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Ethnobotanical investigation on medicinal plants used against human ailments in Erkowit and Sinkat areas, Eastern Sudan

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Abstract. *Adam M, Ahmed AA, Yagi A, Yagi S. 2020. Ethnobotanical investigation on medicinal plants used against human ailments in Erkowit and Sinkat areas, Eastern Sudan. Biodiversitas 21: 3255-3262.* The present study provides ethnobotanical data for the traditionally used medicinal plants of Erkowit and Sinkat, Eastern Sudan. The survey data were collected from 53 traditional healers through a survey carried out in February-December 2018. Fifty-eight plant species represent 34 flowering families and one Parmeliaceae lichen that are used for therapeutic purposes in the selected area. The families of highest prevalence were Euphorbiaceae (8 species) followed by Leguminosae (7 species). To validate information on the use of plants,: Use Value (UV), Fidelity Level (FL), and Informants' Consensus Factor (ICF) were applied. The most commonly used species was *Adansonia digitata* with a UV of 0.89. The majority of the informants agreed on the use of *Oxalis anthelmintica* to treat anemia and *Psidium guajava* in the treatment of tuberculosis and cough, with a very high FL (92% and 91% respectively). All informants agreed on the effectiveness of *Withania somnifera* in treating breast inflammation and cancer, with top ICF of 1. These medicinal plants play an important role in the available healthcare provision in the study area. This preliminary study should be further continued into scientific assessment of their therapeutic use and safety through different biological activity tests and toxicological properties.

Keywords: Eastern Sudan, Erkowit, folklore medicine, medicinal plants, Sinkat, traditional use

Abbreviations: FL: Fidelity Level, ICF: Informants' Consensus Factor, UV: Use Value, RSHS: Red Sea Hills State

INTRODUCTION

Diverse medicinal plants are used in the traditional healing practice and health promotion in Sudan, a country with more than forty million inhabitants, culturally diverse, and scattered over various terrains and climates (World Population on Prospects 2017). Sudan claims wealth of folklore medicine interwoven with the socio-economic, spiritual, rural, and tribal life and as a blend of Egyptian, Indian, Arabian, East, and West African cultural practices which over time have acquired a local mainstay identity. Based on religious and cultural background, indigenous knowledge, and empirical experience, the traditional herbal medicine application in Sudan is reflected differently in the different ethnic groups' practices, be it ritual, ceremonial, or healing. Consequent to centuries of folklore medicine and empirical knowledge, herbal medicine constitutes the main treatment for a high percentage of the population, significant proportion of it is nomadic. In addition, by virtue of economic factors and those in nomadic lifestyle, most of the population has limited access to standard mainstream medical care (Karar and Kuhnert 2017; Issa et al. 2018).

Within the immense diversity of plants, Sudan harbors an asset of flora of significant medicinal and economic importance. Among the flora in the country, records show that of the 3137 documented species of flowering plants in Sudan, 15 % are endemic to the country and that the documented flora are spread along 170 families and 1280 genera (Khalid et al. 2012). However, the country is not yet set up to actively promote products from its huge resource for a share in the rapidly evolving national and global market.

Of the flora of Eastern Sudan, those in the Erkowit and Sinkat areas share a floral gradient with Sahel zone and the Afromontane domain in addition to some with Mediterranean affinities (Vetaas et al. 2012). However, medicinal and economic exploitation of plants in this region is limited due to a lack of documented information, though there have been a few ethnobotanical studies of these plants, one reference being 'The Medicinal plants of Erkowit' by El-Ghazali (1986). Other factors that seem to have negatively influenced sustenance of local traditional knowledge include globalization, modernization, migration, and new healthcare systems. Thus far, the documentation maintains a repertoire of traditional healing skills and knowledge paving the way for future research on medicinal plants potential, aiming at safety, standardization and validation of their use (Bunalema et al. 2014) and towards the initiation of promising drug screening projects (Faruque et al. 2018). The objective of the present study was therefore to document the traditional knowledge of medicinal plants and their uses by local healers in the Erkowit and Sinkat areas, Eastern Sudan.

MATERIALS AND METHODS

Study area

The present study was conducted in Erkowit (18° 42' 0" North, 37° 0' 0" East) and Sinkat (18° 50' 14" North, 36° 49' 58" East) areas, situated in Red Sea Hills State (RSHS), Eastern Sudan (Figure 1). The RSHS covers an area of approximately 125,000 square kilometers where the three main ecological zones could be characterized as the coastal plain, the RSH (3400-4200ft), and the Western plains (Vetaas et al. 2012). The seasonality of precipitation in these regions, namely in winter and summer, is bound to the combination of altitude, physiography, and proximity to the Red Sea (45 km) where the mean annual rainfall rarely exceeds 150 mm with temperature range of 10°C to 25°C during daytime in the course of the year. As to soil, the major area is rocky but there are sandy alluvial plains characterized by high salinity, especially in the coastal area (Manger 2001).

Livelihood in this region is based on livestock, especially camels, raised by the main tribe of Hadendowa who are a subdivision of the main tribe of Beja. Hadendowa people lead a nomadic lifestyle, with their classical shelters of hemispherical or rectangular tents made of straw mats laid over a wooden frame, are adapted to their lifestyle of movement as known camel traders traveling up and down the Red Sea area from Egypt to Eritrea. They also trade their crafts of straw mats and woolen rugs or charcoal and firewood for food. As the area is generally dominated by very rocky and mountainous terrain, it leaves few plots suitable for growing some vegetables like potatoes, carrots, cabbage, and tomato. Hadendowa groups were subjected to continuous famines due to the frequent lack of political entitlement from the Governments during drought periods with consequent deficiency of vital nutritional elements and malnutrition diseases including stunted growth, eye problems, diabetes, and heart diseases (Manger 2001).

Procedures

Data collection and plant identification

Using a structured questionnaire during the study period February-December 2018, in Erkowit and Sinkat, local healers were approached through some of the educated people who explained to them in the Hadendowa language the purpose and methods of the study, and consequently, the healers gave their informed consent. The semi-structured questionnaire included different diseases; vernacular names of each medicinal plant and part, mode of preparation, and routes of administration. Qualitative ethnobotanical data were collected from 53 practicing people (26 from Sinkat and 27 from Erkwoit) aged 20-65 years old. During the surveys in the mountains in Erkowit and the valleys in Sinkat, herbarium specimens were collected and later deposited at the Botany Department, Faculty of Science, University of Khartoum, Sudan. Plant identification was done using keys of standard floras such as Maydell (1990), Elamin (1990), Hutchinson et al. (2014), Darbyshire et al. (2015). The botanical names and plant families are given according to the standards of the plant list (www.ipni.org/).

Data analysis

Data analysis was carried out by using both the classical ethnobotanical systematic investigation and a numerical quantitative approach. The use-value (UV), a quantitative measure for the relative importance of species known locally, was calculated as follows:

$$UV = \sum U_i / n$$

Where:

U_i is the number of use-reports cited by each informant for a given species and n refers to the total number of informants. Use values are high when there are many use-reports for a plant (Srithi et al. 2009).

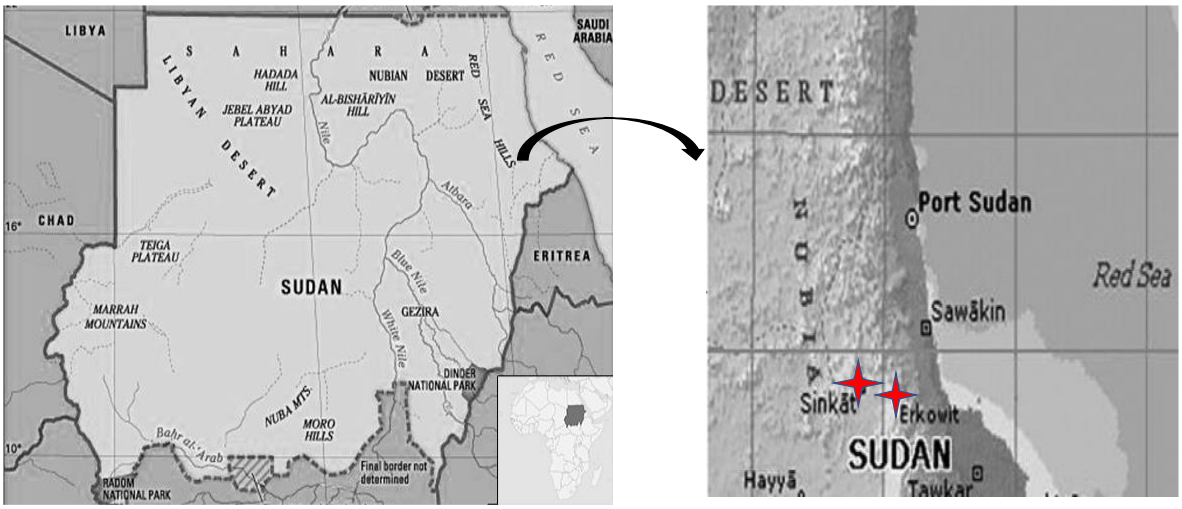

Figure 1. Map of the study area: Erkowit (18° 42' 0" North, 37° 0' 0" East), Sinkat (18° 50' 14" North, 36° 49' 58" East). https://africa2trust.com/countryfacts/?l=1&c=15

The level of homogeneity among information provided by different informants was calculated by the informants' consensus factor (ICF) using the following formula:

$$ICF = N_{ur} - N_t / (N_{ur} - 1)$$

Where:

N_{ur} : number of use reports from informants for a particular plant-use category

N_t : number of taxa or species that are used for that plant use category for all informants.

ICF values range between 0 and 1, where '1' indicates the highest level of informant consent (Trotter and Logan 1986)

Fidelity level (FL), referred to the most preferred species used in treatment of a specific ailment, was calculated as

$$FL (\%) = (N_p / N) \times 100$$

Where:

N_p : number of informants that claim a use of a plant species to treat a particular disease

N : number of informants that use the plants as a medicine to treat any given disease (Friedman et al. 1986)

RESULTS AND DISCUSSION

Medicinal plants and the associated knowledge

Our assessment of the knowledge of the traditional medicinal plants use was carried out by interviewing the informants. They were predominantly men (79%), all of whom were practicing traditional healing as a secondary job. All informants referred their knowledge to information passed on through generations by word of mouth and cultural practices, and this was the foundation for the healthcare provision and other activities that maintained the society and conserved the knowledge. Furthermore, the informants stated that there was a cross-transfer of knowledge and experience between villagers and other groups. Similar to the earlier generations the illiteracy was still widespread in the study area where the rate was 66 % among the informants in the age groups between 40 and 80 years old. However, among the rest of the informants, those in the age groups between 20 and 30 had received some education estimated as 19% at primary and 15% at secondary levels (Table 1).

Medicinal plants diversity and habitat

The diversity of medicinal plants in the present study is characterized by 58 plant species representing 34 flowering families and one lichen species belonging to Parmeliaceae (Table 2). Of the plants studied, the most diverse is the family Euphorbiaceae, comprising the largest number of species (8 spp.), followed by Leguminosae (7 spp.), Malvaceae (5 spp.), Crassulaceae and Solanaceae (3 spp. each) and Lamiaceae and Zygophyllaceae (2 spp. each). However, the remaining families (28) were less diverse, being represented each by only one species.

The majority of medicinal plants were collected from wild habitat (85%) and were comprised mostly by herbs (73%), to a lesser extent by trees (16%), shrubs (9%), and least represented were lichens constituting only 2% (Table 3). Concerning, the rest, they were either cultivated as in the case of *Psidium guajava* (2%), or purchased (13%) in the herbs market, which included fruit pulp of *Adansonia digitata*, fruit peel of *Punica granatum*, leaves and fruits of *Grewia* spp., seeds of *Coriandrum sativum* and *Trigonella foenum-graecum* as well as *Melaleuca alternifolia* leaves.

Parts of the studied medicinal plants, preparation, and administration

All plant parts could be used for treatment, with leaves being the parts mostly applied (48%) followed by the whole plant (23%), fruit (12%), seed (4%), stem/stem bark (7% each), root and bulb (3% each) (Figure 2).

Remedies were mostly administrated orally (68%), as raw (10%) or in the form of potion prepared by maceration (15%), infusion (22%), or decoction (8%). Topical application (32%) was applied as powder (54%), smoke (2%), and poultices (6%) or as a wash and mouth rinsing (3%) (Table 4).

Table 1. Demographic characteristics of the informants

		Number	Percentage (%)
Gender	Women	11	21
	Men	42	79
Age	20-39	18	34
	40-59	24	45
	≥ 60	11	21
Educational level			
	Illiterate	35	66
	Primary school	10	19
	Secondary high school	8	15

Table 3. Growth habit of the wild, cultivated and purchased medicinal plants in the study area

Plant habit	Wild	Cultivated	Purchased
	44 (85%)	1 (2%)	7 (13%)
Herb	32 (73%)	-	2 (29%)
Shrub	4 (9%)	1 (100%)	3 (42%)
Tree	7 (16%)	-	2 (29%)
Lichen	1 (2%)	-	

Table 2. Medicinal plants used by traditional healers collected from Erkowit and Sinkat areas, Sudan

Species/family/voucher no.	Vernacular name	Habit	Use value	Part used	Application	Preparation mode	Adm. mode
Acacia etbaica Schweinf., Leguminosae, AE/E18	Garad	Tree	0.5	Fruit	Cough	Infusion	Oral
Acacia seyal Delile, Leguminosae, AS/S18	Talih	Tree	0.69	Fruit	Diabetes	Maceration	Oral
*Adansonia digitata** L., Malvaceae AD/E18	Gongulase	Tree	0.89	Fruit pulp	Diarrhea	Maceration	Oral
Agrimonia eupatoria L., Rosaceae, AE/E18	Shokran	Herb	0.27	Whole plant	Tuberculosis	Raw powder	Oral
Aloe sinkatana Reynolds, Xanthorrhoeaceae, AS/E18	Kalandoy	Herb	0.13	Leaf	Wounds	Powder sprinkled in wound	Topical
					Headache	Smoke fumigant	Topical
Anastatica hierochuntica L., Brassicaceae, AH/S18	Um Kafait	Herb	0.32	Whole plant	Skin allergies and sore	Dried, mixed with oil and rubbed	Topical
Aristolochia bracteolata Lam., Aristolochiaceae, AB/S18	Yahemyay	Herb	0.13	Leaf	Hypertension	Maceration	Oral
					Dysentery	Maceration and mixed with yogurt	Oral
Artemisia absinthium L., Asteraceae, AA/S18	Dimseesa	Herb	0.38	Whole plant	Urinary tract infections	Maceration	Oral
				Root	Diabetes	Maceration	Oral
Azadirachta indica A. Juss., Meliaceae,AI/S18	Neem	Tree	0.83	Leaf	Malaria	Powder added to lemon juice.	Oral
Balanites aegyptiaca (L.) Delile, Balanitaceae, BA/E18	Shashut	Tree	0.66	Leaf	Tuberculosis	Infusion	Oral
Calotropis procera (Aiton) Dryand., Asclepiadaceae, CP/E18	Ambras	Shrub	0.50	Leaf	Rheumatism	Powder mixed with sesame oil and rubbed	Topical
Chrozophora oblongifolia (Delile) A. Juss. ex Spreng, Euphorbiaceae, CO/E18	Ramtouk/Sumah/tirba	Herb	0.13	Leaf	Skin allergies	Maceration and taken as bath	Topical
					Malaria	Infusion	Oral
Cissus quinquangularis Chiov., Vitaceae, CQ/E18	Katut	Climber	0.05	Leaf	Skin rashes and allergies	Powder rubbed locally	Topical
Citrullus colocynthis (L.) Schrad., Cucurbitaceae, CC/E18	Handal	Herb	0.05	Seed	Skin blemishes	Maceration and taken as bath	Topical
Coleus barbatus (Andrews) Benth., Lamiaceae, CB/E18	Khahab	Herb	0.66	Whole plant	Skin allergies	Smoke fumigant	Topical
Corchorus depressus (L.) Stocks, Malvaceae, CD/E18	Hayaoyanyet	Herb	0.13	Leaf	Malaria	Maceration	Oral
					Anemia	Maceration	Oral
					Gum inflammation	Infusion used as mouth rinsing	Topical
*Coriandrum sativum** L., Apiaceae, CS/S18	Kasspara	Herb	0.22	Seed	Dysentery	Decoction	Oral
Crassula pentandra (Royle ex Edgew.) Schoenl., Crassulaceae, CP/S18	Kalanjo	Herb	0.09	Leaf	Skin rashes	Powder rubbed locally	Topical
Datura stramonium L., Solanaceae, DS/S18	Datura	Herb	0.05	Leaf	Hemophilia and bleeding	Powder added in a very tiny amount to water and drunk	Oral
	Shokaleeb	Herb	0.05	Whole plant	Rheumatism	Powder mixed with Sesame oil and rubbed	Topical
Euphorbia candelabrum Tremaux ex Kotschy, Euphorbiaceae, EC/E18	Zagoum	Tree		Stem	Tuberculosis	Few drops of latex diluted in water	Oral
Euphorbia heterophylla L., Euphorbiaceae, EH/E18	Labna	Herb	0.05	Whole plant	Eczema	Powder rubbed locally	Topical
Euphorbia hirta L., Euphorbiaceae, EH/S18	Ataib	Herb	0.05	Whole plant	Constipation	Infusion	Oral
					Malaria	Infusion	Oral
					Asthma	Infusion	Oral
Euphorbia polycantha Schweinf. Ex Pax, Euphorbiaceae, AP/E18	Zagoum	Shrub	0.07	Stem	Wound	Latex applied locally	Topical
Euphorbia triaculeata Forssk., Euphorbiaceae, AT/S18	Um Libaina	Shrub	0.10	Stem	Syphilis, gonorrhea	Latex applied locally	Topical
Fagonia indica Burm.f., Zygophyllaceae, FI/E18	Um Shouk	Herb	0.59	Whole plant	Toothache	Filling tooth cavity with powder	Topical

Forsskaolea tenacissima L., Urticaceae, FT/S18	Halak Anabaik/ lussaig	Herb	0.05	Leaf	Asthma	Infusion	Oral
				Root	Wounds	Poultice applied to wounds	Topical
*Grewia bicolor** Juss., Malvaceae, GB/S18	Basham Albayad	Shrub	0.05	Leaf	Bilharzia	Infusion	Oral
*Grewia tenax** (Forssk.) Fiori, Malvaceae, GT/S18	Moat	Shrub	0.77	Fruit	Anemia	Maceration	Oral
Haplophyllum acutifolium (DC.) G.Don, Rutaceae, HA/S18	Haza	Herb	0.79	Stem	Jaundice	Infusion	Oral
					Malaria	Infusion	Oral
Hyphaene thebaica (L.) Mart., Arecaceae, HT/E18	Doam	Tree	0.63	Fruit	Hypertension	Decoction after removing the crust	Oral
Jatropha curcas L., Euphorbiaceae, JC/E18	Alambeet	Shrub	0.81	Leaf	Wounds	Powder sprinkled in wound	Topical
Kalanchoe glaucescens Britten, Crassulaceae, KG/E18	Malut	Shrub	0.05	Leaf	Diabetes	Infusion	Oral
Leucas nubica Benth., Lamiaceae, LN/S18	Mayoub	Herb	0.78	Whole plant	Jaundice	Infusion	Oral
Malva parviflora L., Malvaceae, MP/E18	Humaad	Herb	0.59	Leaf	Wounds	Poultice applied to wound	Topical
*Melaleuca alternifolia** (Maiden & Betche) Cheel, Myrtaceae, MA/S18	Shahi	Tree	0.23	Leaf	Fever	Poultice	Topical
Moringa oleifera Lam., Moringaceae	Moringa	Shrub	0.09	Leaf	Anemia	Fresh leaves are eaten	Oral
Ocimum basilicum L., Labiatae, OB/S18	Raihan	Herb	0.05	Leaf	Jaundice	Infusion	Oral
					Kidney disorders	Infusion	Oral
Oxalis anthelmintica A.Rich., Oxalidaceae, OA/E18	Homaid	Herb	0.77	Whole plant	Anemia	Infusion	Oral
Pancratium tortuosum Herb., Amaryllidaceae, PT/E18	Basal sageer	Herb	0.88	Bulb	Malaria	Maceration	Oral
Parmotrema ultralucens (Krog) Hale, Parmeliaceae, PU/S18	Abahagaib	Lichen	0.32	Whole plant	Skin allergies and sore	Powder mixed with sesame oil and rubbed	Topical
Psidium guajava L., Myrtaceae, PG/S18	Gwava	Shrub/ cultivated	0.81	Leaf	Tuberculosis	Decoction	Oral
				Leaf	Cough	Maceration	Oral
					Dysentery	Decoction	Oral
*Punica granatum** L., Lythraceae	Romman	Shrub	0.09	Fruit peel	Dysentery	Infusion	Oral
					Diarrhoea	Infusion	Oral
Salicornia fruticosa (L.) A.J.Scott, Amaranthaceae, SF/E18	Hamad	Herb	0.05	Stem bark	Headache	Infusion	Oral
Salvadora persica L., Salvadoraceae, SP/S18	Araak	Shrub	0.22	Fruit	Cough	Eaten raw	Oral
Senna occidentalis (L.) Link, Leguminosae, SO/E18	Sangasanga	Herb	0.05	Leaf	Toothache	Filling tooth cavity with powder	Topical
Senna alexandrina Mill., Leguminosae, SA/E18	Ambarkwi	Herb	0.09	Leaf	Skin allergies and sore	Powder mixed with sesame oil and rubbed	Topical
					Diabetes	Maceration	Oral
					Malaria	Decoction	Oral
Senna obtusifolia (L.) H.S.Irwin & Barneby, Leguminosae, SO/S18	Anotelai	Herb	0.13	Leaf	Skin allergies and sore	Powder mixed with sesame oil and rubbed	Topical
Solanum schimperianum Hochst, Solanaceae, SS/E18	Domhindib, Hantitrob	Herb	0.79	Leaf	Wounds	Poultice applied to wound	Topical
Solenostemma argel (Delile) Hayne, Apocynaceae, SA/E18	Hargal	Herb	0.13	Leaf	Cough	Decoction and mixed with mint oil.	Oral
					Stomachache	Infusion	Oral
					Malaria	Maceration	Oral
Tamarindus indica L., Leguminosae, TI/S18	Aradaib	Tree	0.09	Fruit	Malaria	Decoction	Oral
Tamarix aphylla (L.) H.Karst., Tamaricaceae, TA/S18	Amab	Herb	0.05	Whole plant	Headache	Infusion	Oral
Trianthema portulacastrum L., Aizoaceae, TP/S18	Rabaa	Herb	0.77	Whole plant	Ulcer	Infusion	Oral
Tribulus terrestris L., Zygophyllaceae, TT/S18	Shishkel/diraisa	Herb	0.18	Leaf & stem	Urinary tract infections	Decoction	Oral
*Trigonella foenum-graecum** L., Leguminosae	Hilba	Herb	0.77	Seed	Stomach ache	Maceration	Oral
Umbilicus botryoides Hochst. ex A. Rich., Crassulaceae, UB/E18	Buscolai	Herb	0.54	Whole plant	Wounds	Poultice applied to wound	Topical
Urginea grandiflora Baker, Asparagaceae, UG/E18	Basal kabeer	Herb	0.78	Bulb	Wounds	Poultice applied to wound	Topical
Withania somnifera (L.) Dunal, Solanaceae, WS/E18	Maykais	Herb	0.14	Whole plant	Breast inflammation, cancer	Poultice applied to swellings	Topical
Ziziphus spina-christi (L.) Desf., Rhamanaceae, ZS/S18	Arad	Tree	0.27	Leaf	Urinary tract infections	Infusion	Oral

Note: * Purchased from local market

Figure 2. Percentage of plant part used

Table 5. Diseases categories and preferred species application by informant consensus factor (ICF) and fidelity level (FL)

Ailment category	Nt	Nur	ICF	Preferred species	Application	FL
Respiratory system diseases	9	63	0.87	*Psidium guajava*	Tuberculosis and cough	91%
Cardiovascular system and hematological disorders	8	68	0.89	*Oxalis anthelmintica*	Anemia	92%
Digestive system disorders	12	115	0.90	*Coriandrum sativum*	Dysentery	80%
				Solenostemma argel	Stomachache	75%
				Ocimum basilicum	Jaundice	70%
Genitourinary system disorders	5	48	0.91	*Artemisia absinthium*	Urinary tractinfections	60%
Infections/infestations	12	38	0.70	*Tamarindus indica*	Malaria	80%
Endocrinological system (diabetes)	3	33	0.94	*Acacia seyal*	Diabetes	40%
Skin diseases	18	120	0.86	*Aloe sinkatana*	Wounds	88%
				Parmotrema ultralucens	Skin allergies and sore	80%
Musculoskeletal system	2	6	0.80	*Euphorbia aegyptiaca*	Rheumatism	67%
Growths	1	53	1	*Withania somnifera*	Breast inflammation and cancer	90%
Pain	5	24	0.826	*Aloe sinkatana*	Headache	30%
				Fagonia indica	Toothache	62%

Respiratory system diseases: cough, asthma, and tuberculosis. Cardiovascular system and hematological disorders: anemia, hypertension, hemophilia, and bleeding. Digestive system disorders: stomachache, diarrhea, dysentery, constipation, ulcer, and jaundice. Genitourinary system disorders: urinary tract infections, kidney disorders, syphilis, and gonorrhea. Infections/infestations: malaria, fever, bilharzia and gum inflammation. Endocrinological system: diabetes. Note: in diseases: skin allergy, wounds, sores, blemishes, rashes, and eczema. Musculoskeletal system: rheumatism. Growths: cancer. Pain: headache and toothache. Nt, number of taxa; Nur, number of use reports

Table 4. Mode of preparations of medicinal plants by the traditional healers

Oral (68%)		Topical (32%)	
Maceration	15 (30%)	Powder	13 (54%)
Infusion	22 (44%)	Poultice	6 (25%)
Decoction	8 (16%)	Smoke	2 (8%)
Powder/latex/eaten raw	5 (10%)	Bath/mouth rinsing	3 (13%)

Use value (UV), informant consensus factor (ICF) and fidelity level (FL)

Culture, ethnicity, religion, and geographical location largely determine the traditional use of the medicinal plants. According to Table 2 the most commonly used species is *Adansonia digitata* with a UV of 0.89, followed by *Pancratium tortuosum* (0.88), *Azadirachta indica* (0.83), and *Jatropha curcas* and *Psidium guajava* (0.81) each. Furthermore, in order to determine the ICF based on their application for different ailments the plants in the study area were assembled into ten categories. Accordingly, an ICF value of 1 was obtained for the category of abnormalities, representing the highest value, followed by metabolic conditions (diabetes) (0.94), skin conditions (0.91), genitourinary disorders (0.90) and digestive ailments (0.90) (Table 5). Furthermore, fidelity level (FL) values were provided for the most important plant species in each ailment category where calculation was based on the information from four or more informants relevant to the treatment of specific disorders. Accordingly, the FL for *Oxalis anthelmintica*, used to treat anemia, was 92%, followed by *Psidium guajava* (91%) for treating tuberculosis and cough, *Withania somnifera* (90%) for treating breast inflammation and cancer and by *Aloe sinkatana* (88%) for wound treatment (Table 5).

Discussion

The chosen study area is unique within its surroundings in view of the significant difference in its climate and vegetation, comprising species representative of East African highland Afromontane and Mediterranean floras (Bullela and Ingrouille 1989). Regarding the prevalence of

medicinal plant species in the region, the highest number is recorded for Euphorbiaceae followed by Leguminosae. This is in contrast to the ethnobotanical studies from other regions of Sudan where Leguminosae is the most reported as the family of highest prevalence (Musa et al. 2011; Suleiman 2015; Issa et al. 2018). However, Euphorbia with its vast diversity of biotopes plays a major role in some communities particularly in the disturbed and severely grazed mountain steppes (Pahlevani et al. 2015). Most of the informants used to gather plants from the wild, being easily accessible, with the perception that such plants have a higher level of curing effect than the cultivated ones. By virtue of the high geographical altitude, the habitat dictates the dominance of herbs over shrubs and trees (Table 3). Here, the use of leaves top the list followed by the whole plant and the fruit. The treatment of most ailments except skin diseases, or rheumatism, and toothache was through oral administration. Potions were mainly prepared by infusion and maceration as the healers are aware of the destructive effect of excessive heating (Table 2).

Considering the reliability index, ICF, the overall category data index (0.70 - 1.00) indicated a high level of compatibility for the number of taxa with their corresponding application for different ailments by the healers in the study area (Table 5). Assessing the data for the categories when both UV and FL are considered, a high level includes the plants species *Oxalis anthelmintica* and *Psidium guajava*; the first, with a high UV of 0.77 and FL of 92%, and highest preference in the treatment of anemia of the hematological disorders category, while the second, with UV 0.82 and FL 91%, was the most preferred in the treatment of tuberculosis and cough of the respiratory system diseases category. It was also noted that some plants with low UV values but high FL values were in use by local healers as in the case of *Withania somnifera* (UV 0.14, FL 90) and *Parmotrema ultralucens* (UV 0.32, FL 80). Regarding the general status of vegetation in the study area, it is noteworthy that the ecosystem was impacted by bouts of drought leading to massive loss of perennial trees and a dwindling vegetation cover subjected to overgrazing and erosion (Vetaas et al. 2012), with widespread malnutrition and disease outbreaks. Consequent upon that the healers meticulously selected plants for treatment of specific disorders as in the case of *Withania somnifera* and *Parmotrema ultralucens* for breast cancer and skin conditions, respectively (Boadu and Asase 2017). As such, the situation reflects the rarity of species and an increasing threat to others like *Aloe sinkatana*, *Pancratium tortuosum*, and *Urginea grandiflora* as a consequence of the massive collecting for profit and study purposes.

A number of the plants in the present study according to their local use show pharmacological properties which tally with the published data for the same species from different areas. For instance certain parts of *Withania somnifera* as well as isolates such as withanolides, withaferins, withanone, and withanosides which have been reported to have antitumor activity towards cancer cell lines (Rai et al. 2016). It was also found that the anti glycemic activity of *Artemisia absinthium* in type II diabetes subjects, significantly reduced fasting serum glucose level (Hassan et al. 2018). Furthermore, the *Kalanchoe glaucescens* even though not proven to have antidiabetic effect, may yet help alleviate type II diabetes complications through its antioxidant activity (Dal and Sigrist 2016, Adam et al. 2018). Moreover, to add to the therapeutic/nutritional role of plants is the effectiveness of *Azadirachta indica* leaf and seed extracts against chloroquine-resistant strains of malaria plasmodium species (Alzohairy 2016; Habluetzel et al. 2019). Besides the purely nutritional role of *Grewia tenax* it is loaded with iron (Aboagarib et al. 2014). The analysis of *Solanum schimperianum* has revealed that it is a source of powerful antibacterial components against *Bacillus subtilis* and *Staphylococcus aureus* (Al-Oqaila et al. 2012; Fadl et al. 2017).

An important concern in the therapeutic use of plants is their toxic side effect, as is in the case with commonly administered plant medicines in the study area and generally in Sudan. Among the plants established to be toxic and cancerogenic is *Aristolochia bracteolata* indigenous to Sudan, due to its content of aristolochic acids, which called for strict control on the use of the plant (Abdelgadir et al. 2011). The widespread use of the medicinal plants in the study area and Sudan, in general, raises serious issues in regard to their toxic side effects. Plant components may vary according to the stage of growth, area season, and soil, and so does their bioactivity. Therefore, it is imperative that measures are put in place to ensure safety of use and by raising the awareness of the healers to this. There is also an urgent need for the establishment of governmental bodies to oversee and direct their us Active efforts by local governmental bodies could put in place plans in coordination with the population for selection and natural propagation of safer plants under advice of specialized scientific institutions.

The study area of Erkowit and Sinkat has a variety of plants used medicinally by local healers based on traditional knowledge with a high level of agreement for use in different conditions. However, the population of highly potent plants is decreasing, due to environmental and human factors that are leading to the loss of their natural habitat. To conserve the medicinal plant species and their diversity in the study area, an appropriate educational plan must be set up, with the local population to promote understanding of the endangerment and protection of these species. A positive approach consists of establishment of ex-situ medicinal gardens such in which the local population is mobilized. Also, in-situ conservation of the highly useful and depleting species could be achieved by propagating, reintroducing, regularly monitoring, and evaluating practices. The reported medicinal plants need to be systematically screened through phytochemical and pharmacological study for potential bioactive compounds which could further be used for designing drugs that will promote the development and expansion of pharmaceutical and herbal industries within Sudan. There is a concern about the toxicity of certain plants which calls for attention and organized approach to raise awareness of the healers and for streamlining of the gathering and the use of the local medicinal plants.

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