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

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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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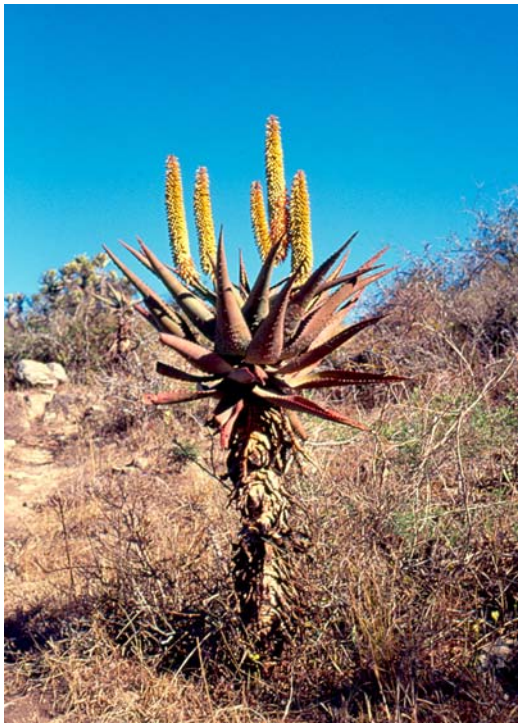

Fig. 1. *Aloe ferox*, South Africa. Photograph Gideon Smith.

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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