CHAPTER 3 UTILITY

3.1Documented utility and biocultural value of *Aloe* L. (Asphodelaceae): a review

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NOTES

The paper presented in 3.1 uses current names from Newton (2001). In a limited number of cases, this has resulted in anomalous use records such as the preservation of *A. elegans* with salt in India (Watt 1889), despite *A. elegans* being a species endemic to the Horn of Africa region described only in 1882 (Walker 2009 pers. comm.). The species cited in the source document (Watt 1889) was, in fact, *A. abyssinica*, now reduced to a synonym of *A. elegans*.

The ethnobotany of *Aloe* spp. on Socotra has been authoritatively documented in the following reference not cited in this Chapter:

MILLER, A. G., MORRIS, M. 2004. Ethnoflora of the Soqotra archipelago. Royal Botanic Gardens, Edinburgh.

ERRATUM

The correct reference for Pole-Evans (1919) is:

Pole-Evans, I. B. 1919. Our aloes: their history, distribution, and cultivation. *Journal of the Botanical Society of South Africa* 5: 11–16.

Documented Utility and Biocultural Value of *Aloe* L. (Asphodelaceae): A Review[1]

Olwen M. Grace[2,3,*], Monique S. J. Simmonds[2], Gideon F. Smith[3,4], and Abraham E. van Wyk[3]

[2]Royal Botanic Gardens, Kew, Surrey, TW9 3AB, United Kingdom
[3]Department of Plant Science, University of Pretoria, Pretoria 0002, South Africa
[4]South African National Biodiversity Institute, Private Bag X001, Pretoria 0002, South Africa
*Corresponding author, o.grace@kew.org

Documented Utility and Biocultural Value of *Aloe* L. (Asphodelaceae): A Review. The genus *Aloe* L. (Asphodelaceae) comprises 548 accepted species, of which at least one-third are documented as having some utilitarian value. The group is of conservation concern due to habitat loss and being extensively collected from the wild for horticulture and natural products. Cultural value is increasingly important in the effective conservation of biodiversity. The present study evaluated the biocultural value of the known uses of *Aloe*, excluding the domesticated and commercially cultivated *A. vera*. Over 1,400 use records representing 173 species were collated from the literature and through personal observation; this paper presents a synopsis of uses in each of 11 use categories. Medicinal uses of *Aloe* were described by 74% of the use records, followed by social and environmental uses (both 5%). Species yielding natural products, notably *A. ferox* and *A. perryi*, were most frequently cited in the literature. Consensus ratios indicate that the most valued uses of *Aloe* are in medicine and pest control against arthropods and other invertebrates.

Key Words: *Aloe*; Asphodelaceae; biocultural value; conservation; Ethnobotany; medicine; Uses.

Introduction

The genus *Aloe* L. (Asphodelaceae), here used in a broad sense to include the segregate genus *Lomatophyllum* Willd., comprises 548 accepted species occurring in Africa, the western Indian Ocean Islands, and the Arabian Peninsula (Newton 2001). Like the related succulent-leaved genera *Gasteria* Duval and *Haworthia* Duval, *Aloe* enjoys popularity among succulent enthusiasts and horticulturalists. Furthermore, *A. vera* L. (= *A. barbadensis* Mill.) is cultivated globally as a source of natural products derived from the leaf exudate and mesophyll. Species such as *A. ferox* Mill. (Figs. 1, 2 and 3) and *A. secundiflora* Engl. support wild harvesting industries in South Africa and Kenya, respectively, supplying unprocessed natural products to export markets, particularly in Europe and Asia (Newton and Vaughan 1996; Oldfield 2004). The literature contains numerous references to the traditional uses of *Aloe* spp., but a comprehensive analysis of the biocultural value and documented uses of the genus has been lacking. Consequently, information on the ethnobotanical significance of *Aloe* has remained largely inaccessible, despite this knowledge being of potential importance in biodiversity conservation and ecotourism (Cocks 2006).

About 4% of *Aloe* species have been assessed according to the International Union for Conservation of Nature (IUCN) Red List criteria; the most endangered species are narrow endemics such as *A. suzannae* Decary and *A. helenae* Danguy on Madagascar and *A. pillansii* L.Guthrie in the Northern Cape, South Africa (IUCN 2007). These assessments identified habitat loss, plant collectors, and leaf exudate tappers as

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Fig. 1. *Aloe ferox*, South Africa. Photograph Gideon Smith.

the principal threats to species of *Aloe*. Due to concerns regarding unsustainable harvesting from the wild for the horticulture and natural products industries, coupled with the difficulty of identifying sterile plant material of members of the group, trade in all species of *Aloe*, except the commercially cultivated *A. vera*, is regulated by the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Newton 2001).

The present study evaluated the biocultural value of the uses of *Aloe* by means of a synthesis of the uses documented in the literature, supplemented by personal observations. We previously reported on the therapeutic uses of *Aloe* in southern Africa, where most species are used medicinally (Grace et al. 2008). Here, we provide the first assessment of documented uses of *Aloe* throughout its range and across all categories. The results are discussed in the context of biocultural value and conservation, highlighted by selected examples of documented plant use to avoid unnecessary repetition of information published in the literature.

Materials and Methods

Literature Survey

Over 350 multidisciplinary publications, mostly in the English language, were surveyed for the uses and useful properties of *Aloe* spp. within their natural range, with the exception of the domesticated *A. vera* (Grace et al. 2008). The sources consulted spanned a period of over 169 years and included ethnographic accounts, Floras, peer-reviewed literature, theses, and the popular press.

The earliest reference consulted, Brande (1839), was among 32 references published prior to 1900 that generally referred to the provenance of drug aloes, their authentication, and commercial uses. References published later in the 19th century included several regional ethnobotanical accounts, such as those of Smith (1888) and Bryant (1909) on southern African ethnobotany and Holland (1922) on Nigerian useful plants. More recently, the uses of *Aloe* spp. have been documented in publications on various subjects, notably medicinal plants (e.g., Githens 1979; Kokwaro 1993) and horticulture (e.g., Jex-Blake 1934; De Wet 1996).

Fig. 2. The succulent leaves of *Aloe ferox* are used for their leaf exudate and mesophyll. Photograph Olwen Grace.

Fig. 3. The traditional method of collecting leaf exudate and mesophyll from *Aloe ferox* continues in South Africa today. Photograph Gideon Smith.

Monographs on *Aloe* published during the 20th century included those of Pole-Evans (1919) and the important contributions of Dr. G. W. Reynolds (e.g., Reynolds 1950, 1966).

Each documented use constituted a "use record" for a species; these were arranged in categories according to the Biodiversity Data Standard (formerly TDWG, the Taxonomic Database Working Group) on economic botany (Cook 1995). Accepted Latin binomial plant names are based on a checklist of the genus (Newton 2001). Nearly 800 vernacular plant names were gathered in 125 languages, of which 86% are in African languages, using the *Ethnologue* language compendium as a standard (Gordon 2005). In total, 1,467 use records for 173 accepted species and infraspecific taxa of *Aloe* were collated (Table 1).

Consensus Analysis

The utility value or biocultural significance of a species generally lies in the extent to which it is used. Culturally important plants are used by many people for the same purpose and are identifiable in the homogeneity of ethnobotanical information (Heinrich et al. 1998). Numerous methods have been developed to quantify this homogeneity as a measure of a taxon's value (for a detailed account, see Tardío and Pardo-de-Santayana [2008]). In the present study, consensus analysis was used to quantify homogeneity in the literature—a surrogate for ethnobotanical field study—in order to express the biocultural value of the known uses of *Aloe*.

The Informant Agreement Ratio derived by Trotter and Logan (1986) is a function of n_{ur}, the total number of use records per use category, and n_i, the total number of plant taxa recorded for that category:

$$\text{Consensus ratio} = \frac{n_{ur} - n_i}{n_{ur} - 1}$$

The formula was originally applied to quantify homogeneity among use records and identify medicinal plants possessing desired bioactivity among the household remedies of Mexican Americans in the state of Texas (Trotter and Logan 1986). The formula has since been applied to datasets that have ranged in volume and geographical extent from 2,260 records of 328 species in Tanzania (Schlage et al. 2000), four datasets each comprising up to 3,059 records of 445 species in Mexico (Heinrich et al. 1998), to 25,000 records of 2,735 species in North America (Moerman 2007). The present dataset differed principally from previous examples in that data were collected from the literature and referred to the known uses of plant species in a single genus throughout its range.

Results and Discussion

Medicines

The majority (73%) of documented uses refer to the use of about one-quarter of recognized species of *Aloe* in medicine. Excluding *A. vera*, the most frequently cited species is *A. ferox* (158 use records), a source of natural products known as Cape aloes, followed by *A. arborescens* Mill. (47 use records), *A. perryi* Baker (53), and *A. marlothii* A.Berger (45). Leaf exudate tapping on Socotra has been identified as a potential threat to the endemic *A. perryi*, the source of Socotrine aloes (Miller 2004). Four hundred and eighty-five use records referred to unspecified medicinal uses of 121 species, while the remainder could be

Table 1. CONSENSUS IN THE LITERATURE ON USES OF *Aloe spp.* (excluding *A. vera*).

Category	Sub-Category	Number of Use Records	Number of Taxa	Consensus Ratio
Medicines	Not recorded	485	121	0.75
	Infections and parasites	136	35	0.75
	Digestion	119	39	0.68
	Injuries	67	22	0.68
	Skin	42	17	0.61
	Pregnancy	33	17	0.50
	Sensory system	33	14	0.59
	Genito-urinary system	30	16	0.48
	Respiratory system	25	16	0.38
	Inflammation	19	11	0.44
	Poisonings	14	11	0.23
	Pain	14	10	0.31
	Muscular-skeletal system	14	8	0.46
	Undefined illness	13	9	0.33
	Endocrine system	8	7	0.14
	Blood system	6	4	0.40
	Nutrition	6	3	0.50
	Circulation	5	5	0
	Neoplasms	2	2	0
	Mental health	2	2	0
	Immune system	1	1	0
	Nervous system	1	1	0
	Abnormalities	1	1	0
Social uses		83	35	0.59
Vertebrate poisons		80	37	0.54
Environmental uses		78	44	0.44
Food		51	24	0.54
Materials		46	23	0.51
Non-vertebrate poisons		18	5	0.76
Animal food		16	10	0.40
Bee plants		8	6	0.29
Food additives		5	3	0.50
Fuel		2	2	0

classified in the subcategories of medicinal use discussed below.

Infections and Parasites. The use of *Aloe* spp. to treat infections and parasites was the most frequently cited of the medicinal uses for the genus; 136 use records were collected for 35 species. In particular, their widespread use as anthelmintic agents was recorded in history (e.g., *A. succotrina* All. in Lindley [1869]) and in contemporary sources (e.g., *A. dhufarensis* Lavranos in Ghazanfar [1994]). *A. dichotoma* Masson, an endangered species occurring in arid regions of Namibia and South Africa, is used to treat tuberculosis (van Damme and van den Eynden 2000; van den Eynden et al. 1992).

Besides medical uses against infections and parasites, 12 species are recorded in ethnoveterinary medicine against foot and mouth disease, lice, rabies, and African horse sickness (Watt and Breyer-Brandwijk 1962; ITFG and IITR 1996; van Damme and van den Eynden 2000).

Digestion. The literature contains numerous references to the use of *Aloe* spp. for digestive ailments, since this is the principal application of commercial preparations containing aloe products. In general, concentrated preparations of the leaf exudate ("drug aloes") are taken for laxative effects attributed to anthraquinones, while the polysaccharide rich mesophyll ("aloe gel") is taken as a source of fiber (Steenkamp and Stewart 2007).

Including possible uses of commercial products, 119 use records for 39 species of *Aloe* were identified in the literature, including *A. ballyi*

Reynolds (Kokwaro 1993; Oketch-Rabah 1996), a species vulnerable to extinction (IUCN 2007).

Injuries. We collected 67 use records that described the use of 22 species of *Aloe* for treating injuries. Leaf mesophyll is commonly applied directly to burns and wounds, such as sunburned skin (*A. marlothii*; Rood 2008b). In Togo, the leaves of *A. buettneri* A.Berger are warmed prior to application (Adjanohoun 1987). Less frequently, leaves of species such as *A. maculata* All. are used in poultices, while *A. ferox* is used to treat tooth abscesses (Powell 1868; Reynolds 1950; Githens 1979). In Kenya, *A. lateritia* Engl., *A. kedongensis* Reynolds, and *A. secundiflora* are used to heal castration wounds in cattle (ITFG and IITR 1996).

Skin. The use of *Aloe* leaves to treat skin conditions was described in 42 use records referring to 17 species. The high polysaccharide and water content of the leaf mesophyll may account for its soothing effect on the skin; the efficacy of *A. arborescens*, *A. ferox*, and *A. vera* in wound healing has been attributed to the skin healing and antimicrobial properties of leaf tissues (Jia et al. 2008; Steenkamp and Steward 2007).

The emollient properties of the leaves were described in therapy of rashes, and the leaf exudate for skin irritations (Ghazanfar 1994; Njoroge and Bussmann 2007; van Wyk et al. 1997). Two species with spotted leaves, *A. greatheadii* var. *davyana* and *A. maculata*, are taken orally and applied topically to heal skin ailments (Hutchings et al. 1996; Watt and Breyer-Brandwijk 1962), although it is unclear if they are selected specially for their leaf markings.

Pregnancy. Seventeen species of *Aloe* (33 use records) were documented for uses in pregnancy, labor, and postnatal care, including the toxic species *A. chabaudii* Schönland in Zimbabwe (Gelfand et al. 1985). Preparations are taken to induce or ease labor and promote expulsion of the placenta. The most common use, however, is of the bitter leaf exudate as a weaning aid.

The use of *A. ferox* may cause purging in infants when taken by nursing mothers (Wren 1975), whereas *A. buettneri* is reportedly given to mothers to stop purging in breast-fed infants (Gill 1992). Despite records of their traditional use, additional records have contraindicated the use of *A. chabaudii* (Gelfand et al. 1985), *A. cooperi* Baker (Hutchings et al. 1996), and *A. ferox* (van Wyk et al. 1997) by pregnant women due to a risk of inducing early labor (see *Vertebrate poisons*).

Sensory System. *Aloe* spp. are commonly used to treat the sensory system (33 use records for 14 species), frequently as eye drops to treat conjunctivitis. An infusion of the leaves of *A. chabaudii* is used to treat ear infections (Morris 1996), while *A. broomii* Schönland is used similarly for ear ailments in sheep (Reynolds 1950).

Genito-Urinary System. We found that 16 species of *Aloe* (30 use records) were cited as medicines used to treat disorders of the genito-urinary system, notably menstruation and infertility. *Aloe hereroensis* Engl. is used to treat urinary incontinence and *A. zebrina* Baker for treating kidney and urinary complaints (van Koenen 2001). A leaf of *A. dawei* A.Berger, warmed on the fire, is used to massage the back for sore kidneys (Olembo et al. 1995).

Respiratory System. Sixteen species of *Aloe* are known to be used in therapy of respiratory ailments, including the common cold, coughs, influenza, and associated symptoms. *Aloe kedongensis* is administered to cattle in East Africa for the same purpose (ITFG and IITR 1996). Species such as *A. asperifolia* A.Berger, *A. dichotoma*, and *A. excelsa* A.Berger are used for asthma (Gelfand et al. 1985; van den Eynden et al. 1992), while *A. volkensii* Engl. is used for whooping cough (Olembo et al. 1995).

Inflammation. Smith (1888) noted that *A. maculata* [= *A. saponaria* (Aiton) Haw.] was "perhaps the best of all the plants which have virtue in healing an inflamed wound." Nineteen topical remedies containing *Aloe* spp. were recorded, while other medicines containing *Aloe* spp. are reportedly ingested, such as *A. sinkatana* Reynolds for tonsillitis (Marshall 1998).

Poisoning. Eleven species were recorded in 14 use records for the treatment of poisoning caused by snake and insect venom. In Namibia, *A. asperifolia* is given to donkeys that have eaten poisonous plants (van Damme and van den Eynden 2000).

Pain. Analgesic applications were documented for 10 species of *Aloe*, commonly for toothache. The Herero people in Namibia use *A. hereroensis* for chest and stomach pains, while *A. secundiflora* is used in Kenya and Tanzania to relieve chest pain and headaches (Kokwaro 1993; van den Eynden et al. 1992).

Muscular-Skeletal System. Historical and contemporary references referred to the use of *A.*

ferox and *A. perryi* for arthritis and rheumatism (Hocking 1997; Powell 1868; van Wyk et al. 1997). *A. maculata* was traditionally used in ethnoveterinary medicine in Lesotho to treat sprains and fractured bones (Reynolds 1950).

Undefined Illness. Use records describing the use of *Aloe* spp. to treat ailments of an unspecified nature included *A. humilis* (L.) Mill. and *A. aristata* Haw. for bathing, to impart tonic effects (Reynolds 1950; Watt and Breyer-Brandwijk 1962).

Endocrine System. References to the use of *Aloe* spp. for hormonal disorders were infrequent in the literature. In total, eight use records referred to the use of *A. massawana* Reynolds (Heine and Legére 1995), *A. maculata* (Maliehe 1997), *A. dhufarensis*, and *A. inermis* Forssk. (Ghazanfar 1994) for diabetes; *A. excelsa* is used for jaundice (Gelfand et al. 1985; Iwu 1993).

Blood System. *Aloe buettneri* (Gill 1992), *A. ferox* (Powell 1868), and *A. rabaiensis* Rendle (Kokwaro 1993) were cited as medicines for ailments of the spleen, while *A. lateritia* is administered for anaemia in Tanzania (Neuwinger 1996).

Nutrition. Food products and commercial preparations containing *A. ferox* have gained popularity in health food markets (Kleinschmidt 2004). Sap sucked from the leaves of *A. secundiflora* is a traditional remedy in Kenya for appetite loss and nausea (Kokwaro 1993). In contrast, the bitter exudate of *A. ferox* and other species has traditionally been painted on children's fingernails to discourage nail biting (Rood 2008b). The leaf exudate of *A. volkensii* has been used as a bitter paint to deter animals from gnawing on objects (Watt and Breyer-Brandwijk 1962).

Circulation. Arteriosclerosis, hypertension, and stress are among the circulatory ailments reportedly treated with *Aloe* spp. For example, a mixture of *A. arborescens* and *A. maculata* is administered for heart problems in Swaziland (Amusan et al. 2002).

Neoplasms. Although several species of *Aloe* have been included in laboratory studies for anticancer potential (e.g., Kametani et al. 2007), only *A. maculata* has been used in traditional medicine to treat tumors (Johnson 1999).

Mental Health. Historically, leaf exudate preparations of *A. perryi* and *A. succotrina* were taken for hysteria (Watt 1889).

Immune System. Hutchens (1994) noted that *A. ferox* is "soothing" to the lymphatic system.

Nervous System. A single use record described *A. asperifolia* as an ingredient in traditional medicine in Namibia for epilepsy (van den Eynden et al. 1992).

Abnormalities. A single use record referred to the use of *A. maculata* to treat unspecified scleroses (Johnson 1999).

Social Uses

The social uses of 35 species of *Aloe* were documented in 83 use records. Magical and ritual uses were frequently cited among these, including uses in fertility and initiation ceremonies (Reynolds 1950), charms for good fortune (Watt and Breyer-Brandwijk 1962), safety at funerals (Morris 1996), and protection for the home (Dold and Cocks 2000). *Aloe gracilis* Haw., a species vulnerable to extinction (TSP 2007), is used as a protective charm (Hutchings et al. 1996). Some 20 use records referred to snuff prepared from the dried or burned leaves of various species. The nectar of *A. ferox* was speculated to possess narcotic properties (Smith 1888). Two southern African species, *A. christianii* Reynolds and *A. chabaudii*, are used to induce abortion (see *Vertebrate Poisons*), although the latter is also known as a medicine taken during pregnancy (Gelfand et al. 1985; van Wyk and Gericke 1999).

The cultural importance of some species of *Aloe* has been conveyed in various media besides the literature. Examples include rock art motifs of *A. broomii* and *A. ferox* in South Africa (Reynolds 1950), illustrations of species such as *A. aculeata* Pole-Evans and *A. lutescens* Groenew. on postal stamps in Zimbabwe and Botswana (Steffens 1991; Smith and Glen 1993), and *A. aculeata* on the first decimal 10-cent coin of South Africa (Smith and Glen 1993). In the landscape, Reynolds (1950) noted in the Congo region that *A. dawei* was planted around the flagpole of a chief, while *A. buettneri*, *A. rivae* Baker, and *A. sinkatana* were reportedly planted on graves (Holland 1922; Reynolds 1966).

Vertebrate Poisons

Aloe buettneri, *A. lateritia*, *A. rabaiensis*, *A. secundiflora*, and *A. zebrina* have been documented as ingredients in arrow poisons throughout Africa (Holland 1922; Neuwinger 1996). Meat painted with *A. ruspoliana* Baker is used as bait to kill hyenas (Newton 1972) and *A.*

volkensii is used as a rodenticide to kill moles (Olembo et al. 1995).

Anecdotal evidence of severe or fatal poisoning in humans, typically caused by an overdose of preparations taken for constipation or to induce abortion, was recorded for 14 species. Risks of poisoning were noted for *A. ferox*, the source of Cape aloes, which is contraindicated in high doses and during pregnancy (Roberts 1990), as are species used to induce labor such as *A. perryi* (Khory and Katrak 1999) and *A. christianii* (Gelfand et al. 1985). While toxicity may be due to the presence of alkaloids in some species (e.g., *A. chabaudii*, *A. globuligemma* Pole-Evans, and *A. orthlopha* Christian & Milne-Redh.), the toxic principles in other species are not documented.

Environmental Uses

The spiny foliage and hardiness of many species of *Aloe* are exploited as living hedges, commonly for livestock enclosures; such hedges may be evident in the landscape for decades after a homestead has been vacated. The environmental uses of 44 species and infraspecific taxa were described in the literature, including *A. striata* Haw. (Glen and Hardy 2000), a species vulnerable to extinction (TSP 2007) although common in some parts of its range. At the ecological level, expansive populations of *A. greatheadii* var. *davyana* are an indicator of heavy overgrazing by domestic livestock in southern Africa (Glen and Hardy 2000). The soil-binding properties of the roots of this species are important in the stabilization and reclamation of eroded or otherwise degraded areas (Smith and Correia 1988, 1992). In Kenya, *A. secundiflora* is an important facilitator species in rangeland plant communities, promoting increased vegetation cover (King 2007; King and Stanton 2007). The Vhavenda of southern Africa use *A. marlothii* as a seed primer; seeds are soaked in the liquid from pounded leaves to make them more resilient and productive when sown (Mabogo 1990).

Food

The literature referred to 51 species of *Aloe* that are locally valued as vegetables, famine food, and occasional food. Most commonly, the flowers are cooked as a vegetable, sometimes with groundnuts (*Arachis hypogaea* L., Fabaceae) (e.g., *A. maculata*), in soup (e.g., *A. buettneri*), porridge (e.g., *A. esculenta* L.C.Leach), or in sweetmeats (e.g., *A. zebrina*) (Rodin 1985; FAO 1988). Immature inflorescences of *A. krausii* Baker and *A. minima* Baker are eaten raw (Heine and Legére 1995; Reynolds 1950; Silberbauer 1981). However, the floral buds of *Aloe greatheadii* var. *greatheadii* may cause vomiting if incorrectly prepared (Hyde and Wursten 2008). The leaves of some species may be cooked as a leafy vegetable or eaten as salad leaves.

Although undocumented, it is probable that the exudate-containing green leaf tissues are peeled from the mesophyll to remove the source of the extremely bitter taste and potential toxins. The peeled leaf mesophyll of *A. ferox* is used to make jam in South Africa (Roberts 1990; Rood 2008a; Smith and van Wyk 2008; Watt and Breyer-Brandwijk 1962). In India, the leaves of *A. elegans* Tod. were historically pickled with salt (Watt 1889). The flowers of *A. volkensii* have been used to preserve butter (Watt and Breyer-Brandwijk 1962). The sweet floral nectar of *A. ferox* and *A. secundiflora*, and perhaps other undocumented species, is favored as a snack food (Maundu et al. 1999; Watt and Breyer-Brandwijk 1962). The roots of *A. kedongensis*, *A. ngongensis* Christian, *A. secundiflora*, and *A. volkensii* are used in brewing traditional beer in East Africa (Maundu et al. 1999). As a famine food, the flowers of *A. angolensis* Baker and *A. zebrina* are cooked and dried or made into a paste for later use (Rodin 1985; Leffers 2003).

Materials

Dyes and ink of various hues from *Aloe* spp. were recorded in the literature. Yellow dyes from *A. maculata* and *A. zebrina* are used to dye sisal and palm fiber for basketry (FAO 1988; van Wyk and Gericke 1999); red-brown, purple, blue-black, and black dye are obtained from six other species (Ghazanfar 1994; Newton 1972; Reynolds 1950; van Wyk and Gericke 1999). Black ink was historically produced from *A. littoralis* Baker (Drury 1858).

Notes were collated on an adhesive prepared from *A. inermis* (Ghazanfar 1994); soap from *A. duckeri* Christian (Lane 2004), *A. maculata* (Newton 1972), and *A. secundiflora* (Wabuyele 2006); cordage from *A. ferox* (Grime 1976); and birdlime from the leaf exudate of *A. lateritia* (Heine and Legére 1995). The spiny leaves of *A. maculata*, *A. marlothii*, and possibly other species have been used to prepare hides for tanning (Morton 1961; Reynolds 1950). In the Eastern

Cape, we have observed short sections of the stem of *A. ferox* mechanically hollowed out and used as decorative containers for household utensils and dried flower arrangements. Explorers in southern Africa documented the use of hollowed branches of *A. dichotoma* as quivers by the San in the 17th century (Reynolds 1950).

The diversity in form among *Aloe* spp. has attracted keen horticultural interest. *Aloe succotrina* was recorded as an ornamental in Europe as early as 1697 (Pole-Evans 1919) and the genus continues to interest plant collectors today (Rowley 1976; De Wet 1996). Indiscriminate collecting for horticulture is of particular concern regarding threatened species including the endangered *A. peglerae* Schönland (Pfab and Scholes 2004) and the Lesotho endemic, *A. polyphylla* Schönland (Marshall 1998).

Non-Vertebrate Poisons

The principal application of *Aloe* spp. for pest control is in dips for poultry (*A. chabaudii*, *A. secundiflora*) and livestock (*A. broomii*, *A. ferox*) (Gelfand et al. 1985; ITFG and IITR 1996; Kokwaro 1993; Roberts 1990). The dried leaves of *A. castanea* Schönland, *A. ferox*, and *A. secundiflora* are burned and the ash from them is used to repel insects (Watt and Breyer-Brandwijk 1962; Timberlake 1987; Spring and Diederichs 2006). Ash from the dried, burned leaves of *A. castanea* is also recommended for pest control when mixed with stored grain (National Department of Agriculture, South Africa 2008). The dried, powdered leaves of *A. ferox* are reportedly an effective pesticide for plants (Spring and Diederichs 2006).

Animal Food

Aloe fulfills important ecosystem functions; 18 use records regarding animal food were gathered for 11 species. The copious floral nectar of *A. marlothii* is an important source of sustenance for many bird species (Symes et al. 2008). Wildlife, including antelope, baboon (*Papio* spp., Cercopithecidae), and rock hyrax (*Procavia capensis* Pallas, Procaviidae), browse on the leaves, fruits, and flowers particularly during droughts, and species recover at different rates. However, concerns have been recorded over damage caused by livestock to populations of *A. arenicola* Reynolds and the critically endangered *A. bowiea* Schult. & Schult.f. (Bornman and Hardy 1971; Smith 1989).

Bee Plants

A. greatheadii is regarded as the most superior species for honey production (Bornman and Hardy 1971). However, bees reputedly become vicious when kept exclusively on *A. greatheadii* var. *davyana* or on *A. zebrina* (Watt and Breyer-Brandwijk 1962).

Food Additives

The leaf exudate of *A. arborescens* is used as a bittering agent in Kenya (Duri et al. 2004), while Cape aloes from *A. ferox* was historically used as such in beer (Robertson 1979). "*Aloe* juice" prepared from the leaves of *A. ferox* is used as a food additive (Kleinschmidt 2004); *A. ferox* and *A. perryi* are approved for use as flavorings in the United States (Review of Natural Products 2004).

Fuel

The dried leaves of *A. ferox* are known to burn quickly (Maliehe 1997). It is likely that other undocumented species are used for kindling since many species accumulate dried leaves at the base of the crown. In East Africa, *A. lateritia* is a substitute for fuel wood and is used for lime burning (Heine and Legére 1995).

Consensus Analysis

Consensus ratios (CR) for the categories of uses documented for *Aloe* ranged from 0–0.76 (Table 1), where consensus increases as the ratio approaches 1.0 (Trotter and Logan 1986). The medicinal uses of *Aloe* spp. for which data were most abundant, were supported by high consensus ratios for both uncategorized medicinal uses (CR 0.75) and those for which detail in the literature allowed them to be classed in subcategories.

Consensus was most convincing for subcategories of medicinal use in which data were numerous, such as against infections and parasites (CR 0.75), digestive complaints, and injuries (both CR 0.68). However, there was no consensus (CR 0) in data-poor categories, such as on the use of *Aloe* spp. for fuel nor on their use to treat abnormalities, neoplasms, mental health, circulation, and disorders of the immune and nervous systems. Non-comparative data comprising a single mention of a single species may be excluded from analyses of large datasets without affecting consensus analyses (Moerman 2007). The volume of data and aim to compare

homogeneity and biocultural value between use categories, however, required that all use categories were analyzed in the present study.

Besides the robust consensus ratios for their medicinal uses, the use of *Aloe* spp. to control invertebrate pests was supported by a consensus ratio of 0.76. Homogeneity among the recorded utility of *Aloe* spp., therefore, indicates that uses for medicine and pest control are of the greatest biocultural importance.

Conclusions

Evaluation of the literature has illustrated the multi-utility value of the genus *Aloe*, in particular for the medicinal uses of 25% of species. Homogeneity among use records indicated the uses of *Aloe* spp. for medicine and invertebrate pest control are of the greatest biocultural importance. Cultural value, in the broad sense, is a necessary consideration for effective conservation of biodiversity (Cocks 2006). It is particularly important for utility species that may be threatened by unsustainable rates of use; the biocultural value placed upon them is reflected by homogeneity among ethnobotanical data (Pardo-de-Santayana 2008).

Despite possible limitations in the detail and accuracy of data recovered, ethnobotanical records gathered by proxy from the literature afforded novel insights into the biocultural importance of utility in *Aloe*. Taking into consideration utility value and commercial demands biocultural importance may be anticipated to sustain the need for and add to the efficacy of the conservation of *Aloe*.

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3.2 Therapeutic uses of *Aloe* L. (Asphodelaceae) in southern Africa

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NOTE

The paper presented in 3.2 is a discussion of a data subset compiled for 3.1 focused on the medicinal uses of *Aloe* spp. in southern Africa.

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Therapeutic uses of *Aloe* L. (Asphodelaceae) in southern Africa

O.M. Grace [a,b,*], M.S.J. Simmonds [a], G.F. Smith [b,c], A.E. van Wyk [b]

[a] *Royal Botanic Gardens, Kew, Surrey TW9 3AB, United Kingdom*
[b] *Department of Plant Science, University of Pretoria, Pretoria 0002, South Africa*
[c] *South African National Biodiversity Institute, Private Bag X01, Pretoria 0002, South Africa*

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ABSTRACT

Ethnopharmacological relevance: The African-Arabian succulent genus *Aloe* L. (Aloaceae/Asphodelaceae) is represented by approximately 120 infrageneric taxa in southern Africa, including *A. ferox* Mill., a species long used in commercial natural products.
Aims of the study: To assess the documented ethnobotanical knowledge and biocultural value of utility in the genus in southern Africa.
Materials and methods: A survey of over 350 multidisciplinary publications was undertaken.
Results: Local uses for medicine and wellbeing were identified for over half the species of *Aloe* occurring in the *Flora of Southern Africa* region. The most frequently cited medicinal uses were the treatment of infections and internal parasites, digestive ailments and injuries. Numerous species were recorded for their social uses, notably as ingredients in tobacco snuff.
Conclusion: The exceptional infrageneric diversity of *Aloe*, and extensive therapeutic uses in southern Africa, indicate its cultural importance in the subcontinent. These factors highlight the need for the conservation of the species as well as their potential as a source of natural products.

1. Introduction

Southern Africa is celebrated for its biological and ethnic diversity. More than three centuries of botanical exploration in South Africa and neighbouring countries have revealed astonishing floristic diversity – approximately 25,000 plant species and >50% endemism – in the region (Cowling and Hilton-Taylor, 2004; Steenkamp and Smith, 2006). More recently, the cultural value of biodiversity and its importance in effective biodiversity conservation planning and ecotourism, have been recognised (Cocks, 2006). The need for ethnobotanical research and the importance of existing accounts of utility in the flora of southern Africa have grown as a result. In this paper, we present an analysis of documented uses for medicine and wellbeing in southern Africa of the genus *Aloe* L. (Aloaceae/Asphodelaceae), a group of leaf succulents used for medicine throughout its range on the African continent, the western Indian Ocean Islands and Arabian Peninsula.

Species such as *Aloe ferox* Mill. in South Africa and *Aloe secundiflora* Engl. in Kenya are wild-harvested for the internation trade in natural products prepared from the bitter leaf exudate ('drug aloes') and jelly-like mesophyll ('aloe gel') of aloes. However, the principal source of these products, *Aloe vera* L., a species native to the Arabian Peninsula, is extensively cultivated around the world (Newton and Vaughan, 1996; Oldfield, 2004). Unsustainable harvesting for the natural products industry is one of the major threats to *Aloe* (Oldfield, 2004), and consequently trade in all species except *Aloe vera* is regulated by the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES). Despite the demand for natural products from *Aloe* spp. and their suitability to cultivation in dryland regions, few species are utilised commercially.

The record of plant use in southern Africa is substantial (see Van Wyk, 2002 for a general review) and includes numerous, scattered references to the ethnomedicinal uses of *Aloe* spp. in the region. In the present contribution, these 'use records' were collated and analysed to postulate the cultural value of *Aloe* spp. used for wellbeing in southern Africa and to highlight species with promise as sources of commercial natural products. The literature-guided approach, using the ethnographic record as a surrogate for ethnobotanical field study to identify plants of pharmacological interest, has previously been used to identify candidates for research against illnesses such as schistosomiasis (Clark et al., 1997) and diabetes (Simmonds and Howes, 2006) or, as in the present study, within a taxon, e.g. *Plectranthus* (Lukhoba et al., 2006). Recent examples of this approach to identify promising candidates from the diverse flora of southern Africa include plants

* Corresponding author at: Royal Botanic Gardens, Kew, Surrey TW9 3AB, United Kingdom. Tel.: +44 20 83325394.
E-mail address: o.grace@kew.org.uk (O.M. Grace).

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with antimalarial activity (Clarkson et al., 2004) and monoamine oxidase inhibitory effects (Stafford et al., 2007).

2. Literature survey

Records of the therapeutic uses and useful properties of *Aloe* spp. in the countries covered by the *Flora of Southern Africa* (FSA) (South Africa, Lesotho, Swaziland, Botswana and Namibia) were identified during a review of over 320 multidisciplinary, mostly English-language, publications. References were identified by searching the extensive library at the Royal Botanic Gardens, Kew, and the online repositories BioMed Central (www.biomedcentral.com), Blackwell Synergy (www.blackwell-synergy.com), CAB Abstracts (www.cabi.org), Elsevier ScienceDirect (www.sciencedirect.com), Ingenta Connect (www.ingentaconnect.com), ISI Web of Knowledge (www.isiknowledge.com), JSTOR (www.jstor.org) and Swetswise (www.swetswise.com). Sources of information included pertinent ethnographic accounts of southern Africa such as those of Bryant (1909), Watt and Breyer-Brandwijk (1962) and Van den Eynden et al. (1992), as well as the Flora, peer-reviewed literature and the popular press. However, fewer than 18% of the publications consulted referred plainly to the use of *Aloe* spp. for medicine and general wellbeing in southern Africa. Records of plant use in South Africa were more abundant than elsewhere in the region covered by the Flora.

The uses of *Aloe* spp. for preventative and rehabilitative therapy, magical and ritual purposes in southern Africa were collated. Accepted names were appended, where necessary, from Newton's (2001) checklist of names and synonyms for *Aloe*. The domesticated *Aloe vera* was omitted from this survey, as the substantial literature documenting its uses and properties has been reviewed frequently (e.g. Grindlay and Reynolds, 1986; Reynolds and Dweck, 1999; Eshun and He, 2004; Richardson et al., 2005). Some 20 use records that could not be attributed to a particular species were also omitted, for example "The Zulu apply a pinch of the ash from the leaf an aloe species and the root of a *Lasiosiphon* [=*Gnidia* L., Thymelaeaceae] species to the eye, in the treatment of opthalmia" (Watt and Breyer-Brandwijk, 1962).

Each documented use for a therapeutic purpose in southern Africa constituted a 'use record' for a species. Using the Biodiversity Information Standard (formerly TDWG, the Taxonomic Database Working Group) standard (Cook, 1995), these records were classified into categories: Medicines (including veterinary medicine), Social Uses and Vertebrate Poisons. Sub-categories were recorded for approximately 60% of the use records in the Medicines category, when detail in the literature allowed (Table 1). In total, 440 use records describing the therapeutic uses of 63 accepted species of *Aloe* in southern Africa were collected (Tables 2 and 3).

3. Documented uses

More than half of the species of *Aloe* recognised in the *FSA* treatment (Glen and Hardy, 2000) are known to be used for medicine and wellbeing in the region. Patterns in the ethnographic literature indicate that widespread, common species of *Aloe* in southern Africa are more likely to be popular, multi-use ethnomedicines than rare species with narrow ranges.

Species for which use records were most numerous included *Aloe maculata* All. (46 records) and *Aloe marlothii* A. Berger (29), two species common in the landscape where they occur in southern Africa (Van Wyk and Smith, 1996). Conversely, species about which little is documented included *Aloe pearsonii* Schönland (1 record), a species with a limited range on the Namibia–South Africa border, and *Aloe suprafoliata* Pole-Evans (2), which occurs in a narrow distribution on rocky slopes in the South Africa–Swaziland border region (Van Wyk and Smith, 1996). Exceptions, however, included the Namibian endemic *Aloe asperifolia* and the very restricted Cape species *Aloe succotrina* All., for which use records were relatively numerous (17 and 16 records, respectively).

Table 1
Frequency of citation of *Aloe* spp. for medicine and wellbeing in southern Africa

Use category[a]	Sub-category	Number of use records	Species cited
Medicine	Unspecified	167	45
Medicine	Infections/infestations	54	11
	Digestion	40	15
	Injuries	24	6
	Pregnancy	23	11
	Skin complaints	16	7
	Sensory system	10	6
	Inflammation	10	4
	Pain	7	5
	Respiratory system	7	4
	Genito-urinary system	6	5
	Muscular–skeletal system	5	3
	Poisoning	6	3
	Circulation	5	5
	Undefined illnesses	4	4
	Nutrition	2	1
	Endocrine system	1	1
	Nervous system	1	1
Social		63	28
Poisons		7	6

[a] After Cook (1995).

3.1. Medicine

The majority (85%) of use records describing the uses and properties of *Aloe* spp. in southern Africa for wellbeing refer to medicinal applications (Table 1). The most frequently cited species was *Aloe ferox*, for which 86 use records were gathered from 31 publications. This species is the source of a natural product known as Cape aloes prepared from the dried leaf exudate (see Hodge, 1953 for a detailed account). Cape aloes was a local traditional medicine adopted by colonists at the Cape of Good Hope and first exported to Europe in the late eighteenth century (Pole-Evans, 1919). Although demands for Cape aloes from *Aloe ferox* have fluctuated, some 600 tonnes of crystalline leaf exudate, collected almost entirely from natural populations, are exported annually from South Africa (Sachedina and Bodeker, 1999).

Cape aloes is most widely used for its potent laxative and cathartic effects, attributed to anthraquinones and in particular aloe-emodin (see Steenkamp and Stewart, 2007) in the leaf exudate. The literature, however, reflects numerous other ethnomedicinal applications of the leaf exudate of *Aloe ferox* in southern Africa, such as relieving arthritis, and, commonly, the use of leaf sap as eye drops for conjunctivitis and other eye ailments (Smith, 1888; Watt and Breyer-Brandwijk, 1962; Crouch et al., 2006).

3.1.1. Infections

The principal therapeutic uses of *Aloe* spp. in southern African ethnography are to treat infections, particularly sexually transmitted infections and internal parasites. Fifty four use records were collected for 11 species in the region, referring to a variety of preparations used for topical and internal administration; *Aloe ferox* and *Aloe maculata* were cited most frequently. Leaf pulp (mesophyll) may be applied directly to the skin, without preparation, to treat ringworm (Reynolds, 1950) or to dress wounds (Morton, 1961). Cape aloes from *Aloe ferox* is applied topically to sores caused by viral infections such as warts, herpes and shingles (Van Wyk

Table 2
Documented social uses and toxicity of *Aloe* spp. in southern Africa

Infrageneric taxon	Category[a]	
	Social use	Vertebrate poisons
Aloe aculeata Pole-Evans	Steffens (1991), Smith and Glen (1993), Glen and Hardy (2000)	
Aloe affinis A. Berger	Smith et al. (2005)	
Aloe angelica Pole-Evans	Steffens (1991)	
Aloe arborescens Mill.	Roberts (1990)	
Aloe aristata Haw.	Cunningham (1993), Mander et al. (1995), Hutchings et al. (1996), Glen and Hardy (2000), Crouch et al. (2006)	
Aloe broomii Schönland	Reynolds (1950)	
Aloe chabaudii Schönland	Van Wyk and Gericke (1999)	Van Wyk and Gericke (1999)
Aloe christianii Reynolds	Van Wyk and Gericke (1999)	
Aloe cooperi Baker	Glen and Hardy (2000)	
Aloe cryptopoda Baker	Steffens (1991)	
Aloe ecklonis Salm-Dyck	Watt and Breyer-Brandwijk (1962), Glen and Hardy (2000)	
Aloe esculenta L.C. Leach	Rodin (1985)	
Aloe ferox Mill.	Smith (1888), Pujol (1990), Hutchings et al. (1996), Maliehe (1997), Glen and Hardy (2000), Smith et al. (2005)	Roberts (1990)
Aloe globuligemma Pole-Evans	Steffens (1991), Glen and Hardy (2000)	Gelfand et al. (1985), Glen and Hardy (2000)
Aloe gracilis Haw.	Hutchings et al. (1996); Arnold et al. (2002)	
Aloe humilis (L.) Mill.	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Dold and Cocks (2000)	
Aloe khamiesensis Pillans	Reynolds (1950)	
Aloe kraussii Baker	Reynolds (1950), Watt and Breyer-Brandwijk (1962)	
Aloe littoralis Baker	Glen and Hardy (2000)	
Aloe lutescens Groenew.	Steffens (1991)	
Aloe maculata All.	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Johnson (1999)	
Aloe marlothii A. Berger	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Bornman and Hardy (1971), Roberts (1990), Hutchings et al. (1996), Van Wyk et al. (1997), Glen and Hardy (2000), Smith et al. (2005)	Glen and Hardy (2000)
Aloe ortholopha Christian & Milne-Redhead		Gelfand et al. (1985)
Aloe peglerae Schönland	Bornman and Hardy (1971)	
Aloe plicatilis (L.) Mill.		Arnold et al. (2002)
Aloe polyphylla Schönland	Maliehe (1997)	
Aloe prinslooi I.Verd & D.S.Hardy	Bornman and Hardy (1971)	
Aloe spicata L.f.	Hutchings et al. (1996)	
Aloe tenuior Haw.	Hutchings et al. (1996), Dold and Cocks (2000)	
Aloe thraskii Baker	Pujol (1990), Hutchings et al. (1996), Smith et al. (2005)	

[a] After Cook (1995).

and Gericke, 1999). The sap and decoctions of the leaves were widely reported for bathing sores caused by sexually transmitted infections or taken orally: the Ndebele drink a preparation of *Aloe globuligemma* Pole-Evans (Gelfand et al., 1985) despite its reported toxicity, *Aloe zebrina* Baker is taken in Botswana (Hedberg and Staugard, 1989), and in Namibia the sap of *Aloe hereroensis* Engl. diluted in water (Van den Eynden et al., 1992) and a water extract of *Aloe littoralis* Baker (Van Koenen, 2001) are among the remedies used. Species such as *Aloe humilis* (L.) Mill., *Aloe marlothii* (Watt and Breyer-Brandwijk, 1962) and *Aloe tenuior* Haw. (Githens, 1979) are administered internally to treat tapeworm, roundworm and other parasites. *Aloe dichotoma* Masson is used in Namibia to treat tuberculosis (Van den Eynden et al., 1992; Van Koenen, 2001).

In addition to medical applications, numerous use records were identified in the literature describing the ethnoveterinary value of *Aloe* spp. in southern Africa, for example against African horse sickness, tick and flea infestations, and rabies in dogs (Van den Eynden et al., 1992; Hutchings et al., 1996; Van Koenen, 2001).

3.1.2. Digestion

The greatest number of *Aloe* species (15) was documented for the treatment of ailments of the digestive system. Among these, *Aloe maculata* and *Aloe marlothii* were cited most frequently. For example, water in which leaves of *Aloe maculata* are steeped was noted by Watt and Breyer-Brandwijk (1962) as a Zulu medicine taken for its laxative and purgative effects, while leaf preparations are known in ethnoveterinary medicine to relieve digestive disorders in animals (Hutchings et al., 1996). A tea of the chopped leaves of *Aloe marlothii* was recorded as a remedy for stomach ailments (Roberts, 1990). Examples of species recorded less widely include *Aloe ecklonis* Salm-Dyck in Lesotho as a purgative (Johnson, 1999), the roots of *Aloe tenuior* in South Africa (Githens, 1979) and a brandy infusion of *Aloe variegata* L. taken for haemorrhoids in South Africa (Watt and Breyer-Brandwijk, 1962).

3.1.3. Injuries

Twenty-four use records recounted the application of *Aloe* spp. to treat injuries, most commonly applied directly to wounds, burns and other injuries. For instance, *Aloe greatheadii* Schönland is used to treat burns, bruises (Van Wyk et al., 1997) and insect bites (Smith, 2003) in South Africa. Uses were often described with related complaints that are dealt with in other sub-categories, such as inflammation. *Aloe maculata*, for instance, was documented by Reynolds (1950) as an effective treatment for boils, sores, and acutely inflamed injuries. *Aloe esculenta* L.C. Leach is used in Namibia to treat cuts and burns (Rodin, 1985; Van Koenen, 2001).

3.1.4. Pregnancy

Pregnancy, labour and postnatal care are among the most frequently documented uses of *Aloe* spp. in southern Africa: 23 use records describing 11 species were identified. For instance, *Aloe arborescens* Mill. and *Aloe greatheadii* were historically recorded as purgatives taken during pregnancy (Reynolds, 1950; Watt and Breyer-Brandwijk, 1962) while more recently, *Aloe cooperi* Baker and *Aloe ecklonis* Salm-Dyck were documented as ethnomedicines taken to ease labour (Hutchings et al., 1996; Johnson, 1999). Most commonly, however, the bitter leaf sap of numerous species is recorded as a weaning aid.

Table 3
Records of the medicinal use of *Aloe* spp. in southern Africa

Infrageneric taxon	Medicine	Medicine sub-category[a]							
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular–skeletal
Aloe affinis A. Berger	Arnold et al. (2002)								
Aloe africana Mill.	Pereira (1855), Wood and Bache (1854), Flückiger (1855), Sebire (1899), Thoms (1929), Reynolds (1950), Arnold et al. (2002)								
Aloe arborescens Mill.	Wills (1893), Thoms (1929), Reynolds (1950), Hodge (1953), Watt and Breyer-Brandwijk (1962), Githens (1979), Roberts (1990), Arnold et al. (2002),	Amusan et al. (2002)	Roberts (1990)					Schwegler (2003)	
Aloe aristata Haw.	Cunningham (1993), Arnold et al. (2002), Te Beest (2004)								
Aloe asperifolia A. Berger	Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000), Arnold et al. (2002)	Van den Eynden et al. (1992)	Van Damme and Van den Eynden (2000)		Van den Eynden et al. (1992)				
Aloe ballyi Reynolds									
Aloe barberae Dyer	Bruce (1974), Arnold et al. (2002)								
Aloe boylei Baker	Arnold et al. (2002)								
Aloe broomii Schönland	Arnold et al. (2002)								
Aloe buettneri A. Berger	Arnold et al. (2002)								
Aloe burgersfortensis Reynolds	Arnold et al. (2002)								
Aloe chabaudii Schönland	Arnold et al. (2002)								
Aloe ciliaris Haw.	Arnold et al. (2002)								
Aloe cooperi Baker	Cunningham (1993), Arnold et al. (2002), Te Beest (2004)								
Aloe cryptopoda Baker	Arnold et al. (2002)								
Aloe dewetii Reynolds	Arnold et al. (2002)								
Aloe dichotoma Masson	Reynolds (1950), Arnold et al. (2002)					Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)			
Aloe ecklonis Salm-Dyck	Arnold et al. (2002)		Watt and Breyer-Brandwijk (1962), Johnson (1999), Glen and Hardy (2000)			Johnson (1999)			
Aloe esculenta L.C. Leach							Rodin (1985), Van Koenen (2001)	Rodin (1985), Van Koenen (2001)	
Aloe excelsa A. Berger	Arnold et al. (2002)								Gelfand et al. (1985)

Table 3 (*Continued*)

Infrageneric taxon	Medicine	Medicine sub-category[a]							
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular–skeletal
Aloe ferox Mill.	Wood and Bache (1854), Pereira (1855), Simmonds (1865), Flückiger (1891), Sebire (1899), Humphrey (1921), Greenish (1929), Thoms (1929), Reynolds (1950), Hodge (1953), Watt and Breyer-Brandwijk (1962), Bruce (1974), Wren (1975), Githens (1979), Robertson (1979), Trease and Evans (1979), Roberts (1990), Hutchings et al. (1996), Van Wyk and Smith (1996), Van Wyk et al. (1997), Sachedina and Bodeker (1999), Glen and Hardy (2000), Arnold et al. (2002), Kleinschmidt (2004), Kambizi et al. (2005), Shackleton and Gambiza (2007)	Van Wyk et al. (1997)	Smith (1888), Greenish (1929), Roberts (1990), Hutchings et al. (1996), Maliehe (1997), Van Wyk et al. (1997), Kleinschmidt (2004), Van Wyk and Wink (2004)		Bryant (1909)	Smith (1888), Bryant (1909), Watt and Breyer-Brandwijk (1962), Githens (1979), Roberts (1990), Hutchings et al. (1996), Van Wyk and Gericke (1999), Glen and Hardy (2000), Kambizi et al. (2005), Crouch et al. (2006)	Bond (1995), Van Wyk et al. (1997), Van Wyk and Gericke (1999), Crouch et al. (2006)	Roberts (1990), Van Wyk et al. (1997)	Van Wyk et al. (1997), Crouch et al. (2006)
Aloe fosteri Pillans	Reynolds (1950), Arnold et al. (2002)								
Aloe globuligemma Pole-Evans	Arnold et al. (2002)					Gelfand et al. (1985)			
Aloe greatheadii Schönland	Gelfand et al. (1985), Arnold et al. (2002)		Mathabe et al. (2006)			Roberts (1990)		Roberts (1990), Van Wyk et al. (1997), Smith (2003)	
Aloe hereroensis Engl.	Arnold et al. (2002)	Van Damme and Van den Eynden (2000)	Van den Eynden et al. (1992), Van Koenen (2001)		Van Koenen (2001)	Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000), Van Koenen (2001)			
Aloe humilis (L.) Mill.	Arnold et al. (2002)		Watt and Breyer-Brandwijk (1962)			Watt and Breyer-Brandwijk (1962)			
Aloe keithii Reynolds	Arnold et al. (2002)								
Aloe kraussii Baker									
Aloe linearifolia A. Berger	Cunningham (1993), Hutchings et al. (1996), Arnold et al. (2002)								Reynolds (1950), Watt and Breyer-Brandwijk (1962)
Aloe littoralis Baker			Van Koenen (2001)			Van Koenen (2001)	Van Koenen (2001)		
Aloe maculata All.	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Glen and Hardy (2000), Arnold et al. (2002)	Amusan et al. (2002)	Watt and Breyer-Brandwijk (1962), Hutchings et al. (1996), Glen and Hardy (2000)	Maliehe (1997)		Smith (1888), Reynolds (1950), Morton (1961), Watt and Breyer-Brandwijk (1962), Githens (1979), Hutchings et al. (1996), Sachedina and Bodeker (1999), Glen and Hardy (2000)	Smith (1888), Watt and Breyer-Brandwijk (1962)	Smith (1888), Reynolds (1950), Watt and Breyer-Brandwijk (1962), Githens (1979), Sachedina and Bodeker (1999), Glen and Hardy (2000)	

Aloe marlothii A. Berger	Hodge (1953), Bruce (1974), Cunningham (1993), Hutchings et al. (1996), Arnold et al. (2002), Te Beest (2004)	Watt and Breyer-Brandwijk (1962), Bredenkamp and Van Vuuren (1987), Roberts (1990), Hutchings et al. (1996), Glen and Hardy (2000)		Watt and Breyer-Brandwijk (1962), Bredenkamp and Van Vuuren (1987), Roberts (1990), Hutchings et al. (1996), Glen and Hardy (2000)	
Aloe micrantha Haw.	Arnold et al. (2002)				
Aloe mutabilis Pillans	Arnold et al. (2002)				
Aloe parvibracteata Schönland	Arnold et al. (2002)				Glen and Hardy (2000)
Aloe pearsonii Schönland	Arnold et al. (2002)				
Aloe pendens Forssk.	Sachedina and Bodeker (1999), Arnold et al. (2002)				
Aloe perryi Baker	Thoms (1929), Greenish (1929), Coimbra (1994)				
Aloe plicatilis (L.) Mill.	Wood and Bache (1854), Pereira (1855), Flückiger (1891), Dragendorff (1898), Sebire (1899), Thoms (1929), Hodge (1953), Arnold et al. (2002), Lindsey et al. (2002)				
Aloe rabaiensis Rendle		Johnson (1999)			
Aloe rupestris Baker	Arnold et al. (2002), Te Beest (2004)		Hutchings et al. (1996)		
Aloe speciosa Baker	Hodge (1953), Bruce (1974), Arnold et al. (2002)				
Aloe spicata L.f.	Wood and Bache (1854), Pereira (1855), Redwood (1857), Boulger (1889), Sebire (1899), Hodge (1953), Hutchings et al. (1996), Arnold et al. (2002), Te Beest (2004)	Watt and Breyer-Brandwijk (1962)			
Aloe striata Haw.		Glen and Hardy (2000)			
Aloe striatula Haw.	ITFG and IITR (1996), Arnold et al. (2002)				
Aloe succotrina All.	Von Mueller (1881), Boulger (1889), Hodge (1953), Bornman and Hardy (1971), Bruce (1974), Arnold et al. (2002)				
Aloe suprafoliata Pole-Evans	Arnold et al. (2002), Lindsey et al. (2002)				
Aloe tenuior Haw.	Arnold et al. (2002)	Githens (1979), Hutchings et al. (1996), Dold and Cocks (2001)		Smith (1888), Watt and Breyer-Brandwijk (1962), Githens (1979), Hutchings et al. (1996)	

Table 3 (*Continued*)

Infrageneric taxon	Medicine	Medicine sub-category[a]							
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular–skeletal
Aloe thraskii Baker	Bruce (1974), Hutchings et al. (1996), Arnold et al. (2002)								
Aloe zebrina Baker	Arnold et al. (2002), Leffers (2003)		Leffers (2003)		Hedberg and Staugard (1989), Van Koenen (2001)	Hedberg and Staugard (1989)			

Infrageneric taxon	Medicine sub-category[a]								
	Nervous	Nutrition	Pain	Poisoning	Pregnancy	Respiratory	Sensory	Skin	Undefined illness
Aloe affinis A. Berger			Smith et al. (2005)						
Aloe africana Mill.									
Aloe arborescens Mill.			Roberts (1990)		Watt and Breyer-Brandwijk (1962)				
Aloe aristata Haw.									
Aloe asperifolia A. Berger	Van den Eynden et al. (1992)			Van den Eynden et al. (1992)	Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)	Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)			
Aloe ballyi Reynolds								Riley and Brokensha (1988)	
Aloe barberae Dyer									
Aloe boylei Baker									
Aloe broomii Schönland							Reynolds (1950)		
Aloe buettneri A. Berger									
Aloe burgersfortensis Reynolds									
Aloe chabaudii Schönland									
Aloe ciliaris Haw.									
Aloe cooperi Baker					Hutchings et al. (1996)				Watt and Breyer-Brandwijk (1962), Hutchings et al. (1996)
Aloe cryptopoda Baker									
Aloe dewetii Reynolds									
Aloe dichotoma Masson						Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)			
Aloe ecklonis Salm-Dyck					Johnson (1999)				
Aloe esculenta L.C. Leach					Rodin (1985), Van Koenen (2001)				
Aloe excelesa A. Berger									
Aloe ferox Mill.		Kleinschmidt (2004), Van Wyk and Wink (2004)	Crouch et al. (2006)				Smith (1888), Watt and Breyer-Brandwijk (1962), Githens (1979), Roberts (1990), Hutchings et al. (1996)	Roberts (1990), Van Wyk et al. (1997), Glen and Hardy (2000), Van Wyk and Wink (2004)	Robertson (1979)
Aloe fosteri Pillans								Watt and Breyer-Brandwijk (1962)	
Aloe globuligemma Pole-Evans								Van Wyk et al. (1997)	
Aloe greatheadii Schönland				Watt and Breyer-Brandwijk (1962), Roberts (1990), Glen and Hardy (2000)	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Glen and Hardy (2000)			Roberts (1990), Van Wyk et al. (1997), Smith (2003)	

Aloe hereroensis Engl.	Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)			Van den Eynden et al. (1992), Van Koenen (2001)	Van Koenen (2001)		
Aloe kraussii Baker			Reynolds (1950)				Reynolds (1950)
Aloe littoralis Baker					Van Koenen (2001)		
Aloe marlothii A. Berger			Watt and Breyer-Brandwijk (1962), Bredenkamp and Van Vuuren (1987), Roberts (1990), Hutchings et al. (1996), Glen and Hardy (2000)				
Aloe maculata All.		Hutchings et al. (1996)		Hutchings et al. (1996)		Raina (1982), Maliehe (1997), Hutchings et al. (1996)	
Aloe parvibracteata Schönland							
Aloe pearsonii Schönland							
Aloe pendens Forssk.							
Aloe perryi Baker							
Aloe plicatilis (L.) Mill.							
Aloe rupestris Baker					Hutchings et al. (1996)		
Aloe spicata L.f.			Hutchings et al. (1996)				
Aloe thraskii Baker			Hutchings et al. (1996)				
Aloe variegata L.	Reynolds (1950), Glen and Hardy (2000)						
Aloe zebrina Baker			Van Wyk and Gericke (1999)		Leffers (2003)	Leffers (2003)	

[a] After Cook (1995).

3.1.5. Skin complaints

Sixteen use records describing the topical application of fresh leaves or sap of seven species were gathered; some of these referred to the use of *Aloe* spp. to treat dermatological ailments caused by infections (see Section 3.1.1). The leaves and roots of *Aloe ferox* are applied topically, sometimes mixed with animal fat, or taken internally to treat conditions such as eczema, dermatitis and acne (Hutchings et al., 1996; Maliehe, 1997; Van Wyk et al., 1997). An infusion of *Aloe maculata* is used in South Africa to promote hair growth (Raina, 1982) while the leaf mesophyll of *Aloe greatheadii* is placed inside shoes to prevent blisters (Hutchings et al., 1996). The wound healing effects of *Aloe vera* have been ascribed to β-sitosterol, increased collagen activity and suppression of contact hypersensitivity (Steenkamp and Stewart, 2007).

3.1.6. Sensory system

Six species were documented for their use to treat ailments of the eye, including opthalmia and conjunctivitis (see Section 3.1.7.). The sap of *Aloe ferox*, *Aloe hereroensis* and *Aloe littoralis* is administered as eye drops (Watt and Breyer-Brandwijk, 1962; Van Koenen, 2001), while preparations containing the leaves of other species of *Aloe* are also used. In the case of *Aloe zebrina*, the leaf mesophyll is applied to the eye (Leffers, 2003).

The liquid from boiled leaves of *Aloe broomii* Schönland was documented by Reynolds (1950) as a remedy for ear ailments in sheep.

3.1.7. Inflammation

Species documented for uses against inflammatory conditions included *Aloe esculenta* L.C. Leach, *Aloe ferox*, *Aloe maculata* and *Aloe littoralis*. These taxa have long been used throughout southern Africa to treat inflammation associated with injuries (Smith, 1888; Rodin, 1985), as well as ailments such as conjunctivitis and sinusitis (Van Wyk and Gericke, 1999; Crouch et al., 2006).

3.1.8. Pain

Seven references to the use of *Aloe* spp. for pain relief were recorded, including the use of *Aloe variegata* for toothache in the Cape (Reynolds, 1950), *Aloe aborescens* Mill. for stomach ache (Roberts, 1990) and *Aloe hereroensis* for chest, heart and stomach pains in Namibia (Van den Eynden et al., 1992; Van Damme and Van den Eynden, 2000).

3.1.9. Respiratory system

The use of *Aloe* spp. to treat respiratory ailments in southern Africa is infrequently recorded in the literature. *Aloe hereroensis* is taken for chest complaints in Namibia (Van Koenen, 2001) while an infusion of the powdered flowers of *Aloe maculata* is a Zulu traditional remedy for colds and fever in children (Hutchings et al., 1996).

3.1.10. Genito-urinary system

Six use records noted the use of *Aloe* spp. to treat disorders of the genito-urinary system. *Aloe ferox* and *Aloe rupestris* Baker were documented for use against infertility in women and impotence in men (Bryant, 1909). *Aloe zebrina* was recorded in Botswana as a treatment for sexual disorders (Hedberg and Staugard, 1989). *Aloe hereroensis* Engl. and *Aloe zebrina* were documented in Namibia for their used to treat urinary and kidney ailments (Van Koenen, 2001).

3.1.11. Muscular–skeletal system

Few species of *Aloe* are listed in the ethnographic literature for therapy of muscular–skeletal disorders. *Aloe excelsa* A. Berger was recorded for the treatment of depressed fontanel in infants (Gelfand et al., 1985) and *Aloe ferox* for arthritis (Van Wyk et al., 1997). Earlier references noted that leaves of *Aloe maculata* were placed beneath the broken limb of an animal to treat the fracture (Reynolds, 1950; Watt and Breyer-Brandwijk, 1962).

3.1.12. Poisoning

In contrast to species that may cause poisoning, *Aloe greatheadii* is documented to be used as an effective treatment for snake bite (Watt and Breyer-Brandwijk, 1962) while *Aloe asperifolia* is used in Namibia to treat donkeys after grazing on poisonous plants (Van den Eynden et al., 1992; Van Damme and Van den Eynden, 2000). An infusion of *Aloe maculata* was recorded as a Zulu traditional remedy for overindulgence in food and alcohol (Hutchings et al., 1996).

3.1.13. Circulation

The treatment of circulatory complaints was among the most infrequently recorded medicinal purposes for *Aloe* spp. in southern Africa. Examples include a mixture of *Aloe arborescens* and *Aloe maculata* reportedly taken to treat cardiac ailments (Amusan et al., 2002) and *Aloe asperifolia* taken for arteriosclerosis in Namibia (Van den Eynden et al., 1992).

3.1.14. Undefined illness

The use of *Aloe* spp. in therapy of ailments of an uncertain nature, categorised as 'undefined illnesses', included reference to the use of *Aloe rupestris* as a strengthening medicine for Zulu chiefs (Hutchings et al., 1996) and smoke from burning leaves of *Aloe cooperi* to protect cattle in kraals from the consequences of a poor diet (Watt and Breyer-Brandwijk, 1962).

3.1.15. Nutrition

Kleinschmidt (2004) described the health benefits of beverages and fortified food products containing the leaf parenchyma of *Aloe ferox*, a by-product of the Cape aloes processing industry in South Africa.

3.1.16. Endocrine system

A single reference described the use of *Aloe maculata* in Lesotho as an ingredient in a traditional remedy for diabetes (Maliehe, 1997).

3.1.17. Nervous system

A single use record in the literature referred to an illness of the nervous system: a leaf decoction of *Aloe asperifolia* is taken for epilepsy (Van den Eynden et al., 1992).

3.2. Social uses

Several species (*Aloe christianii* Reynolds, *Aloe gracilis* Haw. and *Aloe krausii* Baker) were documented only for purposes of wellbeing classified as Social Uses. These included magical and ritual applications, such as the use of plant preparations to protect people and property against harm from lightning or visiting strangers (Dold and Cocks, 2000). Thirteen species were recorded for spiritual purposes such as fertility and initiation rites, including *Aloe arborescens* (Arnold et al., 2002) and *Aloe thraskii* Baker (Pujol, 1990).

Other social uses included species taken as antifertility agents to induce abortion (*Aloe chabaudii* Schönland and *Aloe christianii*) (Van Wyk and Gericke, 1999), in contrast to accidental abortion caused by species taken medicinally, such as *Aloe cooperi* (Hutchings et al., 1996) and high doses of *Aloe ferox* (Roberts, 1990).

The leaves of four *Aloe* spp., notably *Aloe marlothii*, were cited as ingredients in snuff tobacco but this may be a conservative reflection of the number of species that have been used as smoking materials or drugs in southern Africa, owing to vague information in the literature. Smith (1888) reported that the sweet nectar of *Aloe*

ferox, a snack favoured by children, caused intoxication and weakening of the joints. Other social uses indicated the cultural value of *Aloe* spp., such as the depiction on postal stamps of *Aloe aculeata* Pole-Evans, *Aloe angelica* Pole-Evans, *Aloe cryptopoda* Baker, *Aloe globuligemma*, *Aloe lutescens* Groenew. in the erstwhile Republic of Venda (Steffens, 1991) and of *Aloe aculeata* Pole-Evans on the original ten cent coin in South Africa (Smith and Glen, 1993).

3.3. Vertebrate poisons

Roberts (1990) noted that the sap of *Aloe ferox*, the source of Cape aloes, was regarded as an abortifacient and high doses should therefore be avoided. Cautions regarding the risk of poisoning associated with the medicinal use of *Aloe chabaudii*, *Aloe orthiopha* Christian & Milne-Redhead and *Aloe globuligemma* were noted by Gelfand et al. (1985). These southern African species are among a small number of *Aloe* spp. known to contain alkaloids (Dring et al., 1984) which may be the toxic agents. The social use of *Aloe marlothii* as snuff may be hazardous, as it was reported to contain carcinogens comparable to those in cigarette smoke (Watt and Breyer-Brandwijk, 1962).

4. Conclusions

As a surrogate for ethnobotanical field study, the ethnographic record is constrained by potential inaccuracies, preconception and interpretation in the literature and data repetition between sources. In this study, however, novel insight was gained into the species of *Aloe* used for health and wellbeing in southern Africa. Indeed, the diversity of species used (53% of species in the *FSA* region) illustrates the considerable biocultural significance of the genus. Taking into account this and the varied historical and contemporary therapeutic uses, the genus *Aloe* may yet hold promise as sources of commercial natural products. At least some of the phytochemical properties for which the commercially used species *Aloe vera*, *Aloe ferox* and *Aloe secundiflora* are valued, such as aloin and polysaccharide constituents, are known to be widely conserved in the genus (Reynolds, 2004). Frequently documented species such as *Aloe maculata* and *Aloe marlothii* warrant research for their potential as sources of natural products. Experiences from existing enterprises in Africa require consideration, however, such as concerns for the sustainable supply and quality of *Aloe ferox* for processing in South Africa (Sachedina and Bodeker, 1999) and vulnerability of value chains producing *Aloe vera* elsewhere in Africa. The rich ethnobotanical tradition and diversity of *Aloe* spp. in southern Africa highlight the prospects for their sustainable use and the need for their conservation.

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