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), informants’ consensus factor (Fic), use value (UV), relative importance index (RI), 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 (NUC ¼ 6). Medicinal use categories accounted for 149 use-reports (76%) with 1607 citations. The species with the highest numbers of use-reports were Aloe megacanthan subsp. alitica, A. trichosanthera 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 retropiciens and A. rupoliana were reported poisonous to carnivores. Fic 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 ¼ 12.17, df ¼ 3, p ¼ 0.006), which is significant difference in depth of ethno-medicinal knowledge. Men had more knowledge of medicinal uses than women (Wilcoxon test, p ¼ 0.002) significantly different, while women were knowledgeable than men for cultural uses like, cosmetic (Wilcoxon test, p ¼ 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]. Aloe 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. retropiciens 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.
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*. I n 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/ethnic 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 Table 1.

#### 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. manticola*, *A. percrassa*, *A. pulcherrima*, *A. schelpei*, *A. smithii*, *A. steudneri*, *A. trigynantha*, and *A. welomensis* |
| Eastern highlands and lowlands | AF, HA | 7 | *Aloe berteriana*, *A. harlana*, *A. mcloughlinii*, *A. megalacantha* subsp. alticola, *A. pirorata*, *A. pubescens*; and *A. trichsantha* subsp. longiflora |
| Southern highlands, lowlands and rift valley | AR, BA, SD, GG | 11 | *Aloe elkerriana*, *A. friisii*, *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** = Harargae; **AR** = Arsi; **BA** = Bale; **SD** = Sidamo; **GG** = Gamo Gofa.

*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. carina*; 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. pirorata*; 12 = *A. pubescens*; 13 = *A. retrospiciens*; 14 = *A. rivae*; 15 = *A. rugosifolia*; 16 = *A. ruspoliana*; 17 = *A. secundi*; 18 = *A. tewoldei*; 19 = *A. trichsantha* subsp. *longiflora*; 20 = *A. welmelensis*; 21 = *A. yavellana*; 22 = AHU51; 23 = AHU53).*
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 aliments 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 (FCUR)

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

\[
FCUR = \frac{ni}{N} \times 100
\]

where \(ni\) 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)

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 sum-mation of use-report (\(\sum UR\)) of all the informants interviewed for a species divided by \(N\) [37].

\[
RFC = \frac{FC}{N} = \frac{\sum_{i=0}^{n} UR_i}{N}
\]

2.3.3. Informant consensus factor (Fic)

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]:

\[
Fic = \frac{n_i - nt}{n_i - 1}
\]

where \(n_i\) is the “number of use-reports” in each use category and ‘\(nt\)’ is the “number of taxa used”.

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

| Occupation         | 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 ± 4.4)| 3 (76.0 ± 5.7)| 5 (74.5 ± 6.6)| 2 (72.0 ± 5.2)|

* Number of informants = N (mean age ± standard deviation) for each age categories; RI = random informants, TH = traditional healers.
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 Albuquerquee et al. formula [40]:

\[ UV_s = \sum U_i / N, \]

where, \( UV_s \) refers to the use value of Aloe species \( s \), \( U_i \) to the number of different uses mentioned by each informant \( i \), 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]:

\[ RI_i = \frac{RFCs(max) + RNUs(max)}{2} \]

where, RFCs(max) is the relative frequency of citation over the maximum. It is obtained by dividing FCs by the maximum value in all Aloe species of the study (RFCs(max) = FCs/max (FCi)), and RNUs(max) is the relative number of use-categories over the maximum, obtained dividing the number of uses of the species NUs = \( u = u_{NC} \) \( u = u_1 \sum UR_0 \) by the maximum value in all Aloe species of the survey RNUs(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]:

\[ CV_s = \left[ NUs/NC \right] \left[ FCs/N \right] \left[ \sum_{i=1}^{NC} \sum_{j=1}^{U} UR_{ij} \right]/N \]

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 multicomview 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 (NUC = 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 by 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 pedicle, 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. napoliana 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 subsp. megalacantha, A. mcloughlinii, and A. pirottae) 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 caldaphile* | 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 |
| | Infections and infestations | Sexually transmitted infections/ STI | L | Smoke-bathe the genitals | 77.78 |
| | | Malaria | E | Fresh exudate taken orally | 44.44 |
| | | Eye infection | E | Drop in infected eye | 44.44 |
| | | | | Pot on the head & apply externally around infected eye | 27.78 |
| | | | | Genorrhoea | 38.89 |
| | | | | Repel flies from infected eye | 27.78 |
| | Skin and subcutaneous tissue | Small swelling on skin | L | Warm fresh leaf & keep on small swellings | 61.11 |
| | Musculoskeletal system | Bone pain | L | Warm well & keep on painful part repeatedly | 61.11 |
| | | Bone pain of cattle | 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 soap 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 | 62.50 |
| AHU123 | Infections and infestations | Eye infection | E | Drop in infected eye | 75.00 |
| | | | | Malaria | 50.00 |
| | Digestive system | Abdominal disorder | E | Taken orally | 75.00 |
| | | | | Gastric | 50.00 |
| | | | | Stomach disorder of cattle | 50.00 |
| | 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 | 25.00 |
| | Environment al uses | Barrier | LP | Planting | 75.00 |
| | Soil improver | Soil conservation | LP | Planting on terracing | 66.67 |
| Social uses | Memorial | Memorial | LP | Planting on graveyard | 58.33 |
| | | | | Skin inflammation | 83.33 |
| AHU117 | Smoke 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 | 50.00 |
| | Digestive system | Blunted stomach of calves | L | Fresh leaf pulverized & filtrate given orally | 77.78 |
| | | Colic cleaner | E | Taken orally | 75.00 |
| | | | | Powder (locally called SIBRI) taken orally in water | 22.22 |
| | Endocrine system | Liver swelling | L | Pulverized and filtrate taken orally | 22.22 |
| | | | | Spleen swelling/splenomegaly | 22.22 |
| Materials | Domestic utensils | Repel honeybees during honey harvest | L | Smoke while harvesting the honey to prevent bee stings | 38.89 |
| *Aloe harlana* Reynolds | Social uses | Cosmetics | Hair wash | G | Make shampoo for hair wash | 66.67 |
| AHU126 | | | | Soften hard skin | 41.67 |
| Medicines | Skin and subcutaneous tissue | Skin infection | G & E | Used as ointment | 27.78 |
| | Infections and infestations | Eye infection | E | Drop in the eye | 58.33 |
| *Aloe macrocarpa* Tolnay | Social uses | Cosmetics | Emollient | G | Scrape the gel & apply on skin | 65.63 |
| AHU19 | Infections and infestations | Skin diseases/fungal | G & E | Apply on skin | 59.38 |
| | | | | Hair fungus | 50.00 |
| | | | | Eye infection | 40.63 |
| | | | | Malaria | 12.50 |
| | | | | Collect & drink | 12.50 |
| | Skin and subcutaneous tissue | Free burn | G | Apply immediately during an accident | 37.50 |
| | | | | Wound healing | 28.13 |
| | | | | Wound healing of livestock | 28.13 |
| | 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* Tolnay | Medicines | Skin and | Wound healing | E | Powdered and applied on wound | 62.50 |
| Chris. | | | | Wound healing/ scabs | 50.00 |
| Scientific name & category | Major use | Sub-category | Use report | Part used | Use description | FC% |
|-----------------------------|-----------|--------------|------------|-----------|----------------|-----|
| A. megalacantha Baker subsp. megalacantha | Medicines | Skin and subcutaneous tissue | Skin infection | G & E | Concocted & tied onto the skin | 90.91 |
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| AHU162 | Infections and infestations | Eye infection | E | Drop in infected ear | 86.36 |
| AHU24 | Infections and infestations | Eye infection | E | Drop in infected ear | 82.81 |
| Aloe pirottae Baker subc. pirottae | Medicines | Digestive system | Colon cleaner/local called SIBRI | E | Powder of exudate in water solution taken orally | 58.33 |
| AHU107 | Medicines | Endocrine system | Bile duct problem locally called HADHOFTU | E | Taken orally | 60.71 |
| AHU061 | Infections and infestations | Eye infection | E | Drop in infected eye | 58.00 |
| AHU06 | Medicines | Skin and subcutaneous tissue | Skin infection | G & E | Concocted & tied onto the skin | 90.91 |

(continued on next page)
| Voucher No. | Major use category | Sub-category | Use report | Part used | Use description | FC% |
|-------------|-------------------|--------------|------------|-----------|----------------|-----|
| AHU05       | Skin and subcutaneous tissue | Skin infections | E External use on skin | 50.00 | Monsanto | 31.82 |
| AHU106      | Skin and subcutaneous tissue | Itching skin on goat locally called CHITO | L Pulverized | 50.00 | Keep on painful part repeatedly | 77.78 |
| AHU113      | Skin and subcutaneous tissue | Wound healing | E Apply externally | 72.22 | Wound of livestock | 88.89 |
| AHU116      | Skin and subcutaneous tissue | Wound healing | E Prepare for external use on skin | 77.78 | Wound on livestock skin | 61.11 |
| AHU121      | Skin and subcutaneous tissue | Skin infections | E External use on skin | 88.89 | Warm & rub on small swellings | 38.89 |
| AHU124      | Skin and subcutaneous tissue | Wound healing | E Prepare for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU126      | Digestive system | Laxative/Purgative, colon cleaner, Constipation | E Prepared for external use on skin | 50.00 | Powdered & drink in the form of solution or meal with banana | 90.00 |
| AHU127      | Skin and subcutaneous tissue | Wound healing | E Apply externally | 72.22 | Warm & keep on small swellings | 61.11 |
| AHU130      | Skin and subcutaneous tissue | Skin infections | E External use on skin | 50.00 | Monsanto | 31.82 |
| AHU131      | Social uses | Poison | E Taken orally | 22.22 | Woods | 87.50 |
| AHU132      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU133      | Digestive system | Laxative/Purgative, colon cleaner, Constipation | E Prepared for external use on skin | 50.00 | Water | 61.11 |
| AHU134      | Skin and subcutaneous tissue | Wound healing | E Prepare for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU135      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU136      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU137      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU138      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU139      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU140      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU141      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU142      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU143      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU144      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU145      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU146      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU147      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU148      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU149      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU150      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU151      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU152      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU153      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU154      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU155      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU156      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU157      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU158      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU159      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU160      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |
| AHU161      | Skin and subcutaneous tissue | Wound healing | E Prepared for external use on skin | 50.00 | Prepared with lather | 77.78 |

(continued on next page)
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

### Table 2 (continued)

| Scientific name & Voucher No. | Major use category | Use report | Sub-category | Use description | FC% |
|------------------------------|--------------------|------------|--------------|----------------|-----|
| **Aloe vera** | 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 cattle | 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 | Diabetes | 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 3.** Number of uses and percentage of each part used for the respective treatment purposes.

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

**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)).
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 (Fic) of the seven major use categories ranged from 0.86 to 0.22. The highest Fic 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 Fic 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 subsp. 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 aloe

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, alkaldoids, 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-ulecer, 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 retrospicent and A. rupoliana. This study is the second to sample A. retrospicent, 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. rupoliana is used as bait to kill hyenas [49]. Similarly, Aloe buettneri, A. lateritia, A. rabainstis, A. secundi, and A. sebrina 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 Aloe 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. atollensis 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 | Fic |
|----------------------------------------|---------------------|------------------|----------------|---------------|-----|
| 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 puerperal, 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 |
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 noted previously in Kenya [7]. The higher number of use-reports, recorded for *A. calidophila*, *A. megalacantha* 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 as compared to the other three ethnic communities. It was veri
dicated that 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. *alitica*, and *A. megalacantha* subsp. *megalacantha* locally known as *shur*, 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

### 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. *alitica* | 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 javellana*         | 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 otaleensis*        | 2  | 7  | 4.92 | 0.61| 0.60| 0.91|
| *Aloe macracarpa*        | 2  | 9  | 3.44 | 0.55| 0.60| 0.74|
| *Aloe rive*              | 3  | 5  | 3.91 | 0.58| 0.53| 0.49|
| *Aloe cänus*             | 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 tenuiflori*        | 2  | 5  | 2.50 | 0.33| 0.34| 0.18|
| *Aloe melaghiinis*       | 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 rupetisens*        | 1  | 3  | 1.25 | 0.42| 0.37| 0.07|
| *Aloe rupetis*           | 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).
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. aticlica, 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. rapolana 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 aloe species need to focus on exudates for phytochemical and pharmacological analysis. In addition, the result showed the unfortunate decline in bio-cultural and ethnomedical knowledge between genera-tions in most of the study areas. The deterioration of indigenous knowledge coupled with declining wild populations of most Aloe species could stimulate an urgent ethno-botanical study for in-depth investigation before it is lost. It should be followed by 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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