic of the Ethiopian highlands, to the west with the grassland, wooded grassland and bushland of the Nile Valley. This area has also appeared, and has been somewhat differently treated, in other recent attempts at mapping the Ethiopian vegetation (Friis & Sebsebe Demissew 2001), but White's concept seems to us to be the most appropriate.

Our preliminary analyses of what we know so far about this little explored region, including data which we have extracted from the *Flora of Ethiopia and Eritrea* (Hedberg & Edwards 1989, 1995; Edwards *et al.* 1995, 1997, 2000), show that this region has an interesting and partly unique flora.

There is very little detailed information about the environment of this area, but what is said in the following, based primarily on government reports and a project survey of the Benshangul Gumuz National Regional State (Population and Housing Census of Ethiopia 1994; Bureau of Planning and Economic Development 1998; Feasibility Study 2001), may be approximately true for large parts of the western Ethiopian escarpment. The central position of the Benshangul Gumuz National Regional State is indicated in Fig. 1.

The aim of this paper is to demonstrate the endemism of the western Ethiopian escarpment and to illustrate the general interest of the flora of that area, where comparatively much of the natural vegetation is still nearly intact. By doing so, we hope to encourage further studies as the area becomes more generally accessible. We also sincerely hope that an increasing knowledge of this area might contribute to the conservation of the vegetation and flora of this interesting area.

Physical environment

The topography of the western Ethiopian escarpment is characterised by a rolling terrain, sloping sometimes comparatively gently, sometimes dropping steeply from an average of ca. 1800 m (sometimes considerably higher) on the Ethiopian highlands to the east to 500-700 m in the lowlands of the Sudan. In the lowland there are a number of isolated hills and outcrops rising several hundred meters above the prevailing elevation.

The exact area of the western Ethiopian escarpment is not known, but the area of White's *Undifferentiated woodlands (Ethiopian type)* is approximately 145,000 km^2, when estimated from the vegetation map accompanying White (1983).

The average rainfall (more or less unimodal from April to October, sometimes with small peaks in January to February) is 1200 mm in the area around the town of Assosa, capital of the Benshangul Gumuz National Regional State, and this figure is reduced towards north and west to about 800 mm. There are heavy showers associated with thunderstorms over the escarpment (oreographic rain). The mean annual temperature varies from 20º C to 35º C, and the variation is, as elsewhere, strongly correlated with altitude.

The geology of the area comprises predominantly outcrops of very old Precambrian rocks. Deep clayish red soils (dystric nitosols) predominate in most of the zone south of the Blue Nile (Abay) river. These have good physical property with general agricultural potential. North of the Abay, the predominant soils (orthic acrissols) are chemically poorer and have a more limited agricultural potential, although big farms with good potential have been established at the base of the western escarpment near the border between Ethiopia and Eritrea. The soils in many places south of the Benshangul Gumuz National Regional State seem also to have more limited agricultural potential. Particularly in the Benshangul Gumuz National Regional State the western Precambrian formation holds rich mineral deposits, mainly gold, but also copper, lead, and zinc. In addition there are important occurrences of marble, which to some extent are utilised.

Vegetation; species richness

On the western escarpment of Ethiopia the destruction of forest and woodland resources has been less than in other parts of Ethiopia. This is due to the low population density and the general inaccessibility of the region. Most of the region is covered with different types of forests, woodlands and bamboo tickets.

The common woodland type is dominated by small to moderately sized trees with fairly large deciduous leaves. The woodland has a number of floristic characteristics, that have partly been listed by White (1983, p. 107) in his description of the *Undifferentiated woodlands (Ethiopian type)*. Later, but mainly unpublished studies (described in more detail below under *Exploration of the Flora*), have supplemented this information. Species of *Terminalia, Combretum*, and *Lannea* are common, as well as *Entada abyssinica, Erythrina abyssinica, Strychnos innocula, Anogeissus leiocarpus*, and *Stereospermum kunthianum.* Particularly interesting is the common occurrence of the solid-stemmed lowland bamboo (*Oxytenanthera abyssinica*). The ground cover is a tall stratum of perennial grasses, including species of *Cymbopogon, Hyparrhenia, Echinochloa, Sorghum* and *Pennisetum.* This vegetation type, which occurs at most altitudes of the escarpment, is burnt regularly, and is part of a zone of high fire frequency, which occurs across Africa from Senegal to the western Ethiopian escarpment, where it penetrates into the highlands along the deep river valleys (Jensen & Friis 2001: Fig. 3). This vegetation has been burning annually for such a long time that the plants show many adaptations to fire, and the vegetation must be assumed not to be adversely affected by controlled annual fires. Such adaptations in the flora of the region have been dealt with by Jensen & Friis (2001) and Menassie Gashaw *et al.* (2002).

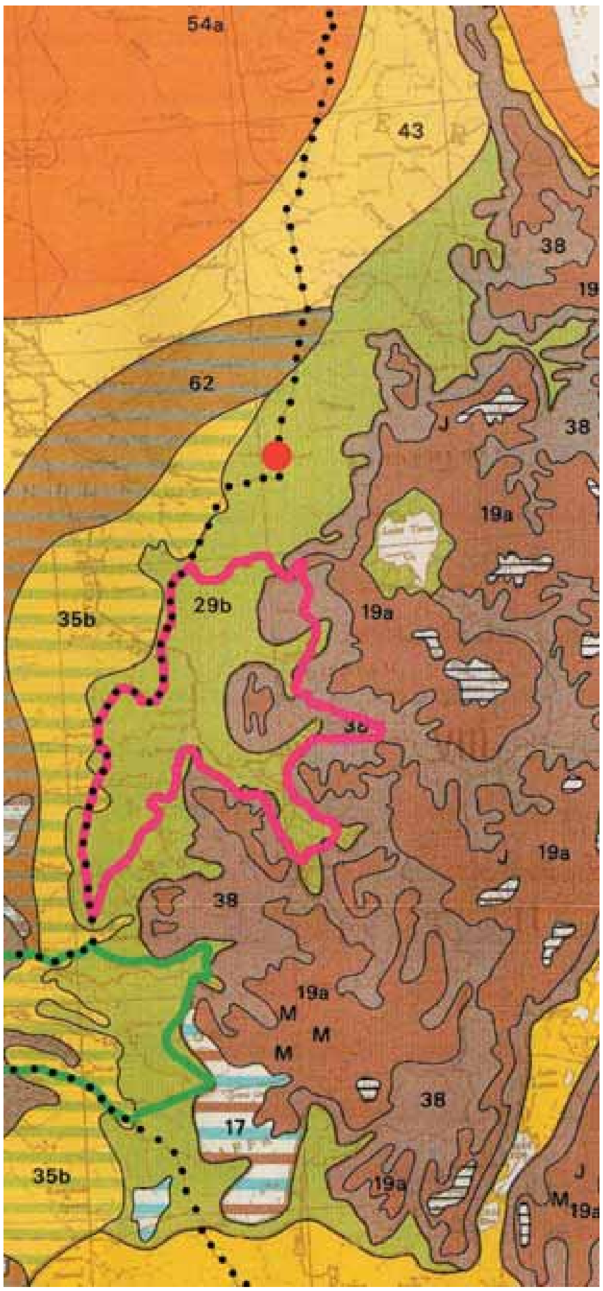

Fig. 1. Section of White's Vegetation map of Africa from 1983, showing the total extent of the mapping unit 29b, "*Undifferentiated woodlands (Ethiopian type)*." The border between Eritrea/Ethiopia (to the right) and the Sudan (to the left) has been marked with a dotted line. The Benshangul Gumuz National Regional State, which is frequently referred to in the text, and which covers a large and topographically very diverse part of White's mapping unit 29b, is marked with red outline. The eastern part of the Gambella National Regional State is marked with green outline. The twin towns of Gallabat and Metemma are marked with a red dot. Reproduced with permission (UPO/D/A/2000-088).

The riparian and swamp vegetation consists of two physiognomically different types, riverine forests and open almost treeless swamps. Typical trees in the riverine forests are *Celtis africana, Ficus sycomorus, Tamarindus indica Syzygium guinense, Kigelia aethiopicum, Lepisanthes senegalensis, Nuxia oppositifolia, Salix mucronata, Trichilia emetica, Diospyros mespiliformis, Mimusops kummel, Breonadia salicifolia, Phoenix reclinata,* and species of *Acacia* and *Ficus*. There is often a shrub layer, and lianas and vascular epiphytes occur. The ground cover includes grasses ferns, and a few herbaceous dicotyledons.

The swamps are dominated by species of Cyperaceae, grasses, and many herbs, of which many are not found elsewhere in Ethiopia. Volume 2(1) of the *Flora of Ethiopia and Eritrea* (Edwards *et al.* 2000) contains an appendix with recently recorded species for the Flora area, and many of these new records have recently been made in the Benshangul Gumuz National Regional State. The flora of ground orchids in the Benshangul Gumuz National Regional State is very diverse for Ethiopia, as is indicated by Cribb *et al.* (2002).

Exploration of the flora

The flora of the western escarpment of Ethiopia has been rather sporadically explored (Cufodontis 1962; Friis 2001). During his travels in the Sudan in 1865-1871 G. Schweinfurth made a detour into Ethiopia and studied the flora in western Amhara region around Gallabat and Metemma (Schweinfurth 1865). R.E.G. Pichi-Sermolli explored in 1937 the western Ethiopian escarpment in the region to the west of Lake Tana (Pichi-Sermolli 1951). The lowlands and the western Ethiopian escarpment in the Gambella Narional Regional State has been studied fairly frequently in the years just before and during the Ethiopian Flora Project (1980-2004), but modern studies of the flora to the north of the Gambella have been rather few. M.G. Gilbert, J.J.F.E. de Wilde, W.J.J.O. de Wilde and B.E. de Wilde-Dufjes and M. Thulin visited the western Ethiopian escarpment in the 1960es and 1970es, Mesfin Tadesse, Sebsebe Demissew and others studied the area several times in the 1970es and 1980es. I. Friis, Menassie Gashaw, S. Bidgood, Sebsebe Demissew and Tesfaye Awas and others paid visits to the Benshangul Gumuz National Regional State the 1990es and in 2000-2001. However, a special contribution to the knowledge of the flora of the Benshangul Gumuz National Regional State has been made by C. Hermann, who spent two years' of work for the Ethiopian Department of Agriculture in Benshangul Gumuz National Regional State during 1999-2001. He has particularly enriched our knowledge of the area because he has stayed there and collected during the rainy season.

Together, these studies have indicated that the western Ethiopian escarpment hosts an interesting and partly unique, but as yet poorly known flora, as is demonstrated by the examples later in this paper.

Socio-economic conditions, development and possible threats to the biodiversity

According to the most recent population census (Population and Housing Census of Ethiopia 1994), the population of the Benshangul Gumuz National Regional State, a core area in this study, is ca. 460.000 people, of which 92% are settled in rural areas. This gives a density of 10.9 individuals pr km^2, while the overall number for Ethiopia is 57.7. Ten years earlier the population was much less dense and the impact on vegetation accordingly only slight. During the famine in Welo and Tigray around 1984 100.000 persons were moved from the areas in north and north-east and settled in the Benshangul Gumuz National Regional State (National Atlas of Ethiopia 1988). The area used for agricultural production in the Benshangul Gumuz National Regional State amounts to 142.223 ha, only about 2.84% of the region's area, or 0.36 ha pr. inhabitant (Bureau of Planning and Economic Development 1998). In many parts of the western Escarpment income is created by collection of gum arabic from *Acacia seyal* and frankincense from *Boswellia papyrifera*. The local tradition of gold mining in the western lowlands, especially in the Benshangul Gumuz National Regional State, goes back to the Axumite Empire, and currently (Bureau of Planning and Economic Development 1998) an average of 180 kg gold/month is produced in the mining season (February to April).

The population on the western escarpment is growing. The population of the Benshangul Gumuz National Regional State is expected to be double within 2030 (Bureau of Planning and Economic Development 1998), and elsewhere a similar or slightly lower increase seems likely.

These changes may present a number of threats to the biodiversity.

(1) Loss of wetlands by draining, which would mean loss of habitat for the many rare orchids and other wetland species, including endemics.

(2) Unsustainable development of the woodlands and bamboo-thickets by uncritical fuelwood cutting, charcoal-burning and mining,

which may harm future sustainable exploitation of the woody vegetation by the local people and might threaten some of the woody endemics.

(3) Unsustainable development of agriculture and mining in the wooded grasslands, which might threaten some of the rare grassland and woodland species.

(4) Change from traditional slash and burn agriculture to large scale cultivation.

It is therefore important that the flora becomes better known so that the threats can be assessed and proper management plans drafted and implemented.

Diversity of the western Ethiopian escarpment

The flora of the area covered by this vegetation is not well known, and it is only possible to present a rough estimate of the diversity. Two of us (Sebsebe Demissew and Tesfaye Awas) have compiled a list of 956 species of vascular plants that are reported to occur in the Benshangul Gumuz National Regional State, a core area in the area under study here. The list has been compiled from published *Flora of Ethiopia and Eritrea* accounts and unpublished sources.

It would currently be very difficult to give a precise count of the species, which occur on the entire western Ethiopian escarpment, or the area of White's *Undifferentiated woodlands (Ethiopian type),* but a reasonable guess would seen to be the number of species in the Benshangul Gumuz National Regional State plus 10-25%, or a total between 1040 and 1180 species. Together, the authors of this paper have visited many small sectors of the western Ethiopian escarpment, and it is our impression that many of the species are widespread in a north-south direction, even some of the species, which are endemic to the escarpment. It is therefore our impression that a list for the Benshangul Gumuz National Regional State will represent a comparatively large proportion of the entire diversity.

Endemism of the western Ethiopian escarpment

In spite of the imperfect knowledge of the flora of the western Ethiopian escarpment, there are a notable number of interesting local endemics or near-endemics which are restricted to or mainly distributed in White's *Undifferentiated woodlands (Ethiopian type)*. The highest concentration seems to be in the Benshangul Gumuz National Regional State, but our knowledge about the distribution of the plant species of the western Ethiopian escarpment is still incomplete. The examples we are aware of from our own studies have been supplemented by examples found through searches through the *Flora of Ethiopia and Eritrea*, but we are sure that many more examples will be found through further studies. These 27 examples are discussed below. We do not know the exact number, but a reasonable guess would probably be to add 10-25%, so the number may increase to 30-40.

Dicotyledones

Asclepiadaceae

Ceropegia recurvata M.G. Gilbert. This a newly described endemic species discovered in the *Oxytenanthera* woodland around Assosa in the Benshangul Gumuz National Regional State at altitudes between 1300 and 2200 m (Gilbert 2002). It is related to *Ceropegia melanops* H. Huber and *C. nigra* N.E. Br. from Central and West Africa. This species occurs in other localities in western Ethiopia, where western taxa reach into the Ethiopian highlands in the deep river valleys; the southernmost example of this is from the Omo Valley in the *Flora of Ethiopia and Eritrea* region GG, a locality which seems to be inside the southernmost extension of White's *Undifferentiated woodlands (Ethiopian type)*.

Asteraceae

Ochrocephala imatongensis (Philipson) Dittrich. This is a species which is fairly widespread in White's *Undifferentiated woodlands (Ethiopian type)*, but transgresses slightly the borders of this area in southern Sudan and northern Uganda. It occurs in areas of fierce annual grass fires in woodlands along the western escarpment of Ethiopia from Gallabat and Metemma to Gambella, and has outlying localities on the Imatong Mountains, both on the Sudanese and the Ugandan side. A rather similar distribution is shown by the climber *Peponium cienkowskii* (Schweinf.) Engl. (Cucurbitaceae, see below). The relationship of this monotypic genus is not yet known.

Vernonia cylindrica Sch. Bip. ex Walp. This species often occurs in undergrowth of *Oxytenanthera* thickets at altitudes between 1200 and 1600 m. It seems to be distributed from western part of the *Flora of Ethiopia and Eritrea* region TU throughout the bamboo thickets of Benshangul Gumuz National Regional State. It is not known elsewhere, and the relationship of it is not yet known.

Vernonia thulinii Mesfin. This is a fairly recently described species (Mesfin Tadesse 1997) that probably should be included here. It is restricted to the woodlands of the Didessa Valley, but it is well known that species from the western Ethiopian escarpment may penetrate into the highlands along the major river valleys. The species is not known elsewhere, and the relationship of it is not yet known.

Vernonia gilbertii Mesfin. This is another fairly recently described species (Mesfin Tadesse 1997) with a similar, but slightly wider known distribution than *V. thulinii*. It occurs in very open *Combretum-Terminalia-Stereospermum* woodland at 1200-1700 m a.s.l., with a concentration in the Benshangul Gumuz National Regional State, but it penetrates further into the highlands along the big river valleys, and it has its southern limit just inside the woodlands of Gambella. It is not known elsewhere, and the relationship of it is not yet known.

Vernonia didessana Mesfin. This is yet another fairly recently described species (Mesfin Tadesse 1997) with a distribution that only just exceeds the Benshangul Gumuz National Regional State, where it occurs in woodland with *Piliostigma, Combretum, Schefflera, Entada,* etc., on sandy soil at altitudes between 1220 and 1700 m. a.s.l. It is not known elsewhere, and the relationship of it is not yet known.

Laggera braunii Vatke. This species occurs in open *Annona senegalensis* woodland and *Oxytenanthera abyssinica* thickets at altitudes between 1300 and 1800 m on the western escarpment of the Ethiopian highlands. In spite of its distribution in White's *Undifferentiated woodlands (Ethiopian type)* it will have to be classified as a near-endemic, because it is also known from the Jebel Marra in western Sudan, but not elsewhere. The relationship of it is not yet known.

Bidens borianiana (Sch. Bip. ex Schweinf.) Cufod. This species occurs in regularly burning woodlands from ca. 300 to 1200 m a.s.l. from south-western Eritrea along the western Ethiopian escarpment to the northern Benshangul Gumuz National Regional State; it also occurs in the immediately adjacent parts of the Sudan. The relationship of it is not yet known.

Combretaceae

Combretum hartmannianum Schweinf. This species is a characteristic small tree in the woodlands along the western border of

Ethiopia from the extreme south-western part of Eritrea to the Benshangul Gumuz National Regional State and the adjacent parts of the Sudan at altitudes between 500 and 1200 m. The remarkable drooping and extremely long drawn-out leaf-tip makes *C. hartmannianum* easy to recognise, and the feature is not found in any other species. It is not known elsewhere, and the relationship of it is not yet known.

Combretum rochetianum A. Rich. ex A. Juss. This species has almost the same distribution area as the previous one. The relationship of this species is not yet known. It is not known elsewhere, and the relationship of it is not yet known.

Cucurbitaceae

Peponium cienkowskii (Schweinf.) Engl. This species has been recorded from rocky outcrops on the border between the Benshangul Gumuz National Regional State and the adjacent part of the Sudan, but is also known from similar habitats in the Imatong Mountains, both on the Sudanese and the Ugandan side, so it is slightly transgressing the limits of White's *Undifferentiated woodlands (Ethiopian type)*. A rather similar distribution is shown by the tall, shrubby Asteraceae *Ochrocephala imatongensis* (Philipson) Dittrich. The relationship of this species is not yet known.

Euphorbiaceae

Phyllanthus dewildiorum M.G. Gilbert. This species occurs in woodlands in the deep river valleys of the western part of the *Flora of Ethiopia and Eritrea* regions WG and KF, and it seems to be restricted to the area of White's *Undifferentiated woodlands (Ethiopian type)*. According to the *Flora of Ethiopia and Eritrea*, it is closely related to *Phyllanthus trichotepalus* Brenan, known from western Uganda, Rwanda, Burundi and Congo DR.

Euphorbia veneifica Kotschy. This species occurs in the *Combretum* woodlands of the Sudan and western Ethiopia, just entering northern Uganda, and it does thus transgress the borders of White's *Undifferentiated woodlands (Ethiopian type)*. The distribution thus resembles that of *Peponium cienkowskii* (Schweinf.) Engl. and *Ochrocephala imatongensis* (Philipson) Dittrich. The relationship of this species is not yet known.

Fabaceae subfam. Papilionoideae

Mucuna melanocarpa Hochst. ex A. Rich. This species is endemic to Ethiopia and occurs mainly on the western escarpment and in the deep river valleys. It is common in the western *Combretum* woodland, but it spreads into suitable habitats elsewhere in Ethiopia, reaching the *Flora of Ethiopia and Eritrea* regions GG and SD, and it may therefore slightly transgress the borders of White's *Undifferentiated woodlands (Ethiopian type)*. The relationship of this species is not yet known.

Rhynchosia stipulosa A. Rich. This species is apparently endemic to the western Ethiopian deciduous woodlands. It was described from the dry woodlands of Shire in Tigray and has also been recorded from similar habitats in western parts of the *Flora of Ethiopia and Eritrea* regions WG and GG, which are all within White's *Undifferentiated woodlands (Ethiopian type)*. However, in the *Flora of Ethiopia and Eritrea* it is suggested that this species may be conspecific with the widespread African species *Rhynchosia luteola* (Hiern) K. Schum.

Vigna frutescens A. Rich. subsp. *kotschyi* (Schweinf.) Verdc. This subspecies is an Ethiopian near-endemic described from *Combretum* woodlands in western Ethiopia and the adjacent parts of the Sudan. It is only known from very few collections, which have been collected inside White's *Undifferentiated woodlands*

(Ethiopian type). However, it may be identical with *Vigna neumannii* Harms, described from woodlands in the Ethiopian Rift Valley, but the type of the later is now lost, and the taxon has apparently not been recollected. Even if the two taxa are united, the resulting taxon would be an endemic or a near-endemic of White's *Undifferentiated woodlands (Ethiopian type)*.

Lamiaceae

Pycnostachys sp. = *Mesfin & Kagnew* 2249. This apparently undescribed and narrowly restricted species has been collected in wetlands near Assosa, capital of the Benshangul Gumuz National Regional State, by *Mesfin & Kagnew* 2249 and *Friis et al.* 7919. It would seem to be narrowly restricted inside White's *Undifferentiated woodlands (Ethiopian type)*. It may be related to *P. niamniamensis* Gürke from the Sudan, Uganda and Kenya.

Scutellaria schweinfurthii Briq. Subsp. *schweinfurthii*. This subspecies occurs in wooded grassland subject to regular burning and in rocky places with woodland. From Ethiopia it is only known with certainty from the western part of the *Flora of Ethiopia and Eritrea* region WG. It is doubtfully recorded from the lowlands of IL (Gambella). Outside Ethiopia, it is known from similar habitats in southern Sudan and the adjacent parts of Uganda, and it does therefore, like a few other species, slightly transgress the borders of White's *Undifferentiated woodlands (Ethiopian type)*. The other subspecies, *Scutellaria schweinfurthii* Briq. subsp. *paucifolia* (Baker) A.J. Paton, is widespread in tropical Africa.

Vitaceae

Cyphostemma pannosum Vollesen. This Ethiopian endemic species was described from a specimen collected by *Friis et al.* (as no. 2409) in *Combretum* woodland on the western Ethiopian escarpment above Gambella (in the *Flora of Ethiopia and Eritrea* region IL), but it has also been found from woodlands of the Benshangul Gumuz National Regional State and in one similar locality in the *Flora of Ethiopia and Eritrea* region GG, at the south-eastern border of White's *Undifferentiated woodlands (Ethiopian type)*. It is most closely related to the West African species *Cyphostemma flavicans* (Bak.) Descoings.

Monocotyledons.

In this group, particularly the petaloid monocots appear to have speciated in the region.

Amaryllidaceae

Crinum bambusetum Nordal & Sebsebe. This is a newly described species, which is distributed near Assosa in the Benshangul Gumuz National Regional State and in adjacent areas of the Sudan (Nordal & Sebsebe 2002). All localities are inside White's *Undifferentiated woodlands (Ethiopian type)*. It belongs among the *Crinum* species with star-shaped rather than bell-shaped flowers, a group with few and rare species in Tropical Africa. It is the only *Crinum* known to grow in bamboo ticket. The sister species appears to be *Crinum subcernuum* Baker, distributed disjunctly in southern Africa.

Anthericaceae

Chlorophytum herrmanii Nordal & Sebsebe sp. nov. This endemic new species will be formally described below. It is only known from open rocky outcrops in the bamboo forest close to Assosa in the Benshangul Gumuz National Regional State. It belongs among the species with prostrate inflorescence, but differs from the others by its much branched inflorescence and pubescent leaf undersides. The sister species appears to be *Chlorophytum neghellense* Cufod., another Ethiopian endemic only found in Bale and Sidamo regions in *Acacia-Commiphora* woodland and bushland.

Chlorophytum serpens Sebsebe & Nordal sp. nov. This new species is endemic to Ethiopia and will be formally described below. It has only been found in open patches in *Combretum-Terminalia* woodland and only in an area north of Assosa in the Benshangul Gumuz National Regional State. Also this species belongs among the taxa with prostrate inflorescence, and it connects to the widely distributed *Chlorophytum comosum* (Thunb.) Jacq. complex, otherwise including rainforest taxa. Superficially it resembles the Cameroonian *C. petrophilum* K. Krause, growing in moss mats in lowland rain forest. The species share the trait of rather short, broadly lanceolate leaves and very long trailing inflorescences producing plantlets (pseudovivipary) and very few flowers.

Hyacinthaceae

Drimiopsis spicata (Baker) Sebsebe & Stedje comb. nov. (formalised below). This species grows in grassland at the margin of *Combretum-Terminalia* woodland and in annually flooded meadows near river banks. It has been recorded from a small area in the *Flora of Ethiopia and Eritrea* region WG, in the lowland part of IL and the adjacent parts of the Sudan. This species is unique in having blue flowers, apparently bridging the morphological gap between the genus *Ledebouria* (with which it shares the flower colour) and the genus *Drimiopsis* (with which it shares the reduced bracts, the closed flowers and the sessile ovary). It might have originated as an inter-generic hybrid, which has overcome sterility and constituted a distinct species. The case is under study by Sebsebe & Stedje (in prep.).

Aloaceae

Aloe sp. = *Friis et al.* 9130. This is an apparently undescribed Ethiopian endemic species from rocky outcrops in the south western part of the Benshangul Gumuz National Regional State. It will be described as a new taxon when adequate material has been obtained. It is unique within the genus in having traits making it resistant to fires.

Commelinaceae

Cyanotis sp. = Gilbert & Thulin 707. This apparently endemic and undescribed species is so far only known from one collection from rock crevices the deep river valleys in the western part of the *Flora of Ethiopia and Eritrea* region WG. The relationship of this species is not yet known.

Cyperaceae

Ascolepis eriocauloides (Steud.) Steud. This western Ethiopian endemic occurs in seasonally wet grassland and seepage areas with shallow soil over rocks, presumably in deciduous woodland. It was described from the *Flora of Ethiopia and Eritrea* region TU and is now also known from western part of the regions WG and KF. It seems to be restricted to White's *Undifferentiated woodlands (Ethiopian type)*. The relationship of this species is not yet known.

Discussion and conclusion

It seems fairly clear that biogeographically, the flora of the western Ethiopian escarpment (White's *Undifferentiated woodlands (Ethiopian type)*) is linked most closely to the flora of the West-African Sudanian region (White 1983), as can be seen from *e.g.* the distribution of dominant tree species such as *Anogeissus leiocarpus* (see Wickens 1976: Map. 55), and in has mostly been included with the Sudanian regional centre of endemism of White (1983).

The western Ethiopian escarpment could perhaps be considered a transition zone between the Afromontane region in Ethiopia and the Sudanian region in the Sudan. In several of his phytogeographical maps, White has indicated the existence of such a transition zone, e.g. on a map of the Sudanian region

(White 1983: Fig. 7), but this transition zone is indicated at higher altitudes and above his mapping unit 29b, *Undifferentiated woodlands (Ethiopian type)*. It is as yet too early to draw any firm conclusions about the precise phytogeographical position of the western Ethiopian escarpment as a separate phytochorion at some rank. Yet, it is tempting to compare some of our preliminary observations on diversity and endemism of the area with the results of Friis *et al.* (in this publication) and see how the area studied in this paper ranks in comparison with other parts of the Horn of Africa.

Rank in comparison with diversity of other areas of the Horn of Africa

In this paper, it has been established that the entire western Ethiopian escarpment, or the area of White's *Undifferentiated woodlands (Ethiopian type)*, has a flora of more than 950 species, and perhaps 1040-1180 species.

Compared to the figures found for the various Flora regions of the Horn of Africa by Friis *et al.* (in this publication: Fig. 3), such a diversity seems to be comparable to a range of Flora regions of the *Flora of Ethiopia and Eritrea*, where there is both highland and lowland, *e.g.* EW, TU, GD, GJ and BA. The Flora regions of *Flora of Ethiopia and Eritrea* are indicated on a map reproduced in all the published volumes, and in Friis *et al.* (in this publication: Fig. 2).

We can calculate the expected diversity of the western Ethiopian escarpment, based on the empirical formula found by Friis *et al.* (in this publication), where T_{exp} is the number of expected taxa in the Flora region and A is the area in square degrees of the region:

$$T_{exp} = 587 + 96.57*A$$

The area of the western Ethiopian escarpment is, as mentioned in the introduction, approximately 145,000 km^2, or, as we consider the latitudinal decline in longitude degree insignificant so close to the equator, 12.0 square degrees, for which area the expected diversity according to the formula is 1746. Hence, the estimated minus the expected value is between -566 and -706. When compared with Friis *et al.* (in this publication: Fig. 4), and if our estimate is correct, this will place the diversity of the western escarpment at approximately the same rank as the *Flora of Ethiopia and Eritrea* region HA and a number of Flora regions in Somalia. However, we must emphasise that so far, this is only based on very limited evidence.

Rank in comparison with local endemism of other areas of the Horn of Africa

In the list of examples, which we have so far been able to put together, there are 27 cases that can be considered endemics or near endemics on the western Ethiopian escarpment (the area covered by White's *Undifferentiated woodlands (Ethiopian type))*, and our estimate is that future studies may add to this figure, so that the number of endemics may increase to 30-40, which – even with conservative estimates – will rank the area analysed here at a higher position than nearly all the Ethiopian and Eritrean Flora regions analysed for single-region endemics in Friis *et al.* (in this publication: Fig. 12), with the exception of HA and SD, but lower than a number of the Flora regions in Somalia.

This means that the endemism (number of endemics/number of species) of the western Ethiopian escarpment (White's *Undifferentiated woodlands (Ethiopian type)*) is approximately 0.03 (3%). A comparison with Friis *et al.* (in this publication: Fig. 13) shows that only the values from the *Flora of Ethiopia and Eritrea* Flora regions of HA and SD are comparable with this, and only among the Flora regions of north-eastern Somalia there are values consistently higher than 0.03.

The diversity and endemism of the western Ethiopian escarpment is not likely to be clearly reflected in the analyses made in the paper by Friis *et al.* (2005) as these analyses use the *Flora of Ethiopia and Eritrea* and the *Flora of Somalia* regions as units. The western escarpment and White's *Undifferentiated woodlands (Ethiopian type)* cut across nine Flora regions (EW, TU, GD, GJ, WG, IL, KF, GG, SD), which is nearly one third of the units. Endemism in a comparatively narrow zone that cuts across so many units would tend to blur the results of the analysis.

Possible reasons for the endemism

The local endemism in White's *Undifferentiated woodlands (Ethiopian type)* has developed in a region where the distance between the mountains and the dry lowlands is relatively small, and the climatic shift may have been very dramatic in relation to Pleistocene fluctuations between wetter and drier periods (cf. White 1993). The flora of such areas would be expected to have suffered from severe extinction, but it has been shown that elsewhere such areas in fact can be rich in species and particularly in endemicity, as is *e.g.* shown by the discussion of the transitional zone between the Afromontane and the Somalia-Masai region in 'the *Flora of Ethiopia and Eritrea* regions BA and SD by Sebsebe Demissew *et al.* (2001, p. 245), and of the transition zone with *Juniperus-Buxus-Acokanthera* between the Afromontane region and the Somalia-Masai region by Friis (1992).

The mechanisms that support the evolution of an endemic flora in such places are as yet undocumented, but a possible explanation of the endemics and near endemics in White's *Undifferentiated woodlands (Ethiopian type)* might be the complex topography and the relatively reliable oreographic rain on the western Ethiopian escarpment, which, with the deep hinterland of deep river valleys, would seem to provide small refugia during time of adverse climatic conditions. This may have secured niches of very restricted range where species could survive unfavourable periods. The best conditions for such niches are likely to have been in the most topographically and geologically complex area in the lower reach and at the mouth of the biggest river system in western Ethiopia, the gorges of the Abay river and its tributaries, an area that approximately agrees with the extension of the Benshangul Gumuz National Regional State, the area apparently most rich in local endemics.

Two new endemic species of *Chlorophytum* (Anthericaceae) and a new combination for an endemic species of *Drimiopsis* (Hyacinthaceae)

Chlorophytum herrmannii Nordal & Sebsebe, sp. nov.

Type: Benshangul Gumuz National Regional State, Anbessa Chaka, ca. 24 km SE of Assosa, 9º 54' 41" N 34º 39' 35" E, 1590 m, 27.05.2001, *Herrmann* 220 (ETH holotype, K isotype, Fig. 2A).

Haec species nova habitu prostrato foliorum et inflorescentiarum C. neghellensi Cufod. similis, sed differt radicibus carnosis (non tenuibus tubera lateralia habentibus), foliis nec secus marginem et in nervis; inflorescentia valde ramosa, pedicello articulato, non curvato. Inflorescentia prostrata ut in C. humifuso, sed foliis brevioribus, prostratis (non erectis), rosulatis, (non distichis), ciliatis (non glabris) et inflorescentia ramosa differt.

Perennial herbs with short horizontal rhizomes carrying fleshy roots. Leaves rosulate, slightly petiolate, lanceolate, up to 20 x 3.5 cm, acute with hyaline, crispy undulate margin, ciliate on margin and the veins abaxially. Peduncles 2-2.5 cm long, prostrate with short hairs. Inflorescence a much branched panicle, 4-12 cm long, also flat on the ground. Bracts large and leaf-like, up to 20 x 5 mm, ciliate along margin and veins. Pedicels straight, 2-4 at each node, 5-6 mm long at anthesis, articulated in the lower half. Flowers white with brownish

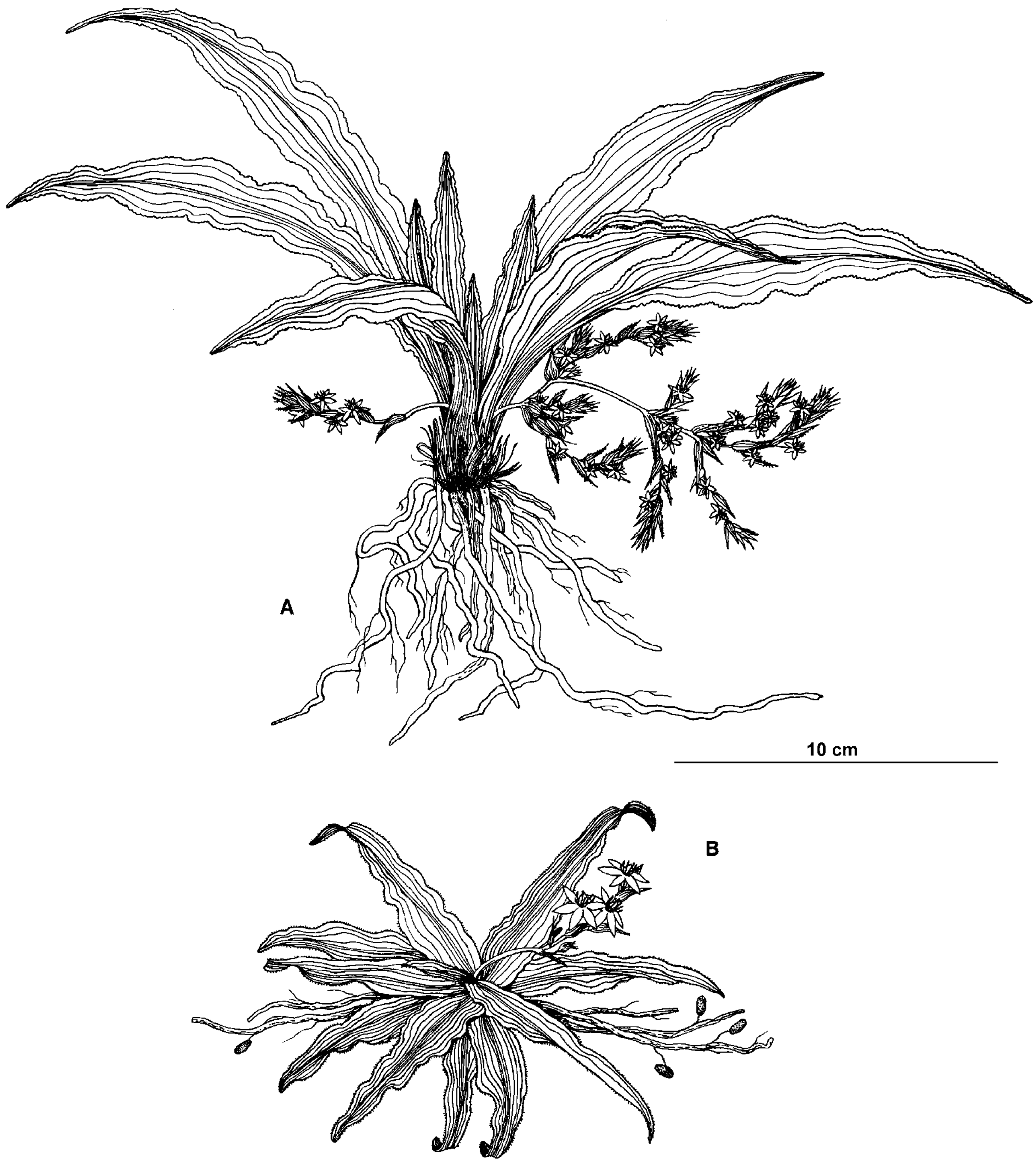

Fig. 2. (A). The new species *Chlorophytum herrmannii* Nordal & Sebsebe, based on the holotype from Benshangul Gumuz National Regional State (*Herrmann* 220). (B). For comparison, *Chlorophytum neghellense* Cufod., based on plant from Sidamo in southern Ethiopia (*Nordal* 2218).

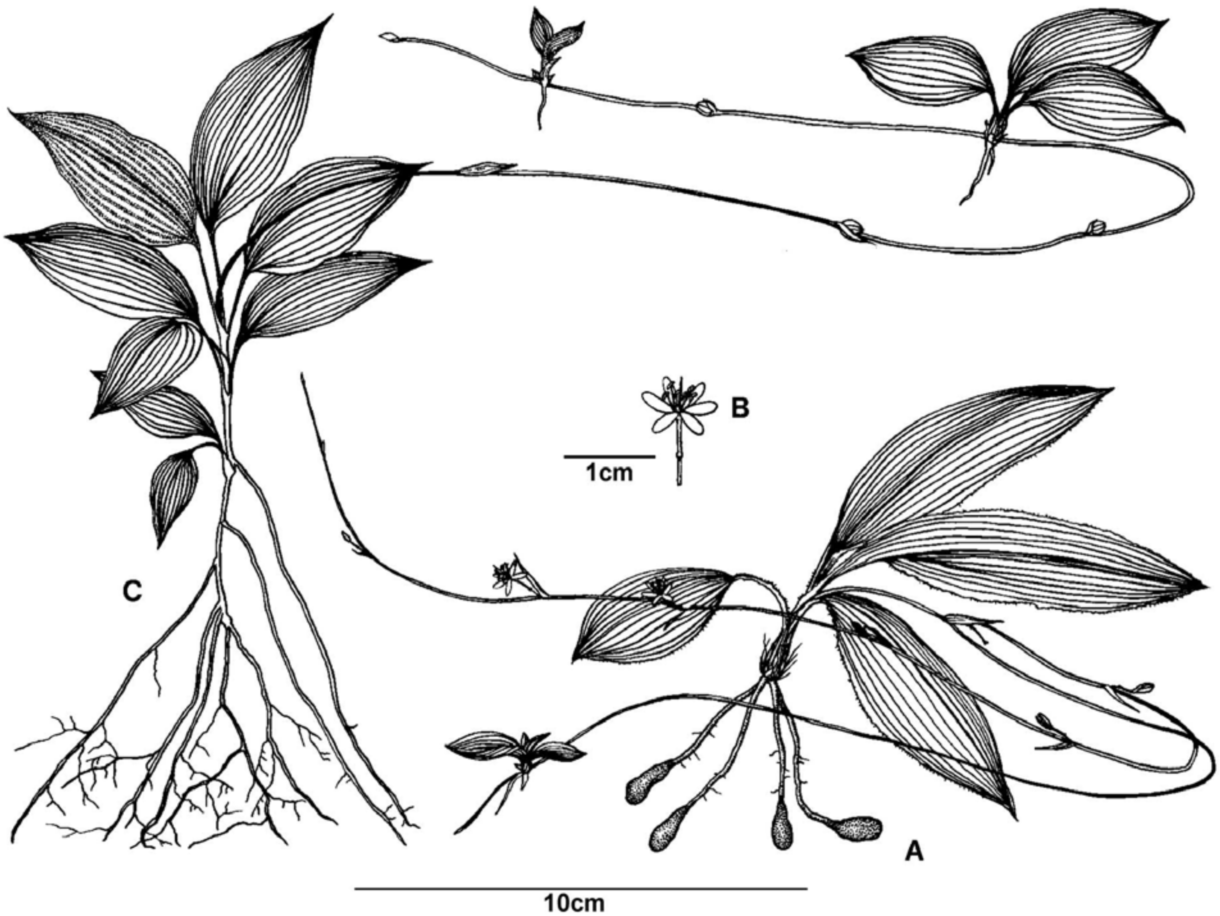

Fig 3. A-B. The new species *Chlorophytum serpens* Sebsebe & Nordal, based on the holotype from Benshangul-Gumuz National Regional State (*Sebsebe Demissew et al.* 6080). Drawn by Svetlana Voronkova. A. complete plant. B. Detail of flower. C. For comparison, *Chlorophytum petrophilum* Krause, based on the holotype from Cameroon (*Zenker* 4846).

tips, tepals 5-6 x 2 mm with 3-5 veins. Stamens shorter than the tepals, filaments 3-4 mm long, anthers 2 mm. Styles straight. Fruits and seeds not known.

The species epithet honours the collector, Christof Herrmann, who, during his work for the Benshangul Gumuz National Regional State, extended the knowledge of the region's biodiversity considerably.

The species grows on open rocky outcrops in bamboo forest, around 1600 m. It is only known from the Assosa area in the Benshangul Gumuz National Regional State (*Flora of Ethiopia and Eritrea* region WG). The main flowering period is in June.

Based on morphology, *C. herrmannii* might well be the sister species of another fairly narrow Ethiopian endemic, *C. neghellense* (Fig. 2B), growing in *Acacia-Combretum-Commiphora* dominated woodland, often heavily grazed, on red sandy soils between 1000 and 1700 m, in *Flora of Ethiopia and Eritrea* regions SD and BA.

Chlorophytum serpens Sebsebe & Nordal, sp. *nov.*

Type: Benshangul Gumuz National Regional State, 71 km from Chagni towards Guba

(Mankush), 11º 12' N 36º 07' E, 1100 m, 23.07.2001, *Sebsebe Demissew, Tesfaye Awas, Melaku Wandafrash & Kagnew H. Sillasie* 6080 (ETH holotype, K isotype, Fig. 3A, B).

Haec species nova C. petrophilo Krause similis, brevissima folia et longissimas inflorescentias habens, praecipue viviparia multiplicans, differt radicibus brevibus, in tuber distinctum terminantibus, rosula foliorum sine internodiis, foliis distincte ciliatis et firmis non membranaceis.

Perennial herbs with short rhizomes carrying short roots ending in distinct tubers. Leaves rosulate, petiolate, broadly lanceolate, 7-10 x 2-3 cm, with ciliate margins. Peduncles lax arcuate to trailing, glabrous. Inflorescence up to 50 cm long, simple or with one branch. Bracts 5 – 15 mm, acute to acuminate. Pedicels, single or paired at the nodes, 4-8 mm long at anthesis, articulated near or below the middle. Flowers white, tepals patent, 3-5 x 1.5-2 mm with 3-veins. Stamens shorter than the tepals, filaments 2-3 mm long, anthers ca. 1.5 mm. Styles straight. Fruits and seeds not known.

The species name refers to the trailing, thus serpent-like habit, of the inflorescence.

The species grows in *Combretum-Terminalia* woodland with tall *Sorghum* and *Pennisetum* species, around 1100 m. It is only known from the type locality in the *Flora of Ethiopia and Eritrea* region GJ. It flowers in July.

Both *C. serpens* and *C. petrophilum* belong in the widespread, heterogeneous *C. comosum* (Thunb.) Jacq. complex, a complex where pseudovivipary is common. *C. petrophilum* is a rainforest taxon, only found in the wettest coastal forests of Cameroon. The particular traits of the relatively short broadly lanceolate leaves and the very long trailing inflorescences might have evolved independently in the two species.

Drimiopsis spicata (Baker) Sebsebe & Stedje, comb. nov.

Basionym: *Scilla spicata* Baker in *Journ. Bot.* 1878: 323 (1878).

Types: The Sudan, Jur, east of the river Wau, Schweinfurth 1641 (K syntype); by the River Wau, Schweinfurth 1652 (K syntype)

[next person in K should lectotypify]

Synonym: *Drimiopsis barteri* sensu Stedje, non Baker, in *Flora of Ethiopia and Eritrea* 6: 139 (1997).

The species is referred to the genus *Drimiopsis* due to its reduced bracts, the closed flower and the sessile ovary. It is, however, easily recognised from other species in the genus by its purplish to bluish flowers, all others have whitish to greenish. The particular flower colour reminds of traits found in the closely related genus, *Ledebouria*.

The species grows in grassland at the margin of *Combretum-Terminalia* woodland, in annually flooded meadows near river banks. It is recorded from the *Flora of Ethiopia and Eritrea* regions WG and IL and from adjacent parts of the Sudan. The flowering period is from April to May.

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II

Plant communities in woodland vegetation of Benishangul Gumuz Region, western Ethiopia

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Abstract

The woodland vegetation of western Ethiopia, particularly in Benishangul Gumuz Regional State (BGRS), is still nearly intact and has comparable vascular plant diversity to other floristic regions in Ethiopia. The Ethiopian Government, however, has recognized this area as suitable for both rain fed and irrigated agriculture, which should be urgently developed. So far there is no area designated for any kind of conservation in BGRS. This study is, therefore, designed to identify the plant communities that could be used as biodiversity surrogates for conservation planning and to identify environmental gradients that are structuring the plant communities in the region. TWINSPAN was used for vegetation classification while CANOCO was used to analyze community-environment relationships. Five plant communities were identified: *Hyphaene thebaica-Pterocarpus lucens, Boswellia papyrifera-Pterocarpus lucens, Securidaca longepedunculata-Albizia malacophylla, Croton macrostachyus-Albizia malacophylla* and *Breonadia salicina-Phoenix reclinata.* These plant communities were characterized by species assemblages that have been formed by overlap of three phytogeographical regions in Africa; Afromontane region in central Ethiopia, Sudanian and Zambezian regions. About 26 environmental variables were measured and altitude, sub soil Base Saturation and top soil Electrical Conductivity, Magnesium, Organic Carbon and Potassium were found to significantly explain variation in species composition along complex gradients at P=0.05. Human impact was found to increase with altitude. Initiations of conservation activities that represent these plant communities were recommended.

Key words: Biodiversity, Braun-Blanquet, Classification, Ordination, Phytogeography
Abbreviation: Benishangul Gumuz Regional State (BGRS)

Introduction

The woodland vegetation of the western Ethiopian escarpment was named by White (1983), as *undifferentiated woodlands (Ethiopian type)*. This vegetation was considered as a transition zone between the Afromontane region in central Ethiopia and the Sudanian phytogeographical region, which extends from the foothills of the Ethiopian highlands to the cost of Senegal. Before the 1980s, little was known about plant distribution in this part of Ethiopia (Friis 1986). Recent botanical expeditions to this area, have come up with several new plant records that are either new to science (Nordal and Sebsebe Demissew 2002; Sebsebe Demissew et al. 2005; Tesfaye Awas and Nordal, in press) or new for the Ethiopian flora (Edwards et al. 2000; Cribb et al. 2002). Particularly the part of this vegetation in Benishangul Gumuz Regional State (BGRS), Western Ethiopia is still nearly intact and has comparable vascular plant diversity to other flora regions in Ethiopia (Sebsebe Demissew et al. 2005). These preliminary studies have indicated the existence of unique flora that may even represent an evolutionary hotspot. The Ethiopian Government, however, has recognized this area as suitable for both rain fed and irrigated agriculture, which should be urgently developed through implementation of integrated development plans (Ministry of Information 2001). The government is allocating land for agriculture, collection of natural gum and incense and extraction of marble.

So far there is no area designated for any kind of conservation in BGRS. Conservationists are concerned that the new development plans may disrupt the ecosystem in general and the interaction of local people with indigenous plants in particular. It may also affect the livelihoods of local people, who are dependent on their immediate ecosystem. The plant communities can also be damaged, severely disturbed and degraded beyond natural recovery. The existence of native biodiversity (original conditions) is unlikely under such conditions. It is, therefore, necessary to identify ecologically representative intact natural habitats and species assemblages/natural plant communities prior to transformation of the natural vegetation through major land-use change. There is an urgent need for information for conservation planning, sustainable biodiversity utilization and environmentally sound decision-making as part of integrated economic development program in the region. However, it is impossible to measure all of biodiversity and it is necessary to use biodiversity surrogates or biodiversity features, which should stand as an indicator of biodiversity in a particular place (Gaston et al. 2002; Sarkar and Margules 2002). The types of biodiversity features most commonly used in conservation planning are taxa/species and broad-scale attributes obtained from data on species assemblages, abiotic data and/or combinations of all (Margules et al. 2002; Brooks et al. 2004). Although Brooks et al. (2004), recommended species data as a more promising option than relying on broad-scale biodiversity attributes, Pressey (2004), argue the importance of using a mixture of biodiversity surrogates, as a more comprehensive array of surrogates gives a better picture. This study is, therefore, designed to meet two primary objectives. The first is to identify the plant communities that could be used as biodiversity surrogates for conservation planning in BGRS. The second objective is to identify the most important environmental gradients that are structuring plant communities in the region.

Materials and methods

Study area

The study was conducted in BGRS, Western Ethiopia, located between latitudes 09°17' and 12°06'N and longitudes 34°10' and 37°04'E (Figure 1). The region has an estimated area size of 51,000 square kilometers. According to the national population census carried out in October 1994 the population of BGRS was 460,459 of which 92% live in rural areas (CSA 1996). This gives a density of 9 individuals per square kilometer while the overall for Ethiopia is 58. The capital town of the region (Asosa) is located at a distance of 687 km from Addis Ababa. The region is bordered by Amhara Regional State to the north, Oromiya Regional State to the east and south, and the Republic of Sudan to the west. The topography is characterized by a rolling terrain. The eastern parts of the region have an elevation of ca. 2,700 m. Elevation decreases gradually toward the western part to an average altitude of 500 m along the Ethio-Sudanese border. The region was established in 1995 by Constitution of the Federal Democratic Republic of Ethiopia (CFDRE 1995). Before this time the area south of the Blue Nile River belonged to Welega while the northern of the river belonged to Gojam administrative regions.

The geology of the area comprises predominantly outcrops of very old Precambrian rocks that underlay all the other rock types in Ethiopia (Mohr 1971). Poly-deformed and poly-metamorphosed crystalline rocks overlay the Precambrian rocks, and the study site is one of the areas in Ethiopia where these rocks are exposed (Solomon Tadesse et al. 2003). These rocks hold

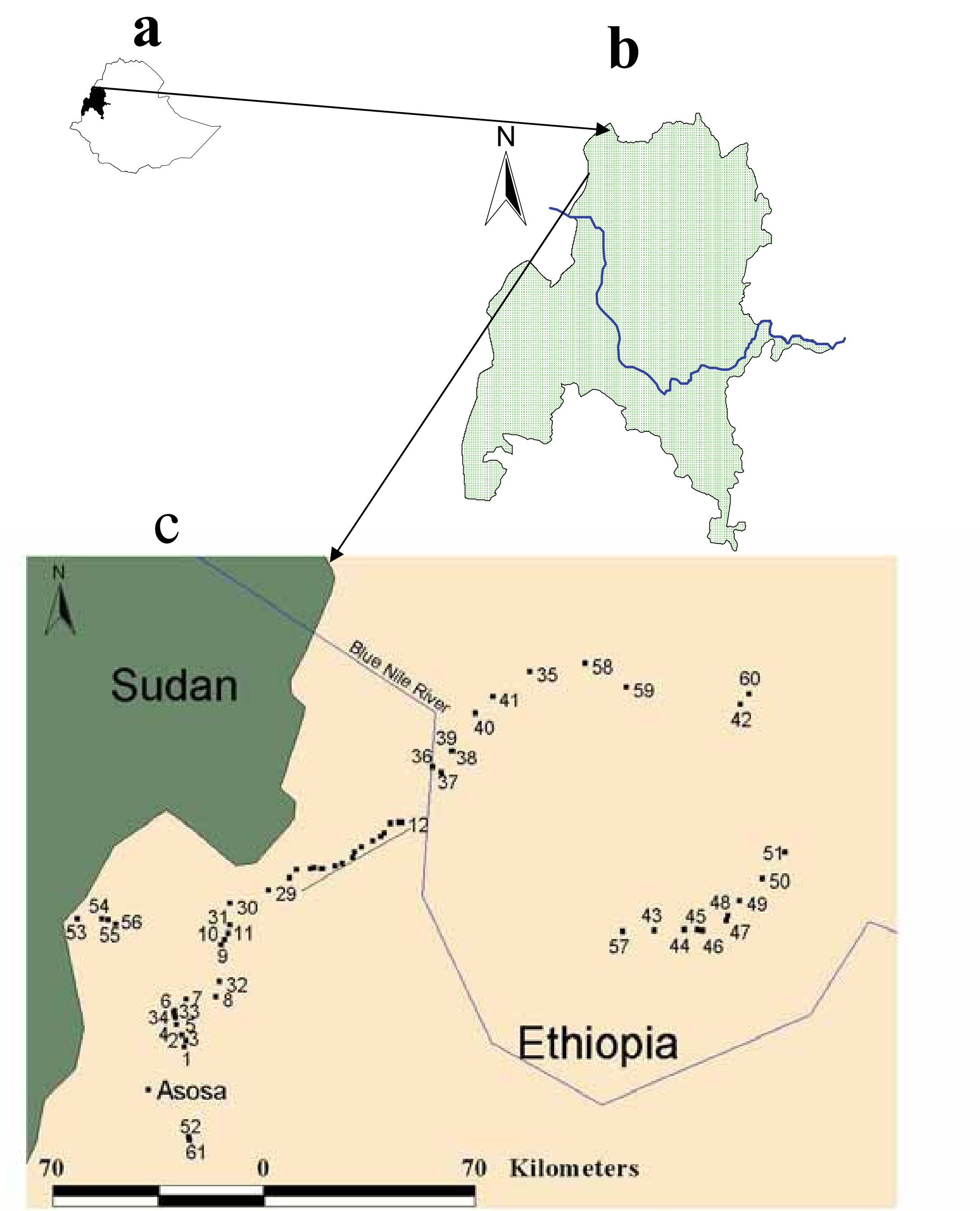

Figure 1. Map of Ethiopia (a), Benishangul Gumuz Regional State (b) and the study site (c). Sampling spots are indicated by square and sample numbers.

most of the mineral deposits: particularly gold but also copper, lead, and zinc. In addition there are important occurrences of marble, which is to some extent utilized. Nitosols and Acrisols are the predominant soil types in BGRS.

The climate in the region is characterized by a single maximum rainfall that runs from April/May to October/November. The average annual precipitation varies from 900 to 1500 mm. The mean monthly minimum and maximum temperature varies from 14 ^{o}C to 18 ^{o}C and 27 ^{o}C to 35 ^{o}C, respectively.

Data collection

A reconnaissance survey was made in July 2004 to identify vegetation stands in BGRS. This was followed by intensive field work at the end of the wet season (in October - November 2004). A systematic sampling method was used to select homogenous vegetation stands along an altitudinal gradient on both sides of Blue Nile River. Stands were selected in areas where human influences were minimal. Data from the wetland was treated separately (not included in this paper) as the underlying environmental factors are different. A total of 61 relevés were sampled following the Braun-Blanquet approach (Braun-Blanquet 1965; Muller-Dombois and Ellenberg 1974). Each relevé was sampled using a square plot of 400 m^2 (20 m by 20 m). The percentage cover/abundance values of all flowering plants in each plot were estimated and transformed to a scale of ordinal transform values from 1 to 9 (van der Maarel 2005).

Human impact on the vegetation through grazing, extraction of plants (including cutting of trees) for various utilities, establishment of exotic plants such as *Tagetes patula* L. and *T. minuta* L. were identified as the major impacts that threaten the plant biodiversity in the region. These impacts were estimated for each relevé on ordinal scales from zero to three (where zero represents the absence of any observable human influence, one for at least one impact, two for a combination of two impacts and three for combination of all impacts). Disturbed areas through deforestation for farmland expansion were excluded from sampling.

The areas were revisited in 2005 both at the beginning and the end of the wet season to collect herbarium specimens of those plants which were not identified during data collection. A total of 504 plant specimens were collected and most of them were identified by comparing with authenticated herbarium specimens and with the help of written descriptions at the National Herbarium (ETH), Ethiopia. A few plant specimens were identified at the Royal

Botanic Gardens, Kew (K), England. All specimens were deposited at the ETH and Institute of Biodiversity Conservation/Ethiopia. Nomenclature follows Hedberg and Edwards (1989), Phillips (1995), Edwards et al. (1995, 1997 and 2000), Hedberg et al. (2003 and 2006) and Mesfin Tadesse (2004).

Environmental data on topographic and soil factors were gathered for each relevé. GPS was used to record the position (latitude and longitude) of each relevé. Everest Altimeter and GPS were used to measure altitude. A clinometer was used to measure slope. A soil auger was used to collect the wet and loose soil while a digger was used for compact and dry soil. Sampling depths were 0-10 cm (top soil) and 40-50 cm (sub soil). Soil was sampled from five spots (four from the corners and one from the centre) within the sample plot and mixed to obtain a composite sample. Soil samples were air dried, passed through a 2-mm sieve and handed to National Soil Research Laboratory in Ethiopia, where the analysis was conducted for Available Phosphorus, Base Saturation, Cation Exchange Capacity, Electrical Conductivity, Exchangeable Base (Calcium, Potassium, Magnesium and Sodium), Organic Carbon, pH and Total Nitrogen.

Data analysis

Classification

The cover/abundance data of 232 plant species in 61 relevés were analyzed and classified using a FORTRAN Computer Program TWINSPAN, TWo-way INdicator SPecies ANalysis, Version 1.0 (Hill 1994). In running the program, default options were followed through out. TWINSPAN is a divisive polythetic method of vegetation classification. It produces a tabular matrix arrangement that approximates the results of a Braun-Blanquet phytosociological analysis table by classifying both relevés and species (Legendre and Legendre 1998). The final table presents both classification and an ordination of the objects. The resulting groups were recognized as community types. Although there are some critics on the method (Belbin and McDonald 1993), it is a useful tool both in scientific research and in nature management and conservation (Bruun and Ejrnæs 2000).

Naming of the plant communities was based on fidelity, the degree to which a species is limited to a definite association. Indicator species with an occurrence of more than 60% in the relevés of a particular association were used to name the plant communities. Combinations of the names of two indicator species were used (Bruun and Ejrnæs 2000), where the first was the indicator species used by TWINSPAN to separate a particular cluster from others at the same level while the second species was the one used to separate a group of clusters at the next higher level. A name bearing actual plant species shows the relationship of the plant communities and gives a more realistic and accurate insight as to the kinds of ecosystems that exist (Grabher and Kojima 1993). The plant communities identified in this study were not placed in a hierarchal syntaxonomic classification system as there is no formalized system of plant communities available for Ethiopia (Bekele 1994).

Ordination

Outliers were identified and four most outlying species were omitted one by one prior to ordination. The data set consisting of 228 species in 61 relevés were used in the final ordination. Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) were run to analyze patterns of variation in the species composition by using the computer program data package CANOCO version 4.5 (ter Braak and Smilauer 2002). All environmental variables were transformed to homogeneity of variances (R. Økland et al. 2001). Automatic forward selection of environmental variables was carried out by CANOCO using Monte Carlo tests (499 permutations) under full model to identify the most important environmental variables that explain variation in the species composition.

Results

Classification

The woodland vegetation in BGRS was classified into five clusters using TWINSPAN (Figure 2). The first division separated relevés of riparian woodland from dry woodland vegetation. The second division separated the relevés of dry woodland vegetation into two, using *Pterocarpus lucens* Guill. & Perr. (indicator species for Left-1), and *Albizia malacophylla* (A. Rich.) Walp. (indicator species for Left-2). The third division separated the latter two groups in four clusters and a total of five clusters were recognized as the plant communities in BGRS. The plant communities are: (1) *Hyphaene thebaica-Pterocarpus lucens,* (2) *Boswellia* *papyrifera-Pterocarpus lucens,* (3) *Securidaca longepedunculata-Albizia malacophylla,* (4) *Croton macrostachyus-Albizia malacophylla* and (5) *Breonadia salicina-Phoenix reclinata.*

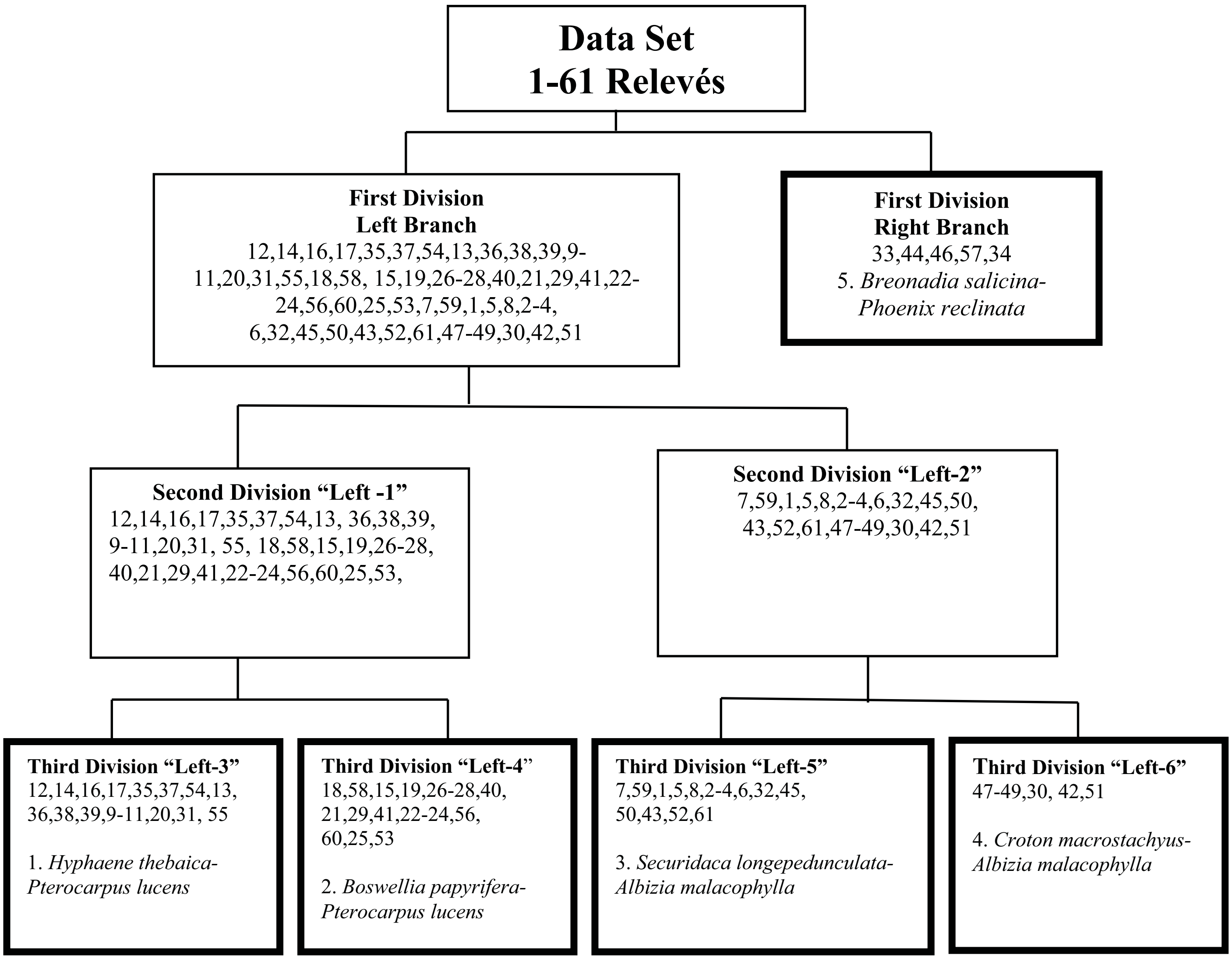

Figure 2. Dendrogram of TWINSPANP output. Relevé numbers are indicated. The first division separate the riparian vegetation from woodland. Subsequent divisions separate the woodland vegetation into four clusters. A total of five plant communities (box highlighted in bold) are identified in Benishangul Gumuz Regional State.

Among the 232 plants used in the classification (see appendix 1.), only ten species were found to occur in all the five plant communities. They are *Ampelocissus schimperiana* (Hochst. ex A. Rich.) Planch., *Andropogon schirensis* Hochst. ex A. Rich., *Asparagus* *flagellaris* (Kunth) Baker, *Clerodendrum alatum* Gürke, *Dichrostachys cinerea* (L.) Wight & Arn., *Hyparrhenia diplandra* (Hack.) Stapf, *Maytenus senegalensis* (Lam.) Exell, *Ochna leucophloeos* Hochst. ex A. Rich., *Oxytenanthera abyssinica* (A. Rich.) Munro and *Spermacoce sphaerostigma* (A. Rich.) Vatke. A total of 101 plant species, i.e. 11, 15, 16, 22 and 36 species were restricted to community 2, 1, 5, 4 and 3, respectively. The remaining 122 species were found in two or more plant communities. The species that characterizes each community are presented as follows.

(1) The *Hyphaene thebaica-Pterocarpus lucens* community occurs at lower elevations between 530 m and 920 m on both sides of Blue Nile River towards the Ethio-Sudanese border. This area has relatively low human impact. The community is characterized by trees such as *Acacia hecatophylla* Steud. ex A. Rich., *Adansonia digitata* L., *Anogeissus leiocarpa (A. DC.) Guill. & Perr., Balanites aegyptiaca* (L.) Del., *Dalbergia melanoxylon* Guill. & Perr., *Diospyros mespiliformis* Hochst. ex A. DC., *Hyphaene thebaica* (L.) Mart., *Sterculia africana* (Lour.) Fiori and *Tamarindus indica* L. Characteristic shrubs include: *Commiphora pedunculata* (Kotschy & Peyr) Engl., *Asparagus racemosus* Willd., and *Strychnos innocua* Del. Lianas such as C*issus populnea* Guill. & Perr., *Dioscorea dumetorum* (Kunth) Pax and *Dioscorea praehensilis* Benth. are also characteristic species in this community.

The ground layer is dominated by a combination of herbs and grasses such as *Dorstenia barnimiana* Schweinf., *Hoslundia opposita* Vahl, *Hyparrhenia diplandra* (Hack.) Stapf, *Hypoxis schimperi* Baker and *Sporobolus festivus* Hochst. ex A. Rich.

(2) The *Boswellia papyrifera-Pterocarpus lucens* community occurs at elevations between 630 m and 12420 m. The community is characterized by trees such as *Boswellia papyrifera* (Del.) Hochst., *Cassia arereh* Del., *Combretum hartmannianum* Schweinf., and *Combretum molle* R. Br. ex G. Don. Characteristic shrubs include: *Grewia mollis* A. Juss., *Grewia velutina* (Forssk.) Vahl, *Strychnos spinosa* Lam., and *Ziziphus mauritiana* Lam.

At the beginning of the wet season, the ground layer is dominated by herbs such as *Bulbine abyssinica* A. Rich., *Costus spectabilis* (Fenzl) K. Schum., *Ledebouria revoluta* (L.f.) Jessop, *Murdannia simplex* (Vahl) Brenan, *Phyllanthus pseudoniruri* Muell. Arg., *Siphonochilus aethiopicus* (Schweinf.) B.L. Burtt and *Tacca leontopetaloides* (L.) O. Ktze.

Towards the end of the wet season, the ground layer is dominated by grasses such as *Andropogon pseudapricus* Stapf, *Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf, *Hyparrhenia hirta* (L.) Stapf, *Pennisetum ramosum* (Hochst.) Schweinf., *Pennisetum schweinfurthii* Pilg. and *Rottboellia cochinchinensis* (Lour.) Clayton.

(3) The *Securidaca longepedunculata-Albizia malacophylla* community occurs at elevations between 950 m and 1610 m. Characteristic trees include: *Dalbergia boehmii* Taub., *Erythrina abyssinica* Lam. ex DC., *Faurea speciosa* Welw., *Ozoroa insignis* Del., *Stereospermum kunthianum* Cham., and *Syzygium guineense* (Willd.) DC. subsp. *macrocarpum* (Engl.) F. White. Characteristic shrubs include: *Annona senegalensis* Pers., *Indigofera garckeana* Vatke, *Ochna leptoclada* Oliv., *Protea gaguedi* J. F. Gmel., *Securidaca longepedunculata* Fresen., *Tephrosia interrupta* Hochst. & Steud. ex Engl. and *Vernonia cylindrica* Sch. Bip ex Walp.

At the beginning of the wet season, the ground layer is dominated by herbs such as *Acalypha villicaulis* A. Rich., *Becium filamentosum* Chiov., *Chlorophytum serpens* Sebsebe & Nordal., *Dorstenia benguellensis* Welw., *Oxalis obliquifolia* A. Rich. and *Solanecio tuberosus* (Sch. Bip. ex A. Rich.) C. Jeffrey. Towards the end of the wet season, the ground layer is dominated by grasses such as *Cymbopogon caesius* (Hook. & Arn.) Stapf, *Hyparrhenia cymbaria* (L.) Stapf, *Hyparrhenia nyassae* (Rendle) Stapf and *Pennisetum thunbergii* Kunth.

(4) The *Croton macrostachyus-Albizia malacophylla* community occurs at elevations between 1410 m and 1890 m. Disturbed parts of this community are being invaded by an ornamental plant - *Tagetes patula* and a farmland weed- *T. minuta*, which have escaped from garden and farmland, respectively. Characteristic trees include: *Acacia polyacantha* Willd., *Croton macrostachyus* Del., *Cussonia ostinii* Chiov., and *Ficus sycomorus* L. Characteristic shrubs include: *Capparis tomentosa* Lam., *Flueggea virosa* (Willd.) Voigt and *Maesa lanceolata* Forssk.

The ground layer is dominated by a combination of herbs and grasses. Characteristic species are: *Acmella caulorrhiza* Del., *Bidens prestinaria* (Sch. Bip.) Cufod., *Cynoglossum lanceolatum* Forssk., *Cynodon nlemfuensis* Vanderyst, *Laggera crispata* (Vahl) Hepper &

Wood, *Panicum atrosanguineum* A. Rich., and *Wissadula rostrata* (Schum. & Thonn.) Hook.f.

(5) The *Breonadia salicina-Phoenix reclinata* community represents riparian woodland vegetation that occurs at elevations between 1390 m and 1550 m. The community is characterized by trees such as *Breonadia salicina* (Vahl) Hepper & Wood, *Ficus vasta* Forssk. and *Syzygium guineense* (Willd.) DC. subsp. g*uineense.* Charactersistic shrubs include: *Acalypha ornata* A. Rich., *Carissa spinarum* L*., Dombeya buettneri* K. Schum., *Kotschya africana* Endl., *Phoenix reclinata* Jacq., *Rhus ruspolii* Engl., and *Sarcocephalus latifolius* (Smith) Bruce. The ground layer is dominated by species such as *Chlorophytum blepharophyllum* Schweinf. ex Baker and *Hypoxis angustifolia* Lam. at the beginning of the wet season. Later towards the end of the wet season, the ground layer is dominated by species such as *Aframomum alboviolaceum* (Ridl.) K. Schum., *Crotalaria pallida* Ait., *Gladiolus abyssinicus* (Brongn. ex Lemaire) Goldblatt & de Vos, *Hibiscus calyphyllus* Cavan., *Justicia bizuneshiae* Ensermu and *Pennisetum unisetum* (Nees) Benth.

Ordination

The first DCA axis represents the long gradient (4.235 S.D. units) and high eigenvalue (0.584). This gradient separated the dry woodland at lower altitude on left hand side and riparian woodlands on the right of the ordination plot (Figure 3). The second DCA axis (2.618 SD units and eigenvalue of 0.273) separated the *Securidaca longepedunculata* dominated woodland (community 3) from *Croton macrostachyus* dominated woodland (community 4). The third and the fourth DCA axis are not presented as they had low eigenvalues (0.189 and 0.152) and short gradients (2.331 and 1.925 S.D. units).

The CCA-biplot of relevés and environmental variables (Figure 4) shows the relationship of variation in the species composition along the gradients and environmental variables. The automatic forward selection of environmental variables, using Monte Carlo test in CANOCO, showed that altitude (P=0.002), Base Saturation in the sub soil (P=0.004), Electrical Conductivity in the top soil (P=0.03) and Magnesium in the top soil (P=0.032), Organic Carbon in the top soil (P=0.006) were significant (at P<0.05) in explaining variation in the species composition along the first axis. Potassium in the top soil (P=0.034) was the only significant (at $P<0.05$) environmental variable in explaining variation in the species composition along the second axis.

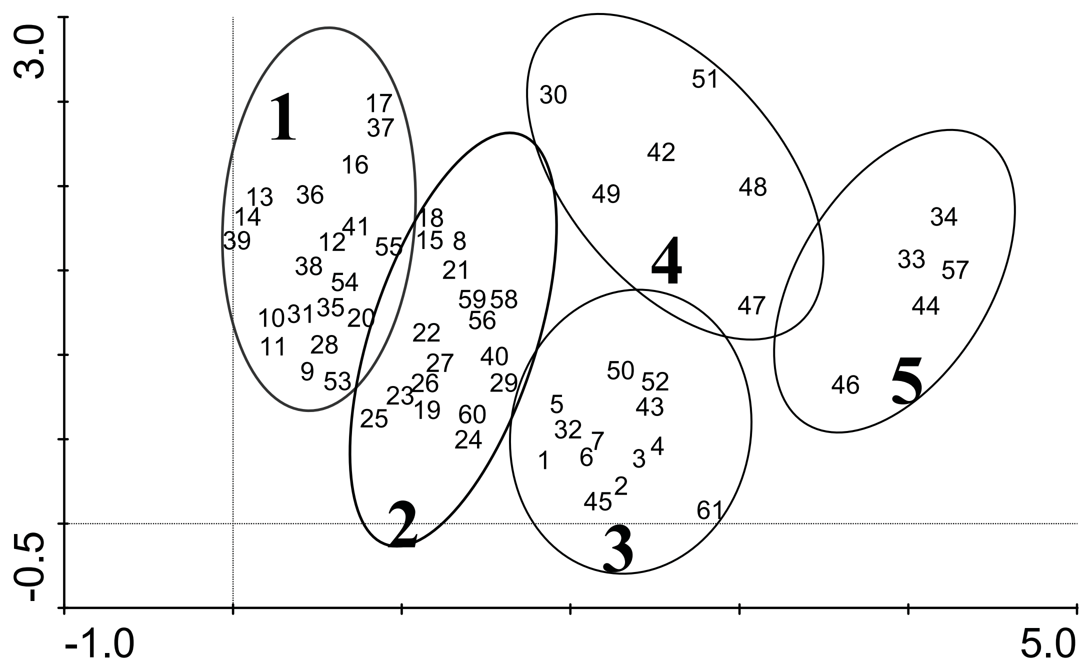

Figure 3. DCA ordination plot obtained by running CANOCO, axis 1 (horizontal) and axis 2 (vertical). Axes are scaled in S.D. units. Relevé numbers are indicated. Overlapping relevés were slightly moved. Bold numbers in circles represent the plant communities identified by using TWINSPAN.

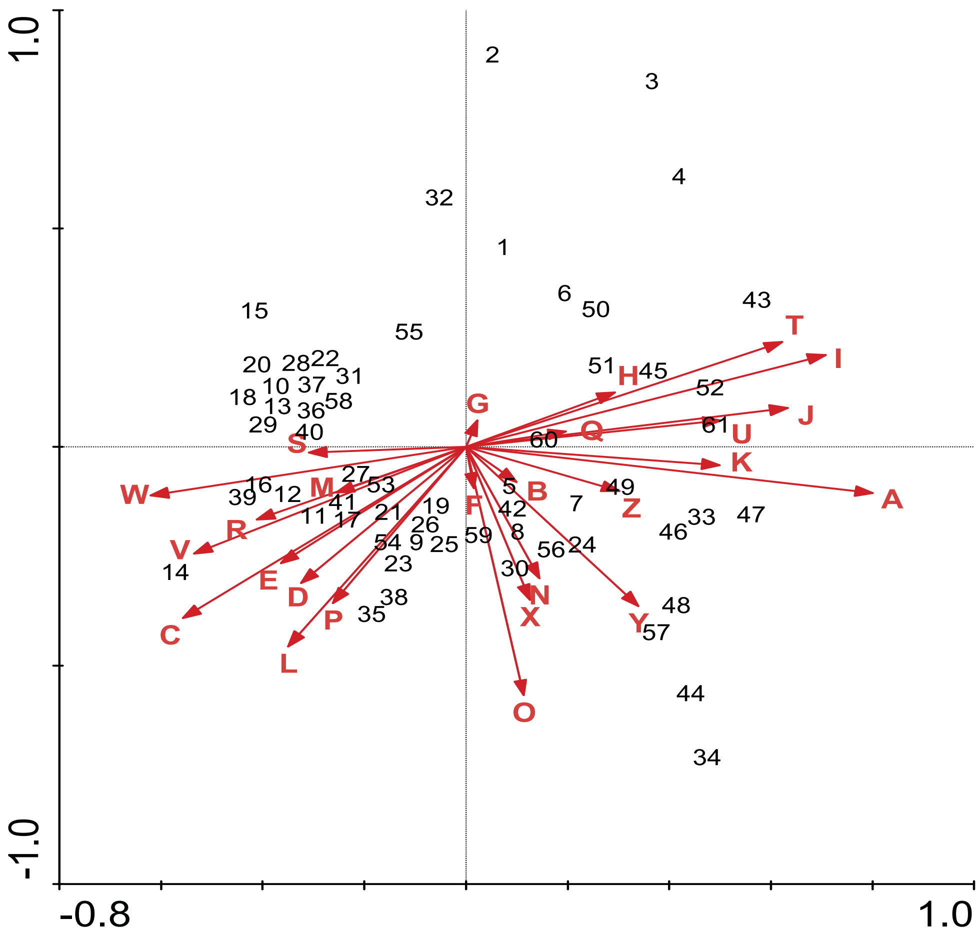

Figure 4. CCA ordination plot produced using CANOCO, axis 1 (horizontal) and axis 2 (vertical). Arrows represent environmental variables. Each arrow points toward the direction of the steepest increase in environmental variables. The angles between arrows indicate correlations between individual environmental variables. Relevé numbers are indicated. Overlapping relevés were slightly moved. A=Altitude, B=Aspect, C=Base Saturation in the sub soil, D=Base Saturation in the top soil, E=Calcium in the sub soil, F=Calcium in the top soil, G=Cation Exchange Capacity in the sub soil, H=Cation Exchange Capacity in the top soil, I=Organic Carbon in the sub soil, J=Organic Carbon in the top soil, K=Disturbance, L=Electrical Conductivity in the sub soil, M=Electrical Conductivity in the top soil, N=Potassium in the sub soil, O=Potassium in the top soil, P=Magnesium in the sub soil, Q=Magnesium in the top soil, R=Sodium in the sub soil, S=Sodium in the top soil, T=Total Nitrogen in the sub soil, U=Total Nitrogen in the top soil, V=pH in the sub soil, W=pH in the top soil, X=Available Phosphorus in the sub soil, Y=Available Phosphorus in the top soil and Z=Slope.

Discussion

The vegetation of Ethiopia has been divided into nine major vegetation physiognomic types: (1) Desert and semi-desert scrubland; (2) Lowland semi-evergreen forest; (3) *Acacia-Commiphora* small-leaved, deciduous woodland; (4) *Combretum-Terminalia* broad-leaved deciduous woodland and savannas; (5) Evergreen scrub; (6) Moist evergreen montane forest / Afromontane rainforest; (7) Dry evergreen and montane forest and grassland; (8) Afro-alpine and subafroalpine zone; and (9) Riparian / riverine and swamp vegetation (Friis 1992; Sebsebe Demissew et al. 1996; CSE 1997; Friis and Sebsebe Demissew 2001). Of these, vegetation type 4 and 9 were found in BGRS. In our vegetation analysis, vegetation type 4 was classified into four plant communities (1-4). Vegetation type 9 consists of at least two physiognomically different vegetation types, riparian woodland, and open, almost treeless vegetation. The former appeared as community 5 while our data on the latter was treated separately (not included in this paper).

The plant communities were characterized by assemblage of species with restricted occurrence and appearing and disappearing individually along the complex gradients. This supports the idea of individualistic continuum concept of vegetation (R. Økland 1990; Kent and Coker 1992). The distribution of plants recorded in this study extends from Ethiopia to Senegal in the western Africa and to Mozambique in the southeastern and Angola in the southwestern Africa. Of 232 species sampled in this study, 19% were shared with flora of Zambeziaca in southern Africa, 18% with flora of Tropical West Africa and 37% with both. The rest 26% of the species were restricted to Eastern African Flora, of which 6% species are endemic/near endemic to BGRS. Thus, the plant comminutes in BGRS hosts plant species assemblages that have been formed by overlap of three phytogeographical regions in Africa; Afromontane region in central Ethiopia, Sudanian and Zambezian regions.

Although there slight difference, the DCA ordination plot (Figure 3) generally supported the classification of the plant communities obtained by running TWINSPAN (Figure 2). The difference was in the placement relevé 8, 28, 41, 53 and 58. Relevé 28, 41 and 53 were clustered in community 2 in TWINSPAN, but in community 1 in DCA. Relevé 8 and 58 were in community 3 in TWINSPAN, but in community 2 in DCA. This difference is may be related to the inherent nature of the methods, as TWINSPAN assumes the existence of one strong gradient dominating the data and its failure to identify secondary gradients (Belbin and

McDonald 1993). Sensitivity of DCA to outliers (T. Økland 1990) and omission of four species from the data set used for ordination have may be contributed to the difference.

The automatic forward selection of environmental variables, using Monte Carlo test in CANOCO, showed that only 6 variables, among the 26 environmental variables measured, were significant (at $P<0.05$) in explaining variation in the species composition along the complex gradients. Four of these variables were found to be correlated either positively or negatively to altitude. Potassium was the only variable which was found uncorrelated with altitude. It was found in high concentrations in the riverine woodlands (community 5) where the canopy covers was high. The canopy cover affects the microclimatic condition and the lower temperature reduce mineralization of humus (Foth and Turk 1972), and the resulting accumulation of soil organic matter increased cation exchange capacity and reduce leaching of nutrients, particularly nitrogen, phosphorus and potassium (Menassie Gashaw and Masresha Fetene 1996, Tesfaye Awas et al. 2001).

Altitude has an indirect effect on plant growth through affecting many environmental factors, mainly climatic factors such as temperature and rainfall. Both temperature and rainfall have an impact on the intensity and frequency of fire, under the influence of which the woodland vegetation in BGRS has evolved. The BGRS is part of a zone of high fire frequency, which occurs across Africa from Senegal to the western Ethiopian escarpment, where it penetrates into the highlands along the deep river valleys (Jensen and Friis 2001). The occurrence of annual fires for a long time in the region shows many adaptations of plants both to burning and its impact on soil properties (Jensen and Friis 2001; Menassie Gashaw et al. 2002).

Our results show a negative correlation between altitude and Base Saturation, Calcium in the sub soil, Electrical Conductivity in the top soil, pH and Sodium. Such a relationship is related to the elevated temperatures at lower altitudes, which increases the intensity and the frequency of woodland fire. Burning reduces the Organic Carbon content of the soil and leads to accumulation of mineral salts, which increases Base Saturation and raises pH. Evapotranspiration under elevated temperature and low rainfall also increases salt accumulation. On the other hand, altitude was positively correlated with an increase in Cation Exchange Capacity in the top soil, Magnesium in the top soil, Organic Carbon and Total Nitrogen. At higher altitude absence of fire allows accumulation of Organic Carbon and nitrogen, which increases the Cation Exchange Capacity of the soil. This facilitates absorption and accumulation of mineral salts in the plant tissue. Many studies on woodland fire have come up with such findings (Marafa and Chau 1999; Jensen and Friis 2001).

Human impact on the vegetation of BGRS through grazing, extraction of plants (including cutting of trees) for various uses and establishment of exotic plants such as *Tagetes patula* and *T. minuta* in natural vegetation were also strongly correlated with an increase in altitude. This result indicates vulnerability of community 3, 4 and 5. The threat to plant communities 1 and 2 is relatively low as they are found in inaccessible areas where there are no roads and population pressure is very low. In these areas, one has to travel more than a day to get to villages which mostly have less than 20 households (CSA 1996).

The increasing population pressure leads to an increasing demand for agricultural land and plant products, thus forcing the people to clear woodlands for settlement and expansion of farmlands. In particular, the resettlement program that was undertaken in 1984 and the influx of refugees from Southern Sudan have lead to the sharp increase in human population, thus triggering the encroachment pressure on vegetation in BGRS. Beside the existing pressure, implementation of other new development activities (Ministry of Information 2001), without conservation planning will lead to significant loss of biodiversity. Establishment of conservation sites in the region is necessary to mitigate developments that may disrupt plant assemblage formed by the overlap of three phytogeographical regions in Africa. In such areas where the ecological processes are complex and poorly understood, conservation targeted to plant communities is the most recommended option. The plant communities identified in this study could be used as biodiversity surrogates for conservation planning in BGRS.

Conclusion

The five plant communities identified in this study were characterized by species assemblages that have been formed by overlap of three phytogeographical regions in Africa; Afromontane region in central Ethiopia, Sudanian and Zambezian regions. Altitude, Base Saturation in the sub soil, Electrical Conductivity in the top soil, Magnesium in the top soil, Organic Carbon in the top soil and Potassium in the top soil were found to significantly explain variation in the species composition along the complex gradients. The treat to the plant communities was found to increase with altitude, which was the most important environmental gradient in structuring vegetation in the region. The plant communities above an altitude of 950 m were recognized as most vulnerable. We strongly recommend initiation of conservation planning to rescue loss of the plant biodiversity in BGRS. The plant communities could be used as biodiversity surrogates for conservation planning in BGRS. The scope of this study is limited to classification of the woodland vegetation into the plant communities and identification of factors structuring the species composition in BGRS. Conservation and management of vegetation resources is more practical when the classification types can be mapped. Studies on spatial and temporal patterns of the plant communities are also important to locate conservation sites and in conservation planning, sustainable biodiversity utilization and environmentally sound decision-making as part of integrated economic development program in the region.

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Appendix 1. List of plants sampled from woodland vegetation of Benishangul Gumuz Region, Western Ethiopia.

S. No.	Botanical name	Family
1	*Abelmoschus ficulneus* (L.) Wight & Arn.	Malvaceae
2	*Acacia hecatophylla* Steud. ex A. Rich.	Fabaceae
3	*Acacia polyacantha* Willd.	Fabaceae
4	*Acacia seyal* Del.	Fabaceae
5	*Acalypha bipartita* Muell. Arg.	Euphorbiaceae
6	*Acalypha ciliata* Forssk.	Euphorbiaceae
7	*Acalypha ornata* A. Rich.	Euphorbiaceae
8	*Acalypha villicaulis* A. Rich.	Euphorbiaceae
9	*Acanthus polystachyus* Del.	Acanthaceae
10	*Achyranthes aspera* L.	Amaranthaceae
11	*Acmella caulirhiza* Del.	Asteraceae
12	*Adansonia digitata* L.	Bombacaceae
13	*Aeschynomene abyssinica* (A. Rich.) Vatke	Fabaceae
14	*Aframomum alboviolaceum* (Ridl.) K. Schum.	Zingiberaceae
15	*Albizia malacophylla* (A. Rich.) Walp.	Fabaceae
16	*Allophylus macrobotrys* Gilg	Sapindaceae
17	*Aloe sp.*	Aloaceae
18	*Amorphophallus abyssinicus* (A. Rich.) N. E. Br.	Araceae
19	*Ampelocissus schimperiana* (Hochst. ex A. Rich.) Planch.	Vitaceae
20	*Andropogon pseudapricus* Stapf	Poaceae
21	*Andropogon schirensis* Hochst. ex A. Rich.	Poaceae
22	*Annona senegalensis* Pers.	Annonaceae
23	*Anogeissus leiocarpa* (A. DC.) Guill. & Perr.	Combretaceae
24	*Ascolepis capensis* (Kunth) Ridl.	Cyperaceae
25	*Asparagus flagellaris* (Kunth) Baker	Asparagaceae
26	*Asparagus racemosus* Willd.	Asparagaceae
27	*Aspilia kotschyi* (Sch. Bip.) Oliv.	Asteraceae
28	*Balanites aegyptiaca* (L.) Del.	Balanitaceae
29	*Becium filamentosum* Chiov.	Lamiaceae
30	*Bidens pilosa* L.	Asteraceae
31	*Bidens prestinaria* (Sch. Bip.) Cufod.	Asteraceae
32	*Blepharis maderaspatensis* (L.) Roth	Acanthaceae
33	*Bonatea steudneri* (Rchb.f.) Th. Dur. & Schinz	Orchidaceae
34	*Borassus aethiopum* Mart.	Arecaceae
35	*Boswellia papyrifera* (Del.) Hochst.	Burseraceae
36	*Breonadia salicina* (Vahl) Hepper & Wood	Rubiaceae
37	*Brucea antidysenterica* J.F. Mill.	Simaroubaceae
38	*Bulbine abyssinica* A. Rich.	Asphodelaceae
39	*Bulbostylis setifolia* (A. Rich.) Bodard	Cyperaceae
40	*Cadaba farinosa* Forssk.	Capparidaceae

Appendix 1. Continued…

S. No.	Botanical name	Family
41	*Capparis tomentosa* Lam.	Capparidaceae
42	*Carissa spinarum* L.	Apocynaceae
43	*Cassia arereh* Del.	Fabaceae
44	*Cayratia gracilis* (Guill. & Perr.) Suesseng.	Vitaceae
45	*Celosia trigyna* L.	Amaranthaceae
46	*Chlorophytum blepharophyllum* Schweinf. ex Baker	Anthericaceae
47	*Chlorophytum serpens* Sebsebe & Nordal.	Anthericaceae
48	*Cissus cornifolia* (Bak.) Planch.	Vitaceae
49	C*issus populnea* Guill. & Perr.	Vitaceae
50	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae
51	*Clerodendrum alatum* Gürke	Lamiaceae
52	*Clerodendrum cordifolium* (Hochst.) A. Rich.	Lamiaceae
53	*Combretum capituliflorum* Fenzl ex Schweinf.	Combretaceae
54	*Combretum collinum* Fresen.	Combretaceae
55	*Combretum hartmannianum* Schweinf.	Combretaceae
56	*Combretum molle* R. Br. ex G. Don	Combretaceae
57	*Commelina africana* L.	Commelinaceae
58	*Commelina benghalensis* L.	Commelinaceae
59	*Commelina imberbis* Ehrenb. ex Hassk.	Commelinaceae
60	*Commelina latifolia* Hochst. ex A. Rich.	Commelinaceae
61	*Commiphora pedunculata* (Kotschy & Peyr.) Engl.	Burseraceae
62	*Corchorus olitorius* L.	Tiliaceae
63	*Cordia africana* Lam.	Boraginaceae
64	*Costus spectablis* (Fenzl) K. Schum.	Costaceae
65	*Crepis rueppellii* Sch. Bip.	Asteraceae
66	*Crinum ornatum* (Ait.) Bury	Amaryllidaceae
67	*Crossopteryx febrifuga* (G. Don) Benth.	Rubiaceae
68	*Crotalaria pallida* Ait.	Fabaceae
69	*Croton macrostachyus* Del.	Euphorbiaceae
70	*Cucumis pustulatus* Naud. ex Hook.f.	Cucurbitaceae
71	*Cussonia arborea* A. Rich.	Araliaceae
72	*Cussonia ostinii* Chiov.	Araliaceae
73	*Cymbopogon caesius* (Hook. Arn.) Stapf	Poaceae
74	*Cynodon nlemfuensis* Vanderyst	Poaceae
75	*Cynoglossum lanceolatum* Forssk.	Boraginaceae
76	*Cyperus dives* Del.	Cyperaceae
77	*Cyphostemma adenocaule* (Steud. ex A. Rich.) Descoings ex Wild & Drummond	Vitaceae
78	*Cyphostemma dembianense* (Chiov.) Vollesen	Vitaceae
79	*Cyphostemma junceum* (Webb) Descoings ex Wild & Drummond	Vitaceae

Appendix 1. Continued…

S. No.	Botanical name	Family
80	*Dalbergia boehmii* Taub.	Fabaceae
81	*Dalbergia melanoxylon* Guill. & Perr.	Fabaceae
82	*Delphinium dasycaulon* Fresen.	Ranunculaceae
83	*Dichrostachys cinerea* (L.) Wight & Arn.	Fabaceae
84	*Dioscorea bulbifera* L.	Dioscoreaceae
85	*Dioscorea dumetorum* (Kunth) Pax	Dioscoreaceae
86	*Dioscorea praehensilis* Benth.	Dioscoreaceae
87	*Dioscorea schimperiana* Kunth	Dioscoreaceae
88	*Diospyros mespiliformis* Hochst. ex A. DC.	Ebenaceae
89	*Disa aconitoides* Sonder	Orchidaceae
90	*Dombeya buettneri* K. Schum.	Sterculiaceae
91	*Dombeya torrida* (J. F. Gmel.) P. Bamps	Sterculiaceae
92	*Dorstenia barnimiana* Schweinf.	Moraceae
93	*Dorstenia benguellensis* Welw.	Moraceae
94	*Drimia altissima* (L.f.) Ker-Gawl.	Hyacinthaceae
95	*Echinops longifolius* A. Rich.	Asteraceae
96	*Ensete ventricosum* (Welw.) Cheesman	Musaceae
97	*Entada africana* Guill. & Perr.	Fabaceae
98	*Eriosema robustum* Bak.	Fabaceae
99	*Erythrina abyssinica* Lam. ex DC.	Fabaceae
100	*Ethulia gracilis* Del.	Asteraceae
101	*Eulophia guineensis* Lindl.	Orchidaceae
102	*Fadogia cienkowskii* Schweinf.	Rubiaceae
103	*Faurea speciosa* Welw.	Proteaceae
104	*Feretia apodanthera* Del.	Rubiaceae
105	*Ficus ovata* Vahl	Moraceae
106	*Ficus sycomorus* L.	Moraceae
107	*Ficus thonningii* Blume	Moraceae
108	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae
109	*Floscopa glomerata* (Willd. ex J. A. Schult. & J. H. Schult.) Hassk.	Commelinaceae
110	*Flueggea virosa* (Willd.) Voigt	Euphorbiaceae
111	*Gardenia ternifolia* Schum. & Thonn.	Rubiaceae
112	*Gladiolus abyssinicus* (Brongn. ex Lemaire) Goldblatt & de Vos	Iridaceae
113	*Gladiolus dalenii* Van Geel	Iridaceae
114	*Gladiolus roseolus* Chiov.	Iridaceae
115	*Gnidia involucrata* Steud. ex A. Rich.	Thymelaceae
116	*Grewia mollis* A. Juss.	Tiliaceae
117	*Grewia velutina* (Forssk.) Vahl	Tiliaceae
118	*Guizotia scabra* (Vis.) Chiov.	Asteraceae
119	*Guizotia schimperi* Sch. Bip. ex Walp.	Asteraceae
120	*Hibiscus calyphyllus* Cavan.	Malvaceae

Appendix 1. Continued…

S. No.	Botanical name	Family
121	*Hibiscus cannabinus* L.	Malvaceae
122	*Hibiscus corymbosus* Hochst. ex A. Rich.	Malvaceae
123	*Hoslundia opposita* Vahl	Lamiaceae
124	*Hygrophila auriculata* (Schum.) Heine	Acanthaceae
125	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	Poaceae
126	*Hyparrhenia confinis* Hochst. ex A. Rich.) Stapf	Poaceae
127	*Hyparrhenia cymbaria* (L.) Stapf	Poaceae
128	*Hyparrhenia diplandra* (Hack.) Stapf	Poaceae
129	*Hyparrhenia hirta* (L.) Stapf	Poaceae
130	*Hyparrhenia nyassae* (Rendle) Stapf	Poaceae
131	*Hyphaene thebaica* (L.) Mart.	Arecaceae
132	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae
133	*Hypoxis angustifolia* Lam.	Hypoxidaceae
134	*Hypoxis boranensis* Cufod.	Hypoxidaceae
135	*Hypoxis schimperi* Baker	Hypoxidaceae
136	*Indigofera garckeana* Vatke	Fabaceae
137	*Ipomoea aquatica* Forssk.	Convolvulaceae
138	*Ipomoea eriocarpa* R. Br.	Convolvulaceae
139	*Ipomoea shupangensis* Bak.	Convolvulaceae
140	*Jasminum schimperi* Vatke	Oleaceae
141	*Justicia bizuneshiae* Ensermu	Acanthaceae
142	*Justicia ladanoides* Lam.	Acanthaceae
143	*Kedrostis foetidissima* (Jacq.) Cogn.	Cucurbitaceae
144	*Kigelia aethiopum* (Fenzl) Dandy	Bignoniaceae
145	*Laggera crispata* (Vahl) Hepper & Wood	Asteraceae
146	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl.	Anacardiaceae
147	*Lannea welwitschii* (Hiern) Engl.	Anacardiaceae
148	*Ledebouria revoluta* (L.f.) Jessop	Hyacinthaceae
149	*Leonotis nepetifolia* (L.) R. Br.	Lamiaceae
150	*Lippia grandifolia* Hochst. ex A. Rich.	Verbenaceae
151	*Lonchocharpus laxiflorus* Guill. & Perr.	Fabaceae
152	*Loudetia arundinacea* (Hochst. ex A. Rich.) Steud	Poaceae
153	*Maesa lanceolata* Forssk.	Myrsinaceae
154	*Maytenus senegalensis* (Lam.) Exell	Celastraceae
155	*Merremia gallabatensis* Hall.f.	Convolvulaceae
156	*Merremia kentrocaulos* Rendle	Convolvulaceae
157	*Momordica foetida* Schum.	Cucurbitaceae
158	*Murdannia simplex* (Vahl) Brenan	Commelinaceae
159	*Neorautanenia mitis* (A. Rich.) Verdc.	Fabaceae
160	*Ochna leptoclada* Oliv.	Ochnaceae

Appendix 1. Continued…

S. No.	Botanical name	Family
161	*Ochna leucophloeos* Hochst. ex A. Rich.	Ochnaceae
162	*Ocimum trichodon* Baker ex Gürke	Lamiaceae
163	*Otostegia tomentosa* A. Rich.	Lamiaceae
164	*Oxalis obliquifolia* A. Rich.	Oxalidaceae
165	*Oxytenanthera abyssinica* (A. Rich.) Munro	Poaceae
166	*Ozoroa insignis* Del.	Anacardiaceae
167	*Ozoroa pulcherrima* (Schweinf.) R. & A. Fernandes	Anacardiaceae
168	*Panicum atrosanguineum* A. Rich.	Poaceae
169	*Panicum maximum* Jacq.	Poaceae
170	*Pavetta gardeniifolia* A. Rich.	Rubiaceae
171	*Pelargonium multibracteatum* Hochst. ex A. Rich.	Geraniaceae
172	*Pennisetum ramosum* (Hochst.) Schweinf.	Poaceae
173	*Pennisetum schweinfurthii* Pilg.	Poaceae
174	*Pennisetum thunbergii* Kunth	Poaceae
175	*Pennisetum unisetum* (Nees) Benth.	Poaceae
176	*Persicaria senegalensis* (Meisn.) Sojak	Polygonaceae
177	*Phoenix reclinata* Jacq.	Arecaceae
178	*Phragmanthera macrosolen* (A. Rich.) M. Gilbert	Loranthaceae
179	*Phyllanthus leucanthus* Pax	Euphorbiaceae
180	*Phyllanthus pseudoniruri* Muell. Arg.	Euphorbiaceae
181	*Piliostigma thonningii* (Schum.) Milne-Redh.	Fabaceae
182	*Pimpinella heywoodii* Abebe	Apiaceae
183	*Pimpinella hirtella* (Hochst.) A. Rich.	Apiaceae
184	*Protea gaguedi* J. F. Gmel.	Proteaceae
185	*Pseudomussaenda flava* Verdc.	Rubiaceae
186	*Pterocarpus lucens* Guill. & Perr.	Fabaceae
187	*Rhus ruspolii* Engl.	Anacardiaceae
188	*Rhynchosia nyasica* Bak.	Fabaceae
189	*Ricinus communis* L.	Euphorbiaceae
190	*Rottboellia cochinchinensis* (Lour.) Clayton	Poaceae
191	*Ruellia prostrata* (Nees) T. Anders.	Acanthaceae
192	*Rumex abyssinicus* Jacq.	Polygonaceae
193	*Rumex nepalensis* Spreng.	Polygonaceae
194	*Sapium ellipticum* (Krauss) Pax	Euphorbiaceae
195	*Sarcocephalus latifolius* (Smith) Bruce	Rubiaceae
196	*Scadoxus multiflorus* (Martyn) Raf.	Amaryllidaceae
197	*Sclerocarya birrea* (A. Rich.) Hochst.	Anacardiaceae
198	*Securidaca longepedunculata* Fresen.	Polygalaceae
199	*Senna obtusifolia* (L.) Irwin & Barneby	Fabaceae
200	*Sesbania quadrata* Gillett	Fabaceae

Appendix 1. Continued…

S. No.	Botanical name	Family
201	*Siphonochilus aethiopicus* (Schweinf.) B.L. Burtt	Zingiberaceae
202	*Solanecio tuberosus* (Sch.Bip. ex A. Rich.) C.Jeffrey	Asteraceae
203	*Solanum dasyphyllum* Schum. & Thonn.	Solanaceae
204	*Sorghum arundinaceum* (Desv.) Stapf	Poaceae
205	*Spermacoce sphaerostigma* (A. Rich.) Vatke	Rubiaceae
206	*Sporobolus festivus* Hochst. ex A. Rich.	Poaceae
207	*Sterculia africana* (Lour.) Fiori	Sterculiaceae
208	*Stereospermum kunthianum* Cham.	Bignoniaceae
209	*Strychnos innocua* Del.	Loganiaceae
210	*Strychnos spinosa* Lam.	Loganiaceae
211	*Syzygium guineense* (Willd.) DC.	Myrtaceae
212	*Tacca leontopetaloides* (L.) O. Ktze.	Taccaceae
213	*Tagetes minuta* L.	Asteraceae
214	*Tagetes patula* L.	Asteraceae
215	*Tamarindus indica* L.	Fabaceae
216	*Tephrosia interrupta* Hochst. & Steud. ex Engl.	Fabaceae
217	*Terminalia laxiflora* Engl. & Diels	Combretaceae
218	*Terminalia macroptera* Guill. & Perr.	Combretaceae
219	*Tragia doryodes* M. Gilbert	Euphorbiaceae
220	*Triumfetta annua* L.	Tiliaceae
221	*Tylosema fassoglensis* (Kotschy ex Schweinf.) Torre & Hillc.	Fabaceae
222	*Vernonia cylindrica* Sch. Bip. ex Walp.	Asteraceae
223	*Vernonia hochstetteri* Sch. Bip. ex Walp.	Asteraceae
224	*Vernonia theophrastifolia* Schweinf. ex Oliv. & Hiern	Asteraceae
225	*Vigna membranacea* A. Rich.	Fabaceae
226	*Vitex doniana* Sweet.	Lamiaceae
227	*Wissadula rostrata* (Schum. & Thonn.) Hook.f.	Malvaceae
228	*Ximenia americana* L.	Olacaceae
229	*Ziziphus abyssinica* Hochst. ex A. Rich.	Rhamnaceae
230	*Ziziphus mauritiana* Lam.	Rhamnaceae
231	*Ziziphus mucronata* Willd	Rhamnaceae
232	*Zygotritonia praecox* Stapf	Iridaceae

III

Benishangul Gumuz Region in Ethiopia: a centre of endemicity for *Chlorophytum* – with a description of *C. pseudocaule* sp. nov. (*Anthericaceae*)

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Summary. The Benishangul Gumuz Region in western Ethiopia is one of the least botanically explored regions and several new records have been published as additions in Flora of Ethiopia and Eritrea. A new species is described, *Chlorophytum pseudocaule* Tesfaye & Nordal, and phytogeographic aspects of the endemicity of *Chlorophytum* in western Ethiopia are discussed.

Key Words: Benishangul Gumuz, *Chlorophytum,* Flora of Ethiopia, Phytogeography.

Introduction

The vegetation of western Ethiopian escarpment, named by White (1983), as *undifferentiated woodlands (Ethiopian type)* has an interesting and partly unique flora (Sebsebe Demissew *et al.* 2005). Comparatively much of this vegetation type is still nearly intact in the Benishangul Gumuz Region. Vegetation in this region is characterised by broadleaved deciduous trees. The most common tree species are *Anogeissus leiocarpa* Guill. & Perr.*, Balanites aegypticus* Wall.*, Boswellia papyrifera* Hochst.*, Combretum collinum* Fresen.*, Dalbergia melanoxylon* Guill. & Perr.*, Lannea fruticosa* Engl.*, L. welwitschii* (Hiern) Engl.*, Lonchocarpus laxiflorus* Guill. & Perr.*, Pterocarpus lucens* Guill. & Perr.*, Piliostigma thonningii* (Schumach.) Milne-Redh., *Stereospermum kunthianum* Cham.*, Terminalia laxiflora* Engl. and *T. macroptera* Guill. & Perr. The solid-stemmed bamboo *Oxytenanthera abyssinica* Munro is common on escarpments and hilly areas. The ground cover is dominated by geophytes such as *Chlorophytum* Ker Gawl.*, Costus* L.*, Crinum* L., *Dorstenia* L.*, Drimiopsis* Lindl. & Paxt.*, Eulophia* R. Br. ex Lindl., *Habenaria* Willd.*, Hypoxis* L. and *Ledebouria* Roth at the beginning of rainy season (May and June). Toward the end of the rainy season (September to November) a tall stratum of perennial grasses, including species of *Andropogon* L., *Cymbopogon* Spreng., *Hyparrhenia* Anderss. ex E. Fourn., *Panicum* L., *Pennisetum* Pers. and *Rottboellia* L.f. become dominant. This vegetation has been adapted to annual fires, which mostly occur in December and January.

Benishangul Gumuz Region is one of the least botanically explored regions and several new records have been published as additions in Flora of Ethiopia and Eritrea (Edwards *et al.* 2000); two new species of *Chlorophytum* were recently described, *C. herrmannii* Nordal & Sebsebe and *C. serpens* Sebsebe & Nordal (Sebsebe Demissew *et al.* 2005). During field work in the area one of us (T.A.) collected a plant that is not included in the Flora of Ethiopia and Eritrea (Nordal 1997), nor in the “Flowers of Ethiopia and Eritrea – Aloes and other Lilies” (Sebsebe Demissew *et al.* 2003). The same taxon also turned up in the collections of Christof Herrmann from the region. It does not fit with any described taxon so far. The aim of this paper is to describe the new species and to discuss phytogeographic aspects of the endemicity of *Chlorophytum* in western Ethiopia.

Results

The undescribed species (Fig. 1) belongs in a group of *Chlorophytum* species with thick spongy roots without tubers and with richly branched panicles, and most often greenish to whitish urceolate flowers, including *C. andongense* Baker, *C. macrosporum* Baker and *C. viridescens* Engl. It differs from all of them in possessing a well developed pseudostem. It has smaller flowers than the two first mentioned species, and larger leaves than the third. *Chlorophytum ruahense* Engl. and *C. nyassae* (Rendle) Kativu are also related to this group, but both are very distinct, the first by having large clasping leaves all along the peduncle, the second by its scale-like leaves on the peduncle and the open stellate flowers. *Chlorophytum hirsutum* A.D. Poulsen & Nordal, a narrow endemic from open forest in the border areas between Burundi, Congo and Uganda, also belongs to this group. This species is hairy and lack pseudostem. There is no doubt that the two known populations of the pseudostemmed taxon deserve recognition at the species level.

Chlorophytum pseudocaule *Tesfaye & Nordal* sp. nov.

Type: Ethiopia, Benishangul Gumuz National Regional State, Hoha Valley, 15 km NE of Asosa, 10.08.42 N 34.38.17 E, 1430 m. 3. June 2000, Christof Herrmann 127 (ETH, holotype).

Chlorophytum viridescenti *Engl. affinis, sed pseudocaule distincto; foliis latioribus (5-5-6 cm non 1-2.5), non undulates; floribus bruneolis, non albidis; filamentis filiformis, non fusiformis.*

Herb up to 105 cm high. Rhizome short with several extensive thick spongy roots without tubers. Leaf bases forming a distinct pseudostem up to 40 cm long, surrounded by cataphylls almost without lamina in lower (outer) part, inner leaves with well developed lamina up to 40 cm long and 5-6.5 cm wide, with 20-28 spaced veins and a distinct midrib. Peduncle with 1-2 bract like leaves, 10-13 cm long 1-1.5 cm wide, below the inflorescence. Inflorescence a much branched panicle with 2-3 flowers at each node; bracts of the side branches up to 5 cm long, floral bracts up to 0.7 cm long. Pedicel up to 10 mm, jointed below the middle, pale brown above the articulation, green below. Flowers urceolate, pale brown; tepals 6 mm long and 1-1.5 mm wide, reflexed and three-veined; filaments filiform, scabrid, subequal longer ones 4-5 mm long, shorter ones 3 mm; anthers 0.7 mm, curved, versatile; style excerted, sligtly bent. Capsules three-locular about 5 mm long and 5 mm wide. Seeds 2-4 per locule, slightly saucershaped, 2 mm in diameter.

The new species is so far known from two localities (Fig. 2): north east of Asosa, 1430 m, 10^{o} 08.42' N and 034^{o} 38.17' E (Herrmann 127, 128, ETH) and south of Asosa, 1560 m., 10^{o} 02.46' N and 034^{o} 31.40' E (Tesfaye 1148, ETH). It grows in open bushed meadows with gray clay soil. It flowers in June and fruits in July. The habitat is dominated by geophytes such as *Crinum ornatum* Herb., *Drimiopsis botryoides* Baker, *Gladiolus roseolus* Chiov., *Habenaria perbella* Rchb.f. and *Ledebouria revoluta* (L.f.) Jessop. The dominant bush in the meadows is *Kotschya africana* Endl. *Cyperus spp*. and grasses such as *Cymbopogon* and *Hyparrhenia* have the highest cover. The dominant trees in the bamboo woodland around the meadows include *Combretum collinum, Piliostigma thonningii, Stereospermum kunthianum, Terminalia laxiflora, T. macroptera* and *Vitex doniana* Sweet.

Fig 1. A - B. *Chlorophytum pseudocaule* based on Herrmann 127 and 128, ETH. **A** complete plant. **B** inflorescence. DRAWN BY SVETLANA VORONKOVA.

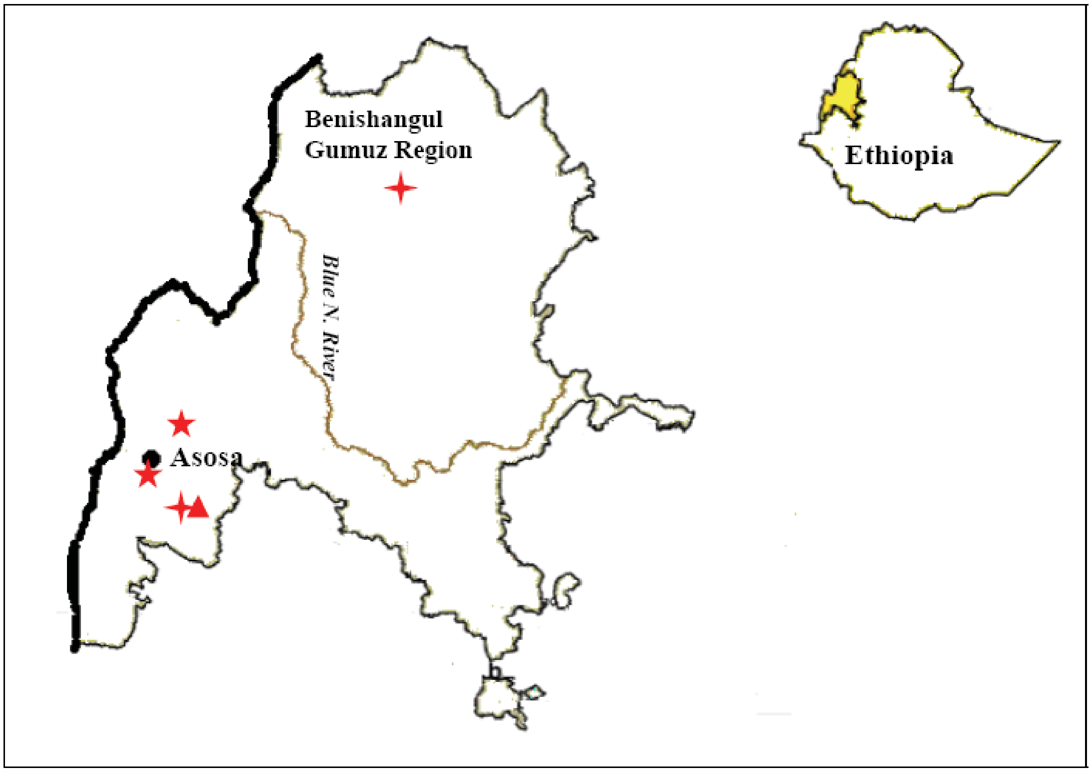

Fig. 2. Distribution of *Chlorophytum herrmannii* (triangle), *C. serpens* (cross) and *C. pseudocaule* (star).

Discussion

Three species of *Chlorophytum* are endemic to the Benishangul Gumuz Region (Fig. 2), i.e. about 12% of the species found in Ethiopia. *Chlorophytum pseudocaule* is related to a group that is widespread in the Sudano-Zambesian phytochorion. *Chlorophytum serpens* belongs in the widespread, heterogeneous *C. comosum* (Thunb.) Jacques complex with mainly Guineo-Congolean affinity. *Chlorophytum comosum* is found in the shade of rain forest and riverine forest on brown to black loamy clay soil in southwestern Ethiopia (Illubabor and Kafa regions) and is found throughout tropical Africa south to the Cape (Sebsebe Demissew *et al.* 2003). *Chlorophytum serpens* grows in *Combretum-Terminalia* woodland and *Oxytenanthera abyssinica* dominated woodland on reddish sandy soil, between 1100 and 1460 m. *Chlorophytum herrmannii* grows on rocky outcrops in *Oxytenanthera abyssinica* dominated closed woodland, around 1600 m. Morphologically, *C. herrmannii* is similar to another fairly narrow Ethiopian endemic, *C. neghellense* Cufod., growing in *Acacia-Combretum-Commiphora* dominated woodland, often heavily grazed, on red sandy soils between 1000 and 1700 m in Sidamo (Sebsebe Demissew *et al.* 2003, 2005). The three endemic species accordingly show relationships with rather different groups ecologically and geographically. The three endemic *Chlorophytum* species are restricted to fragmented wetter habitats of Benishangul Gumuz Region, which are probably the results of recent anthropogenic influence rather than geological and climatological events in the past.

Endemism in sub-Saharan Africa is hypothesised to be related to paleoclimatic fluctuations (Linder 2001). It has further been suggested that centre of endemism would be in places that have shown climatic stability over longer periods (Lovett and Friis 1996). In general, vicariance or fragmentations of distributional ranges by geological or climatological events are the most widely accepted causes of endemism (Evans *et al.* 2004).

There is no clear evidence yet to explain the mechanisms of evolution of an endemic flora in the Benishangul Gumuz Region. However, Sebsebe Demissew *et al*. (2005) suggested that the complex topography and the relatively reliable oreographic rain on the western Ethiopian escarpment, together with the hinterland of deep river valleys, provided small refugia during the periods of adverse climatic conditions. This may have secured niches of very restricted range where species could survive unfavourable periods. The best conditions for such niches are likely to have been in the most topographically and geologically complex areas in the lower reaches and at the mouth of the biggest river system in western Ethiopia, the gorges of the Blue Nile River and its tributaries, an area that approximately agrees with the extension of the Benishangul Gumuz National Regional State. The other area with high concentration of endemic *Chlorophytum* species within Ethiopia is the lowland surrounding Bale Mountains. Here also plants might have found rather stable niches moving up and down the mountain slopes according to climate change.

Acknowledgements

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IV

New plant records for the Ethiopian flora from Benishangul Gumuz Region, western Ethiopia

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Abstract

Six plant species, *Acalypha bipartita* Muell. Arg. (Euphorbiaceae), *Dalbergia boehmii* Taub. (Fabaceae), *Dorstenia benguellensis* Welw. (Moraceae), *Hyparrhenia bracteata* (Willd.) Stapf (Poaceae), *Ochna leptoclada* Oliv. (Ochnaceae) and *Scleria greigiifolia* (Ridley) C. B. Cl. (Cyperaceae) were recorded from Benishangul Gumuz Region, western Ethiopia as new additions to the Ethiopian flora.

Key Words and Phrases: Benishangul Gumuz, Conservation, Ethiopian flora, Phytogeography.

INTRODUCTION

The Ethiopian flora is estimated to contain between 6,500 and 7,000 species of higher plants (Tewolde Brehan Gebre Egziabher, 1991), of which about 12% are endemic. Precise information on the Ethiopian flora could only be obtained when studies are undertaken in the various parts of the country where little or no botanical explorations have been made. Benishangul Gumuz Region in western Ethiopia is one of the least botanically explored regions (Sebsebe Demissew *et al.,* 2005) and a number of new records have been published as additions in Flora of Ethiopia and Eritrea (Edwards *et al.,* 2000).

Vegetation in this region is part of *Sudanian center of endemism* named by White (1983), as *undifferentiated woodlands (Ethiopian type)* and characterized by broadleaved deciduous trees. The most common tree species are *Anogeissus leiocarpa, Balanites aegyptiaca, Boswellia papyrifera, Combretum collinum, Dalbergia melanoxylon, Lannea fruticosa, L. welwitschii, Lonchocarpus laxiflorus, Pterocarpus lucens, Piliostigma thonningii, Stereospermum kunthianum, Terminalia laxiflora* and *T. macroptera.* The solid-stemmed bamboo *Oxytenanthera abyssinica* is common on escarpments and hilly areas, while *Hyphaene thebaica* is characteristic species in the lowland plain. The ground cover is dominated by herbaceous geophytes such as *Crinum*, *Hypoxis*, *Ledebouria*, *Chlorophytum*, *Costus*, *Eulophia*, *Habenaria*, *Dorstenia* and *Drimiopsis* at the beginning of rainy season (May and June). Toward the end of the rainy season (September to November) a tall stratum of perennial grasses, including species of *Hyparrhenia, Andropogon, Rottboellia, Panicum, Cymbopogon* and *Pennisetum* become dominant. This vegetation has been adapted to annual fire which is mostly set by local people in December and January. Among plant specimens collected from this vegetation, six species are recognized as new additions to Ethiopian flora and presented in this paper. Their importance in phytogeographic study and conservation planning were discussed.

MATERIALS AND METHODS

The study was conducted in the Benishangul Gumuz Region, western Ethiopia, located between latitudes 09^{o} 17' and 12^{o} 06' N and longitudes 34^{o} 10' and 37^{o} 04' E. The region is bordered by Amhara Regional State to the north, Oromiya Regional State to the east and south, Republic of Sudan to the west. The eastern parts of the region have an elevation about 2,700 meters above sea level. Elevation decreases gradually toward the western part to an average altitude of 500 m along Ethio-Sudanese Border. The region was established in 1994 by the 1994 constitution of Ethiopia. Before this time the area south of Blue Nile belonged to Welega while the northern part to Gojam Flora Regions.

A total of 504 plant specimens were collected by the first author of this paper between 2001 and 2005. Most of the specimens were identified with the help of Floras and by comparing with already identified herbarium specimens at National Herbarium (ETH), Ethiopia. Those which are new to Ethiopian flora were identified at Royal Botanic Gardens (K), England. All specimens were deposited at the ETH and Institute of Biodiversity Conservation/Ethiopia.

RESULTS

In the course of identification of plant specimens collected from Benishanugul Gumuz Region (Figure 1) by the first author of this paper, five species *Acalypha bipartita* Muell. Arg. (Euphorbiaceae), *Dalbergia boehmii* Taub. (Fabaceae), *Dorstenia benguellensis* Welw. (Moraceae), *Ochna leptoclada* Oliv. (Ochnaceae) and *Scleria greigiifolia* (Ridley) C. B. Cl. (Cyperaceae) did not match with any specimen collected from Ethiopia and deposited at the National Herbarium of Addis Ababa University (ETH), neither possible to key out them to species level using published literatures on Ethiopian flora (Friis, 1989; Thulin, 1989; Gilbert, 1995; Pillips, 1995; Vollesen, 1995; Lye, 1997). The specimens were identified by comparing with already identified herbarium specimens at Royal Botanic Gardens (K), England and with the help of published literatures (Smith, 1987; Gillett *et al.,* 1971, Berg and Hijman, 1989; Berg, 1991; Clayton, 1969; Clayton *et al.*, 2002; Cope, 2002; Verdcourt, 2005; Haines and Lye, 1983). Those species which are not included in the published Flora of Ethiopia and Eritrea were recognized as new additions to Ethiopian flora. Another species, *Hyparrhenia bracteata* (Willd.) Stapf (Poaceae), previously found in Benishangul Gumuz Region in 1998 by Friis *et al.* 9201 (K), but not yet recorded in the Flora of Ethiopia and Eritrea was also recollected and treated here as an addition to Ethiopian flora.

Information on morphology and habitats of all species are given below based on the Ethiopian materials. Their distribution in Africa was extracted from literatures. Some of the specimens examined were also presented.

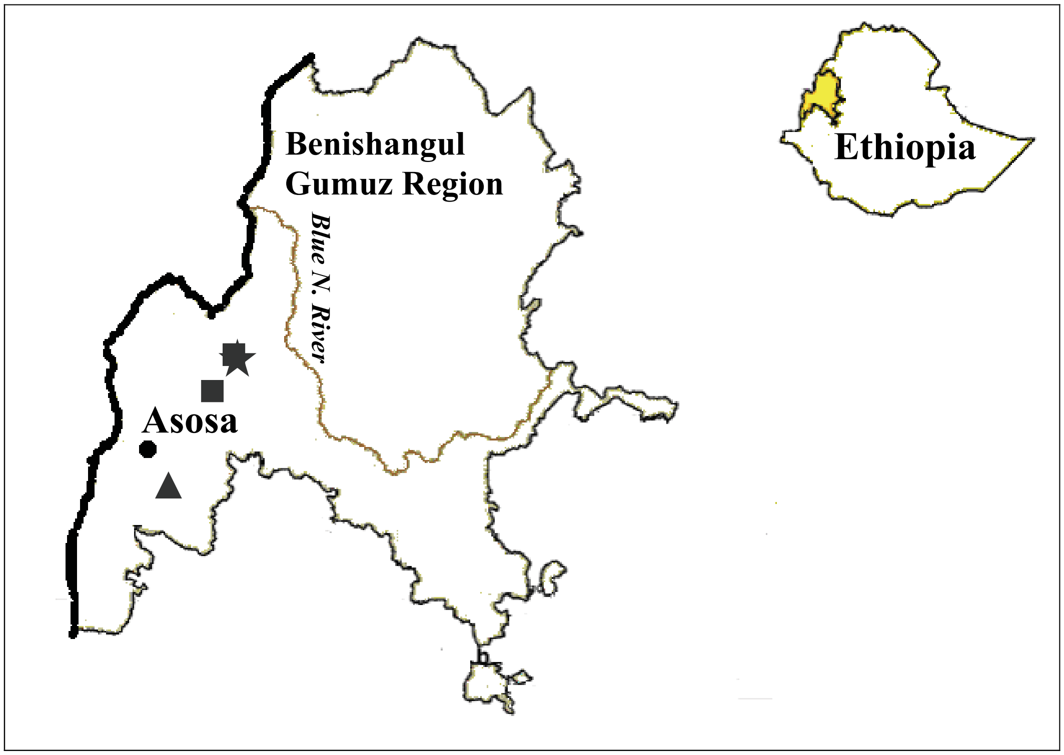

Figure 1. Collection localities of new plant records for Ethiopian flora from Benishangul Gumuz Region: *Acalypha bipartita* (★), *Dalbergia boehmii* (■), *Dorstenia benguellensis* (▲), *Hyparrhenia bracteata* (▲), *Ochna leptoclada* (▲) and *Scleria greigiifolia* (▲).

1. Acalypha bipartita *Muell. Arg.* (Euphorbiaceae)

Acalypha bipartita was previously known from Sudan, Uganda, Kenya, Tanzania, Rwanda, Burundi and Congo at an altitudinal range of 1100-1500 m (Smith, 1987). In Ethiopia it occurs below the lower at altitudinal range known for the species, i.e. 755 m.

Herb 0.5-1 m high from perennial rootstock. Leaves ovate, acuminate, serrate, pubescent on nerves, up to 7.5 cm wide and 15.7 cm long. Inflorescence bisexual, axillary, up to 13 cm long, with a terminal male portion and female bracteate units on peduncle up to 2.2 cm below the male portion. Ovary covered by two clasping sepals. Ovary set seeds before the maturation of male flowers. Fruits pubescent. Seeds black.

Habitat: In riverine vegetation dominated by *Anogeissus leiocarpa, Diospyros mespiliformis* and *Tamarindus indica.*

Specimens Examined**:** **Ethiopia**. Benishangul Gumuz Region, 2 km from Sherkole town to Thoyiba village, 26 June 2001, Tesfaye Awas and Melaku Wondafrash 899A (ETH). Benishangul Gumuz Region, 2 km from Sherkole town to Thoyiba village, 01 July 2005, Tesfaye Awas 1254 (ETH). **Sudan.** Lado Yei River, 10 November 19191, Sillitoe 224 (K). Imatong Mountains, Southern Sudan, 27 November 1980, Friis & Vollesen 512 (K). **Tanzania.** Bokoba District, Karagwe, Expedition to the source of the Nile-1860-1863, Speke and Grant 161 (K, Holotype). **Uganda.** Kitubulu, Entebbe, October 1931, Eggeling 187 (K).

2. Dalbergia boehmii *Taub.* (Fabaceae)*,* Local Name: Tsaba (Berta)

Dalbergia boehmii was previously known from Angola, Cameroon, Congo, Guinea Bissau, Kenya, Malawi, Mozambique, Senegal, Sudan, Tanzania, Zambia and Zimbabwe at an altitudinal range of 0-1720 m (Gillett *et al.,* 1971).

Tree 4-6 m high. Leaves compound, alternate. Leaflets up to 4.8 cm wide and 8 cm long. Pods papery, up to 10 mm wide and 8 cm long, contain 1-3 seeds (Figure 2). Seeds kidney shaped, up to 4 mm wide and 5 mm long.

Habitat: In riverine vegetation dominated by *Anogeissus leiocarpa, Diospyros mespiliformis* and *Tamarindus indica* and broadleaved woodland dominated by *Combretum collinum, Terminalia laxiflora, Albizia malacophylla, Pterocarpus lucens* and *Ozoroa insignis*; 755-1250 m.

***Specimens Examined*:** **Congo**. Katanga Prov., Elisabetville Territ., Keyberg, 8 km S.O. d`E`ville, October 1949, Schmitz 2627 (K). **Ethiopia**. Benishangul Gumuz Region: 47 km along the road from Asosa to Sherkole, 18 June 2001, Tesfaye Awas and Melaku Wondafrash 874 (ETH). Benishangul Gumuz Region: 50 km along the road from Asosa to Sherkole, 24 November 2004, Tesfaye Awas 1205 (ETH). Benishangul Gumuz Region: 2 km from Sherkole town to Thoyiba village. 24 November 2004, Tesfaye Awas 1207 (ETH). **Guinea Bissau**. 25 May 1948, Santo 2479 (K). Guine. **Kenya.** Kwale District, Muhaka Forest, 02 March 1977, Faden 77/595 (K). **Sudan.** Numatinna River (Tributary of Jur), undated, Turner 281 (K). **Tanzania**. Nachingwea District, 2 km east of Mtua Village on Nachingwea-Kilimarondo road, 01 November 78, Magogo and Innes 253 (K).

Figure 2. Pods of *Dalbergia boehmii.*

3. Dorstenia benguellensis *Welw.* (Moraceae)

Dorstenia benguellensis was previously known from Sudan, Uganda, Kenya, Tanzania, Rwanda, Burundi, Central African Republic, Cameroon, Congo, Angola, Zambia, Zimbabwe, Malawi and Mozambique at an altitudinal rang of 1000-2450 m (Berg and Hijman, 1989; Berg, 1991).

Herb 15-55 cm high. Emerge from perennial underground tuber. Tuber discoid, warty. Milky latex ooze out when cut. Leaves up to 16 mm wide and 9 cm long, margin dentate. Inflorescences axial, solitary.

Habitat: Under the shade of broadleaved woodland dominated by *Oxytenanthera abyssinica, Combretum collinum, Terminalia laxiflora, Securidaca longepedunculata, Lonchocarpus laxiflorus, Entada africana, Albizia malacophylla, Piliostigma thonningii* and *Syzygium guineense* (Figure 3); 1460 m.

Figure 3. *Oxthenthera abyssinica* woodland along the road from Asosa to Bambassi town. This locality is locally known as '*Anbesa Chaka'* - Lion forest.

Specimens Examined: **Angola.** December 1859, Welwitsch 1566 (K). **Burundi**. 10 February 1978, Reekmans 7319 (K). **Cameroon.** Buar, May 1914, Mildbraed 9382 (K). **Ethiopia**. Benishangul Gumuz Region: 22 km along the road from Asosa to Bambassi town, 05 July 2005, Tesfaye Awas 1260 (ETH). **Malawi.** Northern Region: Chitipa District, National Park, Escarpment below Jalawe viewpoint. C.25 km North of Chelinda, 25 January 1992, Goyder *et al.* 3582 (K). **Rwanda.** Kibungu, 08 September 1958, Alcool 8180 (K). **Sudan.** Loka-Bibi road, Yei District, undated, Jackoson 3204 (K). **Tanzania.** Sumbawanga District: Tatanda Mission, 23 February 1994, Bidgood *et al.* 2416 (K). **Uganda**. Napak, Karamoja, June 1950, Eggeling 5924 (K). **Zambia.** Mbala District, Itembwe GP, 1968, Richards 22887 (K).

4. Hyparrhenia bracteata *(Humb. & Bonpl. ex Willd.) Stapf*

Hyparrhenia bracteata was previously known from tropical Africa, mainly in the west. It was recorded from Burkina Faso, Ivory Coast, Nigeria, Cameroon, Central African Republic, Congo, Burundi, Uganda, Kenya, Tanzania, Mozambique, Malawi, Zambia, Zimbabwe and Angola (Clayton, 1969). It also occurs in China, India, Malaysia, Mexico and Brazil (Clayton *et al.*, 2002), at an altitudinal range of 1000-1650 m (Cope, 2002).

Perennial grass 1-2 m high. Leaf sheaths pilose. Racemes 2 awned per pair. Awns up to 2 cm long.

Habitat: Habitat: In seasonally wet grassland dominated by *Cyperus spp*., *Kotschya africana, Pycnostacys niamniamensii, Loudetia phragmitoides*, *Platostoma rotundifolium and Scleria spp.*; 1450-1480 m.

***Specimens Examined*: Ethiopia**. Benishangul Gumuz Region: 23 km along the road from Asosa to Bambassi town, O1 December 2004, Tesfaye Awas 1240 (ETH). Benishangul Gumuz Region: c. 28 km South of Asosa along the road to Bambassi, 23 November 1998, Friis *et al.* 9201 (K). **Ivory Coast.** Nr. N. bank of River Fahlogo, N. of Korhogo to Badikaha road and E. of Bandama Blanc River, 16 November 1975, Hall IV16 (K). **Nigeria.** N.E. State, Mabilla Plateau, Nguraje Forest reserve, 29 December 1975, Chapman 4071 (K). **Sudan.** Imatong Mountains, Gilo, near the bridge across Ngairigi River, 13 November 1980, Friis &Vollesen 201 (K).

5. Ochna leptoclada *Oliv.* (Ochnaceae)

Ochna leptoclada was previously known from Congo, Rwanda, Burundi, Sudan, Zambia, Malawi, Mozambique, Tanzania, Uganda and Zimbabwe at an altitudinal range of 250-1650 m (Verdcourt, 2005).

Bushy shrub 30-50 cm high; emerge from woody root stock (Figure 4A). Stem grayish white Leaves oblanceolate, up to 2.5 cm wide and 9 cm long. Fruiting calyx red, up to 8mm wide and 12mm long (Figure 4B).

Habitat: In open places and under the shade of broadleaved woodland dominated by *Oxytenanthera abyssinica, Combretum collinum, Terminalia laxiflora, Securidaca longepedunculata, Lonchocarpus laxiflorus, Entada africana, Albizia malacophylla, Piliostigma thonningii* and *Syzygium guineense* (Figure 3); 1490 m.

***Specimens Examined*: Burundi.** Bubanza, 25 September 1976, Reekmans 5339 (K). **Central African Republic.** Monovo-Gounda, 8 km south of Goumba, 1981, Fay 5345 (K). **Congo.** 22 October 1911, Rogers 10160 (K). **Ethiopia**. Benishangul Gumuz Region: 23 km along the road from Asosa to Bambassi town, 05 July 2005, Tesfaye Awas 1274 (ETH). **Rwanda**. Nyauza, Lake Tangayika, 60 km north of Kigoma, 29 July 1920, Shantz 691 (K). **Sudan.** Numatuna River Distr., undated, Turner 281 (K). **Tanzania.** Ulanga District**,** Msolwa Camp, 02 November 1977, Vollesen 4754 (K).

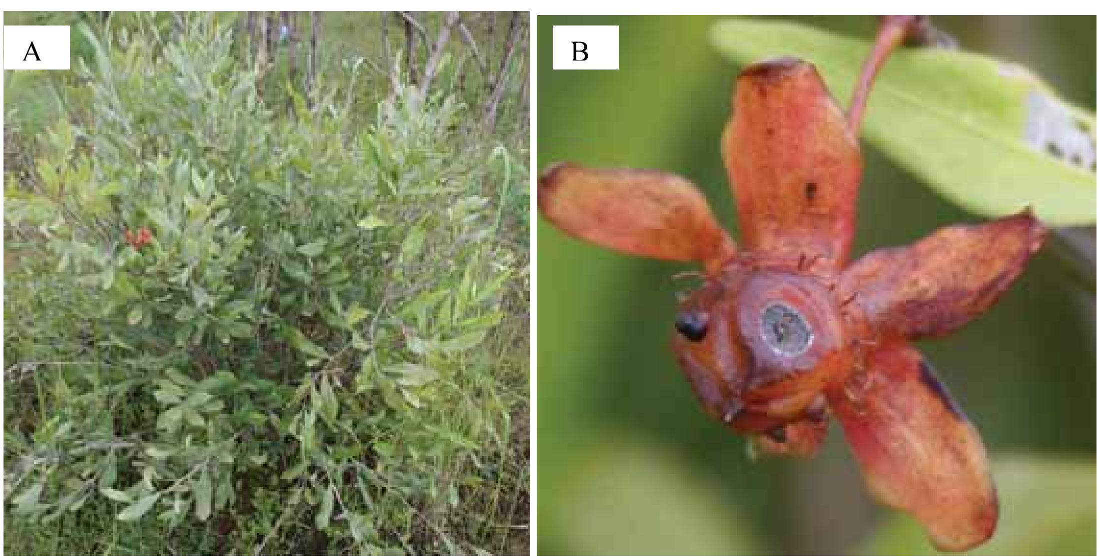

Figure 4A-B. Ochna leptoclada- A. The whole plant. B. Fruit.

6. Scleria greigiifolia *(Ridley) C. B. Cl.* (CYPERACEAE)
Scleria greigiifolia was previously known from Uganda, Tanzania, Congo, Zambia, Malawi, Zimbabwe, Angola and Madagascar at an altitudinal range of 1140-1160 m (Haines and Lye, 1983).

Sedge 1-1.5 m high, emerging from woody rhizomes. Stem triangular, scarbrid on the angles. Leaves up to 60 cm long and 13 mm wide, scarbid on the margin and ribs. Inflorescence brown, consist of one terminal and several lateral panicles. Peduncles up to 20 cm long. .

Habitat: In seasonally wet grassland dominated by *Cyperus spp*., *Kotschya africana, Pycnostacys niamniamensii, Loudetia phragmitoides*, *Platostoma rotundifolium and Scleria spp.*; 1480 m.

***Specimens Examined*: Ethiopia.** Benishangul Gumuz Region: 23 km along the road from Assosa to Bambassi town, 01 October 2005, Tesfaye Awas *et al.* 1355 (ETH). **Tanzania.** Bushasha Swamp, 14 August 1934, Gillman 92 (K). **Uganda**. East of Nabugabo Seminary Resort, 28 July 71, Katende 1218 (K).

DISCUSSION

The distribution of plants recorded in this study extends from Ethiopia to Senegal in the western Africa and to Mozambique in the southeastern and Angola in the southwestern Africa. These areas belong to the Sudanian and Zambezian vegetation regions. Such distribution patterns may help in the analysis of the phytogeographical affinity of the Benishangul Gumuz region's vegetation and in planning conservation activities.

Although all species are wide spread, the Ethiopian populations are geographically marginal towards north east border of the Sudanian vegetation region with elements from Zambezian vegetation region. Marginal populations, being far from the central population and with low rate of gene exchange, might have unique adaptations although morphologically appear rather similar to the plants found in more central areas of the wide distribution. Marginal populations are more sensitive to environmental changes and also affected by factors such as directional selection, genetic drift and inbreeding (Soulé, 1973, Gao *et al.*, 2000). It is therefore, necessary to start conservation initiatives in Benishangul Gumuz Region before loss of these marginal populations.

Previously 14 species of *Acalypha* (Gilbert, 1995), 5 species *Dalbergia* (Thulin, 1989), 7 species of *Dorstenia* (Friis, 1989), 6 species of *Ochna* (Vollesen, 1995), 30 species of *Hyparrhenia* (Pillips, 1995) and 14 species of *Scleria* (Lye, 1997) were recorded for the Ethiopian flora. Five of the newly recoded species, except *A. bipartita,* were collected along all weather roads. *Dorstenia benguellensis*, *Hyparrhenia bracteata, Ochna leptoclada* and *Scleria greigiifolia* were collected from the same locality (Figure 1), about 21-28 km along the road from the capital town of Benishangul Gumuz Region (Asosa) to Addis Ababa. This locality is locally known as '*Anbesa Chaka'*-Lion forest, previously well known site to see Lion (Figure 3). Recently this site is reduced to a patch of *Oxthenthera abyssinica* woodland by the pressure from settlers. Detailed botanical exploration to this site and other inaccessible areas in Benishangul Gumuz is recommended to come up with complete information on the plants in Benishangul Gumuz Region in particular and Ethiopian flora in general.

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V

Escape of introduced ornamentals in Asteraceae - with main focus on *Tagetes patula* L. in western Ethiopia

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ABSTRACT

Plants species are introduced to new localities to meet the needs of growing human population. Such introductions might increase biodiversity in the area, but most often lead to negative consequences when the plants become invasive. This study was carried out on an introduced ornamental - *Tagetes patula* which has escaped cultivation in Benishangul Gumuz Regional State (BGRS), western Ethiopia. Another introduced ornamental - *Zinnia elegans* and the native species - *Bidens prestinaria* were included in some of the experiments for comparison. Discussion made with the local people show that escape *T. patula* has no negative impact on their daily life, except weeding in farmlands. *Tagetes patula* was associated with species that prefer shade and moisture in semi-natural vegetation. It produces a large number of small diaspores, has a seed bank and trampling stimulates growth of side shoots. It is well known that most invasive plants share these characters. The result of fire simulation experiment, however, revealed that fire had an effect on seed germination as there was no seed germination under higher temperature treatment (120ºC/5 minute). From this finding, it is possible to conclude that the annual fire existing in the woodlands of BGRS may not allow invasion by species which is not adapted to fire, like *T. patula* and *Z. elegans.* In the absence fire or at least when the temperature is low, invasion of the woodland vegetation in BGRS is inevitable.

Key Words and Phrases: Biodiversity, Fire, Soil Seed Bank, Invasive Species
Abbreviation: BGRS = Benishangul Gumuz Regional State

INTRODUCTION

The human population is increasing every year, particularly in tropical and subtropical regions. Plant species have been and are being introduced all over the world to meet ever increasing human needs. Even many of the major crops that sustain the human population have been introduced species (Pimentel et al. 2000) and have given clear benefits to humans all over the world (Myers and Bazely 2003). Also ornamentals are intentionally introduced and as there is a public demand for new and exciting species (Mack and Lonsdale 2001). These encourage gardeners and horticulturalists to frequently and intentionally spread ornamental plant species (Reichard and White 2001).

Introductions of alien species in an area might have unexpected consequences in several respects, but a general predictive theory of species invasions is lacking (Peterson and Vieglas 2001). The species which are useful in some areas are not necessarily a success in other areas. Under unfortunate circumstances, species that have given positive contributions somewhere, may escape proper management and become invading weed elsewhere (Hailu Shiferaw et al. 2004). Introductions might have serious consequences for ecological, economic and social systems. Once an invasive species becomes established, its control may be difficult and eradication sometimes impossible (Pimentel et al. 2000). Moreover, the impact of invaders on natural communities, i.e. biodiversity and ecosystem processes, can be serious (Chapin et al. 2000, Hailu Shiferaw et al. 2004). Exotic weeds in conservation areas are increasingly recognized as representing a major threat to the preservation of biodiversity, and can profoundly alter ecosystem structure and function (Cronk and Fuller 1995). In extreme situations introduced species might (on a global scale) contribute to a biodiversity crisis. On a regional scale the introduced species may outcompete native vegetation and become annoying or devastating weeds in farmlands. If the ecological conditions are favorable, exotic weeds can become very aggressive in their new habitat (Mack et al. 2000). The reason for this is that they often outcompete natural species not adapted to competition. They also lack the “natural enemies”, such as insects that feed on the plant and pathogens that cause diseases that kept them in check in their native range. The actual invasion of an environment by new species is influenced by three factors (Lonsdale 1999): (1) the number of propagules entering the new environment, i.e. propagule pressure; (2) the characteristics of the new species; (3) the susceptibility of the environment to invasion by new species, i.e. invasibility. Many invasive plants are efficient seed producers. This contributes to their local reproduction, as well as their potential for dispersal (Gross 1990). A persistent seed bank might also facilitate invasion.

Whether fire facilitates invasions by introduced species is disputed (Myers and Bazely 2003). Fire may cause extinction of invasive species, but recovery from fire is a balance between immigration and extinction (Collins et al. 1995). Vegetation in eastern African savanna areas often burns at least once a year, usually following the onset of the dry season. Subsequent fires are generally patchy because of the discontinuity of fuel, differences in relative moisture and wind intensity (Menassie Gashaw and Michelsen 2002). In general fire has an important impact in shaping biodiversity patterns in Africa (Getachew Tesfaye et al. 2004).

The vegetation in Benishangul Gumuz Regional State (BGRS), situated in the western Ethiopia, has been burning annually and the plants show several adaptations to fire (Jensen and Friis 2001, Menassie Gashaw and Michelsen 2002). Much of the natural vegetation in this region is still nearly intact, but the area has generally become more accessible because of increased road development. The spread of any introduced plant species in this kind of environment might have serious consequences.

Most gardens in BGRS are dominated by useful plant species, e.g. vegetables, spices, tobacco, or species which give shade. Some gardens also include ornamental plants such as *Tagetes patula* L., *Canna indica* L., *Lantana camara* L., *Zinnia elegans* Jacq., *Datura metel* L., and *Brugmansia arborea* (L.) Lagerh. They are all introduced plants. *Tagetes patula* and *Z. elegans*, both in the family Asteraceae, are the only introduced ornamentals which have been noticed outside gardens, spreading into woodlands. This study was, therefore, conducted to investigate ecological and biological factors that may facilitate invasion by *T. patula* in western Ethiopia. The introduced ornamental *Z. elegans* and the native species *Bidens prestinaria* (Sch. Bip.) Cufod. were included in some of the experiments for comparison.

MATERIALS AND METHODS

Study site

The fieldwork was undertaken in Bulen, Dibatie and Mandura districts of BGRS, western Ethiopia where *Tagetes patula* was found as an escape over large areas (Figure 1). BGRS is bordered by Amhara Regional State to the north, Oromiya Regional State to the east and south, and the Republic of Sudan to the west. The topography is characterized by a rolling terrain, sloping relatively gently but sometimes dropping steeply from an average of ca. 1800 m in the Ethiopian highlands (to the east), to 500-700 m close to the lowlands of Sudan (Sebsebe Demissew et al. 2005). The climate in the region is characterized by a single maximum rainfall that runs from April/May to October/November. The average annual precipitation varies from 900 to 1500 mm. The mean monthly minimum and maximum temperature varies from 14 ^{o}C to 18 ^{o}C and 27 ^{o}C to 35 ^{o}C, respectively. The variation is strongly correlated with altitude (Sebsebe Demissew et al. 2005).

Target plants

The genus *Tagetes* includes about 50 species which are indigenous in an area stretching from the south-western United States to Argentina. The greatest diversity of the genus is found in south-central Mexico. Three species of *Tagetes* are introduced to Ethiopia. Two of them, *Tagetes patula* and *T. erecta* L. are cultivated ornamentals. The third species, *T. minuta* L. is a noxious weed of farmlands, waste places and roadsides, and is found all over Ethiopia (Mesfin Tadesse 2004). *Tagetes patula* (Figure 2a) is used to color foods (butter, cheese, etc.) and as a fabric dye in some parts of Africa and India. In addition the leaves are used as a seasoning in central Africa, and the dried flowers are sometimes used to adulterate saffron. The whole plant is harvested when in flower and distilled for its essential oils. The oil is used in perfumery and has also a wide range of biological activities (Romagnoli et al. 2005). The plant grows in full sun and is according to Gilman (1999) not known to be invasive.

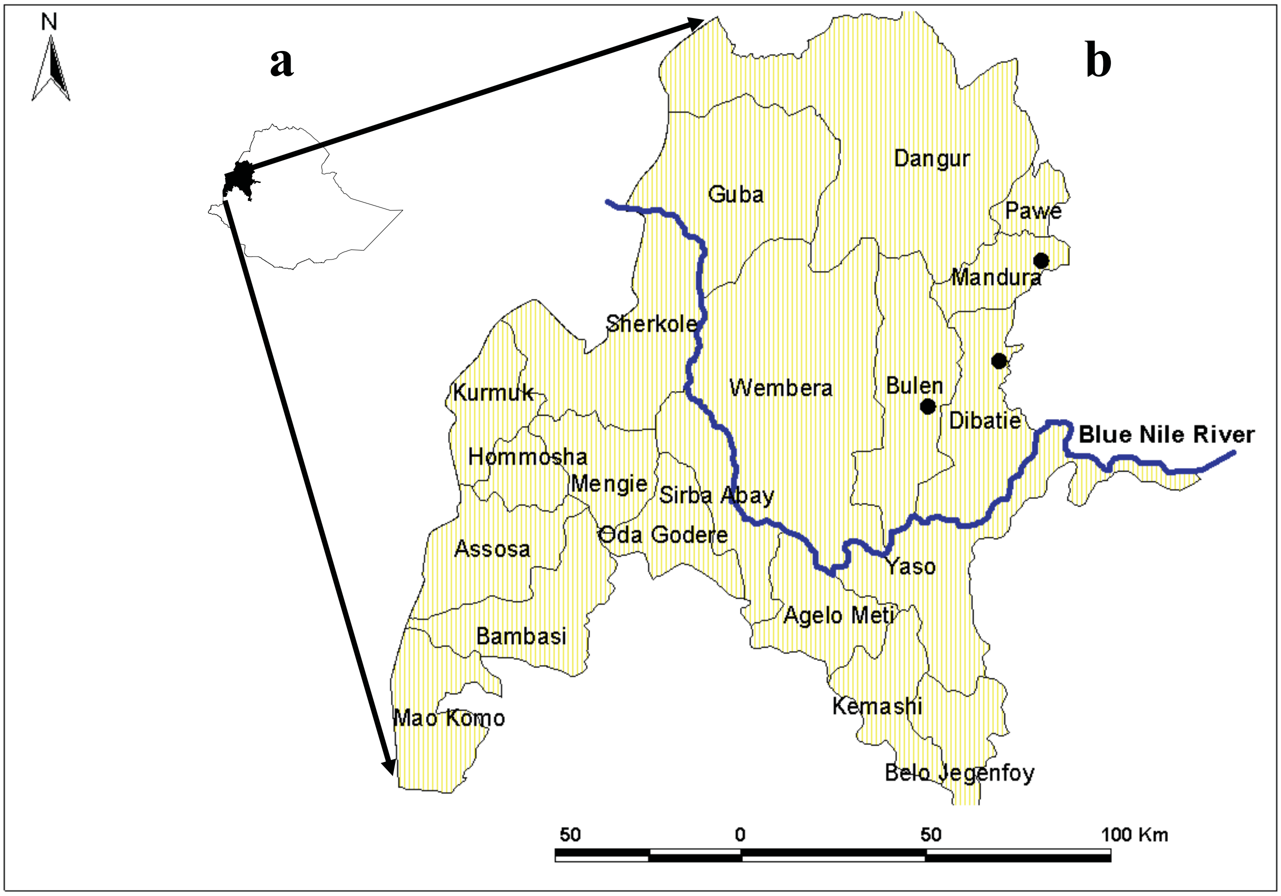

Figure 1. Map of Ethiopia (a) and Benishangul Gumuz Regional State showing districts (b). Sampling sites are indicated by dots.

The genus *Zinnia* includes about 23 species. They are mainly native to North America. Only two species, *Zinnia elegans* and *Z. peruviana* (L.) L. are known to occur in Ethiopia (Mesfin Tadesse 2004). *Zinnia elegans* (Figure 2b) is a widely cultivated ornamental plant throughout the world. It is not known to be invasive, but it has been recorded escaped in the central part of Ethiopia (Mesfin Tadesse 2004) and about 31.2 km east of Asosa in BGRS.

The genus *Bidens* contains about 340 species. The tropical and subtropical regions of North and South America and Africa are diversity centers of the genus. About 20 species are found in Ethiopia (Mesfin Tadesse 2004). *Bidens prestinaria* (Figure 2c) grows in short grassland, gentle mountain slopes, and on river and stream banks. The species is also extending into the margins of arable land and is sometimes found along roadsides from 950 to 2850 m in

Ethiopia (Mesfin Tadesse 2004). *Bidens prestinaria* was included in this study for comparison as it is endemic for Ethiopia and Sudan.

a b c

Figure 2. Flowers of the three study species Benishangul Gumuz Regional State: a) *Tagetes patula,* b) *Zinnia elegans* (Photos: first author, October 2005) and c) *Bidens prestinaria* (Photo: second author, October 2005).

Data collection

Information from local people

A reconnaissance survey was made in July 2004 and vegetation stands that had been invaded by *Tagetes patula* were found in Bulen, Dibatie and Mandura districts of BGRS. In October 2005, one site was selected from each district for detailed study. In the three study sites people were interviewed about the positive and negative effects of the target plants, when it arrived (for *T. patula*), if it was of any use, if it was eaten by animals, if it was actively or passively spread. *Zinnia elegans* was not found in the three districts and was not included in the interview.

Species association analysis

In each site, transects were laid from the roadside towards more or less natural woodland and the percentage cover of all plants in 2m X 2m quadrats were recorded. A total of 26 quadrats were sampled at an interval of 25m along transects. GPS was used to record the altitude, latitude and longitude of each quadrat. All plant specimens were collected and identified by comparing with authenticated herbarium specimens and with the help of written descriptions at the National Herbarium (ETH). All specimens were deposited at ETH and the Institute of

Biodiversity Conservation/Ethiopia. Nomenclature follows Hedberg and Edwards (1989), Phillips (1995), Edwards et al. (1995, 1997 and 2000), Hedberg et al. (2003 and 2006) and Mesfin Tadesse (2004).

Seed production

To determine the number of seeds produced per capitula during the flowering period, inflorescences of all *Tagetes patula* and *Bidens prestinaria* plants in the association analysis quadrats were collected. The capitulas were opened and the number of diaspores per head was counted.

Fire simulation experiment

The diaspores of *Tagetes patula, Zinnia elegans* and *Bidens prestinaria* were collected from ripe inflorescences for fire simulation experiment. All the diaspores were collected from naturalized or naturally existing plants. The diaspores were cleaned and sorted out by selecting the ones without evidence of insect and fungal damage, and then the most mature diaspores were chosen for the experiment, which was carried out at the University of Oslo. About five weeks after collection, ten diaspores were randomly chosen from each species and subjected to heat treatment according to six different prescriptions: 60, 90, and 120 ºC, for 1 and 5 minutes duration (treatments denoted: control, 60ºC/1 minute, 60ºC/5 minute, 90ºC/1 minute, 90ºC/5 minute, 120ºC/1 minute and 120ºC/5 minute, respectively). These are temperatures likely to be reached at the soil surface or the first few centimeters below ground in savanna fires (DeBano et al. 1998). Mechanical scarification and sulpheric acid treatments may be used to simulate fire, and are sometimes preferred to alternative treatments of hot water or dry heat treatments (Cavanagh 1987). The dry heat treatment was chosen for comparison with other studies conducted in Ethiopia using the same method (Menassie Gashaw and Michelsen 2002). Dry heat treatments were accomplished in an oven, with rapid insertion and removal of an aluminum tray containing the diaspores. For each species, a total of 350 diaspores in five replicates of sets of 10 diaspores were used. Untreated diaspores were used as control (stored at 20 ºC), with the same number of replicates as that of the other, higher temperature treatments (Menassie Gashaw and Michelsen 2002). Treated and untreated diaspores were soaked in water on a filter paper in a Petri Dish. Ten diaspores were placed in each Petri Dish.

The Petri Dishes were placed in a thermo regulated greenhouse with an average temperature of 26 ºC during the day (12 h) and 20 ºC during the night, to create simulated environment similar to the field. The filter papers were moistened every day for the first month, and then every third day till the end of the experiment. Seeds were considered to have germinated when the radicle penetrated the seed coat. Germination was recorded daily the first two weeks, after this every third day. The germinated seeds were removed from the Petri Dishes. The experiment ended after 18 weeks.

Soil seed bank

Soils samples were collected from three sites dominated by *Tagetes patula* and *Bidens prestinaria.* "Site 1" was a woodland dominated by *T. patula* (6 soil samples) and situated about two km south of the Bulen town in Bulen district, "Site 2" was a hilly area dominated by a combination of both *T. patula* and *B. prestinaria* (5 soil samples) and situated about one km north of Dibatie town, and "Site 3" was a field dominated by *B. prestinaria* (5 soil samples) and situated about one km south of Dibatie town. Both "Site 2" and "Site 3" were located in Dibatie district. The soil samples were taken underneath the target species. The surface of the soil was weeded, and the uppermost layer (ca. 0.3cm) removed. Two fairly close 10 x 10 cm blocks of soil, 4 cm deep were collected, and bulked. The soil samples were air-dried in the sun, and roots, rhizomes, tubers, undecomposed litter and plantlets were removed. The soil samples were stored in paper bags and transported to the University of Oslo. Then, sixteen black trays (53 x 32 cm) with holes were filled (half their depth) with a fresh sterile soil and perlite mix. The soil was compressed a bit, and then watered. The soil samples collected for soil seed bank study were distributed on top. The trays were watered and placed in the same greenhouse used for fire simulation experiment (mentioned above). The soil samples were watered once every day. Emerging seedlings were recorded, tagged and potted on until they could be taxonomically identified. All flowering plants were pressed, identified and deposited in the National Herbarium (ETH) of Addis Ababa University. Mosses were not included in the study.

Data analysis

The percentage cover data on plant species composition were transformed to ordinal transform values (OTV) (van der Maarel 2005), and analyzed using a FORTRAN Computer Program TWINSPAN, TWo-way INdicator SPecies ANalysis, Version 1.0 (Hill 1979). TWINSPAN is a divisive polythetic method of vegetation classification. It classifies both samples and species. Four samples (14, 18, 21 and 22) became outliers, it was not possible to determine their exact position, and they were omitted. The number of pseudospecies cut levels was set to 3. The cut levels were 1, 3 and 6. The maximum number of species in the final tabulation was set to 40, in this way rare and common species were excluded from the final ordered two-way table. The default option was used in the rest of the analysis. One Way ANOVA statistics was used to find out if there were significant different germination fractions in the heat treatments in PAST (Ryan et al. 1995).

RESULTS

Information from local people

All people interviewed explained that *Tagetes patula* had been present in the study area for more than twenty years. In most places it was just called "the plant", but in one location outside Dibatie it was called the "*Derg weed*", where *'Derg'* refers to the political period that took place from 1974 to 1991 in Ethiopia. The main use of the species was as an ornamental and negative impact was not mentioned, except weeding in farmlands. A general consensus among people on how *T. patula escape* was that the seeds had been deposited into farmlands with manure which is usually composed of wastes of garden cleaning, ash and cattle dung. Then, the plant takes its way from farmlands into grazing fields and finally reached semi-natural vegetation. None of the interviewed people could confirm that it was eaten by animals.

The people interviewed about the importance of *Bidens prestinaria* in the local environment explained that the species was important in the production of honey. It has a popular name *"Adey Abeba"* in Amharic (National language of Ethiopia) and "*Egile"* in Gumuz (local language). Honey collected on a special day, the 1st of October in the Ethiopian calendar (11th

of October Gregorian calendar) is believed to have a particular medicinal effect, and is not sold in stores, but kept for the family. Around this date the landscape is completely dominated by *B. prestinaria* and the plants are accordingly the most important contributor to honey production. It is weeded from farmlands, but is otherwise left undisturbed by man. *Bidens prestinaria* is grazed by domestic animals in areas where grasses are scarce.

Species association analysis

A total of 114 plant species, belonging to 38 plant families, were found in the 26 quadrats sampled to analyze plants associated with *Tagetes patula* (see appendix I). The most species rich families were Poaceae (24 species), Asteraceae (14) and Fabaceae (10). Thirteen families contain 2 to 7 species while the rest 22 families contain one species only.

The ordered two-way table from TWINSPAN (Table 1) shows the plant associations obtained by the analysis. The species on the top are more abundant on the left side of the primary division than on the right side. The species on the bottom are more abundant on the right side of the primary division than on the left side. The species in the middle are somewhat constant, occurring widely on both sides. TWINSPAN used two species, *Centella asiatica* and *Asterolinon adoense*, as an indicator species to demarcate the group of samples to the left of the primary division ("Association 1"). On the other hand *Bidens biternata* and *Rhynchosia nyasica* were used as an indicator species for the right side of the primary division "Association 2". The species in "Association 1" are mainly herbs, except *Ziziphus abyssinica,* which is shrubby. In "Association 2" three tree species *Acacia hecatophylla*, *A. polyacantha* and *Ficus sycomorus* were found in addition to one shrubby species, *Flueggea virosa.* Weedy species are found in both associations; *Guizotia schimperi* and *Galinsoga quadriradiata* in "Association 1", and the grasses *Eleusine africana*, *Panicum atrosanguineum* and *Penisetum polystachyon* in "Association 2". Only two plots (24 & 25) were sampled from undisturbed natural vegetation and they were linked to "Association 2". Only one, of the mentioned weeds (*G. quadriradiata*) was found in these plots. *Tagetes patula* was not found in these two plots.

Table 1. The ordered two-way table from TWINSPAN showing the plants associated with *Tagetes patula.* The main divisions of the species and samples are indicated by horizontal and vertical lines, respectively. Values indicate a scale of abundance, with absence represented by -.

	Samples		
Species	**1 5680271349**	**212112111122 690233156745**	
Brachiaria brizantha	1-1111111-	------------	
Asterolinon adoense	122122--22	------------	
Centella asiatica	2333332323	------------	
Spermacoce chaetocephala	2122111---	---1--------	
Guizotia schimperi	333233-333	---1--------	
Paspalum scrobiculatum	22-121-111	---2--------	
Sporobolus piliferus	322211-11-	-2-----2----	
Chloris pycnothrix	2-12------	-2----1-3---	**Association 1**
Eragrostis schweinfurthii	-2-1-1----	--23--------	
Justicia ladanoides	-11-111-11	---1--------	
Commelina subulata	-11-122111	-1-1--1-----	
Aneilema hirtum	--1-112111	1-----------	
Ziziphus abyssinica	---133--3-	--2---------	
Crotalaria ononoides	----2-332-	------3-----	
Galinsoga quadriradiata	----1-2122	----------11	
Plectranthus sp.-Coll.1427	---1112111	---22-11----	
Leucas martinicensis	-111-1212-	1--1--112---	
Brachiaria semiundulata	-11211--11	3-22--22-1--	
Digitaria ternata	2221111211	-223--131---	
Trifolium rueppellianum	1221231211	1322--222---	
Setaria pumila	1-111-1111	2321-12121--	**Constant**
Bidens prestinaria	21--112141	-1-2-32323--	**Species**
Hygrophila auriculata	2112--232-	222--1--1-1-	
Ageratum conyzoides	111-11-321	21-2-1212--1	
Spermacoce sphaerostigma	122-221121	3-1221111-11	
Phyllanthus pseudoniruri	11-1211122	--11--1111-1	
Panicum atrosanguineum	1---------	-121---21---	
Tagetes patula	----13222-	3123333333--	
Acacia hecatophylla	------2---	----------33	
Oplismenus burmannii	------2--	-23-32----33	
Eleusine africana	-------1--	2332--113---	
Bidens biternata	--------1-	211222222221	**Association 2**
Polygala persicariifolia	--------1-	-11111---211	
Pennisetum polystachion	----------	3-22122-2---	
Flueggea virosa	----------	2-23323---33	
Rhynchosia nyasica	----------	-111--211311	
Acacia polyacantha	----------	-1-3132233--	
Ocimum trichodon	----------	--212-1321--	
Jasminum grandiflorum	----------	------23-3--	
Ficus sycomorus	----------	------3---33	
	Cluster 1	**Cluster 2**	

Seed production

An average number of diaspores per capitula were calculated based on 100 *Tagetes patula* and 20 *Bidens prestinaria*. The diaspores production and the average number of capitula per plot are given in Table 2. *Bidens prestinaria* has less florets in total per capitula (ca. 44) than *T. patula* (ca. 56). On the other hand, *B. prestinaria* has more flower heads per plot (ca. 10) than *T. patula* (ca. 4). Both species have a high diaspore production, *B. prestinaria*, however, have over twice as many diaspores per plot (ca. 455) compared to *T. patula* (ca. 225).

Table 2. Average diaspores production in *Tagetes patula* (n=100) and *Bidens prestinaria* (n=20), mean ± the S.D.

Parameters	**Tagetes patula**	**Bidens prestinaria**
No. of Capitula/Plot (4 m^2).	4.0 ± 4.6	10.4 ± 24.0
Average No. of diaspores /Capitula	56.2 ± 8.7	43.8 ± 7.8
Average No. of Diaspore/Plot (4 m^2).	Ca. 225	Ca. 455

Fire simulation experiment

The germination of the heat-treated diaspores of *Tagetes patula*, *Zinnia elegans* and *Bidens prestinaria* (control, 60ºC/1 minute, 60ºC/5 minute, 90ºC/1 minute, 90ºC/5 minute, 120ºC/1 minute and 120ºC/5 minute) was followed for 18 weeks. Within this time, the seeds of the three plant species in the experiment had germinated. *Tagetes patula* had the longest diaspores of the three species (Table 3). The seeds started germinating on the second day after heat treatment. The germination rate for diaspores exposed to higher temperatures was slightly lower compared to the control and no germination was observed in the diaspores treated at 120ºC/5 minute (Figure 3).. Mean total germination frequency in *T. patula* for all the treatments combined was 59% (± S.D. 17%).

Zinnia elegans had the heaviest diaspores (Table 3). *Z. elegans* required 91 days to germinate after heat treatment. Mean total germination frequency in *Z. elegans* for all the treatments combined was 81% (± S.D. 13%), with highest germination frequency in the 120ºC/1 minute treatment (98%). *Zinnia elegans* had the highest germination frequency in all treatments compared to the other species. The control treatment (78%) gave the lowest germination frequency of all treatments except the 120ºC/5 minute treatment (36%).

Bidens prestinaria had the lightest, and shortest diaspore (Table 3) and started germinating on seventh day after heat treatment. The last germination was registered 126 days after heat treatment. Mean total germination frequency in *B. prestinaria* for all the treatments combined was 29% (± S.D. 7%), which is the lowest frequency of the three species. *Bidens prestinaria* showed an increased germination frequency in the intermediate and higher heat treatments compared to the control treatment (20%). The 60ºC/1 minute treatment gave the highest germination frequency (42%).

One Way ANOVA was used on the data to find out if there were significant differences in germination frequency in the different temperature treatments. The total p-value between groups for *T. patula*, was 6.136E-11, there is therefore a significant difference between treatments to a confidence interval of at least 95%. The p-value between groups for *Z. elegans* was 3.09E-7, also significant, whereas the p-value for *B. prestinaria* was 0.3381, thus not significant.

Table 3. The characteristics of the diaspores of the three study species (mean ± S.D., n =10 per species).

Plant species	**Diaspore length (mm)**	**Diaspore weight (mg)**	**First day of germination**	**Duration of germination**
Tagetes patula	10.4± 0.6	1.9± 0.4	2. day	6 days
Zinnia elegans	6.3± 1.0	4.9± 0.8	3. day	91 days
Bidens prestinaria	6.0± 0.8	2.6 ± 2.4	7. day	126* days

* Experiment terminated

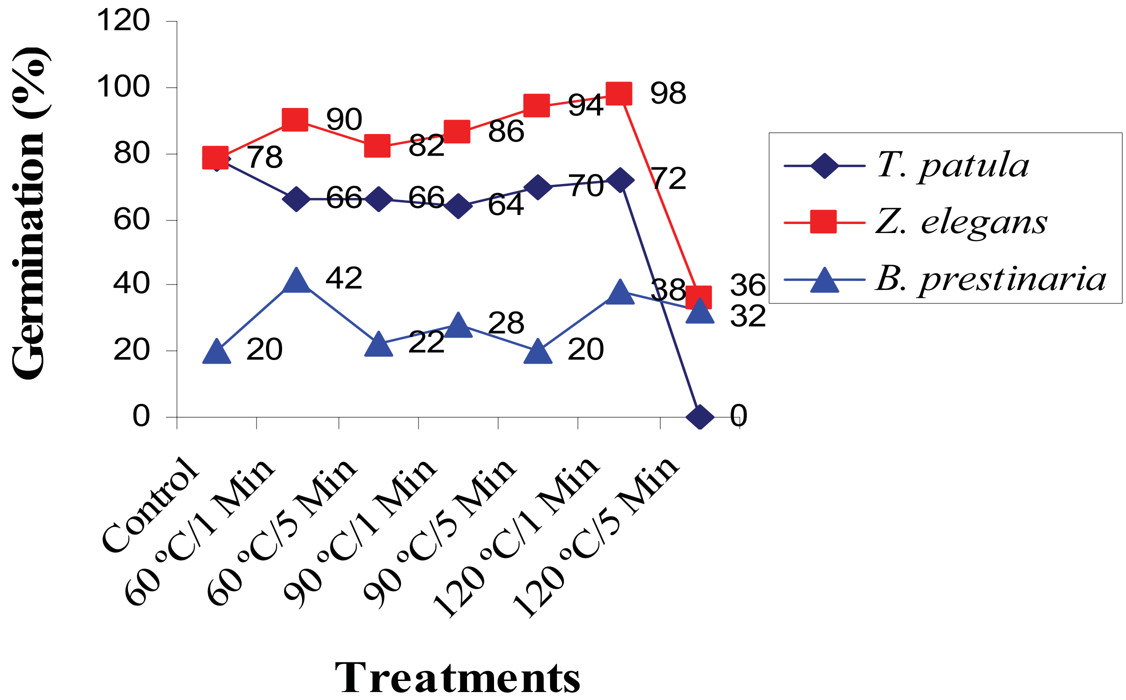

Figure 3. Germination rate for the three study species *Tagetes patula*, *Zinnia elegans* and *Bidens prestinaria* exposed to different heat shock treatments.

Soil seed bank

A total 1204 seedlings belonging to 37 species were germinated from the soil samples (see appendix I). Of these, 800 were recorded from seed banks in “Site 1”, 193 seedlings were recorded from seed banks in “Site 2”, and 211 seedlings were recorded from seed banks in “Site 3”. Both of the target species, *Tagetes patula* and *Bidens prestinaria* appeared in the seed bank, the former with 10 seedlings in total (7 in “Site 1”, and 3 in “Site 2”), and the latter with 16 seedlings in total (14 in “Site 1”, 1 in both “Site 2” and “Site 3”). Three different growth forms (grasses (7 species), herbs (27) and trees (3)) appeared in the seed bank and about 24 species were recorded in the field and also in soil seed bank while 13 were represented in the soil seed bank only.

DISCUSSION

The escaped populations of *Tagetes patula* were found over fairly large areas in Bulen, Dibatie and Mandura districts of BGRS at an altitudes from ca. 1100 m to ca. 1900 m. Garden populations are found in altitudes up to 2300 m. *Tagetes patula* was not observed as an escape at high altitudes where low temperatures possibly restricts its competitive potential. In addition, there might be less available niches at higher altitudes because of the higher density of people. Another reason for escapes, only at lower altitudes, might be that the species has existed in cultivation for a longer period here, and accordingly had more time to escape in these regions.

The species has been grown in gardens in the area for more than 20 years. The Amharic name "*Derg weed*" is associated with the political Derg period, during which *T. patula* has most likely escaped first and considered as a weed. Even since 2001, the area invaded by *T. patula* has apparently increased. It has repeatedly been shown that populations may increase according to a sigmoid curve after escape/invasion (Krebs 2001). Initially, the population grows more slowly in absolute size, reaches a maximum rate of increase near the middle of the curve, and grows slowly again as it approaches the asymptote of maximal density. Being recently introduced, *T. patula*, as an exotic colonizer, might be situated in the first slowly increasing phase of the curve, in which its impact is rather insignificant. The exponential part of the curve might not have been reached, but if/when such a phase is obtained, the impact on other species might increase considerably.

In the species association analysis, *T. patula* was not found in undisturbed/pristine woodlands and mainly found with high abundance in "Association 2" which was characterized by trees and species that demand some shade and moisture (Edwards et al. 1995, 1997 and 2000; Hedberg and Edwards 1989; Phillips 1995; Hedberg et al. 2003 and 2006; Mesfin Tadesse 2004). It was less frequent in "Association 1" which, as judged from the species composition represents open and drier habitat types. Both associations where *T. patula* occurs include weedy species, indicating that a certain amount of disturbance has taken place. Thus, *T. patula* prefers disturbed areas, but are rare in sun exposed and dry areas. *Bidens prestinaria* was found in both associations, and appears to be indifferent when it comes to conditions separating “Association 1” and “Association 2”. Observations revealed that it often co-occurs with *T. patula* in open landscapes, and in such situations *B. prestinaria* tends to dominate. In the situation of co-occurrence *B. prestinaria* might create the necessary shade regime for *T. patula*.

The ability to produce relatively high numbers of small diaspores might be among important factors that contributed to the apparent success of *T. patula* as invader in BGRS. It has been suggested that the size of diaspores represents a compromise between the requirement for dispersal, which would favor small diaspores and the requirement for seedling establishment, which would favor large diaspores (Hailu Shiferaw et al. 2004). For plants like *T. patula*, occurring in more or less disturbed sites where open ground is created relatively frequently, a large number of small diaspores might be more important than large diaspores with elaborate dispersal mechanisms. The relatively small size of *T. patula* diaspores facilitates burial because they might easily filter into cracks or small openings that often are created in disturbed soil. The cypselas of *T. patula* have no distinct adaptations for being dispersed by either wind or animals. In comparison to *T. patula*, *B. prestinaria* produced approximately twice as many diaspores per plot. This implies that *B. prestinaria* might have a better dispersal potential than *T. patula*. In addition, *B. prestinaria* has distinct hooks on the cypsela, obviously adapted to more efficient ectozoochory.

Results from the fire simulation experiment revealed that 78% of *T. patula* seeds in the study germinated from the control, while germination was lower for diaspores treated with different dry heat treatments (except the highest temperature impact -120ºC/5 minute in which there was no germination at all). The statistical analysis also revealed that only the higher temperature treatment has significant impact on the seeds of *T. patula.* This suggests that the diaspores, to a certain degree will withstand heat, unless the heat becomes excessive.

Zinnia elegans showed a higher germination frequency than *T. patula* in all heat treatments. Even though some diaspores treated at the highest temperature impact survived, the germination rate was significantly lower compared to the other treatments. This suggests that

Z. elegans cypselas have a higher heat resistance than *T. patula*. This might be related to the fact that *Z. elegans* has the thickest cypsela wall of the three study species.

Bidens prestinaria showed no sign of being affected by the different heat treatments, as the difference between the control and the harshest treatment was more or less the same. However, relatively elevated germination frequency at 60ºC/1 minute treatment supports the findings of Menassie Gashaw and Michelsen (2002) where a brief exposure of diaspores of some species in fire prone area to fire resulted in higher germination frequency. Being an indigenous species in fire prone area, *B. prestinaria* might have been adapted to natural fire regimes through evolution.

The soil seed bank sample areas were categorized into three groups: most *T. patula* seedlings germinated from soil banks from “Site 1”- the *T. patula* dominated woodland. Although *B. prestinaria* was not dominant in this site, many seeds germinated from the soil sample. This might be due to the fact that this species is widespread and has been in the area “always”. Seedlings of both species were also observed in soil sample collected from “Site 2” - *T. patula* and *B. prestinaria* dominated hill and “Site 3” - *B. prestinaria* dominated field. The density of viable seeds recovered from soil samples collected at the study sites indicates that both *T. patula* and *B. prestinaria* accumulates seed reserves in the soil. Relatively small seeds are characteristic of species which have persistent seed banks in the soil (Thompson and Grime 1979; Demel Teketay, 1998). These reserves serve as one way of regeneration/invasion ensuring recruitment of seedlings in the event of disturbance. Studies conducted in Ethiopia have shown that many, particularly early successional plant species, possess numerous long-lived soil seed banks, which contribute to their perpetuation after disturbance (Demel Teketay, 1998, Hailu Shiferaw et al. 2004). The longevity of the seeds of both species seed bank is, however, not known.

CONCLUSION

The introduced and escaped species, *Tagetes patula* has several characters that might enhance its invasive ability and it might be considered as a potential threat to at least grazing fields the natural landscapes in western Ethiopia. It produces a large number of relatively small diaspores, has a seed bank and grazing/trampling stimulates growth of side shoots. It is well known that most invasive plants turning weedy, share these characters. From the result of fire simulation experiment, however, it is possible to conclude that the annual fire existing in the woodlands of western Ethiopia may not allow invasion by species which is not adapted to fire, like *T. patula* and *Zinnia elegans.* In the absence of annual fire or at least when the temperature is low, invasion of the woodland vegetation in BGRS might be inevitable. If fire is intended to be used as a control method, temperatures/time regimes similar to the harshest experimental treatment (120ºC/5 minute) might be necessary to control invasion. Some other ways to control the invasion of *T. patula* may include pulling up the plants or cutting the plants near the ground. All methods would have to be repeated over several years because of the soil seed banks which provide seeds for germination under favorable conditions. So far *T. patula* has no impact on the daily life of the local people and they like it as it is an ornamental species. They are not aware of the potential invasiveness of the species. It is necessary to inform people about the species characters and what will happen if its growth increases exponentially. When people become aware of the situation, it will be easier to propose possible management methods. It is also beneficial to inform people about the economical importance *T. patula* elsewhere so that they would have control over it and limit its further invasion. Introduction of techniques for collection and extraction of essential oils are may be advantageous in regards to both control and economic development in BGRS in particular, and Ethiopia in general.

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Appendix I. List of plant species sampled to analyze plants associated with an escape *Tagetes patula* in Benishangul Gumuz Regional State.

S. No.	Botanical names	Family	Collection No.§
1	*Acacia hecatophylla* Steud. ex A. Rich.	Fabaceae	1563
2	*Acacia polyacantha* Willd. *	Fabaceae	1523
3	*Acalypha villicaulis* A. Rich.	Euphorbiaceae	1547
4	*Achyranthes aspera* L. **	Amaranthaceae	1589
5	*Acmella caulirhiza* Del. *	Asteraceae	1470
6	*Ageratum conyzoides* L. *	Asteraceae	1481, 1552
7	*Aira caryophyllea* L.	Poaceae	1478b, 1503
8	*Albizia malacophylla* (A. Rich.) Walp.	Fabaceae	1574
9	*Alysicarpus rugosus* (Willd.) DC.	Fabaceae	1531
10	*Aneilema hirtum* A. Rich.	Commelinaceae	1448
11	*Annona senegalensis* Pers.	Annonaceae	1518
12	*Anogeissus leiocarpa* (A.DC.) Guill. & Perr.	Combretaceae	1579
13	*Arthraxon micans* (Nees) Hochst. *	Poaceae	1489
14	*Asterolinon adoense* Kunze *	Primulaceae	1464, 1473
15	*Bidens biternata* (Lour.) Merr. & Sherff	Asteraceae	1486, 1534
16	*Bidens pilosa* L. *	Asteraceae	1575
17	*Bidens prestinaria* (Sch. Bip.) Cufod. *	Asteraceae	1487, 1551
18	*Brachiaria brizantha* (A. Rich.) Stapf *	Poaceae	1457
19	*Brachiaria semiundulata* (A. Rich.) Stapf	Poaceae	1466
20	*Bulbostylis hispidula* (Vahl) R. Haines	Cyperaceae	1500
21	*Celosia trigyna* L. **	Amaranthaceae	1603
22	*Centella asiatica* (L.) Urban *	Apiaceae	1453
23	*Chloris pycnothrix* Trin.	Poaceae	1499
24	*Chloris virgata* Sw. **	Poaceae	1597
25	*Clematis hirsuta* Guill. & Perr.	Ranunculaceae	1536
26	*Combretum collinum* Fresen.	Combretaceae	1580
27	*Commelina imberbis* Ehrens. ex Hassk. *	Commelinaceae	1483b
28	*Commelina latifolia* Hochst. ex A. Rich.	Commelinaceae	1483a
29	*Commelina subulata* Roth	Commelinaceae	1456
30	*Cordia africana* Lam. **	Boraginaceae	1608
31	*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore	Asteraceae	1444
32	*Crotalaria ononoides* Benth.	Fabaceae	1494
33	*Croton macrostachyus* Del.	Euphorbiaceae	1578
34	*Cucumis prophetarum* L.	Cucurbitaceae	1561
35	*Cynodon dactylon* (L.) Pers.	Poaceae	1542

Appendix I. Continued…

S. No.	Botanical names	Family	Collection No.§
36	*Cyperus divulsus* Ridley	Cyperaceae	1479
37	*Cyperus flavescens* L.	Cyperaceae	1462
38	*Cyperus metzii* (Steud.) Mattf. & Kük.	Cyperaceae	1463
39	*Cyperus sesquiflorus* (Torr.) Mattf. & Kük.	Cyperaceae	1507
40	*Cyphostemma adenocaule* (Steud. ex A. Rich.) Descoings ex Wild. & Drummond	Vitaceae	1570
41	*Cyphostemma cyphopetalum* (Fresen.) Descoings ex Wild. & Drummond	Vitaceae	1459
42	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	1556
43	*Dicrocephala integrifolia* (L. f.) Kuntze *	Asteraceae	1490
44	*Digitaria ternata* (A. Rich.) Stapf *	Poaceae	1455, 1546
45	*Dioscorea bulbifera* L.	Dioscoreaceae	1577
46	*Diplolophium africanum* Turcz.	Apiaceae	1528
47	*Echinochloa colona* (L.) Link	Poaceae	1539
48	*Eleusine africana* Kenn. –O'Byrne	Poaceae	1484
49	*Entada africana* Guill. & Perr.	Fabaceae	1492
50	*Eragrostis schweinfurthii* Chiov.	Poaceae	1496a
51	*Eragrostis tef* (Zucc.) Trotter **	Poaceae	1601
52	*Ethulia gracilis* Del. *	Asteraceae	1553
53	*Euphorbia hirta* L. *	Euphorbiaceae	1497
54	*Ficus sycomorus* L. *	Moraceae	1517
55	*Fimbristylis dichotoma* (L.) Vahl	Cyperaceae	1465
56	*Flacourtia indica* (Burm. f.) Merr.	Flacourtiaceae	1573
57	*Flueggea virosa* (Willd.) Voigt	Euphorbiaceae	1520
58	*Galinsoga parviflora* Cav.	Asteraceae	1482
59	*Galinsoga quadriradiata* Ruiz & Pavon	Asteraceae	1449
60	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	1508
61	*Guizotia schimperi* Sch. Bip. ex Walp. *	Asteraceae	1525
62	*Hackelochloa granularis* (L.) Kuntze	Poaceae	1502
63	*Hibiscus calyphyllus* Cavan. **	Malvaceae	1609
64	*Hygrophila auriculata* (Schum.) Heine *	Acanthaceae	1477
65	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae	1545
66	*Hypoxis angustifolia* Lam.	Hypoxidaceae	1504
67	*Indigofera spicata* Forssk.	Fabaceae	1467, 1541
68	*Jasminum grandiflorum* L.	Oleaceae	1524

Appendix I. Continued…

S. No.	Botanical names	Family	Collection No.§
69	*Justicia ladanoides* Lam.	Acanthaceae	1521
70	*Justicia* sp. **	Acanthaceae	1587
71	*Kohautia tenuis* (S. Bowd.) Mabberley	Rubiaceae	1474
72	*Lactuca inermis* Forssk.	Asteraceae	1501
73	*Lannea fruticosa* (A. Rich.) Engl.	Anacardiaceae	1548
74	*Leonotis ocymifolia* (Burm.f.) Iwarsson	Lamiaceae	1446b, 1559
75	*Leucas martinicensis* (Jacq.) R. Br. *	Lamiaceae	1446a
76	*Lindernia nummulariaefolia* Wettst.	Scrophulariaceae	1471
77	*Lobelia inconspicua* A. Rich.	Campanulaceae	1472
78	*Lobelia* sp. **	Campanulaceae	1599
79	*Maytenus senegalensis* (Lam.) Exell	Celastraceae	1543
80	*Momordica foetida* Schum.	Cucurbitaceae	1566
81	*Nephrolepis undulata* J. Sm.	Oleandraceae	1512
82	*Nervilia kotschyi* (Rchb. f.) Schltr.	Orchidaceae	1511
83	*Ocimum trichodon* Baker ex Gürke	Lamiaceae	1530, 1537
84	*Oldenlandia corymbosa* L. **	Rubiaceae	1602
85	*Oplismenus burmannii* (Retz.) P. Beauv.	Poaceae	1476, 1538
86	*Oreoschimperella verrucosa* (A. Rich.) Rauschert	Apiaceae	1509
87	*Orobanche minor* Smith.	Orobanchaceae	1505
88	*Osyris quadripartita* Decn.	Santalaceae	1519
89	*Panicum atrosanguineum* A. Rich.	Poaceae	1495
90	*Panicum pusillum* Hook. f.	Poaceae	1454
91	*Panicum* sp. **	Poaceae	1611
92	*Paspalum scrobiculatum* L.	Poaceae	1468
93	*Pennisetum petiolare* (Hochst.) Chiov. *	Poaceae	1569
94	*Pennisetum polystachion* (L.) Schult.	Poaceae	1527
95	*Persicaria nepalensis* (Meissn.) H. Gross	Polygonaceae	1458
96	*Phyllanthus ovalifolius* Forssk. **	Euphorbiaceae	1612
97	*Phyllanthus pseudoniruri* Muell. Arg. *	Euphorbiaceae	1450
98	*Plectranthus* sp.	Lamiaceae	1447
99	*Plectranthus* sp.	Lamiaceae	1480
100	*Polygala persicariifolia* DC.	Polygalaceae	1488
101	*Rhus glutinosa* A. Rich.	Anacardiaceae	1515
102	*Rhynchosia nyasica* Bak.	Fabaceae	1522
103	*Schizachyrium brevifolium* (Sw.) Büse	Poaceae	1565

Appendix I. Continued…

S. No.	Botanical names	Family	Collection No.§
104	*Selaginella kraussiana* (Kunze) A. Br.	Selaginellaceae	1485
105	*Senecio* sp. **	Asteraceae	1614
106	*Senna obtusifolia* (L.) Irwin & Barneby	Fabaceae	1564
107	*Setaria pumila* (Poir.) Roem. & Schult	Poaceae	1452
108	*Sida alba* L.	Malvaceae	1554
109	*Sida ovata* Forssk.	Malvaceae	1469
110	*Sida urens* L.	Malvaceae	1491
111	*Solanum alatum* Moench. **	Solanaceae	1584
112	*Solanum incanum* L.	Solanaceae	1583
113	*Spermacoce chaetocephala* DC.	Rubiaceae	1493
114	*Spermacoce sphaerostigma* (A. Rich.) Vatke	Rubiaceae	1451, 1461
115	*Sporobolus africanus* (Poir.) Robyns & Tournay	Poaceae	1460b
116	*Sporobolus festivus* Hochst. ex A. Rich.	Poaceae	1496b
117	*Sporobolus panicoides* A. Rich.	Poaceae	1529
118	*Sporobolus piliferus* (Trin.) Kunth	Poaceae	1460a, 1498
119	*Stereospermum kunthianum* Cham.	Bignoniaceae	1544
120	*Syzygium guineense* (Willd.) DC.	Myrtaceae	1581
121	*Tagetes patula* L. *	Asteraceae	1277
122	*Thunbergia alata* Bojer	Acanthaceae	1506
123	*Trifolium rueppellianum* Fresen. *	Fabaceae	1445
124	*Triumfetta pilosa* Roth	Tiliaceae	1532
125	*Triumfetta rhomboidea* Jacq. *	Tiliaceae	1550, 1576
126	*Vernonia theophrastifolia* Schweinf. ex Oliv. & Hiern *	Asteraceae	1560
127	*Ziziphus abyssinica* Hochst. ex A. Rich.	Rhamnaceae	1582

§All collection numbers belongs to Tesfaye A. et al. and the herbarium specimens were deposited in the National Herbarium (ETH) of Addis Ababa University, Ethiopia.
*Plant species found both in the field and soil seed bank
**Plant species found in the soil seed bank only

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VI

Ethnobotany of Berta and Gumuz People in western Ethiopia

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Abstract
The way the Berta and Gumuz people use and manage the botanical resources of their surroundings was studied as part of research on plant diversity in western Ethiopia. Pre-prepared semi-structured and structured interviews were administered with open discussion and informal chatting to collect ethnobotanical information on useful plants. The interviews covered 125 informants, of which most were from farming families. The people provided information on 185 useful plant species that are the sources of food, medicine and other products essential for their livelihoods. The study showed that the people rely on assemblage of plants through cultivation of some (30%) and direct collection of others from wild stands (70%). Ethnobotanical knowledge of the people was related with age and educational level of the informants. Over harvesting of wild plants that give immediate economic returns, change in plant use due to increased dependence on fabricated materials, cultivation of crops in response to market and domestication of new plants are the areas that need intervention through *in-situ* and *ex-situ* conservation. The traditional conservation options that ensured the maintenance of the plant diversity and the indigenous knowledge base have to be encouraged and enhanced through application of modern approaches to of biodiversity conservation.

Key words: Benishangul, Biodiversity, Conservation, Domestication, Folk taxonomy

Introduction

Ethnobotany is the investigation of the biological, including the ecological basis of interactions and relationships between plants and people over evolutionary time and geographical space (Bye 1985; den Eynden et al. 1992). Specifically ethnobotany tries to find out how people have traditionally used plants in the past and are still using at present. Ethnobotanic studies allow documentation of important information that serve as base line data for future research and preservation of valuable traditional knowledge for both other communities and future generations.

Ethnobotany has been developed over the years from simple listing of useful plants into a new scientific field with appropriate methodology for documenting and studying society's indigenous/experiential knowledge on plants (Phillips and Gentry 1993a, b; Martin 1995; Maundu 1995; Cotton 1996; Höft et al. 1999). Also important is the development of quantitative methods and predictive models, rather than lists of species or anecdotal data (Cunningham 2001). Quantitative methods such as species use values also enable comparisons of use between vegetation types or ecological zones, between people of different ages, gender or occupation within or between communities (Cunningham 2001). Such methods and models can also lead to a more effective conservation of the remaining habitats.

The failure of conservation through establishment of strict protected areas due to conflicts with local people has increased the application of ethnobotany in conservation. Particularly information on ethnobotany becomes useful in the introduction of alternative resource management systems that involves local people - the key generators, custodians and promoters of local biodiversity (Rastogi et al. 1998; Berkes 1999). In recent years participation of local people is seen as crucial above all in discussions on sustainable resource use and sustainable development. The immediate and intimate dependence of indigenous people on the local plants and other natural resources in their environment contributed to the accumulation of a wealth of useful indigenous knowledge which is rooted in its environment. People-centered approaches which allow local participations are, therefore, becoming a prerequisite for sustainable conservation and management of natural resources (Stave et al. 2006).

Conservationists have also widely recognized that successful biodiversity conservation cannot fully be achieved unless the needs and the priorities of local communities, as well as traditional and indigenous resource use practices are understood and taken into account (Loudiyi and Meares 1993; United Nations Environmental Program 1994). This has stimulated the awareness that biodiversity conservation is not only conservation of natural resources but includes indigenous knowledge, cultural diversity and access to and the rights of indigenous people over natural resources (Hyndman 1993). The local communities in the developing countries still live in close intimacy with biological diversity, on the whole not only depending on it, but also conscious that they are part of it, and that all taxa have the right to continue existing. Since the local communities in the developing countries have both biological diversity and information on its use and management, it is necessary to tap valuable indigenous knowledge which is relevant to science and conservation (Stave et al. 2006).

This study is, therefore, initiated as part of research to generate data for plant diversity conservation planning and sustainable development of Benishangul Gumuz Regional State in Western Ethiopia. Vegetation in this region is part of *Sudanian center of endemism* named by White (1983) as *undifferentiated woodlands (Ethiopian type)* and characterized by broadleaved deciduous trees. The most common tree species are *Anogeissus leiocarpa, Balanites aegyptiaca, Boswellia papyrifera, Combretum collinum, Dalbergia melanoxylon, Lannea fruticosa, Lannea welwitschii, Lonchocarpus laxiflorus, Pterocarpus lucens, Piliostigma thonningii, Stereospermum kunthianum, Terminalia laxiflora* and *T. macroptera.* The solid-stemmed bamboo *Oxytenanthera abyssinica* is common on escarpments and hilly areas, while *Hyphaene thebaica* is a characteristic species in the lowland plain. The ground cover is dominated by herbaceous geophytes belonging to genera *Chlorophytum*, *Costus*, *Crinum, Dorstenia, Drimiopsis, Eulophia*, *Habenaria*, *Hypoxis* and *Ledebouria* at the beginning of rainy season (May and June). Toward the end of the rainy season (September to November) a tall stratum of perennial grasses belonging to the genera *Andropogon, Cymbopogon, Hyparrhenia, Rottboellia, Panicum* and *Pennisetum* become dominant. This vegetation has been adapted to annual fire which is mostly set by local people in December and January.

So far there is no area designated for any kind of conservation in Benishangul Gumuz Regional State. Some preliminary studies in this region have indicated the existence of unique flora that may even represent an evolutionary hotspot (Edwards et al. 2000; Cribb et al. 2002; Sebsebe Demissew et al. 2005, Tesfaye Awas and Nordal 2007). The Ethiopian Government, however, has recognized this area as suitable for both rainfed and irrigated agriculture, which should be urgently developed through implementation of integrated development plans (Ministry of Information 2001). The government is allocating land for agriculture, collection of natural gum and incense and extraction of marble. Conservationists are concerned that the new development plans may disrupt the proper functioning of ecosystem in general and the interaction of local people with indigenous plants in particular. It may also affect the livelihoods of local people, who are dependent on their immediate ecosystem. This study reports indigenous botanical knowledge and direction of change in local plant use among two dominant socio-cultural groups in Benishangul Gumuz Regional State - Berta and Gumuz people. The study focused on plants that are important in their lives including those that grow in the natural habitats as well as those maintained in the fields and homegardens under cultivation. It is hoped that the study provides baseline information that can be used in conservation planning and sustainable resource development programs in addition to documenting the cultural heritage of the people.

Materials and methods

Study area

The study was conducted in Benishangul Gumuz Regional State, Western Ethiopia, located between latitudes 09°17' and 12°06'N and longitudes 34°10' and 37°04'E (Figure 1). The capital town of the region (Asosa) is located at a distance of 687 km from Addis Ababa. The region is bordered by the Amhara Regional State to the north, the Oromiya Regional State to the east and south, and the Republic of Sudan to the west. The eastern parts of the region have an elevation of ca. 2,700 m. Elevation decreases gradually towards the western part to an average altitude of 500 m along the Ethio-Sudanese border. The region was established in 1995 by Constitution of the Federal Democratic Republic of Ethiopia (Constitution of the

Federal Democratic Republic of Ethiopia 1995). In the earlier administrative structure, the area south of the Blue Nile River was included in Welega administrative region while that north of the river was part of the Gojam region.

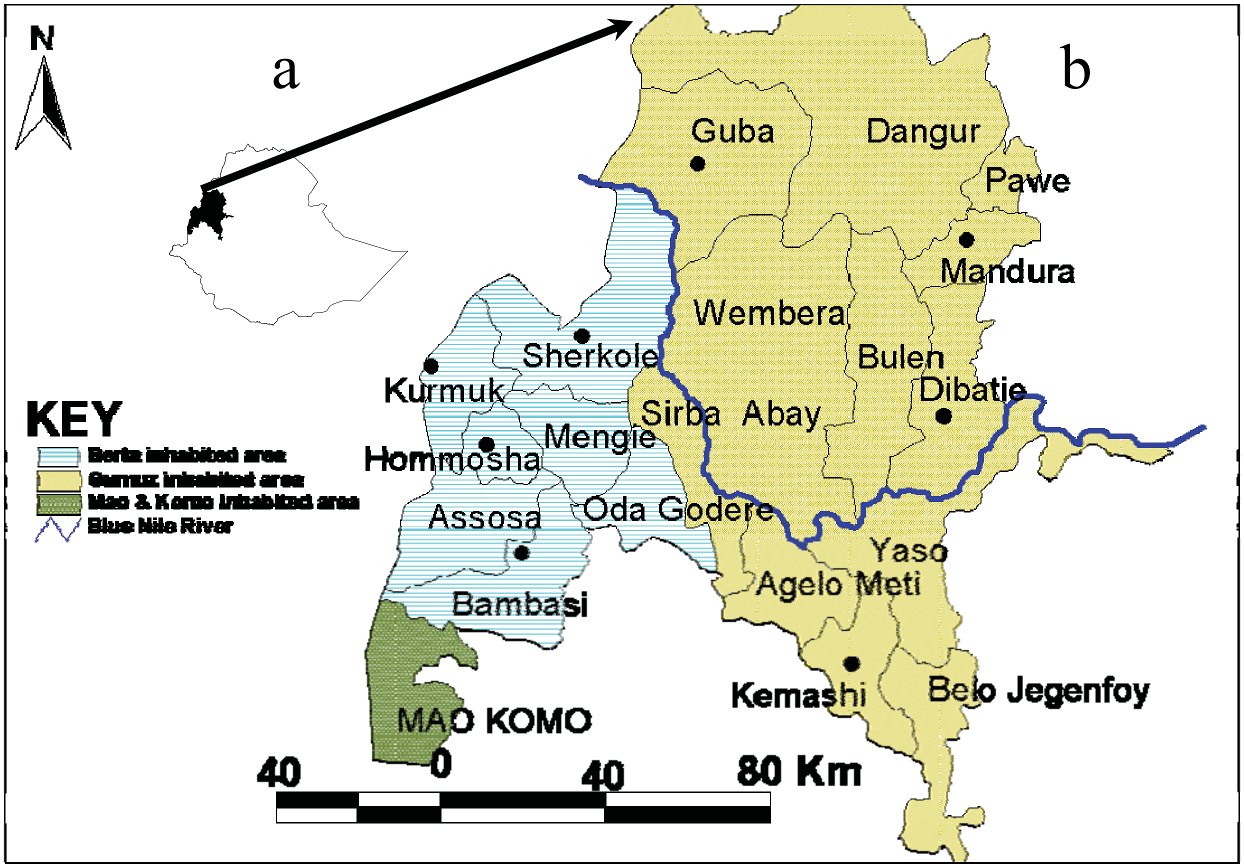

Figure 1. Map of Ethiopia (a) and Benishangul Gumuz Regional State showing districts (b). Sampling sites are shown by dots.

People

Berta and Gumuz people live both in rural and urban areas. Basically they are sedentary agriculturists, but rarely engage in animal husbandry due to Trypanosomiasis, participate in gold panning, bee keeping, fishing and commerce. The gold panning is done in traditional manner like other Nilotic people (Kurimoto 1996). Linguistically, the language of Berta and Gumuz people belongs to Nilo-Saharan language family.

According to the national population census carried out in October 1994 the population of Benishangul Gumuz Regional State was about 460,459 of which 92% live in rural areas (Central Statistical Authority 1995). This gives a density of 9 individuals per kilometer square while the overall for Ethiopia is 57.7. The same census has indicated: 26.7% are Berta (Jeblawi), 23.4% Gumuz, 22.2% Amahara, 12.2% Oromo, 6.9% Shinasha and others constituted 8.0%. The educational profile shows 18% is literate and 82% is illiterate. The high percentage of illiteracy and rural community indicate the high degree of dependence of the people on traditional life style. It is obvious that these numbers have changed over the past several years with the increased development underway in the region.

Berta and Gumuz live in geographically adjacent and similar habitats. Berta people live in the Asosa Zone, south of the Blue Nile River and had contacts with Gumuz, Mao, Komo and Oromo people. Amahara (settlers) are the only people in large population that live within Berta territory. All Berta people practice Muslim religion.

Gumuz live both on the northern and southern sides of the Blue Nile River, in Metekel and Kemashi Zones, respectively. Gumuz people have contacts with different people that live within and on various sides of their territory. In Metkel Zone Gumuz people live with Shinasha, Oromo, Agew-Awi and Amhara people. The Kemashi zone is totally occupied by Gumuz people except towns and marginal overlap with Oromo people. Gumuz people practice diverse religions of various doctrines of Christian, Muslim and indigenous religion.

Data collection

The data collections have been conducted in two phases. In the first phase, four districts were randomly selected for both Berta and Gumuz people. In each district one village was selected and visited three times, in October-November 1998, May-June 2001 and January 2002. Pre-prepared semi-structured interviews were administered with extended discussion by taking individual respondents, groups in which the people's representative officials and farmers' family were included. Observations were made in homegarden, farmland, rangeland and natural vegetation. The local names of plants and use were recorded on the spot when informants reach to consensus.

Plant specimens were collected and identified in the National Herbarium (ETH), Addis Ababa University by comparing with already identified specimens and using taxonomic literature at ETH. Identified plant specimens have been deposited at ETH and Institute of Biodiversity Conservation/Ethiopia. Nomenclature follows Hedberg and Edwards (1989), Phillips (1995), Edwards et al. (1995, 1997 and 2000), Hedberg et al. (2003 and 2006), and Mesfin Tadesse (2004).

In the second phase (October –November 2004 and July and October 2005), the botanical names were listed along their respective local names and used in preparing format for structured interview. The houses in each village were numbered starting from one corner and 20 of them were selected using random numbers. In each house one person (by alternating female and male) was interviewed about the part of the plant used, for what purposes and preference for market. Informants who were willing to respond to the questions were considered. A total of 125 informants (59 Berta and 66 Gumuz) were interviewed independently to avoid influence by others. Some social factors like age, gender and education were recorded during the interview. The informants were compensated for their time.

Data analysis

Information obtained from single informant was omitted as it has negligible scientific validity (Tippo 1989). Descriptive statistics were mainly used to summarize the data. The relationship of the number of plants used for construction, food, fuel wood, commercial purpose and medicine with informant's age and educational level were correlated using multivariate computer program PAST - PAlaeontological STatistics, ver. 1.56 (Ryan et al. 1995). The informant verse species matrix (with the number of use in the cell) was used as a raw data for Principal Component Analysis (Höft et al. 1999). The data was analyzed using PAST (Ryan et al. 1995), to see consistency of information given by informants, variation among individuals and social groups in using certain plant species.

Results

Diversity of useful plants

A total of 185 plant species that are used in the daily life of Berta and Gumuz people have been recorded (see Appendix I). About 131 genera in 58 flowering plant families were represented. Family Fabaceae accounted for 14% and followed by family Poaceae (9%), Solanaceae (4%) and the rest accounted from 0.5 to 3% of the total species. The highest proportion was covered by herbs (32.43%), followed by shrubs (27.03%), trees (23.78%), climbers (8.65%) and grasses (8.11%). About 30% of these plants are cultivated while 70% were collected from the wild. Two plant species, *Dioscorea bulbifera* and *Ricinus communis,* were found both under cultivation and in the wild. There are also three more plants, *Abelmoschus ficulneus, Hibiscus cannabinus* and *Corchorus olitorius,* which are very common in the wild stand but also tolerated in farmlands and homgardens. Generally from the total of 185 plant species, 29 % were used only by Berta people while 24% were only used by Gumuz people. About 47% of the plants are commonly used by Berta and Gumuz. This study, therefore, managed to document ethnobotanic information on 141 and 139 useful plants for Berta and Gumuz, respectively.

The plant part used were also diverse and include: bark, bulbs, fiber, flowers, fruits, inflorescence, leaves, nectar, resin, rhizome, roots, sap, seedlings, seeds, spines, stem, straw and tuber. Stem accounted for the highest proportion of useful part followed by leaves (Figure 2). Most of the plant species have many useful parts, where about 34% have two useful parts, 19.5% three, 11% four and 6.5% five. Only about 29% of the species has one useful part. *Coriandrum sativum* and *Jatropha curcas* are the two cultivated plants that have five useful parts each. Among wild plant species such as *Acacia polyacantha, Albizia malacophylla, Flueggea virosa*, *Gardenia ternifolia, Grewia mollis, Lannea fruticosa, Lannea welwitschii, Lonchocarpus laxiflorus*, *Momordica foetida* and *Sterculia africana* have five useful parts each.

Management and use of cultivated plants

From a total of 55 cultivated plants recorded, 56% were cultivated by both Berta and Gumuz while about 24% and 20% were cultivated only by Berta and Gumuz people, respectively. Cultivated plants were used for 18 purposes: broom, construction, cultural, fence, food, forage, fuel wood, greasing baking plate, hair-oil, honey production, medicinal, musical instrument, ornamental, shade, stimulant, tanning, tool handle and utensil. Berta and Gumuz use cultivated plants mainly for food and medicine (Figure 3). About 24% plant species are only cultivated for their food value. The rest 76% plants species are cultivated for two to eight uses. Among cultivated plants, the highest number of uses was recorded for *Ricinus communis*. This species has eight uses; fence, food, fuel wood, greasing baking plate, hair-oil, medicinal, musical instrument and tanning. Other cultivated plants with many uses include *Jatropha curcas* with seven, *Gossypium arboreum* with six and *Melia azedarach* with five uses.

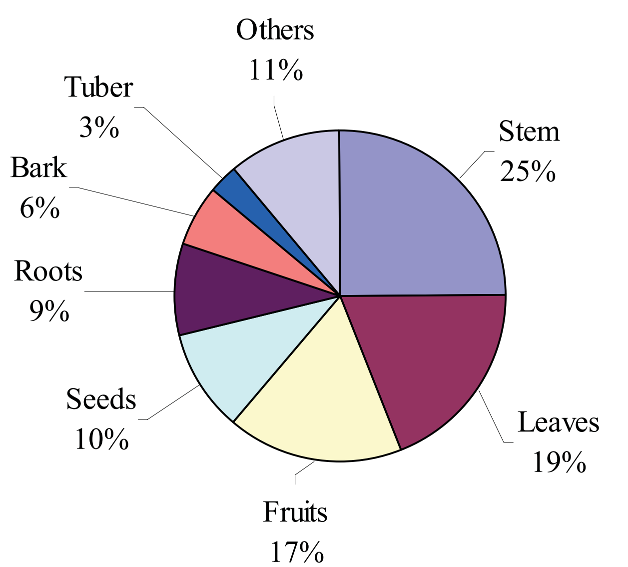

Figure 2. Proportion of plant parts used by Berta and Gumuz people.

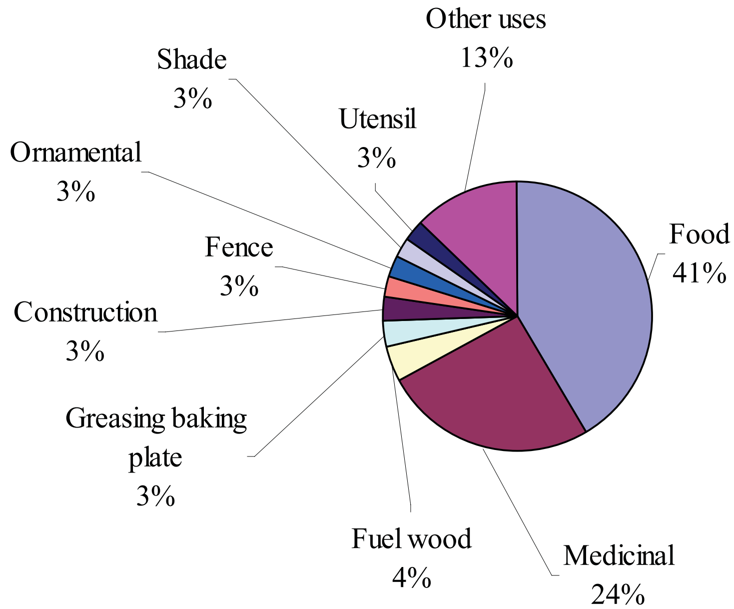

Figure 3. Proportion of use categories of plants cultivated by Berta and Gumuz people.

The main staple food crops are *Zea mays* and *Sorghum bicolor*, which are widely cultivated by both Berta and Gumuz people. The former is cultivated both in the homegardens and field while the latter is mainly cultivated in the fields. In homegardens, *Zea mays* is inter-cropped with a wide range of plants such as *Abelmoschus esculentus, Brassica carinata, Capsicum annuum, Colocasia esculenta, Cucurbita pepo, Lablab purpureus, Phaseolus vulgaris* and *Xanthosoma sagittifolium*. In the field, both *Zea mays* and *Sorghum bicolor* are mostly inter-cropped with *Sesamum indicum,* oil crop that is mainly grown for commercial purpose. In addition to household consumption, all 125 informants confirmed the commercial importance of species such as *Abelmoschus esculentus, Capsicum annuum*, *Capsicum frutescens, Carica papaya*, *Cucurbita pepo, Gossypium arboreum, Musa* x *paradisiaca*, *Nicotiana tabacum*, *Sorghum bicolor*, *Zea mays* and Z*ingiber officinale.*

In the field, both Berta and Gumuz people practice slash and burn method of shifting cultivation. In such practice, the people keep the stumps and some trees which have the capacity to regenerate when the field is abandoned. Some trees in the field are also used as a support for crops such as *Lablab purpureus* (Figure 4). The Berta and Gumuz people are living in relatively good harmony with the natural vegetation, particularly when compared with recent settlers who completely remove natural vegetation in and around farmlands.

Figure 4. *Eleusine coracana* field with some trees used as support for *Lablab purpureus.*

Uses of wild plants

From a total of the 132 useful wild plants, about 48% were found to be used by both Berta and Gumuz people while 27% and 25% were used by Berta and Gumuz, respectively. Berta and Gumuz people use wild plants for about 28 purposes. The use categories recorded included: arrow, bow, broom, construction, cultural, farm implement, fence, food, forage, fuel wood, furniture, greasing baking plate, gum, honey production, incense, insect repellent, insecticide, medicinal, musical instrument, poison, rope, shade, soap, tanning, timber, tool handle, tooth brush and utensils. The highest proportions of wild plants were used for food, fuel wood, construction and medicine (Figure 5). Many wild plants have multiple uses, for example, *Oxytenanthera abyssinica* has about 12 uses and followed by three tree species (*Breonadia salicina*, *Lannea fruticosa* and *Terminalia macroptera)* each with nine uses. Other tree species such as *Acacia seyal*, *Boswellia papyrifera, Lannea welwitschii*, *Piliostigma thonningii*, *Pterocarpus lucens* and *Terminalia laxiflora* have eight uses each. The rest of the useful wild plants have two to seven uses (75%) and only 17% of them have one use only. In addition to such uses for households, significant proportions of wild plants were preferred for commercial purposes (76%) and generate income for households. Some wild plant species were highly preferred for market, for example, more than 90% of informants reported the commercial importance of *Breonadia salicina, Oxytenanthera abyssinica* and *Pterocarpus lucens* (Table 1). The tubers of *Dioscorea praehensilis,* young unopened flowers of *Grewia mollis* and leaves of *Corchorus olitorius* are collected from the wild both for household consumption and market. The fruits of *Ximenia americana* are also collected from wild and sold in local markets mainly by children.

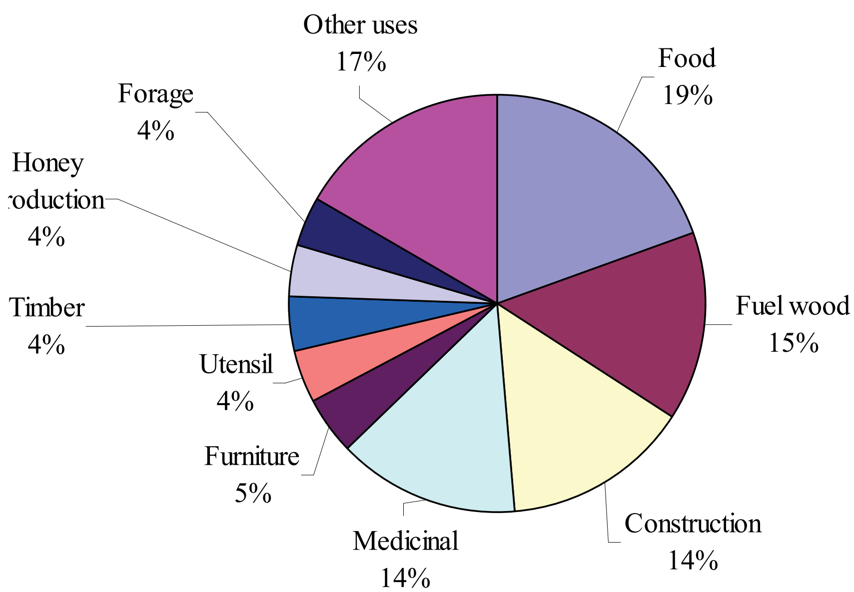

Figure 5. Proportion of use categories of wild plants used by Berta and Gumuz people.

Table 1. Commercially preferable wild plants and percentage of informants preferring the plant for commercial purposes.

S. No.	Botanical name	Part sold	% of informants
1	*Abelmoschus ficuleneus*	Capsule	55.2
2	*Albizia malacophylla*	Stem	61.6
3	*Anogeissus leiocarpa*	Stem	72
4	*Balanites aegyptiaca*	Fruits and Stem	52
5	*Boswellia papyrifera*	Incense	64
6	*Breonadia salicina*	Stem	91.2
7	*Combretum collinum*	Stem	67.2
8	*Combretum molle*	Stem	56
9	*Corchorus olitorius*	Leaves	56.8
10	*Cordia africana*	Stem	66.4
11	*Dioscorea praehensilis*	Tuber	83.2
12	*Entada africana*	Stem	60.8
13	*Hibiscus cannabinus*	Bark	77.6
14	*Lannea fruticosa*	Stem	60
15	*Oxytenanthera abyssinica*	Stem	95.2
16	*Pterocarpus lucens*	Stem	92
17	*Securidaca longepedanculata*	Roots	59.2
18	*Tamarindus indica*	Fruits	56
19	*Terminalia laxiflora*	Stem	80
20	*Terminalia macraopetra*	Stem	68
21	*Vitex doniana*	Fruits	49.6
22	*Grewia mollis*	Flowers	48

There are many cases where many plants are used in combination. The musical instrument called ***'Waza'*** in Berta language is, for example, prepared from articulations of dry fruits of *Lagenaria abyssinica.* The fruits with various sizes are fixed together by the sticky bark of *Albizia malacophylla.* The articulation is further strengthened by the stem of *Oxytenanthera* *abyssinica* that is tied by a string made from the fiber of *Gossypium arboreum.* Another second example is from Gumuz people, where Gumuz youngsters form holes through the fruits of the wild plant *Oncoba spinosa.* They remove the seeds and the pulp. They introduce small gravels into the exocarp of the fruits. Then, they pass a string made from the fiber of *Gossypium arboreum* through the fruits to assemble the fruits like beads. They tie this assemblage, called ***'Sisiya'*** in Gumuz**,** on their legs while dancing. The way Gumuz women carry materials using plant products provides another striking example of the skilful use of local plant products. They use the bar made from the stem of *Oxytenanthera abyssinica* as a lever where the fulcrum is made to fall exactly on the shoulder of the woman. The load is placed on the rope tied at the two ends of the bar. The rope is made from the bark of *Hibiscus cannabinus*. They suspend the container made from the fruit of *Lagenaria siceraria* to carry liquid. Containers like a basket made from the stem of *Oxytenanthera abyssinica* are suspended on the rope to carry loads like grains or vegetables. When they carry materials like firewood, they simply put it on the rope. Thus, all materials used for carrying the load are of local plant origin. This way of carrying materials is unique to Gumuz people in Ethiopia and girls are trained on how to make and use it properly starting from their childhood period. Currently, Gumuz women have started using fabricated materials instead of plant products. Such dependence on fabricated materials has both positive and negative impacts. Its positive aspect is that it reduces the pressure on wild plants. It also helps to save time and energy expended to collect plants and prepare the utensils. The negative aspect is decline of traditional knowledge on plant use. Once this knowledge is lost, traditional management and conservation of useful plants will decline. Genetic erosion or species extinction, at least locally, is inevitable.

Folk taxonomy

Among 141 plant species that were recognized as useful by Berta people, about 59% have similar Berta names in the four districts studied. *Sorghum bicolor* is the only plant that appeared with different Berta names in four districts, i.e. '***Silbilo'*** (in Sherkole district), '***Sili'*** (Hommosha), ***'Zilbabenee'*** (Bambasi), ***'Zilqilign'*** (Kurmuk). Among the 139 plants mentioned by Gumuz people, only 24% of them have similar Gumuz names in all four districts studied.

Berta and Gumuz have very few plant names in common (see Appendix I). *Luffa cylindrica* is the only plant species that has identical Berta and Gumuz name –'*Lifa'*. Some introduced plant species have more close local names, for example, *Ipomoea batatas* ***-'Bambee'*** in Berta and ***'Bambaya'*** in Gumuz, *Musa x paradisiaca* ***-'Almoz'*** in Berta and ***'Muza'*** in Gumuz, *Nicotiana tabacum* ***-'Timbaq'*** in Berta and ***'Timbaqa'*** in Gumuz and *Zingiber officinale* ***-'Ajenzebil'*** in Berta and ***'Janjibil'*** in Gumuz. The only indigenous plant species that has more or less related Berta and Gumuz name is *Boswellia papyrifera,* ***'Agolgolo'*** in Berta and ***'Gologo'*** in Gumuz.

Both Berta and Gumuz follow similar pattern of plant naming, where they refer to color, habitat, origin of germplasm in the case of cultivated plants and relationship among plants. *Sesamum indicum,* for example, is called ***'Eshe Fudi'*** in Berta language and ***'Giziqua Eimpuchichima'*** in Gumuz language in Kemashi district, where ***'Fudi'*** in Berta and ***'Eimpuchichima'*** in Gumuz refer to white color. A wild plant species *Abelmoschus ficulneus* is called ***'Qenqetse Melejida'*** in Berta and ***'Andeha Yiza'*** in Gumuz. '***Melejida'*** in Berta and ***'Yiza'*** in Gumuz refer to forest, indicating that it is wild plant similar to cultivated plant species *Abelmoschus esculentus,* which is called ***'Qenqetse'*** in Berta and ***'Andeha'*** in Gumuz. Referring to germplasm origin, Berta people distinguish two varieties of *Mangifera indica*, ***'Mangal Mesri'*** and ***'Mangal Hindi'***. The former is sweeter than the latter. The people believe that the two *M. indica* varieties were introduced to Ethiopia through the Sudan by the British from Egypt and India, respectively. Similarly, Gumuz people give local names to introduced plants. ***'Qosha'*** is the local Gumuz name for *Ricinus communis*. Gumuz people in Kemashi district call *Jatropha curcas* as ***'Qoshish Sudana'****,* to refer that it is *Ricinus communis* of the Sudan. Gumuz people in Dibate and Guba districts call *Cissus cornifolia* ***'Antsiqina Guanja'*** to distinguish it from *Ampelocissus schimperiana* which is called ***'Antsiqina'.*** In this case ***'Guanja'*** in Gumuz refers to a wild animal -*Sylvicapra grimmia*. Such name shows that *Ampelocissus schimperiana* is consumed by humans while *Cissus cornifolia* is for *Sylvicapra grimmia.*

Variation in plant use among social groups

Pearson's correlation analysis showed that, the elderly person knows a higher number of plants used for commercial purpose, construction, fuel wood and medicine than the younger (Table 2). Although weak, youngsters know a higher number of food plants than old people. Pearson's correlation analysis further showed that, there is a negative relationship between the educational level of informants and their ethnobotanic knowledge (Table 2).

The out put of Principal Component Analysis (Figure 6) showed that the first principal axis separated Berta and Gumuz People. The second principal axis further separated Gumuz people in the north (Dibate, Guba and Mandura districts) and the south (Kemashi district) of the Blue Nile River. The informant-species scatter plot (figure not shown), indicated species that are characteristic to divide the informants into three clusters, i.e. Berta, Gumuz people in Kemashi district and those in Dibate, Guba and Mandura districts. The plant species that have a higher number of uses and are unique to Berta are cultivated plants such as *Hibiscus sabdariffa, Melia azedarach* and *Pennisetum glaucum;* and wild plants like *Erythrina abyssinica, Commiphora pedunculata, Borassus aethiopum, Ficus thonningii, Phragmites karka* and *Diospyros mespiliformis*. Gumuz people differed from Berta people due to their special use and high number of use of cultivated plants such as *Jatropha curcas* and *Portulaca* sp.; and wild plants such as *Oncoba spinosa, Acacia polyacantha, Celosia trigyna, Justicia ladanoides*, *Ocimum canum* and *Solanum alatum.* The Gumuz people in Kemashi district appeared a separate cluster from Dibate, Guba and Mandura districts due to their unique use of cultivated species *Vigna subterranea* and wild plants such as *Asystasia gangetica, Clerodendrum alatum, Crossopteryx febrifuga, Cucumis pustulatus, Sarcocephalus latifolius* and *Tristemma mauritianum.*

Table 2. The out put of Pearson's correlation to show the relationships of the age and educational level of informants with the number of useful plants they mentioned in five main use categories using PAST computer program.

Use category	Pearson's r					
	Berta		Gumuz		Both Berta and Gumuz	
	Age	Educational level	Age	Educational level	Age	Educational level
Commercial preference	0.25321	-0.03675	0.53538	-0.30131	0.42124	-0.21964
Construction	0.69823	-0.3551	0.54384	-0.4111	0.61898	-0.38491
Food	-0.19063	-0.04775	-0.00892	-0.21101	-0.1094	-0.11232
Fuel wood	0.21064	-0.06638	0.37166	-0.13566	0.29273	-0.10274
Medicine	0.47767	-0.45681	0.57214	-0.41137	0.52619	-0.42617

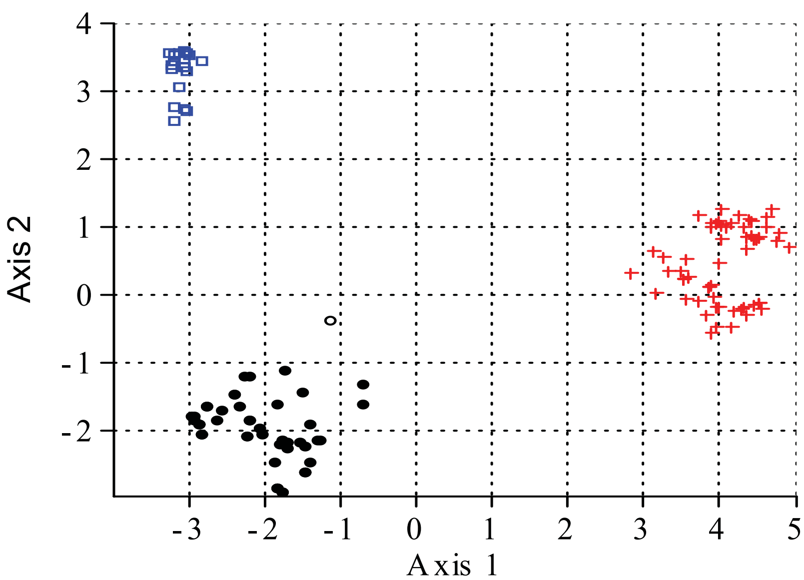

Figure 6. Principal Component Analysis obtained by running multivariate computer program PAST showing the difference in plant use between informants from Berta (cross) and Gumuz people (people in north and south of Blue Nile River in dots and squares, respectively).

Discussion

This study is the first of its kind in reporting that the Berta and Gumuz people use quite many plants. The plants given in this paper are those that are regularly and frequently put to definite uses. Cultivated plants take a major share in making of livelihoods for Berta and Gumuz people. Most cultivated plants are equally important for both Berta and Gumuz people. There are, however, cultivated plants which have special importance and cultural significance for a particular people or community. *Vigna subterranea (‘**Akala’*** in Gumuz) was recorded in Kemashi zone. It is extensively cultivated in West Africa for its underground seeds. In Ethiopia, its cultivation is restricted near Dedessa River (Thulin 1989). Its cultivation is declining because farmers switched to a more profitable plant such as *Sesamum indicum.* This is inline with the arguments that economic and cultural changes are responsible in many parts of the world for the weakening of “traditional” plant use and conservation practices (Cunningham 2001).

Plants from the wild habitats also contribute significantly to the livelihood of both Berta and Gumuz people as food, medicine, construction and other general utilities. Such diverse uses of wild plants demonstrate that the people have intimate relations with botanical resources and their life is based on the use and management of diverse plant taxa.

Ethnobotanical knowledge of both Berta and Gumuz people on plants that are important for commercial purpose, construction, food, fuel wood and medicine was very high. The number of plants mentioned as useful for forage was low compared to other studies undertaken in pastoral areas of Ethiopia such as Borena (Gemedo Dalle et al. 2005). This reflects that livestock production is not the main production system for Berta and Gumuz people. This is also an indicative that such production system is not profitable or does not work under local condition in Berta and Gumuz inhabited area, i.e. Benishangul Gumuz Regional State.

The non-cultivated edibles provide considerable amount of supplementary and coping up food. They also contribute in generating additional income for the households. Three wild plant species: *Abelmoschus ficulneus* (close relative of cultivated *Abelmoschus esculentus*), *Hibiscus cannabinus* and *Corchorus olitorius* represent wild-semi-wild-domesticated continuum of wild edibles of Ethiopia as described by Zemede Asfaw and Mesfin Tadesse (2001). These species are under domestication by Berta and Gumuz people. Such plants were also considered by Zemede Asfaw and Mesfin Tadesse (2001) as good indicators of the path through which domesticated plants had passed during the course of human civilization. These species further demonstrate that both Berta and Gumuz people retain some remnant features of the interface of hunter-gatherer and sedentary agricultural lifestyles**.** Domestication of these plants has both positive and negative impacts that need mitigation. Increasing inter-specific crop diversity through domestication is the positive aspect to meet farmers' needs. It also meets the objectives of traditional farmers who strive to optimize the use of resources which are available locally, to minimize the risk of crop failure and to ensure the sustainability of their production methods (Cotton 1996). As newly domesticated plants offer some better quality, farmers may discard old crops. Such circumstances may lead to loss of genetic diversity of older crops. *In-situ* conservation or at least collection and *ex-situ* conservation of the germplasm of *Abelmoschus esculentus* in particular and indigenous crops in general, might be the immediate action that should be executed.

Herbal medicine is important in the life of Berta and Gumuz people. Like any other people in Africa (Kessy 1998; Fekadu Fullas 2001), traditional medicine collection takes place at two levels, i.e. by specialized healers and by household members. Knowledge of plants that treat common diseases is shared by most of the household members, making it necessary to consult a specialist only when the case is complicated. Rather few individuals of the society have reliable knowledge on medicinal plants and treatment. In Ethiopia, as described by Jansen (1981), Wilson and Woldo Gebre Mariam (1979), and Fekadu Fullas (2001), the traditional healers are the best source of information about medicinal plants. The traditional healers among Berta and Gumuz people consider their knowledge as professional secret that is only entrusted to their successor in the job, like other traditional healers in Ethiopia (Fassil 2005). This study was, therefore, restricted to plants that are commonly used at public domain. Traditional healers need suitable form of intellectual property protection and were not the partners of this study. This had some limitations on the depth and breadth of the ethnobotanic information relating to the medicinal plants and their uses.

The plants used by Berta and Gumuz people are also suppliers of some critical recreational materials like musical instruments, in addition to other utilities. Such instruments are very important during festivals and are useful in the psychological well being of the society.

Like other rural people in Ethiopia (Zemede Asfaw and Mesfin Tadesse 2001), both Berta and Gumuz people have plant local names that have direct reference to human, wild animals or domestic animals and to the special utilization features of the plants. Such names give clues for further development of the plants, *in-situ* and *ex-situ* conservation and sustainable use (Zemede Asfaw 1990; Martin 1995; Zemede Asfaw and Mesfin Tadesse 2001).

Although Berta and Gumuz people live in the same type of habitat, they are in contact on their territories and about 47% of the plants they use are similar, they share the local name of very few introduced plants and only one indigenous tree – *Boswellia papyrifera.* Plant naming was found to be more localized among Gumuz people where lower number of plants has similar Gumuz names in the four districts studied. The out put of Principal Component Analysis has also showed the difference in plant use between Berta and Gumuz people, as well as the difference with in Gumuz people in the north and south of the Blue Nile River. This pattern may be related to some geographical barriers posed by deep gorges, precipitous escarpments and historical events connected to the influence of outsiders in search of people to be taken into the notorious slave trade that took place in the past in areas that are now delineated as districts (Abdussamad H. Ahmad 1999; Young 1999). Such isolations of communities may have created a gap of communication and led to internal divergence in plant naming and utilization mainly between the Gumuz living in the south and north of the Blue Nile River and, to some extent, among the districts in the north of the Blue Nile River.

Pearson’s correlation analysis showed that, there is a general positive relationship between the age of informants and their ethnobotanic knowledge. Like any traditional society (Cotton 1996), among the Berta and Gumuz people, indigenous knowledge on plants is transferred orally/by word of mouth from generation to generation, via adult-performed activities that are staged during deliberate gatherings of adults and youth. Pearson’s correlation analysis further showed that, informants who go to school know lower number of useful plants. This finding is inline with the general trend in Ethiopia, where people that go to school tend to discard traditional knowledge and lifestyles (Million Belay et al. 2005). This leads to rapid disappearance of ethnobotancial knowledge when new generation gets the opportunities that were not available to their elders, such as attending school and living in urban areas (Tesfaye Awas et al. 1997). The negative correlation of age of informants and knowledge on the number of plants used for food was similar with the results of previous studies conducted in Ethiopia (Zemede Asfaw and Mesfin Tadesse 2001) hinting that young people are the most frequent users and sellers of wild edible plants.

Conclusion

Although this study is restricted to plants used in the public domain, it reflects the cultural heritage of both Berta and Gumuz people with respect to their ethnobotanic knowledge on both cultivated and wild plants of the area. The diverse plant resources and the associated knowledge are the basis for present survival and future prosperity of the people. The experiential knowledge of the people is fundamental for the development of the existing potential in plant resources. Over harvesting of wild plants that give immediate economic return, change in plant use due to dependence on fabricated materials, market oriented cultivation of crops and domestication of new plants are the areas that need intervention through *in-situ* and *ex-situ* conservation. The traditional conservation options that ensured the maintenance of the plants and the indigenous knowledge base have to be encouraged and enhanced through application of modern approaches of both *in-situ* and *ex-situ* biodiversity conservation. It is obvious that ecological changes that lead to losses of plants would lead to loss of valuable information. Creating mechanisms to keep ethnobotanic information in the society's domain is another area of intervention. In this regard, the lists of plant local names along with the corresponding Latin (appendix I) is valuable tool for various professionals working in various sectors (agriculture, conservation, education, health, etc.) to communicate with local people about the useful plants.

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Appendix I. Plants used by Berta and Gumuz people in Benishangul Gumuz Regional State, western Ethiopia.

When a plant has more than one local name, the specific district where the local name was collcted is indicated in parenthesis, where for:
*Berta names: B = Bambasi, H = Homosha, K = Kumruk and S = Sherkole.
**Gumuz names: D = Dibate, G = Guba, K = Kemashi and M = Mandura.

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
1	*Abelmoschus esculentus* (L.) Moench.	Malvaceae	Qenqetse	Andeha
2	*Abelmoschus ficulneus* (L.) Wight & Arn.	Malvaceae	Qenqetse Melejida	Andeha Yiza (D,G,M)
3	*Acacia hecatophylla* Steud. ex A. Rich.	Fabaceae	Qudu	Quatsirqa (D,G,M), Chicha (K)
4	*Acacia polyacantha* Willd.	Fabaceae		Sipe (D,G,M), Chicha (K)
5	*Acacia seyal* Del.	Fabaceae	Qashi Fudi (B,K), Qashi (S)	Asandiya (D), Meela (G), Chicha (K), Eskophinja (M)
6	*Acanthus polystachyus* Del.	Acanthaceae		Dadiha (D,M)
7	*Adansonia digitata* L.	Bombacaceae	Agungulees	
8	*Aframomum alboviolaceum* (Ridl.) K. Schum.	Zingiberaceae	Eimplametsumu/Lelentsewa (B), Alilintsewa (H)	Ola (K)
9	*Albizia malacophylla* (A. Rich.) Walp.	Fabaceae	Gendher	Ansisiwa (D,M), Tiyoka (K)
10	*Allium cepa* L.	Alliaceae	Bilia Beegneni	
11	*Allium sativum* L.	Alliaceae	Bilia Fudi	
12	*Amaranthus hybridus* L.	Amaranthaceae	Tsunta	
13	*Amaranthus spinosus* L.	Amaranthaceae		Tekihinenuwa (D,M), Chichariya (K)
14	*Ampelocissus schimperiana* (Hochst. ex A. Rich.) Planch.	Vitaceae	Mangu	Antsiqina
15	*Andropogon schirensis* Hochst. ex A. Rich.	Poaceae	Abendu	Gizipha (D,M), Amberta (G)
16	*Anethum graveolens* L.	Apiaceae	Ashumshumar	Shala (D,M), Besheella (K)
17	*Annona senegalensis* Pers.	Annonaceae	Adegella	Bambutta
18	*Anogeissus leiocarpa* (A. DC.) Guill. & Perr.	Combretaceae	Qey	Sigah
19	*Arachis hypogaea* L.	Fabaceae	Alful	Lefura
20	*Asparagus flagellaris* (Kunth) Baker	Asparagaceae	Moro (B,S)	Eliya

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
21	*Asystasia gangetica* (L.) T. Andress.	Acanthaceae		Derguya (K,M)
22	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	Qaha	Qota (D,G,M)
23	*Beta vulgaris* L.	Chenopodiaceae	Benjer (B,H,S)	
24	*Bidens pilosa* L.	Asteraceae		Tsetsaqa (M), Wasqenda (D)
25	*Bidens prestinaria* (Sch.Bip.) Cufod.	Asteraceae	Awushenshe (B), Aburmereree (S)	Egile (M)
26	*Borassus aethiopum* Mart.	Arecaceae	Dur (B,H,S)	
27	*Boswellia papyrifera* (Del.) Hochst.	Burseraceae	Agolgolo	Golgola (D,G,M)
28	*Brassica carinata* A. Br.	Brassicaceae	Shasha	Tiba (D, M), Baga (G,K)
29	*Brassica nigra* (L.) Koch	Brassicaceae		Shenafich (K,M)
30	*Breonadia salicina* (Vahl) Heppehr & Wood	Rubiaceae	Digle	Dijiha (D,G,K), Tongo (M)
31	*Bridelia scleroneura* Muell. Arg.	Euphorbiaceae	Hargjelo (B,H,K)	Ejjiga (D,K,M)
32	*Cadaba farinosa* Forssk.	Capparidaceae	Hinush (S)	
33	*Cajanus cajan* (L.) Millsp.	Fabaceae	Ades	
34	*Capsicum annuum* L.	Solanaceae	Ashetta	Fidhenzsia (K), Fikahanshza (M), Firzsha (D), Shittetta (G)
35	*Capsicum frutescens* L.	Solanaceae	Kebanit	Birbira/Phiriwa (D), Embawuza (M), Funishza (G), Shininchawa (K)
36	*Carica papaya* L.	Caricaceae	Albabaya	Papaya
37	*Carissa spinarum* L.	Apocynaceae	Iyang	Sikwaha (D, M), Simah (G), Suwiyah (K)
38	*Cassia arereh* Del.	Fabaceae	Atrash (S)	
39	*Celosia trigyna* L.	Amaranthaceae		Abershewa (K), Wublanda (D,M), Yedinkuwa (G)
40	*Cicer arietinum* L.	Fabaceae		Shimbira (D,G,M)
41	*Cissus cornifolia* (Bak.) Planch.	Vitaceae	Meme (B,H,S)	Antsiqina Guanja (D,G)
42	*Cissus populnea* Guill. & Perr..	Vitaceae	Gilu (H,S)	Iwe
43	*Citrus aurantifolia* Swingle	Rutaceae		Lemuna

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
44	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae		Fitiya (K), Tirmenzuwa (D), Wobiza (M)
45	*Cleome gynandra* L.	Capparidaceae	Arezruzu (H,S)	
46	*Clerodendrum alatum* Güerke	Lamiaceae	Etsebulandi/Angeled (B)	Jiggnewiya (G,M), Hiji Seteena (K)
47	*Clerodendrum cordifolium* (Hochst.) A. Rich.	Lamiaceae	Halale (B,H,S)	
48	*Coffea arabica* L.	Rubiaceae	Albun	
49	*Colocasia esculenta* (L.) Schott.	Araceae	Abegeru (B,H,S)	Kompha
50	*Combretum collinum* Fresen.	Combretaceae	Gushel	Engifa (G), Ephtseya (M), Hafa (K)
51	*Combretum hartmannianum* Schweinf.	Combretaceae		Enquha (M), Jipiwa (G)
52	*Combretum molle* R. Br. ex G. Don	Combretaceae	Ageraa	Hafa (K), Enquha (M)
53	*Commelina imberbis* Ehrenb. ex Hassk.	Commelinaceae		Ibeshanta (M)
54	*Commiphora pedunculata* (Kotschy & Peyr.) Engl.	Burseraceae	Golgolofale (H,K,S)	
55	*Corchorus olitorius* L.	Tiliaceae	Agembang	Ezerticha (D,M), Laliqa (G)
56	*Cordia africana* Lam.	Boraginaceae	Abanga	Banja
57	*Coriandrum sativum* L.	Apiaceae	Athehol (B,H,S)	Tinkosa
58	*Costus spectabilis* (Fenzl) K. Schum.	Zingiberaceae	Qeqelo (B,H,S)	Yempedema (G,K,M)
59	*Crassocephalum rubens* (Jacq.) S. Moore.	Asteraceae	Shaqadona (B,H,S)	
60	*Crossopteryx febrifuga* (Afzel. ex G. Don) Benth.	Rubiaceae	Hadhigni (S)	Piwe (G,K,M)
61	*Cucumis pustulatus* Naud ex Hook.f.	Cucurbitaceae		Jigawuha (K), Weqneniwa (G,M)
62	*Cucurbita pepo* L.	Cucurbitaceae	Agu (B,H,S), Tsabi (K)	Patuwa (D,K,M)
63	*Cymbopogon caesius* (Hook. & Arn.) Stapf.	Poaceae	Gneerawoni	Bisa (D,M), Mamusa (G)
64	*Cynodon nlemfuensis* Vanderyst	Poaceae		Kifa (D), Sasiqida (G), Tanga (M)
65	*Dalbergia boehmii* Taub.	Fabaceae	Tsaba	
66	*Dalbergia melanoxylon* Guill. & Perr.	Fabaceae	Shangur	

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
67	*Dichrostachys cinerea* (L.) Wight & Arn.	Fabaceae	Tari (S)	
68	*Dioscorea alata* L.	Dioscoreaceae	Qyeda Tayo	Una
69	*Dioscorea bulbifera* L.	Dioscoreaceae	Mejiru Tayo (Cultivated), Mejiru Gneero (Wild)	
70	*Dioscorea cayenensis* Lam.	Dioscoreaceae		Boqa (D,G,M)
71	*Dioscorea dumetorum* (Kunth) Pax	Dioscoreaceae	Ashada Bugudo	
72	*Dioscorea praehensilis* Benth.	Dioscoreaceae	Qeyeda Gneero	Echa
73	*Diospyros mespiliformis* A. DC.	Ebenaceae	Murqe	
74	*Dombeya torrida* (J. F. Gmel.) P. Bamps	Sterculiaceae	Fodog	Ejesiya
75	*Eleusine coracana* (L.) Gaertn.	Poaceae		Tanqa
76	*Ensete ventricosum* (Welw.) Cheesman	Musaceae	Kaze (B), Kafee (H), Gaze (S)	Achegua (D,G,M)
77	*Entada africana* Guill. & Perr.	Fabaceae	Dirtsegn	Bambeluwa (G), Ewuya (M), Eyguyeguya (D), Tiyoka (K)
78	Eragrostis tef (Zucc.) Trotter	Poaceae	Gasha (B,H,S)	Dhafa (D,K,M)
79	*Erythrina abyssinica* Schweinf.	Fabaceae	Amblish (B,H,S)	
80	*Faurea speciosa* Welw.	Proteaceae	Atteettee (B,H,K)	
81	*Feretia apodanthera* Del.	Rubiaceae	Menzimiyo (S)	
82	*Ficus ovata* Vahl	Moraceae	Andamenu (B,H,S)	
83	*Ficus sur Forssk*.	Moraceae		Ebeya (D,M)
84	*Ficus sycomorus* L	Moraceae	Neyisha	Fuqa (D,G,M), Yecha
85	*Ficus thonningii* Blume	Moraceae	Tseera	
86	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	Agnagnsheqe (B,H,S)	
87	*Flueggea virosa* (Willd.) Voigt.	Euphorbiaceae	Ugutsey (S)	Weele
88	*Gardenia ternifolia* Schum. & Thonn.	Rubiaceae	Aqenda	Kota
89	*Gossypium arboreum* L.	Malvaceae	Haphani	Gebeba

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
90	*Grewia flavescens* Juss.	Tiliaceae	Hattab (B,H,S)	
91	*Grewia mollis* A.Juss.	Tiliaceae	Hornotse	Gediya
92	*Grewia velutina* (Forssk.) Vahl	Tiliaceae	Hornotse Gelu	Gideya (D,G,M)
93	*Guizotia abyssinica* (L.f.) Cass	Asteraceae	Heesha Mili (B,H,S) Hazra Mili (K)	Bilza (G), Giziqua Mehichima (K), Mekhima Giziqua (D), Wobilza (M)
94	*Helianthus annuus* L.	Asteraceae	Heeshansaaro (B,H), Heeneshemish (S)	Ferenji bilza (G), Giziqua Raba (M), Tufa (D)
95	*Hibiscus cannabinus* L.	Malvaceae	Shuri	Ankerphapha (M), Siyamuduqa (D,K), Tisha (G)
96	*Hibiscus corymbosus* A. Rich.	Malvaceae		Ejegaha (D), Ephegaha (M)
97	*Hibiscus sabdariffa* L.	Malvaceae	Kerkedee	
98	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	Poaceae		Andidekuwa (M), Bidigua (G)
99	*Hyparrhenia filipendula* (Hochst.) Stapf.	Poaceae		Hesiniya (G), Yehoba (D,M)
100	*Hyphaene thebaica* (L.) Mart.	Arecaceae	Gora (H,S)	Babenga (G), Gokhen (D,M)
101	*Indigofera garckeana* Vatake.	Fabaceae	Akomkom (H)	
102	*Ipomoea batatas* L.	Convolvulaceae	Bambee	Emandeela (D,K), Bambaya (G,M)
103	*Jatropha curcas* L.	Euphorbiaceae		Bogonda (G), Qoshishsudana (D,K), Qoshishturka (M)
104	*Justicia ladanoides* Lam.	Acanthaceae		Elangiya (K), Elangiya/Kakime (D,G), Kakime (M)
105	*Kotschya africana* Endl.	Fabaceae	Shiqi (B,H)	
106	*Lablab purpureus* (L.) Sw.	Fabaceae	Offee	Opa
107	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	Aguqasi	Manchiga (D), Machanchiga (G,K), Kibuwa (M)
108	Lagenaria sp.	Cucurbitaceae	Adimish	
109	*Lannea fruticosa* (Hochst. ex A. Rich.) Engl.	Anacardiaceae	Quwa	Bilga (G), Yempite (G,M), Edimba (K)
110	*Lannea welwitschii* (Hiern) Engl.	Anacardiaceae	Quwa hurhodu	Biilga

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
111	*Leonotis nepetifolia* (L.) R. Br.	Lamiaceae	Angesho (B,H,S)	Pepe (D,M), Achiquwa (G)
112	*Lepidium sativum* L.	Brassicaceae		Sambila (D,M)
113	*Linum usitatissimum* L.	Linaceae	Bululitu (B,H)	Chintta (D,K,M)
114	*Lonchocarpus laxiflorus* Guill. & Perr.	Fabaceae	Afud	Beewa
115	*Luffa cylindrica* (L.) M. J. Roem.	Cucurbitaceae	Lifa	Bafuchochuwa (K), Lifa (G), Wofchacha (D,M)
116	*Lycopersicum esculentum* Mill.	Solanaceae	Ambenattur	Bedanjila (M), Berendula (G,K), Heeraba (D)
117	*Mangifera indica* L.	Anacardiaceae	Menga	Menga
118	*Manihot esculenta* Crantz	Euphorbiaceae	Degig (B,H), Albafra (K,S)	
119	*Maytenus senegalensis* (Lam.) Exell	Celastraceae	Agero	Tisha (D,K,M), Bembeda (G)
120	*Melia azedarach* L.	Meliaceae	Mim	Musa paradisiaca L.
121	*Momordica foetida* Schum.	Cucurbitaceae	Fesh (B,H,S)	Beda
122	*Musa x paradisiaca* L.	Musaceae	Almoz	Muza
123	*Nicotiana tabacum* L.	Solanaceae	Timbaq	Timbaqa
124	*Ochna leucophloeos* Hochst. ex A. Rich.	Ochnaceae		Andidiha (K,M), Yetsegeda (D)
125	*Ocimum basilicum* L.	Lamiaceae	Beshuwe (B,H)	Zazuqambiya (G), Zeshima (D,K,M)
126	*Ocimum canum* Sims.	Lamiaceae		Biyangua
127	*Oncoba spinosa* Forssk.	Flacourtiaceae		Atsisa
128	*Oxytenanthera abyssinica* (A. Rich.) Munro	Poaceae	Gagu	Enta
129	*Ozoroa pulcherrima* (Schweinf.) R. & A. Fernand.	Anacardiaceae		Ejimbaya (D,K,M)
130	*Pavetta gardeniifolia* A. Rich.	Rubiaceae	Reba (B,H,S)	
131	*Pennisetum glaucum* (L.) R. Br.	Poaceae	Adihun	
132	*Pennisetum schweinfurthii* Pilg.	Poaceae		Begngira (G), Gzimisse (D,M)
133	*Pennisetum thunbergii* Kunth	Poaceae	Gnera Mekosh (B,H)	Etissayaqua

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
134	*Pennisetum unisetum* (Nees) Benth.	Poaceae	Begene (S)	Pille (D,M)
135	*Phaseolus vulgaris* L.	Fabaceae	Dheberi	Egaguwa/Aranguawaya (D), Arenguya/Gaguwa (G), Gagojia (K), Tiweega/Aranguawaya (M)
136	*Phoenix reclinata* Jacq.	Arecaceae	Shibee (B,H,S)	Goha (D,G,M), Metiya (K)
137	*Phragmites karka* (Retz.) Steud.	Poaceae	Agamo (B,H,S)	
138	*Physalis peruviana* L.	Solanaceae		Berantutia (K), Ejekuya (D,M), Ejesiya (G)
139	*Piliostigma thonningii* (Schum.) Milne-Redh.	Fabaceae	Megel	Donga (D), Mecha (G,M), Waga (K)
140	*Portulaca* sp.	Portulacaceae		Beella/Kima (K), Betita (G), Kima (D,M)
141	*Protea gaguedi* J. F. Gmel.	Proteaceae	Qedeber (B,H)	Edeeduwa (K)
142	*Pterocarpus lucens* Guill. & Perr.	Fabaceae	Amroro	Chaya (D,G,M), Miwa (K)
143	*Rhus ruspolii* Engl.	Anacardiaceae	Silgalo (B,S), Silmitso (H)	
144	*Ricinus communis* L.	Euphorbiaceae	Shenshemuq	Qosha (D,K,M), Bogonda (G)
145	*Rottboellia cochinchinensis* (Lour.) Clayton	Poaceae		Eboba (D,G,M)
146	*Rumex abyssinicus* Jacq.	Polygonaceae		Eyampisah (M), Yenegasha (D)
147	*Ruta chalepensis* L.	Rutaceae		Chelatiya (D,M)
148	*Saba comorensis* (Boj.) Pichon	Apocynaceae	Bishqor	
149	*Saccharum officinarum* L.	Poaceae	Sheqee (B), Sheegee (H), Gesebe Sukar (S)	
150	*Sapium ellipticum* (Krauss) Pax	Euphorbiaceae	Tseiya Fudi (H,K,S)	
151	*Sarcocephalus latifolius* (J. E. Smith) E. A. Bruce.	Rubiaceae		Andowa (D,M), Bekiya (K)
152	*Securidaca longepedunculata* Fresen.	Polygalaceae	Sheqet	Siqida
153	*Senna obtusifolia* (L.) Irwin & Barneby	Fabaceae		Alkola (G), Giziqua Hoha (M)
154	*Sesamum indicum* L.	Pedaliaceae	Eshe Fudi	Giziqua Kifa (D), Giziquam Eimpuchichima (K), Qosha (G), Wequsha (M)
155	*Solanum alatum* Moench.	Solanaceae		Antutiya (G), Aebosiya (K), Bosiya (D,M)

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
156	*Solanum dasyphyllum* Schum. & Thonn.	Solanaceae	Adundurutse	
157	*Solanum incanum* L.	Solanaceae	Adundurutse	
158	*Sorghum bicolor* (L.) Moench	Poaceae	Silbilo (S), Sili (H), Zilbabenee (B), Zilqilign (K)	Kuancha (D,K,M), Gisa (G)
159	*Sterculia africana* (Lour.) Fiori	Sterculiaceae	Qombo	Ephuwa (D,G,M), Heephuya (K)
160	*Stereospermum kunthianum* Cham.	Bignoniaceae	Aqulqa (B,H), Sanemerta (S)	Andegila (D,G,K), Odanjuwa (M)
161	*Strychnos innocua* Del.	Loganiaceae	Abombuqo	Begiya (D,G,M)
162	*Strychnos spinosa* Lam.	Loganiaceae		Anderkukuwa (G), Andukhabiya (M), Chicha (K)
163	*Syzygium guineense* (Willd.) DC. subsp *guineense*	Myrtaceae	Bulummtsee (B,H,S)	Diwa (D,G,K), Banjazaka (M)
	Syzygium guineense (Willd.) DC. subsp. *macrocarpum* (Engl.) F. White	Myrtaceae	Anzum	Shawa
164	*Tacca leontopetaloides* (L.) O. Ktze.	Taccaceae	Ferentseon (H), Feefentseon (S)	
165	*Tamarindus indica* L.	Fabaceae	Mela	Doga (G,M)
166	*Tamarix nilotica* (Ehrnb.) Bunge	Tamaricaceae	Atsegeda (S)	
167	*Tephrosia interrupta* Hochst. & Steud. ex Engl.	Fabaceae	Tseign (B,H,S)	
168	*Terminalia laxiflora* Engl. & Diels	Combretaceae	Ashihur	Beguha (M), Beguwa (K), Bora (G), Shanduka (D)
169	*Terminalia macroptera* Guill. & Perr.	Combretaceae	Gebugur	Babegoha (G), Beguha (M), Shanduka (D), Werekiya (K)
170	*Tragia doryodes* M. Gilbert	Euphorbiaceae		Bebdaja (G), Obdaja (D,M)
171	*Trigonella foenum-graecum* L.	Fabaceae		Gira (D), Mejira (G,M)
172	*Tristemma mauritianum* J.F. Gmel.	Melastomataceae		Metseeya (G,K)
173	*Triumfetta annua* L.	Tiliaceae	Harangafinasignee (B,H)	Eqephaqiwa (D,M)
174	*Vernonia hochstetteri* Sch.-Bip.	Asteraceae		Attettashza (D,M), Ebicha (K)
175	*Vernonia theophrastifolia* Schweinf. ex Oliv. & Hiern	Asteraceae		Egidima (D,K,M)

Appendix I. Continued…

S.No.	Botanical Name	Family	Berta name*	Gumuz name **
176	*Vigna membranacea* A. Rich.	Fabaceae	Dheberimugu (H,S)	
177	*Vigna subterranea* (L.) Verdc.	Fabaceae		Akala (K)
178	*Vitex doniana* Sweet.	Lamiaceae	Atsoda	Gohigmenza (M), Qokora (K), Teja (D), Tisheza (G)
179	*Wissadula rostrata* (Schum. & Thonn.) Hook.f.	Malvaceae		Banshzegona (G), Bohzikuna (D,M)
180	*Xanthosoma sagittifolium* (L.) Schott	Araceae	Abegeru (B,H,S)	Kompha
181	*Ximenia americana* L.	Olacaceae	Bibi	Feya (D,M), Heya (G,K)
182	*Zea mays* L.	Poaceae	Amhulee	Bafukacha (K), Gisinaba (G), Gisiraba (M), Ufiwacha (D)
183	*Zingiber officinale* Roscoe	Zingiberaceae	Ajenzebil	Janjibil
184	*Ziziphus abyssinica* Hochst. ex A. Rich.	Rhamnaceae	Morqoqo	Anguga (D,G,M), Ezeshiga (K)
185	*Ziziphus mauritiana* Lam.	Rhamnaceae	Amhorson	Sirah (D), Songah (G), Qota(M)

VII

Ethnobotanical study of medicinal plants in Kafficho people, southwestern Ethiopia

Tesfaye Awas[1] and Sebsebe Demissew[2]*

ABSTRACT

Ethnobotanical study of medicinal plants used by Kafficho people was carried out in Kafa zone, Southern Nations, Nationalities and People's Regional States in Southwestern Ethiopia. Kafficho are the dominant indigenous people living in the zone. Their language is Kaffinono, which belongs to Omotic language family. Inquiries were made regarding the local names of medicinal plants and the disease treated. Informants were asked to rank medicinal plants used to cure a specific disease. A total of 124 medicinal plants were identified. Medicinal plant use among Kafficho is localized and dependent on plants that are found around them. The ethnobotanical knowledge on medicinal plants also varies among various social groups. Kafficho people obtain about 74% of medicinal plants from the wild. The forest vegetation in Kafa zone was relatively intact a few decades ago, but recently faced heavy pressure from human activities. With the present ecological and socio-economical changes, medicinal plants together with the associated ethnobotanical knowledge are under serious threat and may be lost faster than imagined. In order to avoid or at least retard the trend, some recommendations are proposed for conservation and sustainable utilization of medicinal plants of Kafficho people.

Key words: Ethnobotany, Homegarden, Kafa, Kaffinono, Traditional medicine

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1. INTRODUCTION

Traditional medicine is used throughout the world as it is dependent on locally available plants, which are easily accessible, and capitalizes on traditional wisdom-repository of knowledge, simple to use and affordable. These medical systems are heavily dependent on various plant species and plant based products. The current account of medicinal plants of Ethiopia, as documented for National Biodiversity Strategy and Action Plan by Tesema *et al.* (2002), shows that about 887 plant species were reported to be utilized in the traditional medicine. Among these, about 26 species are endemic and they are becoming increasingly rare and are at the verge of extinction. Equally threatened is the knowledge base on which the traditional medicinal system is based, as the ethnobotanical information is not documented and remains in the memory of elderly practitioners. Therefore, detailed information on the medicinal plants of Ethiopia could only be obtained when studies are undertaken in the various parts of the country where little or no botanical and ethnobotanical explorations have been made.

Ethnobotany tries to find out how people have traditionally used plants, for whatever purposes, and how they are still doing so (den Eynden *et al*. 1992). Thus, ethnobotany tries to preserve valuable traditional knowledge for both future generations and other communities. Recently, the subject has adopted a much more scientific and quantitative methodology and has studied the ways in which people manage their environment (Phillips and Gentry 1993a, b; Martin 1995; Cotton, 1996; Höft *et al.* 1999). Quantitative methods and species use values enable comparisons of use between vegetation types or ecological zones, between people of different ages, gender or occupation within or between communities (Höft *et al.* 1999, Cunningham 2001).

Except for recording the medicinal plants constituting the agrobiodiversity of Kafficho homegardens by Feleke (2000), no systematized study on the ethnobotany of Kafficho medicinal plants has been conducted before. The Knowledge on medicinal plants is not easily accessible and this study was restricted to Chena and Decha districts where people are aware about the need to conserve plants. The awareness was created by the Institute of Biodiversity Conservation/Ethiopia while running a project supported by Global Environment Facility - "Dynamic Farmer Based Conservation of Ethiopia's Plant Genetic Resources Project" (Tesfaye 2001). The project has established Community Gene Banks at Baha and Wacha villages, in Decha and Chena districts, respectively. Since the study may be regarded as one of the pioneer in its nature, the obtained result will hopefully contribute for implementing *in-situ* conservation, promotion and usage of the plants in a sustainable manner, and also open up the way for future research and development of new drugs from the medicinal plants. It also contributes in improving health care in the rural areas of Kafa.

2. LOCATION OF THE STUDY AREA

The study was carried out between August 2000 and October 2003 in Kafa zone, Southern Nations, Nationalities and People Regional State, Southwestern Ethiopia. The capital town of the zone, Bonga, is located 440 km southwest of Addis Ababa, capital city of Ethiopia. The name of the study area “Kafa” is well known and is every day on the minds of the many people throughout the globe who savor the juice extracted from the berry of a plant which originally grew in Kafa, coffee (Gruhl 1932). Kafa zone is bordered by Oromiya region on the north, Semen Omo zone on the east, Debub Omo zone in south east, Bench Maji zone on south and south west and Shaka zone on the west. The zone is subdivided into 10 districts, namely Bitta, Chena, Cheta, Decha, Gaweta, Gesha, Ginbo, Menjiwo, Silam and Telo. Chena and Decha are the two districts of the zone in which the present study was carried out. In each district, the villages near the Community Gene Banks (Baha in Decha and Wacha in Chena) were selected for detailed data collection (Figure 1).

Based on figures from the CSA (2005), Kafa zone has an estimated population of 851,063 of which 417,605 were males and 433,458 were females. With an estimated area of 10,610.65 square kilometers, this zone has an estimated population density of 80.21 people per square kilometer. Kafficho are the dominant indigenous group of people living in Kafa zone. Their language is Kaffinono, which belongs to Omotic language. They are sedentary agriculturists and practice mixed farming, cultivating crops, raising livestock and bee keeping. They follow either or Christian or Muslim or Traditional Religion.

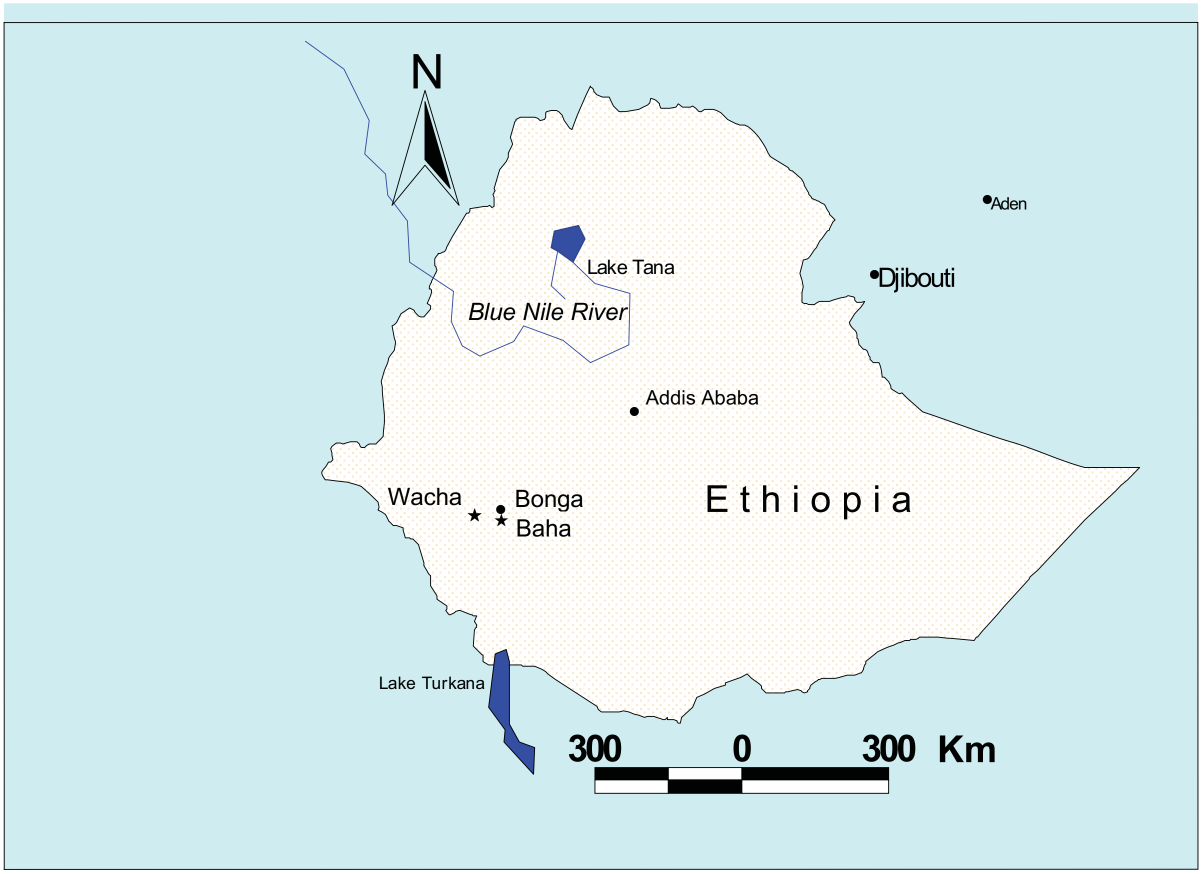

Figure 1. Map Ethiopia, stars showing the study sites.

3. MATERIALS AND METHODS

The data collection was conducted in two phases. In the first phase informants were asked to locate medicinal plants, which were, then, collected, pressed, dried and made ready for taxonomic identification. The plant specimens were identified at the National Herbarium (ETH), Addis Ababa University/Ethiopia. The specimens were identified by comparing with already identified (authentic) specimens and using taxonomic literatures such as Hedberg and Edwards (1989), Phillips (1995), Edwards *et. al.* (1995, 1997 and 2000), Hedberg *et al.* (2003), Mesfin (2004), and unpublished manuscripts at ETH. Identified plant specimens have been deposited at ETH and Institute of Biodiversity Conservation/Ethiopia. After botanical identification of medicinal plants, structured questioner was prepared for the second phase of data collection.

In the second phase, houses in each village were numbered starting from one corner and 30 of them were selected using random numbers. In each house one person was asked to rank medicinal plants used to treat a particular disease according to personal preference. A total of 60 informants (22 men and 38 women) were interviewed independently to avoid others influence. Some social factors like age, gender and education were recorded during interview. The informants were compensated for their time.

Each rank was given an integer number with the most important or preferred item being assigned the highest number. The informant verse species matrix (with the rank in the cell) was used as a raw data for analysis (Höft *et al.* 1999). Information obtained from single informant was omitted as it has negligible scientific validity (Tippo 1989). The data was analyzed using multivariate computer programs CANOCO version 4.5 (ter Braak and Smilauer 2002), NTYSYS pc 2.0 (Rohlf 1993) and PAST - PAlaeontological STatistics, ver. 1.56 (Ryan *et al.* 1995), to see consistency of information given by informants, variation among individuals and social groups in using certain medicinal plant species. The resulting ordination diagram (with people in plant space) obtained by running the three commuter programs were similar. The out put obtained by latter was presented in our result.

4. RESULTS AND DISCUSSION

4.1 Diversity of medicinal plants

A total of 124 medicinal plants, which belong to 107 genera and 49 families of vascular plants (see Appendix) were recorded in Kafa zone. The Kafficho people use these plants to treat about 18 aliments of human and domestic animals (Table 1). Some families were represented by many species, like family Asteraceae (12 species), Fabaceae (10), Lamiaceae (nine), Solanaceae (six) and Poaceae (five). Four families were represented with four species each, eight families with three species, 10 families with two species and 22 families with one species. Herbs accounted highest proportion and followed by shrubs and trees (Table 2). A significant proportion of medicinal plants (about 74%) are collected from the wild and about 26% are cultivated in homegarden.

Table 1. Aliments treated and the number of medicinal plants used by Kafficho people.

S. No.	Aliments	No of medicinal plants used	S. No.	Aliments	No of medicinal plants used
1	Abdominal pain	23	10	Rabies	12
2	Back pain	8	11	Sexually Transmitted Diseases	10
3	Bone setting	6	12	Skin Diseases	14
4	Cough	14	13	Snake Poison/Repellant	14
5	Dysentery	7	14	Tooth Pain	14
6	Ear diseases	3	15	Wounds	15
7	Eye diseases	10	16	Internal diseases of domestic animals	9
8	Headache	21	17	Fever of domestic animals	20
9	Intestinal parasites	13	18	Wounds of domestic animals	10

Table 2. Life form classes and proportion of cultivated and wild medicinal plants.

Habit	Cultivated	Wild	Grand Total	%
Climber	1	5	6	4.84
Grass	3	1	4	3.23
Herb	22	56	78	62.90
Sedge	-	2	2	1.61
Shrub	5	12	17	13.71
Succulent	1		1	0.81
Tree	-	16	16	12.90
Grand Total	32	92	124	
%	25.81	74.19		

The medicinal plants are always cultivated on the upper slope of the homegarden, specifically behind the house (Figure 2). The zone of medicinal plant cultivation and collection is always kept clean. Animal wastes or any other garbage are not damped in this zone. Weedy medicinal plants are also collected from this site, even when they occur throughout the garden. Kafficho people give four reasons for this: to prevent contamination by discharge of animal waste in the lower slope of their house, protection from livestock and to make out of human sight. The latter is related to traditional belief. The fourth reason is related to plant nutrition and the consequent plant performance. If medicinal plants are grown in homegarden quarters with high soil nutrient, they grow faster, complete their life cycle within a relatively shorter period and then die – a situation not appreciated by farmers. Instead, the farmers want the medicinal plants to remain longer in their gardens so as to ensure a prolonged harvest, and they achieve this by maintaining the plants under stressed conditions that subdue plant growth.

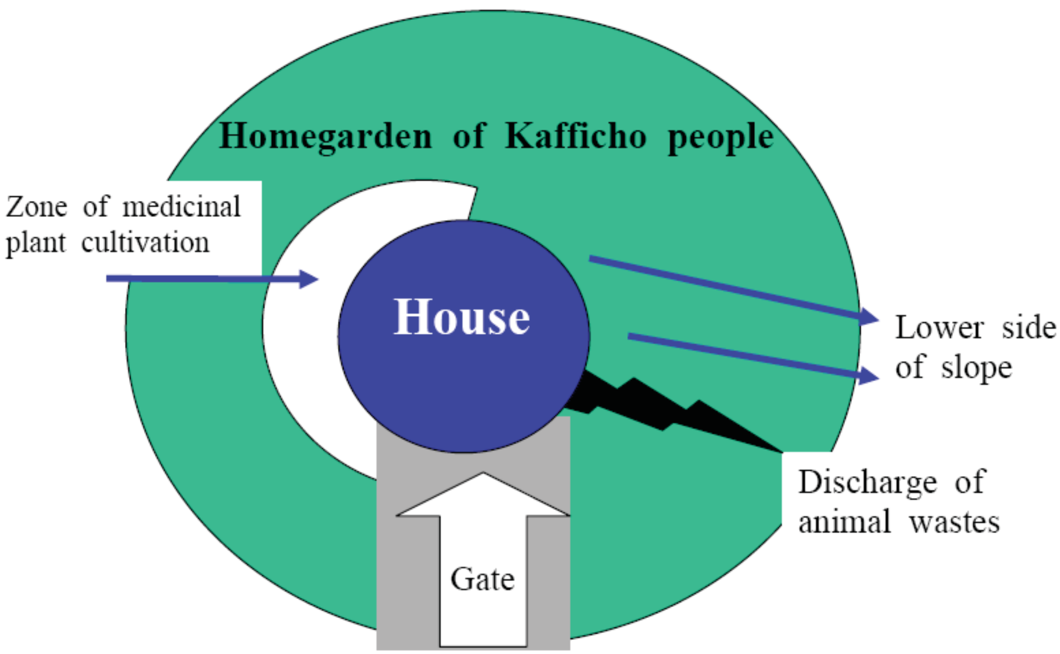

Figure 2. The zone of medicinal plant cultivation in the homegarden of Kafficho people

The people use various parts of medicinal plants (Figure 3). Leaves contribute about 50% of part used and followed by seeds (15%) and roots (10%). There are instances where different parts of the same plant being used for different purposes. There are also cases where more than one plant is used to treat a particular aliment. Headache is, for example, treated with a combination of either six or nine or 12 medicinal plants. There also cases where a particular plant is used to treat many aliments. For example, both *Clerodenderum myricoides* and *Croton macrostachyus* are used to treat seven aliments.

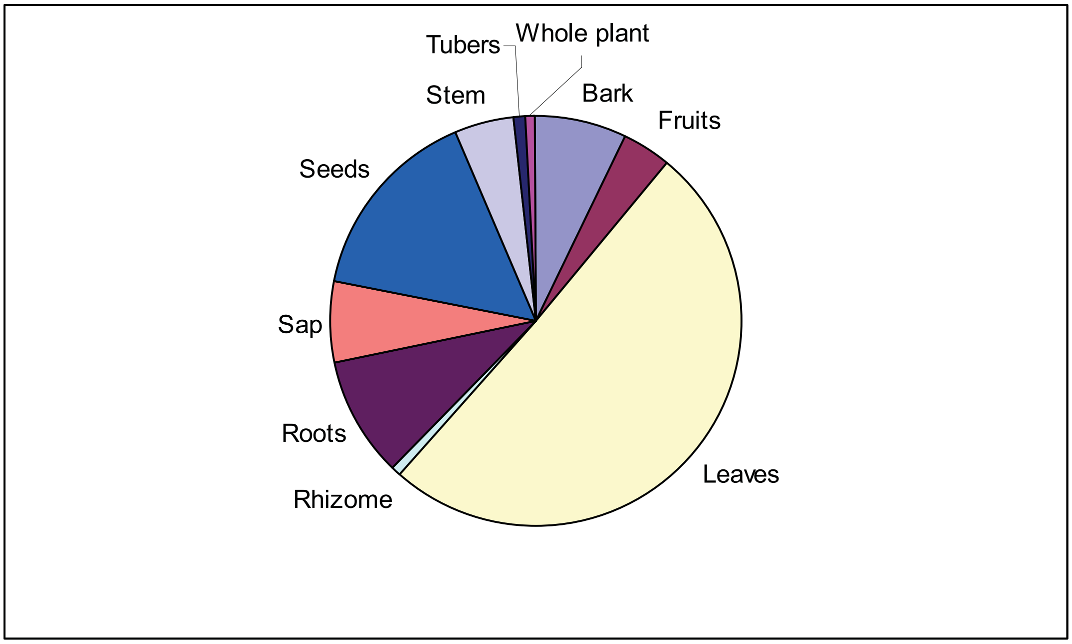

Figure 3. Proportion of parts of medicinal plants used in the treatment of various aliments.

4.2 Naming of medicinal plants -folk taxonomy

Kafficho people name medicinal plants by using the disease treated followed by '*ato'*. For example two medicinal plants, *Vernonia auriculifera* and *Datura metel* are both used to treat snake poison and are collectively named as '*Dingerato'*, where '*Dinger*' is snake and '*ato'* means medicine. Some names are attributed to wild animals or domestic animals, like '*Shetti Offio'* -Monkey's Kororima ('*Shetti'* means Monkey while '*Offio'* is Kororima) for *Aframomum zambesiacum* to distinguish it from *Aframomum corrorima.* The latter is mainly used as a spice. An example of plant names attached to domestic animal is '*Bege Gicho'* – 'Sheep's Spine' for *Achyranthes aspera*. The relationship or similarities among plants are also expressed in plant naming like – '*Damo Gebo'*, where '*Gebo'* means brother and *Ocimum suave* is a bother of '*Damo*' - *Ocimum lamiifolium.* The people also name plants using colors like- ‘*Chele Dukusho’* and ‘*Neche Dukisho’* to distinguish *Alium cepa* and *Alium sativum,* respectively. In this case ‘*Chele’* means red, ‘*Neche’* means white and ‘*Dukisho’* means onion.

Our result shows that 88.7% of medicinal plants have one to one matching of the local name to the botanical name. The plant naming system is mainly at species level. There are a few cases where one local name is used for two species (6.5%), one species with two local names (3.2%) and plants with infraspecific names (1.6%).

4.3 Variation in ethnobotanical knowledge among social groups

Our result showed that medicinal plant use among Kafficho is site specific and there is variation in plant use between the two districts (Figure 4). People in Decha district use many medicinal plants from the near by forest. They collect medicinal plants such as *Teclea nobilis* and *Trilepisium madagascariense* from forest. Within each district there is difference in medicinal plant knowledge between women and men (Figure 4). The formers ranked best those medicinal plants that are available in homegardens or close to homestead. This is related to the role of women in the management of homegardens (Feleke 2000) and cultivation of medicinal plants. The men ranked best plants that grow in the wild where they expend most of their time.

Our result also shows that there is a positive relationship ($r = 0.1801$) between the age of informants and their ethnobotanic knowledge. The older person knows more medicinal plants than youngsters (Figure 5). Like any other traditional societies in Africa (Fekadu 2001), ethnobotanical knowledge of medicinal plants of Kafficaho is transferred from the older people to younger generations at household level. This knowledge is not existent in written form, their losses or distortion at every transfer is inevitable. Our result further shows that, there is a negative relationship ($r = -0.0954$) between the educational level of informants and their ethnobotanic knowledge (Figure 6). This show the occurrence of rapid disappearance of ethnobotancial knowledge when new generation gets the opportunities that were not available to their elders, such as attending school and living in urban areas (Tesfaye *et al.* 1997). Access to modern clinics also contributes to loss of indigenous medical systems (Abbink 1995). It is obvious that those people who went to school consider traditional use of medicinal plants as harmful and backward and prefer to go to modern clinics.

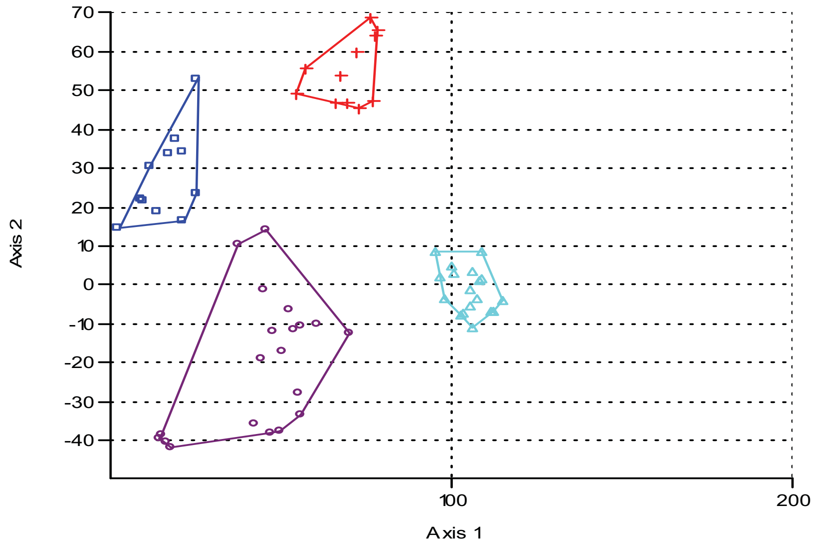

Figure 4. Principal Component Analysis obtained by running multivariate computer program PAST showing the difference in medicinal plant use between informants from Chena (Women = Triangle, Men = Cross) and Decha (Women = Circle, Men = Square).

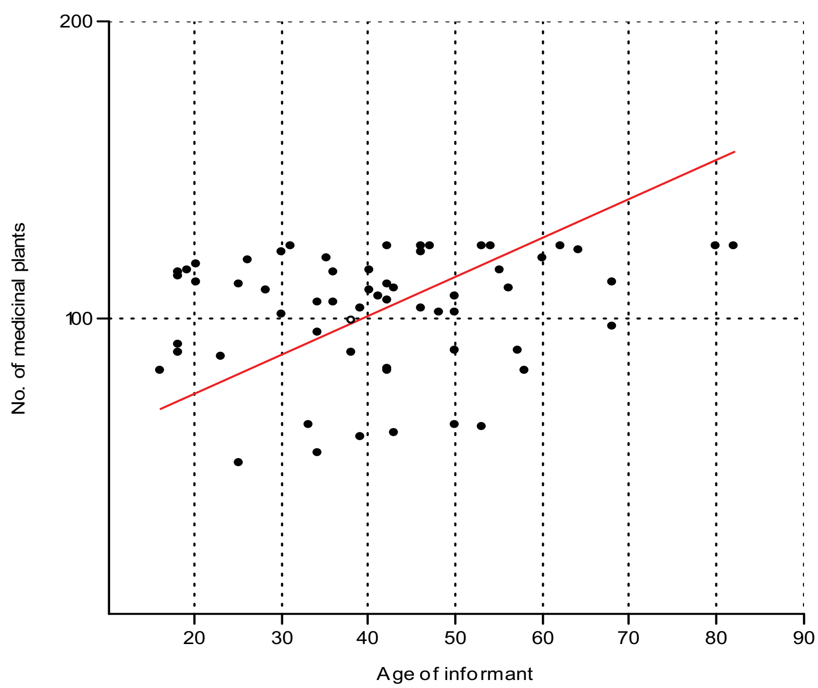

Figure 5. The relationship of age of informant and number of medicinal plants recognized

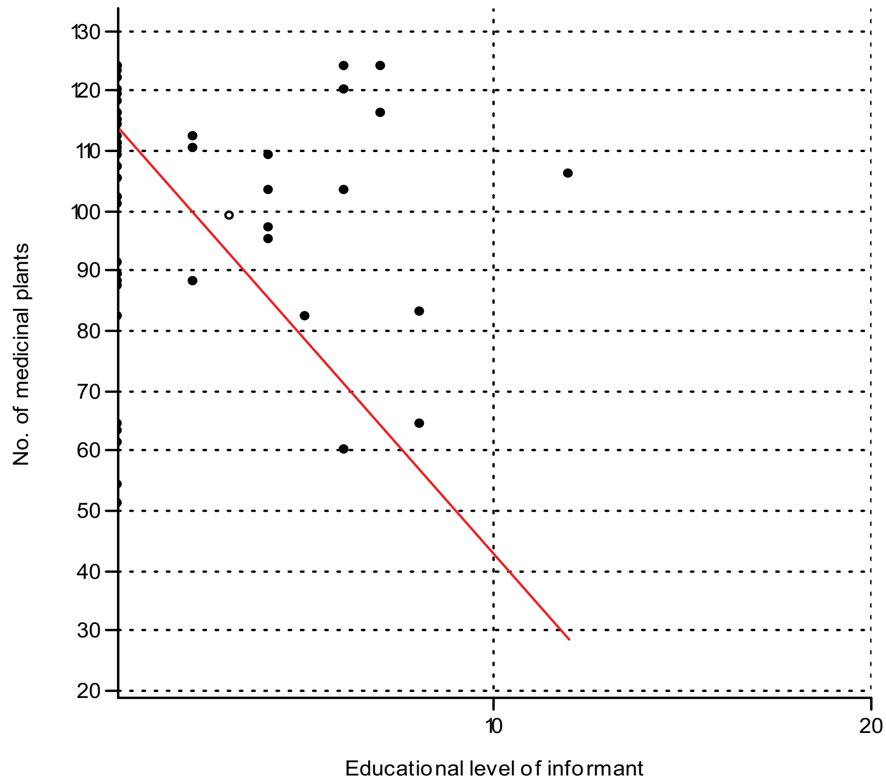

Figure 6. The relationship of educational level of informant and number of medicinal plants recognized.

5. CONCLUSION AND RECOMMENDATIONS

Medicinal plants have an immense contribution to the health care of Kafficho people. As practiced in other societies, traditional medicine is practiced; one at the house hold level and the other is through traditional healers. In the later case, there is specialization, where people go to different specialists. Our study is limited to the former case and focused on the ethnobotanical knowledge of Kafficho which is available at the public domain. The aliments are also presented as they are mentioned by the informants and were not described as they are used by health sectors.

Medicinal plant use among Kafficho is localized and dependent on plants that are found around them. The ethnobotanical knowledge on medicinal plants also varies among various social groups. A significant proportion of medicinal plants used by Kafficcho people are collected from wild. Although the reasons for the loss of medicinal plants and associated traditional knowledge systems are many, deforestation is the most visible one in Kafa zone. With high rate of population growth, expansion of farmlands by clearing vast area of forest annually, the loss or scarcity of many medicinal plants at least locally is inevitable. Under such circumstances the use of plants for medicinal purposes will also decline and consequently the once effective traditional health care system will also be lost. This will affect the health service provided by the traditional sector in the area.

One way of preserving such important traditional knowledge in the new generation is through integrating to school curricula or at least introducing the idea as an extra curricular school activity. The lessens learned in creating awareness about the need for conservation of crop farmer varieties are also important in preserving *in situ* both the medicinal plants and associated ethnobotanical knowledge among farmers. Strengthening the gardens in community gene banks, which have been serving as source for the exchange of medicinal plants among farmers is also important. Conducting further collection of medicinal plants identified and their *ex situ* conservation in cold rooms and field gene banks is also recommended.

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Appendix I. List of medicinal plants used by Kafficho people: Botanical names, family names, Kafficho names in Kaffinono, part used and aliments treated. The average preference rank of each medicinal plant was given in parenthesis following the aliment. Lowest number indicates the best one.

1. *Acanthus eminens* C.B. Clarke, ACANTHACEAE, *'Phecho',* Stem, Fever of domestic animals (19), Wounds (13), Wounds of domestic animals (8).
2. *Achyranthes aspera* L., AMARANTHACEAE, *'Begegecho',* Leaves, Headache (17).
3. *Acmella caulirhiza* Del., ASTERACEAE, *'Shishimo',* Inflorescence & Leaves, Cough (10), Headache (9).
4. *Aeollanthus densiflorus* Ryding, LAMIACEAE, *'Dicho',* Leaves, Eye diseases (1), Skin diseases (2).
5. *Aframomum corrorima* (Braun) Jansen, ZINGIBERACEAE, *'Ogio/Ofiyo',* Seeds, Abdominal pain (4), Tooth pain (7).
6. *Aframomum zambesiacum* (Baker) K. Schum., ZINGIBERACEAE, *'Shetti Ogio/Shetti Ofiyo',* Seeds, Back pain (4), Fever of domestic animals (13).
7. *Ageratum conyzoides* L., ASTERACEAE, '*Shetti Mitto',* Leaves, Wounds (12).
8. *Ajuga alba* (Gürke) Robyns, LAMIACEAE, *'Koro',* Stem, Headache (20).
9. *Albizia gummifera* C.A.Sm., FABACEAE, *'Chatto',* Leaves, Snake poison/repellant (4).
10. *Allium cepa* L., ALLIACEAE, *'Chele Dukusho',* Bulbilis, Cough (2).
11. *Allium sativum* L., ALLIACEAE, *'Neche Dukisho',* Bulbilis, Cough (4).
12. *Aloe kefaensis* Gilbert & Sebsebe, ALOACEAE, *'Ginwaro,* Sap, Wounds (2).
13. *Amaranthus caudatus* L., AMARANTHACEAE, *'Chele Shullo/Neche Shullo',* Seeds, Back pain (5), Tooth pain (10).
14. *Amorphophallus gallaensis* (Engl.) N.E. Br., ARACEAE, *'Shimbishitto',* Tubers, Wounds of domestic animals (1).
15. *Anethum graveolens* L., APIACEAE, *'Mechwelago',* Leaves, Cough (8).
16. *Artemisia abyssinica* Sch. Bip. ex A. Rich., ASTERACEAE, *'Shukindo',* Leaves, Cough (3), Headache (6).
17. *Artemisia afra* Jack. ex Wild., ASTERACEAE, *'Ae'macho',* Leaves, Abdominal pain (8), Internal diseases of domestic animals (4) Fever of domestic animals (3).

18. *Arundinaria alpina* K. Schum., POACEAE, *'Shinatto',* Leaves, Internal diseases of domestic animals (8).
19. *Asparagus racemosus* Willd., ASPARAGACEAE, *'Ufikaro',* Roots & Stem, Wounds (11).
20. *Bidens prestinaria* (Sch. Bip.) Cufod., ASTERACEAE, *'Kello',* Leaves, Headache (14).
21. *Bothriocline schimperi* Oliv. & Hiern ex Benth., ASTERACEAE, *'Yemesho',* Leaves, Headache (11), Sexually transmitted diseases (8).
22. *Brassica carinata* L., BRASSICACEAE, *'Shano',* Roots, Dysentery (6).
23. *Brassica nigra* (L.) Koch, BRASSICACEAE, *'Shanafo',* Seeds, Cough (6), Internal diseases of domestic animals (1).
24. *Brassica oleracea* L., BRASSICACEAE, *'Kafishano',* Roots, Snake poison/repellant (9).
25. *Brucea antidysenterica* J.F. Mill., SIMAROUBACEAE, *'Nukisho',* Leaves, Bone setting (1), Rabies (11).
26. *Carduus leptacanthus* Fresen., ASTERACEAE, *'Guchino',* Roots, Abdominal pain (18), Headache (16), Sexually transmitted diseases (2), Skin diseases (11).
27. *Catha edulis* (Vahl) Forssk. ex Endl., CELASTRACEAE, *'Chele Chato/ Neche Chato',* Leaves, Cough (7).
28. *Caylusea abyssinica* (Fresen.) Fisch. & Mey., RESEDACEAE, '*Yamo',* Leaves, Internal diseases of domestic animals (3), Fever of domestic animals (9), Skin diseases (4).
29. *Celosia trigyna* L., AMARANTHACEAE, '*Degicho',* Leaves & Seeds, Intestinal worms (3).
30. *Centella asiatica* (L.) Urb., APIACEAE, '*Tepheleshe (1)',* Leaves, Eye diseases (8).
31. *Chenopodium* aff. *schraderianum* Schult., CHENOPODIACEAE, '*Yocho',* Seeds, Dysentery (7), Eye diseases (9), Headache (19).
32. *Clausena anisata* (Willd.) Benth., RUTACEAE, '*Embricho',* Leaves & Stem, Tooth pain (1), Wounds (4).
33. *Clerodenderum myricoides* (Hochst.) R.Br. ex Vatke, VERBENACEAE, '*Agiwo',* Leaves & Sap, Abdominal pain (20), Dysentery (4), Eye diseases (5), Headache (8), Fever of domestic animals (15), Skin diseases (8), Wounds (9).
34. *Coffea arabica* L., RUBIACEAE, '*Buno',* Leaves, Eye diseases (3), Snake poison/repellant (10).

35. *Commelina diffusa* Burm.f., COMMELINACEAE, ‘*Naletto’,* Sap, Skin diseases (7).
36. *Corandrium sativum* L., APIACEAE, ‘*Debo’,* Seeds, Cough (9).
37. *Cordia africana* Lam., BORAGINACEAE, ‘*Deo’,* Leaves, Abdominal pain (16), Wounds (14).
38. *Crotalaria incana* L., FABACEAE, ‘*Okesh’,* Leaves, Wounds (15).
39. *Crotalaria* sp., FABACEAE, ‘*Shetto’,* Leaves & Roots, Tooth pain (9).
40. *Croton macrostachyus* Del., EUPHORBIACEAE, ‘*Wago’,* Leaves, Eye diseases (4), Headache (5), Intestinal worms (2), Fever of domestic animals (8), Sexually transmitted diseases (7), Wounds of domestic animals (3).
41. *Cucurbita pepo* L., CUCURBITACEAE, ‘*Buko’,* Seeds, Intestinal worms (4)
42. *Cyathea manniana* Hk., CYATHEACEAE, ‘*Shishino’,* Leaves, Sexually transmitted diseases (9)
43. *Cymbopogon martini* (Roxb.) J.Watson, POACEAE, ‘*Tocho’,* Roots, Abdominal pain (22), Fever of domestic animals (10).
44. *Cynodon dactylon* (L.) Pers., POACEAE, ‘*Chamiro’,* Roots, Snake poison/repellant (7).
45. *Cynoglossum lanceolatum* Forssk., BORAGINACEAE, ‘*Chako’,* Roots, Abdominal pain (10).
46. *Cyperus distans* L.f., CYPERACEAE, ‘*Micho(1)’,* Roots, Snake poison/repellant (13).
47. *Dalbergia lactea* Vatke, FABACEAE, ‘*Bitbito’,* Leaves & Roots, Snake poison/repellant (5).
48. *Datura metel* L., SOLANACEAE, ‘*Dingerato (1)’,* Whole plant, Snake poison/repellant (11).
49. *Datura stramonium* L., SOLANACEAE, ‘*Nafnifo’,* Seeds, Rabies (3).
50. *Dicliptera laxata* C.B.Clarke, ACANTHACEAE, *Togo,* Leaves, Eye diseases (6), Headache (2).
51. *Dracaena steudneri* Engl., DRACAENACEAE, ‘*Udo’,* Roots, Rabies (6).
52. *Drymaria cordata* (L.) Schultes, CARYOPHYLLACEAE, ‘*Hakeato’,* Leaves, Tooth pain (14), Wounds (10).
53. *Drymaria* sp., CARYOPHYLLACEAE, ‘*Mocho’,* Leaves, Wounds (8).
54. *Echinops kebericho* Mesfin, ASTERACEAE, ‘*Kaphero’,* Roots, Fever of domestic animals (1), Snake poison/repellant (1).

55. *Ekebergia capensis* Sparrm., MELIACEAE, '*Ororo',* Bark, Intestinal worms (13), Rabies (5).
56. *Embelia schimperi* Vatke*,* MYRSINACEAE, '*Dupho',* Fruits, Intestinal worms (1).
57. *Ensete ventricosum* (Welw.) Cheesman*,* MUSACEAE, '*Wutto',* Sap, Back pain (6), Bone setting (6), Cough (12).
58. *Eragrostis tef* (Zucc.) Trotter*,* POACEAE, '*Gasho',* Seeds, Back pain (3), Bone setting (4), Intestinal worms (10).
59. *Erythrina abyssinica* Lam.*,* FABACEAE, '*Bero',* Bark, Abdominal pain (17), Fever of domestic animals (14), Snake poison/repellant (8), Tooth pain (6).
60. *Erythrina brucei* Schweinf.*,* FABACEAE, '*Kolacho',* Bark, Rabies (7).
61. *Euphorbia ampliphylla* Pax*,* EUPHORBIACEAE, '*Gineato',* Sap, Rabies (9), Wounds (1), Wounds of domestic animals (4).
62. *Euphorbia schimperiana* Scheele*,* EUPHORBIACEAE, '*Abromo',* Sap, Abdominal pain (3), Skin diseases (1).
63. *Ficus ovata* Vahl*,* MORACEAE, '*Chaphero',* Bark, Rabies (8)
64. *Girardinia diversifolia* (Link) Friis.*,* URTICACEAE, '*Shimbriko',* Roots, Rabies (4), Sexually transmitted diseases (5).
65. *Guizotia scabra* (Vis.) Chiov.*,* ASTERACEAE, '*Tuffo',* Leaves, Intestinal worms (8), Wounds (5).
66. *Hagenia abyssinica* J.F. Gmel.*,* ROSACEAE, '*Kohosho',* Inflorescence, Intestinal worms (9).
67. *Hordeum vulgare* L.*,* POACEAE, '*Sheko',* Seeds, Bone setting (3).
68. *Hydrocotyle mannii* Hook.f.*,* APIACEAE, '*Tepheleshe (2)',* Leaves, Eye diseases (7)
69. *Impatiens ethiopica* Grey-Wilson*,* BALSAMINACEAE, '*Ekeko',* Leaves, Internal diseases of domestic animals (7).
70. *Isodon ramosissimus* (Hook.f.) Codd*,* LAMIACEAE, '*Dingermiko (1)',* Leaves & Stem, Tooth pain (13).
71. *Justicia schimperiana* (Hochst. ex Nees) T. Anders*,* ACANTHACEAE, '*Shersharo',* Leaves & Roots, Headache (10), Fever of domestic animals (12), Rabies (2), Sexually transmitted diseases (4).

72. *Kalanchoe densiflora* Rolfe, CRASSULACEAE, '*Kachamiitobo',* Leaves, Wounds of domestic animals (5).
73. *Kosteletzkya begoniifolia* (Ulbr.) Ulbr., MALVACEAE, '*Shatshato',* Leaves, Wounds of domestic animals (7).
74. *Lagenaria abyssinica* (Hook.f.) C. Jeffrey, CUCURBITACEAE, '*Tojo',* Fruits, Abdominal pain (9).
75. *Laggera crispata* (Vahl) Hepper & Wood, ASTERACEAE, '*Shetti Uphicho',* Leaves, Headache (18), Fever of domestic animals (20).
76. *Leonotis* sp., LAMIACEAE, '*Rasemro',* Leaves, Abdominal pain (23).
77. *Lepidium sativum* L., BRASSICACEAE, '*Shipho',* Seeds, Cough (1), Fever of domestic animals (2).
78. *Linum usitatissimum* L., LINACEAE, '*Muto',* Seeds, Abdominal pain (7).
79. *Lobelia gibberoa* Hemsl., CAMPANULACEAE, '*Shamburo',* Leaves, Intestinal worms (12).
80. *Lysimachia ruhmeriana* Vatke, PRIMULACEAE, '*Michichiniato',* Roots, Dysentery (3).
81. *Maesa lanceolata* Forssk., MYRSINACEAE, '*Chego',* Sap, Fever of domestic animals (17), Skin diseases (13).
82. *Mariscus* sp., CYPERACEAE, '*Micho(2)',* Roots, Snake poison/repellant (12).
83. *Maytenus arbutifolia* (A. Rich.) Wilczek, CELASTRACEAE, '*Angitto/Shiko',* Leaves, Eye diseases (10), Snake poison/repellant (6).
84. *Melilotus suaveolens* Ledeb., FABACEAE, '*Cholo',* Seeds, Cough (13), Ear diseases (3).
85. *Millettia ferruginea* (Hochst.) Bak., FABACEAE, '*Bibero/Yago',* Seeds, Back pain (2), Skin diseases (5), Tooth pain (2).
86. *Momordica foetida* Schum., CUCURBITACEAE, '*Umbrao',* Leaves & Roots, Headache (13), Sexually transmitted diseases (10), Tooth pain (8).
87. *Nicotiana tabacum* L., SOLANACEAE, *Tumbao,* Leaves, Internal diseases of domestic animals (5), Fever of domestic animals (5), Snake poison/repellant (2), Wounds of domestic animals (2).
88. *Nigella sativa* L., RANUNCULACEAE, '*Ae'affo',* Seeds, Abdominal pain (2).
89. *Ocimum lamiifolium* Hochst., LAMIACEAE, '*Damo',* Leaves, Cough (5), Ear diseases (1), Headache (1), Fever of domestic animals (4).

90. *Ocimum* sp., LAMIACEAE, '*Kudo',* Leaves, Ear diseases (2), Headache (3), Sexually transmitted diseases (6).
91. *Ocimum urticifolium* Roth, LAMIACEAE, '*Dame Gabo',* Leaves, Headache (4), Fever of domestic animals (16).
92. *Oxalis procumbens* Steud., OXALIDACEAE, '*Michiato',* Leaves, Headache (12)
93. *Oxalis corniculata* L., OXALIDACEAE, '*Kakeato',* Leaves, Tooth pain (11).
94. *Papaver somniferum* L., PAPAVERACEAE, '*Barteffo',* Seeds, Abdominal pain (15)
95. *Pavonia* sp., MALVACEAE, *Sheto,* Leaves, Wounds (6).
96. *Pavonia urens* Cav., MALVACEAE, '*Shurnoko',* Leaves, Abdominal pain (19), Wounds of domestic animals (9).
97. *Pentas schimperiana* (A. Rich.) Vatke, RUBIACEAE, '*Machibutto',* Leaves, Back pain (7), Internal diseases of domestic animals (6).
98. *Perscaria senegalensis* (Meisn.) Sojak, POLYGONACEAE, '*Gergoato',* Leaves, Insecticide (1).
99. *Phytolacca dodecandra* L'Hér., PHYTOLACCACEAE, '*Yengamo',* Roots, Rabies (1). Sexually transmitted diseases (1).
100. *Piper capense* L.f., PIPERACEAE, '*Turfo',* Inflorescence, Fever of domestic animals (6).
101. *Pittosporum abyssinicum* Del., PITTOSPORACEAE, '*Shollo',* Bark, Abdominal pain (14), Cough (11).
102. *Prunus africana* (Hook.f.) Kalkm., ROSACEAE, '*Omo',* Bark & Leaves, Abdominal pain (21), Intestinal worms (11), Sexually transmitted diseases (3), Wounds (7).
103. *Pycnostachys abyssinica* Fresen., LAMIACEAE, '*Yearo',* Leaves, Dysentery (2), Insecticide (2), Intestinal worms (6).
104. *Ranunculus multifidus* Forssk., RANUNCULACEAE, '*Hogiyo',* Fruits, Leaves & Roots, Dysentery (5), Eye diseases (2), Skin diseases (10), Tooth pain (3).
105. *Ricinus communis* L., EUPHORBIACEAE, '*Teso',* Seeds, Skin diseases (6).
106. *Rumex abyssinicus* Jacq., POLYGONACEAE, '*Ambatto',* Leaves, Headache (15).
107. *Rumex nepalensis* Spreng., POLYGONACEAE, '*Goricho',* Roots, Intestinal worms (5), Rabies (10).
108. *Ruta chalepensis* L., RUTACEAE, '*Chedramo',* Fruits & Leaves, Abdominal pain (1), Dysentery (1), Fever of domestic animals (7).

109. *Satureja paradoxa* (Vatke) Engl., LAMIACEAE, '*Nedo'*, Leaves, Abdominal pain (11), Headache (7).

110. *Solanum americanum* Mill., SOLANACEAE, '*Acho'*, Leaves, Abdominal pain (13).

111. *Solanum dasyphyllum* Schumach., SOLANACEAE, '*Kumbaffo'*, Fruits, Internal diseases of domestic animals (2).

112. *Stellaria mannii* Hook.f., CARYOPHYLLACEAE, '*Dingermiko (2)'*, Leaves & Stem, Skin diseases (12).

113. *Stephania abyssinica* (Dill. & A. Rich.) Walp., MENISPERMACEAE, '*Eko'*, Leaves, Wounds of domestic animals (6).

114. *Teclea nobilis* Del., RUTACEAE, '*Shengaro'*, Leaves, Internal diseases of domestic animals (9).

115. *Thalictrum rhynchocarpum* Dill. & A. Rich., RANUNCULACEAE, '*Shunawedi'*, Leaves & Roots, Snake poison/repellant (14), Tooth pain (12), Wounds of domestic animals (10).

116. *Trigonella foenum-graecum* L., FABACEAE, '*Kaffigiraro'*, Seeds, Abdominal pain (5), Back pain (1), Bone setting (2).

117. *Trilepisium madagascariense* DC., MORACEAE, '*Gebo'*, Sap, Wounds (3).

118. *Vepris dainellii* (Pichi-Serm.) Kokwaro, RUTACEAE, '*Mengereto'*, Bark & Fruits, Intestinal worms (7), Skin diseases (9), Tooth pain (5).

119. *Verbena officinalis* L., VERBENACEAE, '*Ambelacho'*, Leaves, Abdominal pain (6).

120. *Vernonia amygdalina* Del., ASTERACEAE, '*Grawo'*, Bark, Fever of domestic animals (11), Skin diseases (3).

121. *Vernonia auriculifera* Hiern, ASTERACEAE, '*Dingerato (2)'*, Leaves, Fever of domestic animals (18), Snake poison/repellant (3).

122. *Vicia faba* L., FABACEAE, '*Bakello'*, Seeds, Bone setting (5).

123. *Withania somnifera* (L.) Dunal, SOLANACEAE, '*Gizawa'*, Roots, Headache (21).

124. *Zingiber officinale* Roscoe, ZINGIBERACEAE, '*Yanjibelo'*, Rhizome, Abdominal pain (12), Tooth pain (4).