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Research article

Ethno-medicinal and bio-cultural importance of aloes from south and east of the Great Rift Valley floristic regions of Ethiopia

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ABSTRACT

There are 46 *Aloe* species identified from Ethiopia out of which 67.3% are endemics but comprehensive data on their ethno-medicinal and bio-cultural values are lacking. Interview, focus group discussion (FGD), and guided field walks were conducted with 210 respondents (152 men and 58 women). Relative frequency of citation (RFC_s), informants' consensus factor (F_{ic}), use value (UV_s), relative importance index (RI_s), and cultural value index (CV) were analyzed. Non-parametric Kruskal Wallis and Wilcoxon tests were performed using R software. Twenty-three *Aloe* species were recorded in the study areas with 196 use-reports and 2158 citations, grouped into six major use categories ($N_{UC} = 6$). Medicinal use categories accounted for 149 use-reports (76%) with 1607 citations. The species with the highest numbers of use-reports were *Aloe megalacantha* subsp. *alticola*, *A. trichosantha* subsp. *longiflora* and *A. calidophila* of which 87, 75 and 61.1% respectively were medicinal uses. *Aloe calidophila* has highest values in all indices UV (11.72), RFC (0.68), RI (0.89), and CV (6.2). Among *Aloe* parts, leaf exudate accounted for 111 use-reports (49.1%) of which 92.9% were used for medicinal purposes. *Aloe retrospiciens* and *A. ruspoliana* were reported poisonous to carnivores. F_{ic} values of the six major use categories ranged from 0.86 to 0.22. Elderly people (>60) had more knowledge than 25–40 and 41–60 age groups (Kruskal-Wallis chi-squared = 12.17, df = 3, $p = 0.006$), which is significant difference in depth of ethno-medicinal knowledge. Men had more knowledge of medicinal uses than women (Wilcoxon test, $p = 0.002$) significantly different, while women were knowledgeable than men for cultural uses like, cosmetic (Wilcoxon test, $p = 0.06$), not significantly different. The ways in which aloes are used and valued have implications for their future medicinal utility, which instigate detailed phytochemical and pharmacological studies.

1. Introduction

The genus *Aloe* L. belongs to family Asphodelaceae [1], which has 560 accepted species and 21 infraspecific taxa [2] is renowned for its use in herbal medicine throughout its native range in Africa South of the Sahara, the Arabian Peninsula, Madagascar and the Mascarene Islands [3]. The dried latex extracted from the leaves has been used medicinally in Africa, Asia, Europe and the Middle East for hundreds of years [4, 5, 6, 7, 8]. Aloes has been used for the treatment of wounds and skin complaints, malaria, microbial infections, and complaints of the digestive system [9, 10, 11, 12, 13]. In addition, commercial preparations containing *Aloe* species include laxative drugs, health drinks and tonics, after shaving gel, mouthwash and toothpaste, hair tonic and shampoo, and skin-moistening gel [14, 15, 16].

Ethiopia, a likely centre of diversity for *Aloe*, has 46 identified and documented species with three subspecies, of which 67.3% are endemic. Several of these are highly threatened [17, 18]. Three local centres of endemism are recognised in Ethiopia, each with characteristic endemic species (Table 1) [18,19]. Six species of *Aloe* in Ethiopia were classified on the IUCN Red List [20] as endangered (*A. harlana* and *A. yavellana*), near threatened (*A. tewoldei* and *A. pubescens*), and vulnerable (*A. retrospiciens* and *A. rugosifolia*), while many of the remaining species are still data-deficient [21, 22, 23, 24]. Despite conservation concerns, aloes have been recognised for their economic potential in Ethiopia [19], particularly for livelihood security, economic development and enhancing biodiversity

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Table 1. The three local centres of *Aloe* endemism recognised in Ethiopia.

Center of endemism	Floristic regions	Number of endemic species	List of endemic species and infraspecific taxa
Northern and central highlands, north and west of the great rift valley	SU, KF, IL, WG, GJ, GD, WU, TU	15	*Aloe adigratana, A. ankoberensis, A. benishangulana, A. camperi, A. clarkei, A. debrana, A. elegans, A. monticola, A. percrassa, A. pulcherrima, A. schelpei, A. sinana, A. steudneri, A. trigonantha*, and *A. weloensis*
Eastern highlands and lowlands	AF, HA	7	*Aloe bertemariae, A. harlana, A. mcloughlinii, A. megalacantha* subsp. *alticola, A. pirottae*; *A. pubescens*; and *A. trichosantha* subsp. *longiflora*
Southern highlands, lowlands and rift valley	AR, BA, SD, GG	11	*Aloe elkerriana, A. friisii, A. ghibensis, A. gilbertii* subsp. *gilbertii, A. gilbertii* subsp. *megalacanthoides, A. jacksonii, A. kefaensis, A. otallensis, A. tewoldei, A. welmelensis*, and *A. yavellana*

SU = Shew; KF = Kefa; IL = Ilubabur; WG = Welega; GJ = Gojam; GD = Gonder; WU = Welo; TU = Tigray; AF = Afar; HA = Hararge; AR = Arsi; BA = Bale; SD = Sidamo; GG = Gamo Gofa.

conservation on marginal lands [25]. For example, *Aloe debrana* leaf mesophyll is used in a thickening agent [26] and for treating sisal fibre for packing Ethiopian export coffee (e.g. www.gseventiplc.com). In the Borena of Oromia region in Southeast Ethiopia, the local community has been cultivating *A. calidophila* to collect aloe leaf exudate and gel for small-scale aloe-soap manufacturing [27]. Data collated from the literature indicated that the medicinal uses of the genus *Aloe* comprised 74% of the use records [28] in which the use of exudate was common.

Despite the limited reports on the uses and conservation concerns for aloes of Ethiopia, their ethnomedicinal and biocultural values, and the impact of these values on sustainable use have not previously been assessed systematically. It is expected that people will be motivated to conserve resources that are most important to them, in contrast to resources perceived as less useful [29, 30, 31]. In this regard, further effort to improve the perception of local community towards the resource is needed. This can be achieved by indicating the invisible but potential values of the genus *Aloe* for effective conservation of the genus *Aloe*. In addition, it has been hypothesized that the local communities in all the study areas make use of *Aloe* species arbitrarily for similar purpose and irrespective of different cultural/ethinic communities on the use of *Aloe* species. Therefore, we comprehensively investigated ethnomedicinal values, biocultural importance, and the emic perception of the wild population status of *Aloe* species in the East and South of the Great Rift Valley floristic region of Ethiopia.

2. Materials and methods

2.1. Study areas

This study focused on the eastern, southeastern, and southern floristic regions of Ethiopia called Hararge (HA), Bale (BA), Sidamo (SD), Arsi (AR), and Afar (AF) floristic regions, which are stated as east and south of the Great Rift Valley floristic regions in this study (Figure 1).

2.2. Data collection

Comprehensive data was collected on the ethno-medicinal and biocultural values, population trends of species in the natural habitat from

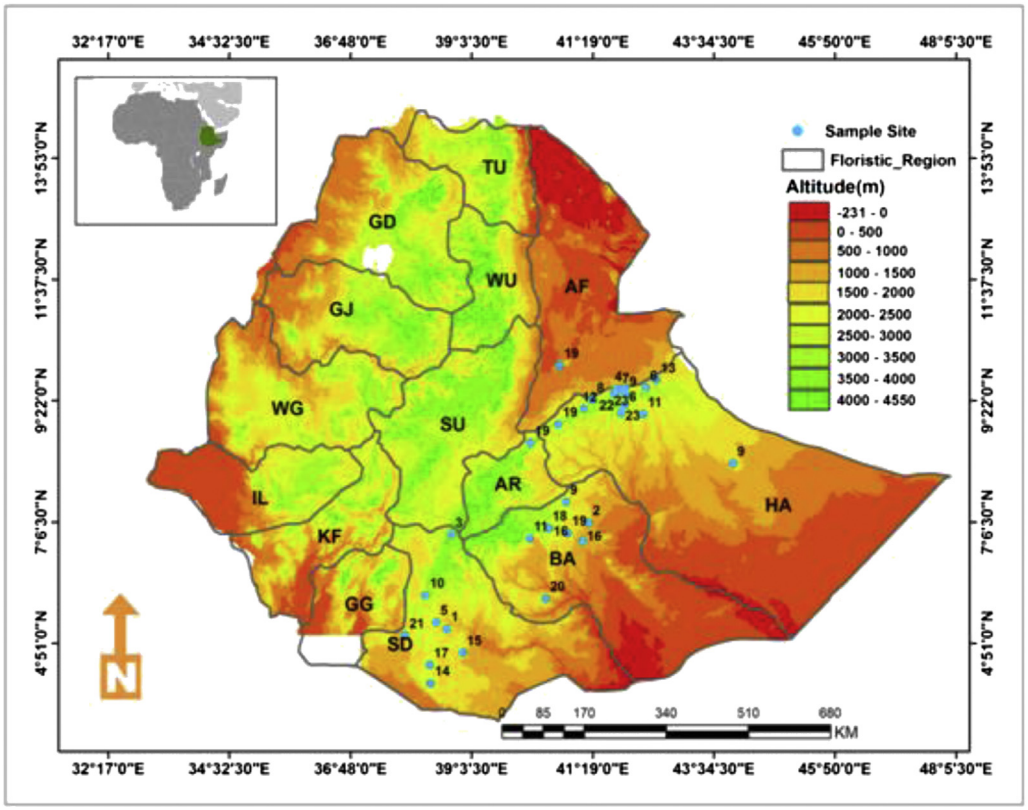

Figure 1. The study areas, stated as east and south of the Great Rift Valley floristic regions in this study (Site numbers indicated *Aloe* species: 1 = *A. calidophila;* 2 = *A. citrina;* 3 = *A. gilbertii* subsp. *gilbertii;* 4 = *A. harlana;* 5 = *A. lateritia;* 6 = *A. macrocarpa;* 7 = *A. mcloughlinii;* 8 = *A. megalacantha* subsp. *alticola;* 9 = *A. megalacantha* subsp. *megalacantha;* 10 = *A. otallensis;* 11 = *A. pirottae;* 12 = *A. pubescens;* 13 = *A. retrospiciens;* 14 = *A. rivae;* 15 = *A. rugosifolia;* 16 = *A. ruspoliana;* 17 = *A. secundiflora;* 18 = *A. tewoldei;* 19 = *A. trichsantha* subsp. *longiflora;* 20 = *A. welmelensis;* 21 = *A. yavellana;* 22 = AHU51; 23 = AHU53).

Table 2. Demographic characteristics of informants representing ethnic communities in east and south of the Great Rift Valley Floristic regions, Ethiopia.

Total Informant	Oromo (N = 140)	Somali (N = 32)	Afar (N = 24)	Harari (N = 14)
Men	97 (69.3%)	25 (78.1%)	19 (79.2%)	11 (78.6%)
Women	43 (30.7%)	7 (21.9%)	5 (20.8%)	3 (21.4%)
RI				
Men	60	16	14	8
Women	33	5	4	2
TH/key informants				
Men	37	9	5	3
Women	10	2	1	1
Age categories*				
25–40	50 (32.8 ± 5.3)	9 (31.1 ± 5.5)	4 (30.3 ± 4.0)	4 (32.6 ± 4.1)
41–60	65 (51.7 ± 5.8)	20 (50.3 ± 6.8)	15 (51.9 ± 5.9)	8 (51.1 ± 6.0)
above 60	25 (70.1 ± 6.4)	3 (76.0 ± 5.7)	5 (74.5 ± 6.6)	2 (72.0 ± 5.2)
Occupation				
Farmers	104	0	0	6
Agro-pastoralist	12	4	2	0
Pastoralist	18	26	22	0
Others	6	2	0	8

* Number of informants = N (mean age ±standard deviation) for each age categories; RI = random informants, TH = traditional healers.

the emic perspective, and associated indigenous knowledge of *Aloe* species in these floristic regions. Data was collected in the different seasons from 2017 (March to April and October to November) to 2018 (January to February and June to July). A total of 210 respondents (152 men and 58 women) from four cultural communities (Oromo, Somali, Afar, and Harari) participated. Informants were either randomly chosen (RI) or were systematically selected traditional healers (TH/key informants) who have in-depth traditional knowledge concerning multi-utility of *Aloe* species of their locality. Age, gender, and occupation (Table 2) were considered, as suggested by Martin [32] and Caruso *et al*, [33].

Ethnobotanical data collection procedures were approved by ethical committee for human involvement and use of lab animals in school of animal and range sciences of Haramaya University. Semi-structured interviews, focus group discussion (FGD), practical observation sessions, and guided field walk in *Aloe* localities were conducted after Oral Prior Informed Consent (PIC) was sought from every respondent. Most interviews were conducted in the field in order to avoid the risk of confusing identity of *Aloe* species. By repeated inquiries at least two times with the same informants the validity and reliability of recorded information was confirmed [32, 33, 34]. The respondents were asked to freely list all possible uses of each *Aloe* species, each time a plant was mentioned as "used" was considered as one "use-report", and repeated mention of same use-report by different informants was taken as "use mention or number of citation". Data recorded were: vernacular names of *Aloe* species, local uses, parts used, ingredients added during the use formulations (if any), and locally marketable aloe products produced. For medicinal use-reports, the ailments treated, preparation procedures, method of administration, and antidote (if any) were recorded. In addition, population trends (noticeably increasing, increasing, noticeably decreasing, decreasing, stable, and not sure/uncertain) from emic perspective were recorded (Appendix II). However, vague use-reports, from which it was difficult to distinguish the specific values were avoided, e.g. "used for livestock disease treatment"; "it has cultural importance"; etc. Finally, the use-reports recorded were categorized into major use categories (UC) of level 1 and sub-categories of level 2 using the Economic Botany Data Standard [35].

Aloe specimens were identified using taxonomic keys in the Flora of Ethiopia and Eritrea [17], through visual comparisons with authenticated plant specimens kept at the National Herbarium (ETH) of Addis Ababa University and at Herbarium of Haramaya University, and authenticated by Prof. Sebsebe Demissew (Professor of Plant Systematics and Biodiversity). Voucher specimens of all species with all herbarium sheet data were deposited at both herbaria. Voucher numbers of Haramaya University were used in this study.

2.3. Data analysis

The data were organized and cleaned in an Excel spreadsheet (Microsoft office 2016), to be suitable for both qualitative and quantitative analysis. Qualitative data were analyzed following [32, 34, 36] like, free listing, part used, use-reports and use mentions. Quantitative data were analyzed using the corresponding formulas as follows:

2.3.1. Frequency of citation for use-report (FC_{UR})

Frequency of citation for use-report (FC_{UR}) is the percentage of informants who mentioned each use-report of particular *Aloe* species, which has been calculated using the formula:

$$FC_{UR}(\%) = n_i/N \times 100 \quad (1)$$

where n_i is the number of informants who cites each use-report per species and N is total number of informants.

2.3.2. Relative frequency of citation (RFC_s)

Relative frequency of citation was calculated by dividing the frequency of citation (FC) of a species by total number of informants (N) involved in the five floristic regions that makes N to varies or the summation of use-report ($\sum UR_i$) of all the informants interviewed for a species divided by N [37].

$$RFC_s = \frac{FC_s}{N} = \sum_{i=i_1}^{i_N} UR_i \Big/ N \quad (2)$$

2.3.3. Informant consensus factor (F_{ic})

The informant consensus factor (Fic) of each *Aloe* species is the proportion of informants who independently reported its use against a particular use category calculated using the formula [38, 39]:

$$Fic = n_{ur} - nt/n_{ur} - 1 \quad (3)$$

where, 'n_{ur}' is the "number of use-reports" in each use category and 'nt' is the "number of taxa used".

2.3.4. Use value (UV)

Use value was used to demonstrate the relative importance of each *Aloe* species known locally, which can be calculated according to Albuquerque *et al.* formula [40]:

$$UV_s = \sum U_i/N_s \quad (4)$$

where, UV_s refers to the use value of *Aloe* species 's', U_i to the number of different uses mentioned by each informant i per specific *Aloe* species, and N is the total number of informants interviewed for *Aloe* species 's'.

2.3.5. Relative importance index (RI)

This index takes into account the number of major use-categories only and calculated as follows [37]:

$$RI_s = \frac{RFCs(max) + RNUs(max)}{2} \quad (5)$$

where, $RFC_s(max)$ is the relative frequency of citation over the maximum. It is obtained by dividing FC_s by the maximum value in all *Aloe* species of the study [$RFC_{s(max)}$ = FCs/max (FC)], and RNUs(max) is the relative number of use-categories over the maximum, obtained dividing the number of uses of the species $NU_s = u = u_{NC}\, u = u_1 \sum UR_u$ by the maximum value in all *Aloe* species of the survey RNs(max) = NUs/max (NU).

2.3.6. Cultural value index (CV)

This index estimates the cultural significance of each *Aloe* species, which combines the three variables, informant (i), a species (s), and use-category (u), which is calculated using the following formula [41]:

$$CV_s = \left[NU_s/NC\right]\left[FC_s/N\right]\left[\sum_{U=U_i}^{uNC}\sum_{i=i_1}^{i_N} UR_{ui}/N\right] \quad (6)$$

The first factor is the relationship between the numbers of different uses reported for ethnospecies (each *Aloe species*) and total number of use-categories. The second factor is the relative frequency of citation of a species. The third factor is the sum of all the UR for a species, i.e., the sum of number of participants who mentioned each use of a species, divided by N.

To test if there was any correlation between age of the informant and their knowledge on use of aloes (number of use-reports), the nonparametric Kruskal Wallis Test was performed. If there was a significant difference between the informant's gender and knowledge about use of aloes, the non-parametric pair wise Wilcoxon test was performed using R software version 3.3.4. for Windows using multicompview and R companion packages. P-values of less than 0.05 were taken as statistically significant difference.

3. Results

3.1. Ethno-medicinal and bio-cultural values of aloes with frequency of citation

A total of 23 *Aloe* species (Appendix I) were recorded in the study areas, of which 21 are found in the Flora of Ethiopia and Eritrea [17] and two (recorded as unknown, voucher number AHU51 and AHU53) could not be identified to species level. Among the *Aloe* species reported in this study, 11 species (52%) are endemic and near endemic. The total number of use-reports was 196, were categorized into six major use categories (N_{UC} = 6) with 2158 citations (use mentions) from the 23 *Aloe* species (Table 3) by 210 respondents (Table 1). The major use categories (UC) are medicines (Md), social uses (SU), materials (Mt), environmental uses (EU), vertebrate poisons (VP), and food (Fd). The medicinal use category accounted 149 use-reports (76%) with 1607 citations. The highest number of use-reports was recorded for *Aloe megalacantha* subsp. *alticola* with 23 use-reports, of which about 87 % were medicinal uses for humans and livestock. The next most frequently cited species was *A. trichosantha* subsp. *longiflora* with 20 use-reports followed with *A. calidophila* with 18 use-reports, in which 75% and 61.1% were medicinal (human and veterinary) uses, respectively (Table 3).

The highest frequency of citation was 100% recorded for *Aloe otallensis* leaf exudate used for weaning children from breast-feeding followed with 94.4% for *A. yavellana* leaf exudate used to treat jaundice, 91.6% for *A. rivae* leaf gel used for body and hair wash, and 90.9% for *A. megalacantha* subsp. *alticola* exudate to treat skin infections (Table 3).

The most frequently cited use of *Aloe* species in the study areas was for medicines (human and veterinary): 149 use-reports (76%) from 22 *Aloe* species, with a total number of 1607 citations (use mentions) were recorded. The least use-report was for food use-category: three use-reports (1.5%) from three *Aloe* species with 19 citations (Figure 2).

A total of nine different plant parts were used in the diverse bio-cultural uses (Figure 3) within the six major use categories. Leaf exudate was the most frequently sought part, accounting for 111 use-reports (49.1%) in which about 89 (80.2%) were for human medicinal formulations and 12 (11.7%) were for livestock medicinal formulations. That means, 92.9% of exudate were used for medicinal purposes and the remainder in formulations were in social uses and vertebrate poisons categories. In addition, the entire leaf for 47 use-reports (20.8%), which also include the use of exudate as part of entire leaf. This would suggest that the use of exudate exceeds 69% of the plant parts used for medicinal purpose. The fewest use-reports were reported from formulations made from the inflorescence and pedicel, with just a single use-report, which is 0.4% each (Figure 3).

The local communities practiced nine types of preparation methods for medicinal applications, out of these 42% are prepared in the form of pure exudate collection from the fresh leaf to be used for different application followed by pulverization (11.5%) and concoction (10.8%) (Figure 4).

3.2. Use-reports among cultural communities

The distribution of use-reports among the cultural communities in the study areas showed 161 use-reports for the Oromo community (N = 140), followed with 17 for the Somali community (N = 32), 9 for the Afar community (N = 24), and 9 use-reports for the Harari community (N = 14). In most of the study areas, the medicinal uses of *Aloe* species were found more popular among the Oromo community, which accounted for 125 medicinal use-reports, in which 77.6% of the total use-report of this community. The fewest uses were reported from the Afar and Harari communities with 9 use-reports each. Among the bio-cultural values, environmental use-reports like boundary marking, soil conservation, and living fence support were documented only from the Oromo community, from four *Aloe* species. A unique use-report "poisonous to carnivores" was reported by the Somali and Oromo communities for two *Aloe* species called *Aloe retrospiciens* Reynolds & Bally and *A. ruspoliana* Baker, respectively.

The Oromo community used 22 out of the 23 species documented in this study (the exception was *A. retrospiciens*). The Somali community used four species (*A. retrospiciens, A. megalacantha* subs. *megalacantha, A. mcloughlinii*, and *A. pirottaei*) followed by the Afar community who use two species, *A. retrospiciens* and *A. trichosantha* subsp. *longiflora* and the Harari community who also use two species, *A. trichosantha* subsp. *longiflora* and *A. macrocarpa.*

3.3. Ethno-medicinal and bio-cultural knowledge among gender and age categories

The level of knowledge of *Aloe* species diversity and use-reports are noticeably lower in the younger age categories compared to elderly

Table 3. List of *Aloe* species, major use categories, and frequency of citation per use reports (FC). E = Exudate; F = Flower; G = Gel; I = Inflorescence; L = Leaf; LP = Live plant; P = Pedicel; R = Root.

Scientific name & Voucher No.	Major use category	Sub-category	Use report	Part used	Use description	FC%
Aloe calidophila	Social uses	Memorial	Memorial	LP	Planting on graveyard	94.44
Reynolds		Weaning	Weaning child from breastfeeding	E	Apply to the nipple/breast	88.89
AHU103		Magic	Belief to increase livestock herd size	LP	Planting at gate of the traditional cattle shelter	61.11
		Cosmetics	Skin softening	G	Apply on skin as a balm	22.22
	Medicines	Endocrine system	Bile duct problem/Jaundice	R	Pulverize with honey & drink	83.33
				P	Chew & swallow the fluid	27.78
		Infections and infestations	Sexually transmitted infections/STI	L	Smoke-bathe the genitals	77.78
			Malaria	E	Fresh exudate taken orally	44.44
				R	Pulverize with water & drink filtrate	44.44
			Eye infection	E	Drop in infected eye	44.44
				E	Put on the head & apply externally around infected eye	27.78
			Gonorrhea	L	Smoke-bathe the genitals	38.89
			Repel flies from infected eye	E	Apply externally all around the eye	27.78
		Skin and	Wound healing	E	Apply externally	72.22
		subcutaneous tissue	Small swelling on skin locally called BOCHA	L	Warm fresh leaf & keep on small swellings	61.11
			Wound of livestock due to carnivore/hyena attack	L	Fresh leaf crushed and tied on wound & smoke-bathed	55.56
		Musculo-skeletal system	Bone pain	L	Warm well & keep on painful part repeatedly	61.11
			Bone pain of cattles	L	Warm well & keep on painful part repeatedly	61.11
	Materials	Domestic utensils	Repel flies from wounds	E	Apply externally	38.89
		Soap making	Soap making	G	Used in small-scale soep production with ingredients	22.22
	Food	Metabolic system	Water source	G	Fresh gel eaten as source of water in extremely hot areas	33.33
Aloe citrina Carter & Brandham	Medicines	Skin and subcutaneous tissue	Wound healing	E	Apply externally	75.00
			Leg and hand swelling	G	Tie onto swollen part	62.50
AHU123			Wound healing in livestock	E	Apply externally	75.00
		Infections and infestations	Eye infection	E	Drop in infected eye	75.00
			Malaria	E	Taken orally	50.00
		Digestive system	Abdominal disorder	E	Taken orally	75.00
*[1]*Aloe gilbertii* Reynolds ex Sebsebe & Brandham subsp. *gilbertii*	Medicines	Endocrine system	Bile duct problem/Jaundice	E	Taken orally	91.67
		Digestive system	Colon cleaner	E	Taken orally	75.00
			Gastric	L	Fresh young leaf pulverized & filtrate take orally	58.33
			Stomach disorder of cattles	L	Fresh young leaf pulverized & filtrate given orally	41.67
		Skin and subcutaneous tissue	Wound healing	E	Apply externally	75.00
AHU102		Infections and infestations	Eye infection	E	Drop in infected eye	58.33
			Malaria	L & E	Concocted & taken orally	25.00
	Environment al uses	Barrier	Boundary marker	LP	Planting	75.00
		Soil improver	Soil conservation	LP	Planting on terracing	66.67
	Social uses	Memorial	Memorial	LP	Planting on graveyard	58.33
*[1]*Aloe harlana* Reynolds	Medicines	Skin and subcutaneous tissue	Wound	E	Apply on wound	83.33
AHU117			Skin inflammation	G & E	Used as ointment	27.78
		Snake and spider bites	Snakebite	L	Pulverized with water & filtrate taken orally	72.22
		Infections and infestations	Hair fungus	G	Apply on hair or wash with fresh gel daily	61.11
			Skin fungus	G & E	Used as ointment	50.00
		Digestive system	Bloated stomach of calltes locally called BELELO	L	Fresh leaf pulverized & filtrate given orally	77.78
			Colon cleaner	E	Powder (locally called SIBRI) taken orally in water	27.78
		Endocrine system	Liver swelling	L	Pulverized and filtrate taken orally	22.22
			Spleen swelling/Splenomegaly	L	Pulverized and filtrate taken orally	22.22
	Materials	Domestic utensils	Repel honeybees during honey harvest	L	Smoked while harvesting the honey to prevent bee stings	38.89
Aloe lateritia Engler	Social uses	Cosmetics	Hair wash	G	Make shampoo for hair wash	66.67
AHU125			Soften hard skin	G	Scrape the gel & apply on skin	41.67
	Medicines	Skin and subcutaneous tissue	Skin infection	G & E	Apply on skin	58.33
		Infections and infestations	Eye infection	E	Drop in the eye	58.33
Aloe macrocarpa	Social uses	Cosmetics	Emollient	G	Scrape the gel & apply on skin	65.63
Todaro	Medicines	Infections and	Skin diseases/fungal	G & E	Apply on skin	59.38
AHU19		infestations	Hair fungus	G	Apply on hair or wash with fresh gel	50.00
			Eye infection	E	Drop in eye	40.63
		Infections and infestations	Malaria	E	Collect & drink	12.50
		Skin and subcutaneous tissue	Fire burn	G	Apply immediately during an accident	37.50
			Wound healing	E	Apply on wound as a cream	28.13
			Wound healing of livestock	E	Apply on wound as a cream	31.25
		Reproductive system and sex health	Sexual impotency	R	Pulverized, mix with fresh butter and use as ointment & smoke-bathe the penis	9.38
Aloe mcloughlinii	Medicines	Skin and	Wound healing	E	Powdered and applied on wound	62.50
Chris.		subcutaneous tissue	Wound healing/goats	E	Apply on infected part	50.00

(*continued on next page*)

Table 3 (*continued*)

Scientific name & Voucher No.	Major use category	Sub-category	Use report	Part used	Use description	FC%
AHU161		Infections and	Eye infections	E	Drop in infected eye	50.00
		infestations	Antiparasite	E	Powdered solution taken orally	29.17
		Snake and spider bites	Snakebite	S & E	Concocted and filtrate taken orally	29.17
		Digestive system	Laxative	E	Collect & drink	20.83
Aloe megalacantha Baker subs. *megalacantha*	Medicines	Skin and subcutaneous tissue	Skin infection	G & E	Concocted & tied onto the skin	90.91
AHU24		Infections and infestations	Eye infection	E	Drop in infected ear	86.36
		Digestive system	Colon cleaner/locally called SIBRII	E	Crystallized & juice made is taken orally in the morning	81.82
			Stomach ulcer	E	Powder/SIBRII in water taken oral	54.55
		Blood and Cardiovascular system	Blood pressure	E	Powder/SIBRII of exudate in water solution taken oral	31.82
		Musculo-skeletal system	Leg and back pain	L	Cross-section leaf slices warmed & tied on foot while a bit hot	13.64
	Environment	Barrier	Boundary marker	LP	Planting	81.82
	al uses	Boundaries	Fence support	LP	Planting	68.18
		Soil improver	Soil conservation	LP	Planting on terracing	54.55
Aloe megalacantha Baker subs.	Medicines	Digestive system	Colon cleaner/locally called SIBRII	E	Collect fresh exudate, crystallized & Juice made taken orally	85.71
alticola			Stomach disorder in cattles	L	Pulverized & filtrate taken orally	57.14
AHU162		Infections and	Eye infection	E	Drop in infected ear	67.86
		infestations		E	Apply external around the eye	28.57
			Ear infection	E	Drop in infected eye	32.14
			Tonsillitis	E	Drop on throat	25.00
			Itching eye	E	Apply externally around the eye	21.43
			Foot and mouth disease	S	Smoke-bathe infected part	21.43
		Endocrine system	Bile duct problem locally called HADHOFTUU	E	Taken oral	60.71
			Diabetics	E	Powder in water solution taken orally	53.57
		Skin and subcutaneous tissue	Skin infection	S	Smoke-bathe infected part with wet stem	57.14
			Goats skin wound	L	Crush & rub on affected part	50.00
			Camel skin wound	L	Crush & rub on affected part	42.86
			Skin infection	G & E	Concocted & tied onto infected part	39.29
			Itching skin of goats	L	Crush & rub on affected part	32.14
		General Ailments with unspecific Symptoms	Cold problem	L	Pulverized & massage the body	42.86
			Cold problem locally called QORRAA	S	Smoke-bathe body with fresh leaf until well sweating locally called QAYYAA	28.57
			Body pain feeling	L	Warm well & keep on the painful part repeatedly	28.57
			Weak body feeling	E	Drops in water & drink	21.43
		Musculo-skeletal system	Knee pain due to cold	G	Softly massage the knee	42.86
				E	Apply on the knee	28.57
		Blood and Cardiovascular system	Clean the blood	E	Drops in water, mix & drink	21.43
	Materials	Domestic utensils	Honey harvesting	S	Smoke near the bee hive while harvesting	75.00
	Social uses	Cosmetics	Smoke bath for women	S	Smoke-bathe the genital part with dried and wet stem	64.29
		Tattoo	Colouring hand and leg/women	S	Smoke bath of hand and leg with wet stem	28.57
Aloe otallensis Baker	Social uses	Weaning	Weaning child from breastfeeding	E	Apply to the nipple/breast	100.00
AHU107	Medicines	Endocrine system	Bile duct problem called HADHOFTU	L	Pulverized & filtrate given oral	75.00
		Skin and subcutaneous tissue	Wound due to carnivore/hyena attack	L	Burned and blackish ash mixed with butter used as ointment	75.00
			Wound healing	E	Apply external	66.67
			Hand/leg swelling	L	Warm & put on swollen part	41.67
		Digestive system	Colon cleaner	E	Powder in water solution taken orally	58.33
			Chicken disease/diarrhea	E	Given orally	75.00
Aloe pirottae	Medicines	Skin and	Wound healing	E	Apply externally	87.50
Berger		subcutaneous tissue	Tropical ulcer	G & E	Concocted & used external as ointment	70.83
AHU13		Infections and	Eye infections	E	Drop in infected eye	87.50
		infestations	Malaria	E	Powder of exudate in water solution taken orally	54.17
			Gonorrhea	E	Mixed with honey and taken oral	25.00
			Antiparasite	E	Taken orally	20.83
		Endocrine system	Bile duct problem	E	Taken orally	58.33
			Gallstone	G & E	Taken orally	20.83
		Snake and spider bites	Snakebite	E	Taken orally	37.50
		Digestive system	Colon cleaner/SIBRI	E	Powder of exudate in water solution taken orally	33.33
		Musculo-skeletal system	Muscular pain	G	Boiled & soft massage painful part	16.67
	Social uses	Weaning	Weaning child from breastfeeding	E	Apply to the nipple/breast	75.00
	Materials	Domestic utensils	Insect repellent	L	Smoking around the area to stifle insects	62.50
			Mosquito repellent	L	Smoke of dried leaves to stifle mosquitoes	41.67
*,◇*Aloe pubescens* Reynolds	Medicines	Digestive system	Colon cleaner	E	Powder of exudate locally called SIBRI in water solution taken orally	86.36
AHU06			Soften alimentary canal	L	Young leaf eaten	59.09
			Gastric	G	Fresh gel eaten	54.55
			Stomachache/kurtet	R & F	Concocted & filterate taken orally	18.18
		Endocrine system	Bile duct problem locally called Hadhoftu	E	Taken orally	59.09
		Skin and subcutaneous tissue	Wound	E	Apllied on dermal wound	54.55

(*continued on next page*)

Table 3 (*continued*)

Scientific name & Voucher No.	Major use category	Sub-category	Use report	Part used	Use description	FC%
		Endocrine system	Liver disease	E	Taken orally	31.82
		Infections and infestations	Anthrax	L, F & R	Concocted & given orally	13.64
	Sicial uses	Memorial	Graveyard	LP	Planting on graveyards	72.73
	Environment	Boundaries	Fence support	LP	Planting	68.18
	al uses	Soil improver	Soil conservation	LP	Planting on mountain slopes along the terrace	36.36
	Food	Food	Food	G	Fresh gel scraped and eaten	31.82
****Aloe retrospiciens** Reynolds & Bally	Vertebrate poisons	Poison	Poison carnivore	E	Concentrated exudate hide in meat to feed hyena	58.33
AHU160		Poison	Kill goats if eaten in dry season, due to starvation	L	If eaten in the drought season can kill goats	41.67
		Poison	Poison rats	E	Dried exudate and apply in rat feed	25.00
Aloe rivae Baker	Social uses	Cosmetics	Body & hair wash	G	Make shampoo for washing	91.67
AHU115	Medicines	Snake and spider bites	Snakebite	E	Taken orally	75.00
		Skin and subcutaneous tissue	Wound healing	E	Apply externally	66.67
		Cancer	Breast cancer	E	Taken orally	25.00
	Materials	Domestic utensils	Repel flies	E	Apply externally on wound	41.67
****Aloe rugosifolia** Gilbert & Sebsebe	Medicines	Musculo-skeletal system	Bone pain	L	Warmth well & keep on painful part repeatedly	77.78
AHU113		Skin and subcutaneous tissue	Wound healing	E	Apply externally	72.22
			Wound of livestock	E	Apply externally	61.11
			Small swelling on skin locally called BOCHA, on hand and legs	L	Warm & keep on small swellings	38.89
		Infections and infestations	Eye infection	E	Drop in infected eye	44.44
Aloe ruspoliana Baker	Vertebrate poisons	Carnivor prevention	Deter carnivore from night shelter of livestock	LP	Planting around livestock night shelter	87.50
AHU121		Rodent control	Deter rats due to bad smell	LP	Planting around rats nests	50.00
	Medicines	Skin and subcutaneous tissue	Itching skin on goat locally called CHITO	L	Warm & rub the skin while warmer	37.50
Aloe secundiflora	Medicines	Skin and subcutaneous tissue	Skin infections	E	External use on skin	88.89
Engler			Wound healing	E	Drop on wound and bandage	83.33
AHU106			Skin infection of livestock	L & E	Prepared for external use on skin	77.78
			Wound on livestock skin	L & E	Prepared & applied to wound	61.11
		Musculo-skeletal system	Inflammation in muscles/Rheumatism	G & E	Mix & tie on inflamed part	38.89
		Infections and infestations	Ectoparasite	L & E	Concocted for external use on skin	50.00
			Malaria	E	Taken orally	33.33
			Diarrhea	E	Taken orally	22.22
***,◇Aloe tewoldei** Gilbert & Sebsebe	Medicines	Musculo-skeletal system	Bone fracture	G	Bandage the gel around to soften the part before traditional fracture medication	87.50
AHU120		General Ailments with Unspecific Symptoms	Cold problem	L	Pulverized & filterate taken orally	87.50
		Digestive system	Stomach disorder	L	Pulverized & filterate taken orally	87.50
		Skin and subcutaneous tissue	Itching skin on goat locally called CHITO	L	Put in fire until very soft then rub on skin	62.50
	Social uses	Poison	Crop pest control	E	Powder used in crop storage	50.00
*****Aloe trichosantha* subsp. *longiflora* Gilbert & Sebsebe	Medicines	Digestive system	Laxative/Purgative, colon cleaner, Constipation	E	Powdered & drink in the form of solution or swallow with banana	50.98
		Skin and subcutaneous tissue	Infection on skin or wound/Antidermatosic	E	Apply on infected skin	33.33
			Fire burn	G	Applied externally	9.80
AHU05			Skin hardening/emollient	G & E	Make juicy & apply on skin	4.90
		Snake and spider bites	Snakebites antidote	L & E	Concocted with water & taken oral	23.53
		Endocrine system	Bile duct problem	L	Pulverized kept for 12 h and drink filtrate/young leaf	22.55
		Infections and	Tonsillitis	E	Drops on the throat	11.76
		infestations	Malaria	E	Taken orally	10.78
				L	Pulverize & filtrate taken orally	1.96
			Eye infection	E	Drop in infected eye	6.86
		Skin and subcutaneous tissue	After male circumcision	L	Smoke bathed after circumisision to prevent potential infection	14.71
			Wound on livestock skin	E	Apply externally on wound	14.71
		General Ailments with Unspecific Symptoms	Pain due to cold	G	Massage the pain part softly	10.78
		Sensory system	Improve poor sight	E	A drop in eyes	0.98
		Reproductive system and sex health	Infertility of man and woman	G	Wash the body and genitalia	0.98
		Pregnancy, birth and puerperial	Delayed placenta in cattles	L & R	Concoction given orally	5.88
	Social uses	Weaning	Weaning child from breastfeeding	E	Apply to the nipple/breast	50.00
		Magic	Increase herd size of livestock and camel	L	Smoke-bathe milking utensils	1.96
		Illuminant	Lighting bonfire	I	Lighting bonfire/torch with dried sticks used in Christian holidays	6.86
	Materials	Domestic utensils	Repel flies from wounds	E	Apply on and around the wound	18.63
	Food	Metabolic system	Relief dehydration in extreme hot condition	G	Make it free from exudate & eaten	5.88
*****Aloe welmelensis* Sebsebe & Nordal	Medicines	Skin and subcutaneous tissue	Wound healing	E	Apply externally	75.00
AHU124			Wound healing for cattles	E	Apply externally	75.00
***,▽Aloe yavellana**	Social uses	Weaning	Weaning child from breastfeeding	E	Apply to the niple/breast	94.44
Reynolds	Environment al uses	Soil improver	Soil conservation	LP	Planting on terracing	88.89
AHU116		Boundaries	Fence support	LP	Planting	61.11
	Medicines	Skin and subcutaneous tissue	Wound healing	E	Apply externally	72.22

(*continued on next page*)

Table 3 (*continued*)

Scientific name & Voucher No.	Major use category	Sub-category	Use report	Part used	Use description	FC%
		Skin and subcutaneous tissue	Wound healing of livestock	E	Apply externally	72.22
			Ectoparasite of livestock	L & E	Concocted for external use on skin	50.00
		Snake and spider bites	Snake poison	E	Taken orally	44.44
	Materials	Domestic utensils	Mosquito repellent	L	Smoking around to stifle mosquito	66.67
*Highly spotted aloe	Medicines	Snake and spider	Snake poison	E	Drink very soon after snakebite	63.33
AHU53		bites	Spider poison	E	Drink very soon after spiderbite	56.67
		Skin and subcutaneous tissue	Wound healing	E	Powder apply on wound	56.67
		Digestive system	Diarrhea in cattles	L	Pulverized & filtrate given orally	46.67
	Materials	Pest control	Crop pest	E	Powdered & applied in traditional crop storage	36.67
Unidentified	Medicines	Infections and	Hair fungus	G	Apply on hair	83.33
AHU51		infestations	Tonsillitis	E	Drop in the throat	61.11
		Endocrine system	Diabetics	E	Powder in solution & drink daily morning	72.22
	Social uses	Cosmetics	Skin softening	G	Apply on skin	66.67

* Endemic.
* Narrowly endemic.
¤ Endangered.
◊ Near threatened.
** Vulnerable.

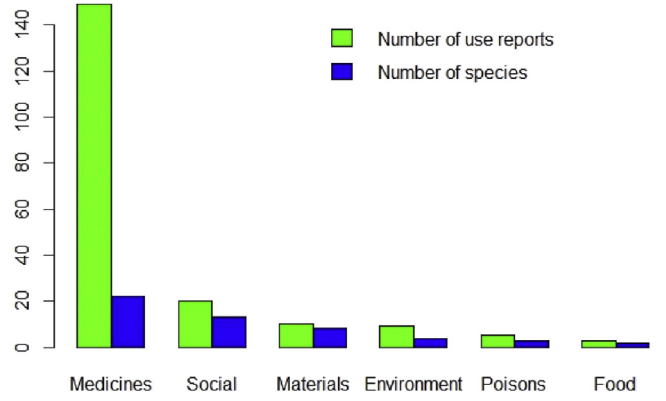

Figure 2. The number of use-reports and number of *Aloe* species used in each major use category.

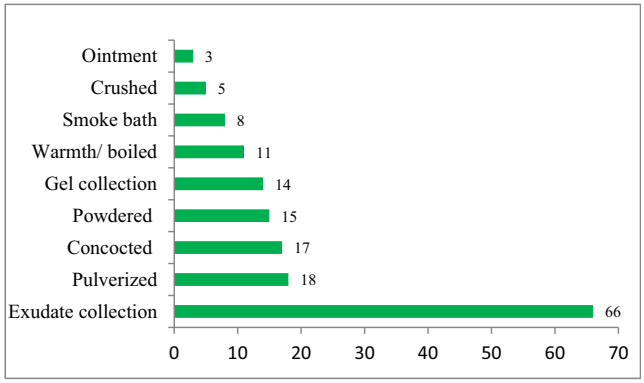

Figure 4. Number of preparation in each type of preparation method for medicinal uses.

informants. For example, out of the total citations (1336) for human medicinal uses, 654 were by elderly people (above 60 years, N = 35) followed with 398 use mention by adults (age 41–60, N = 108) and 284 by young informants (age 25–40, N = 67). The highest number of use-report in all major use categories such as medicines (Md), social uses (SU), materials (Mt), environmental uses (EU), vertebrate poisons (VP), and food (Fd) were reported by elderly people (Figure 5). In the medicines category, 21 species were reported by elderly people (above 60 years, N = 35) followed by 16 species by adults (age 41–60, N = 108) and eight species by young informants (age 25–40, N = 67) (Figure 6).

The depth of comprehensive bio-cultural knowledge among different age groups indicated that elderly people (above 60 years) had a much deeper knowledge than the two age group ranging from 25 to 40 and 41–60 (Kruskal-Wallis chi-squared = 12.17, df = 3, p = 0.006*). There is a significant difference in the depth of ethno-medicinal knowledge

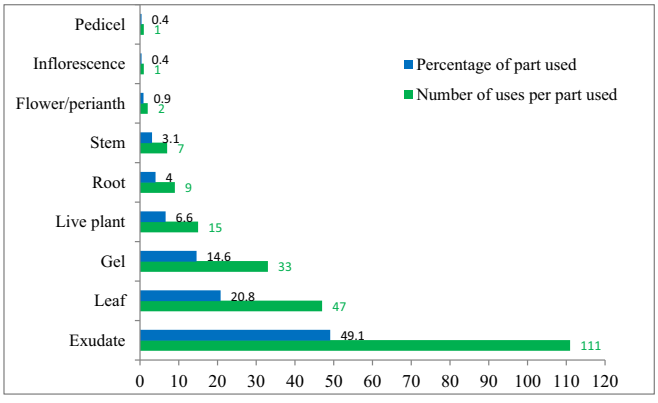

Figure 3. Number of uses and percentage of each part used for the respective treatment purposes.

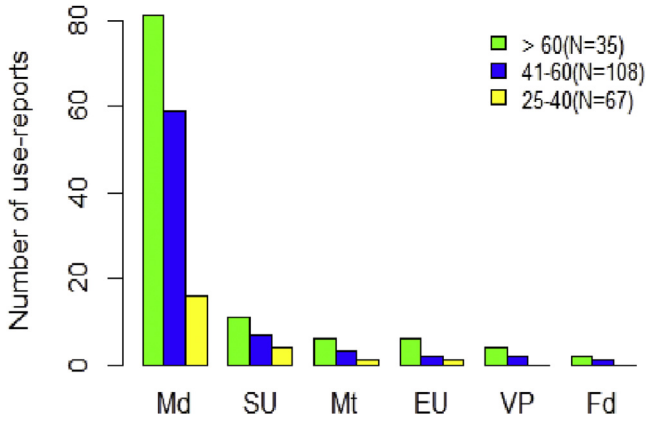

Figure 5. Number of use-reports in each major use category for each age group (medicines (Md), social uses (SU), materials (Mt), environmental uses (EU), vertebrate poisons (VP), and food (Fd)).

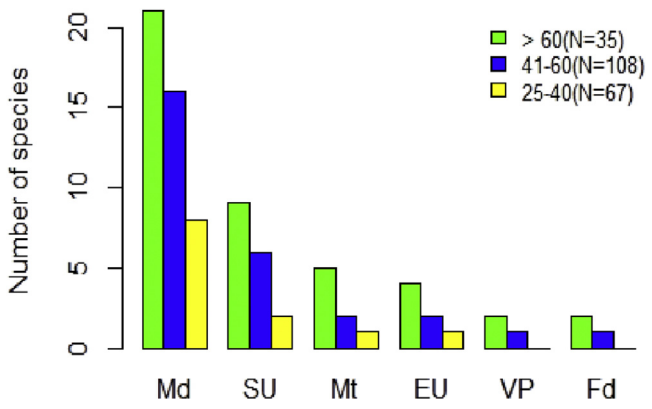

Figure 6. The number of *Aloe* species reported in each major use category for each age group (Md), social uses (SU), materials (Mt), environmental uses (EU), vertebrate poisons (VP), and food (Fd)).

between the 25–40 age group and the above 60 age group ($p = 0.0004^{**}$), and a significant difference between 41-60 year olds and the above 60 age group ($p = 0.02^{*}$) ($p < 0.05$). It was observed that many young people in the study areas were found less knowledgeable about the different *Aloe* species and associated medicinal and bio-cultural values. In addition, men are more knowledgeable on identifying *Aloe* at the lower taxonomic level and diverse medicinal use-reports than women. The men from all communities had deeper knowledge in the medicinal use category than women (Wilcoxon test, $p = 0.002$), which is significantly different ($p < 0.05$). Women were found more knowledgeable than men for cultural uses like, cosmetic (Wilcoxon test, $p = 0.06$), not significantly different ($p > 0.05$).

3.4. Informant consensus factor and value indexes

Informant consensus factors (F_{ic}) of the seven major use categories ranged from 0.86 to 0.22. The highest F_{ic} value 0.86 was for medicines with 22 species and 11 use sub-categories, followed by 0.63 for environmental uses with four species and three sub-categories, and least F_{ic} value was 0.22 for materials with eight species and two sub-categories (Table 4).

Aloe species were compared based on the values of importance metrics. Some species like *Aloe calidophila, A. megalacantha* subs. *alticola, A. pirottae,* and *A. gilbertii* subsp. *gilbertii* showed higher values across the indices due to be mentioned by a higher number of informants, relatively higher number of use-categories, and larger number of use-reports to elucidate species that were of high importance in all indices (Table 5).

4. Discussion

4.1. Ethno-medicinal and bio-cultural values of aloes

Most of the *Aloe* species were reported to have multiple uses, but the majority of uses were medicinal [42, 43]. In this study, it has been shown that most common traditional use of *Aloe* species was in the traditional health care system. This compares closely with the value of 74% of literature-based use records describing the medicinal uses of *Aloe* [28] and 73% for human medicines from 11 *Aloe* species in Tanzania [43]. There are 12 sub-categories under the medicine (Md) major use category like the most cited applications of *Aloe* species were for skin and subcutaneous tissue ailments accounted for 29.6%, followed with infections and infestations 26.5%, and digestive system 14.5%. *Aloe* exudates was the most cited *Aloe* part used in the medicinal uses deserve further investigation into the phytochemistry and pharmacological activities. The beneficial health-promoting properties present in the exudates of *Aloe* leaves are attributed to their diverse phytochemical composition [44]. Phytochemical studies on the genus *Aloe* indicated that over 200 compounds belonging to different classes such as anthrones, chromones, pyrones, coumarins, alkaloids, glycoproteins, naphthalenes, anthraquinones and flavonoids have so far been reported [44, 45, 46, 47]. These classes of compounds have been shown to possess antiviral, anti-tumor, and antibacterial activities [10, 13, 28, 42]. Numerous *in vitro* and *in vivo* pharmacological and clinical trials have been revealed the traditional uses of *Aloe* including wound healing, anti-ulcer, anti-diabetic, hypoglycaemic, anti-cancer, anti-bacterial, anti-viral, and anti-hyperlipidemic activities [10, 42, 48].

A unique use-report: "poisonous to carnivores" was reported for two *Aloe* species: *Aloe retrospiciens* and *A. ruspoliana*. This study is the second to sample *A. retrospiciens*, 60 years after the first collection of a type specimen for this species. There was no any data on this species except that it was listed as vulnerable (VU) in IUCN category with an unknown population trend [22]. Meat painted with *A. ruspoliana* is used as bait to kill hyenas [49]. Similarly, *Aloe buettneri*, *A. lateritia*, *A. rabaiensis*, *A. secundiflora*, and *A. zebrina* have been documented as ingredients in arrow poisons throughout Africa [50]. The leaf exudates of these two species have an unpleasant smell and found free from the most common Aloes compound called aloin using TLC profile using pure aloin as standard.

The higher frequency of citations of some use-reports can be explained by the fact that these *Aloe* species are best known and have long been used by the majority of informants, representing a source of reliability. For example, the highest FC value for *A. otallensis* used for weaning breast feeding child could be attributed for the more effectiveness of its exudate, which is much bitter than others. Similarly, the local communities in Kenya claimed that *Aloe lateritia* is not as bitter as *A. secundiflora*, and hence not as effective [7] so the community has preference of specific *Aloe* species for the purpose.

Among the 23 *Aloe* species reported in this study, five species were reported whose gel is used for cosmetic purposes: *Aloe calidophila, A. lateritia, A. macrocarpa, A. rivae*, and the unidentified/AHU 51. The cosmetic value reported with higher FC for *A. rivae* makes this species a good candidate for detailed study of its gel. Taxonomic reports have indicated that *A. lateritia* and *A. macrocarpa* are grouped in the Saponaria [19] or maculate group, a name that came from the Latin *"sapo"* meaning soap, as the gel makes a soapy lather in water. The gel of AHU51 is used for cosmetic purposes, which has been observed while making soapy

Table 4. Major use categories with the corresponding sub-categories, number of *Aloe* species used and informant consensus factor values.

Major use categories with sub-categories	No. of sub-category	N. of use reports	No. of citation	No. of species	F_{ic}
Medicines: Blood and cardiovascular system, cancer, digestive system, infections and infestations, general ailments with unspecific symptoms, endocrine system, snake and spider bites, pregnancy, birth and puerperial, reproductive system and sex health, sensory system, skin and subcutaneous tissue, & musculo-skeletal system	12	146 (76%)	1607	22	0.86
Social uses: Weaning, illuminant, magic, memorial, tattoo & cosmetics	7	20 (10.2%)	276	13	0.37
Materials: Domestic utensils & soap making	2	10 (5.1%)	107	8	0.22
Environmental uses: Soil improver, boundaries, & barrier	3	9 (4.6%)	112	4	0.63
Vertebrate Poisons: Poison, carnivore prevention, rodent control, & pest control	6	5 (2.6%)	37	3	0.50
Food: Metabolic system & edible	2	3 (1.5%)	19	2	0.50

Table 5. Relative Importance metrics of *Aloe* species used in the Great Rift Valley floristic regions of Ethiopia.

Species	UC	UR	UV	RFC	RI	CV
Aloe calidophila	4	18	11.72	0.68	0.89	6.20
Aloe megalacantha subsp. *alticola*	3	23	10.89	0.52	0.88	5.66
Aloe pirottae	3	14	6.92	0.49	0.66	2.06
Aloe gilbertii subsp. *gilbertii*	3	10	6.00	0.60	0.66	1.55
Aloe pubescens	4	12	5.86	0.49	0.62	1.49
Aloe megalacantha subsp. *megalacantha*	2	9	5.63	0.63	0.66	1.39
Aloe yavellana	4	8	5.00	0.63	0.63	1.10
Aloe harlana	2	10	4.83	0.48	0.57	1.01
Aloe secundiflora	1	8	4.55	0.57	0.59	0.90
Aloe trichosantha subsp. *longiflora*	4	20	3.14	0.24	0.61	0.64
Aloe otallensis	2	7	4.92	0.61	0.60	0.91
Aloe macrocarpa	2	9	3.44	0.55	0.60	0.74
Aloe rivae	3	5	3.91	0.58	0.53	0.49
Aloe citrina	1	6	4.12	0.51	0.51	0.55
Aloe rugosifolia	1	5	2.94	0.39	0.39	0.25
Unidentified (AHU51)	2	4	2.83	0.61	0.54	0.30
Unidentified (AHU53)	2	5	2.60	0.52	0.49	0.28
Aloe tewoldei	2	5	2.50	0.33	0.34	0.18
Aloe mcloughlinii	1	6	2.42	0.40	0.43	0.25
Aloe lateritia	2	4	2.25	0.56	0.50	0.22
Aloe welmelensis	1	2	1.50	0.38	0.32	0.12
Aloe retrospiciens	1	3	1.25	0.42	0.37	0.07
Aloe ruspoliana	2	3	1.17	0.28	0.27	0.05

UC = number of major use categories per species; UR = number of use-reports per species; UV = use value of a species; RFC = relative frequency of citation for species; RI = relative importance index; CV = cultural value index of species, which considered the three factors i.e. s (species), i (informants), and u (uses).

lather in water. Though *A. calidophila* is not in the Saponaria group, its gel is used for soap making and in few sites of the study areas two women associations were observed cultivating this species and used in small-scale soap production for local market, branded as "*Yoya*" meaning 'peace' in Borena and labelled to treat skin fungus and infections. It has been reported that the gel of *Aloe* species exhibited faster wound healing effects [48].

4.2. Use-reports among the cultural communities

People of the five floristic regions use 23 species of *Aloe*, and the diversity in uses suggests that species are not used interchangeably. The highest number of use-reports, recorded for *A. calidophila, A. megalacantha* subs. *megalacantha, A. trichosantha* subsp. *longiflora,* and *A. pirottae* could be associated with the wider geographic distribution of species and their use by different ethnic communities, a pattern that has been noted previously in Kenya [7]. The higher number of *Aloe* species and use-reports from the Oromo community could be attributed to the diverse ecology and the wider geographic distribution of *Aloe* species in the floristic regions inhabited by the Oromo community as compared to the other three ethnic communities. It was verified that there were no significant difference (p-value = 0.061) between the uses of *Aloe* species among the three cultural/ethinic communities (Afar, Somali, and Harari).

4.3. Ethno-medicinal and bio-cultural knowledge among gender and age categories

The practice of traditional medicine is restricted to men in Ethiopia [51, 52] and, not surprisingly, men were found to hold deeper knowledge of the medicinal uses of *Aloe.* However, women were found to be more knowledgeable on the cultural uses of aloes such as weaning children from breastfeeding, cosmetics, colouring hand and leg/tattoo, and body fumigation.

Most of the young and some adult informants were found to be less knowledgeable about the diversity of *Aloe* species and their uses as compared to majority of adults and elderly informants. This could be attributed to the current cultural transformation, and increasing accessibility of education and health centers in rural areas that has challenged the acquisition of indigenous knowledge among young people. An alternative interpretation is that knowledge accumulates over time, and that older people have had longer to learn about plant uses. Similar results were reported in some other cultural groups in Ethiopia [53, 54] and among users of *Aloe* species in Tanzania [43]. Some studies indicated that valuable ethno-medicinal information was shared with researchers mostly from informants over 60 years of age [55]. In addition, the knowledge of older people might not have been affected by the need to find new subsistence activities, and was thus preserved without external influence. For example, the dried and powdered exudate of *Aloe harlana, A. megalacantha* subs. *alticola,* and *A. megalacantha* subsp. *megalacantha* locally known as SIBRII, which was used as colon cleaner, were sold in the open local market places of nearby towns. The processing, selling, and use of this local product is mainly restricted to elderly people. The knowledge of medicinal values of most *Aloe* species was particularly evident among elderly informants and also still retained with the majority of adults, but younger participants showed much less knowledge, and if knowledge gain has indeed slowed down, this could have negative consequences for their conservation in future.

4.4. Informant consensus factor and value indexes

The most popular indices used to evaluate the relative importance of the different species, which are used in the traditional system are based on "informant consensus," i.e., the degree of agreement among the various interviewees [40, 56]. In this respect, there was a strong consensus for the medicinal value of the leaf exudate. Efficacy of traditional medicinal plants is strongly correlated with Fic value, meaning pharmacologically effective remedies are expected to have greater Fic value, and vice versa [38]. The species with higher values in all indices of

UV, RFC, RI, and CV like *A. calidophila, A. megalacantha* subs. *megalacantha, A. gilbertii* subsp. *gilbertii,* and *A. pirottae* were identified to be the most ethno-medicinal and bio-culturally important species.

5. Conclusion

Aloe species were reported to have multiple uses, but it has been shown that the most common local use was in the traditional health care system. In priority setting for *Aloe*-based product development and cultivation, species like, *A. calidophila, A. megalacantha* subsp. *alticola,* and *A. pirottae* were identified to be the top three ethno-medicinal and bio-culturally important endemic *Aloe* species. In addition, unidentified *Aloe* samples could instigate taxonomic discussion and investigation. More importantly, the unique use-report: "poisonous to carnivores" from two *Aloe* species called *A. retrospiciens* and *A. ruspoliana* could initiate detailed phytochemical and toxicity studies, which have not been done so far, and are of particular importance for this study. In this study, it has been shown that the leaf exudates were highly valued in medicinal applications. Therefore, research interests on medicinal values of Ethiopian endemic aloes need to focus on exudates for phytochemical and pharmacological analysis. In addition, the result showed the unfortunate decline in bio-cultural and ethnomedicinal knowledge between generations in most of the study areas. The deterioration of indigenous knowledge coupled with declining wild populations of most *Aloe* species could stimulate an urgent ethnobotanical study for in-depth investigation before it is lost. It should be followed with phytochemical and pharmacological analyses in order to give scientific ground to the ethno-medicinal knowledge as well as to signify conservation attention and future potential utilization. In general, the output of this comprehensive ethno-medicinal and bio-cultural knowledge will encourage the community to conserve, manage, and sustainable use *Aloe* species in the natural habitat as well as through cultivation.

Declarations

Author contribution statement

A. Belayneh, S. Demissew: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

N.F. Bussa: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

D. Bisrat: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

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