



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

O.M. Grace<sup>a,b,\*</sup>, M.S.J. Simmonds<sup>a</sup>, G.F. Smith<sup>b,c</sup>, A.E. van Wyk<sup>b</sup>

<sup>a</sup> Royal Botanic Gardens, Kew, Surrey TW9 3AB, United Kingdom

<sup>b</sup> Department of Plant Science, University of Pretoria, Pretoria 0002, South Africa

<sup>c</sup> South African National Biodiversity Institute, Private Bag X01, Pretoria 0002, South Africa

### ARTICLE INFO

#### Article history:

Received 29 April 2008

Received in revised form 3 July 2008

Accepted 8 July 2008

Available online 16 July 2008

#### Keywords:

*Aloe*

Asphodelaceae

Ethnobotany

Medicine

Southern Africa

### 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.

© 2008 Published by Elsevier Ireland Ltd.

### 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 international trade in natural products prepared from the bitter leaf exudate

\* Corresponding author at: Royal Botanic Gardens, Kew, Surrey TW9 3AB, United Kingdom. Tel.: +44 20 83325394.

E-mail address: [o.grace@kew.org.uk](mailto:o.grace@kew.org.uk) (O.M. Grace).

(‘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

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](http://www.biomedcentral.com)), Blackwell Synergy ([www.blackwell-synergy.com](http://www.blackwell-synergy.com)), CAB Abstracts ([www.cabi.org](http://www.cabi.org)), Elsevier ScienceDirect ([www.sciencedirect.com](http://www.sciencedirect.com)), Ingenta Connect ([www.ingentaconnect.com](http://www.ingentaconnect.com)), ISI Web of Knowledge ([www.isiknowledge.com](http://www.isiknowledge.com)), JSTOR ([www.jstor.org](http://www.jstor.org)) and Swetswise ([www.swetswise.com](http://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 ophthalmia" (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

**Table 1**

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

Use category <sup>a</sup>	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

<sup>a</sup> After Cook (1995).

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).

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

<sup>a</sup> 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 <sup>a</sup>							
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular-skeletal
<i>Aloe affinis</i> A. Berger	Arnold et al. (2002)								
<i>Aloe africana</i> Mill.	Pereira (1855), Wood and Bache (1854), Flückiger (1855), Sebire (1899), Thoms (1929), Reynolds (1950), Arnold et al. (2002)								
<i>Aloe arborescens</i> 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)	
<i>Aloe aristata</i> Haw.	Cunningham (1993), Arnold et al. (2002), Te Beest (2004)								
<i>Aloe asperifolia</i> 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)				
<i>Aloe ballyi</i> Reynolds									
<i>Aloe barberae</i> Dyer	Bruce (1974), Arnold et al. (2002)								
<i>Aloe boylei</i> Baker	Arnold et al. (2002)								
<i>Aloe broomii</i> Schönland	Arnold et al. (2002)								
<i>Aloe buettneri</i> A. Berger	Arnold et al. (2002)								
<i>Aloe burgersfortensis</i> Reynolds	Arnold et al. (2002)								
<i>Aloe chabaudii</i> Schönland	Arnold et al. (2002)								
<i>Aloe ciliaris</i> Haw.	Arnold et al. (2002)								
<i>Aloe cooperi</i> Baker	Cunningham (1993), Arnold et al. (2002), Te Beest (2004)								
<i>Aloe cryptopoda</i> Baker	Arnold et al. (2002)								
<i>Aloe dewetii</i> Reynolds	Arnold et al. (2002)								
<i>Aloe dichotoma</i> Masson	Reynolds (1950), Arnold et al. (2002)								
<i>Aloe ecklonis</i> Salm-Dyck	Arnold et al. (2002)		Watt and Breyer-Brandwijk (1962), Johnson (1999), Glen and Hardy (2000)						
<i>Aloe esculenta</i> L.C. Leach							Rodin (1985), Van Koenen (2001)	Rodin (1985), Van Koenen (2001)	
<i>Aloe excelsa</i> A. Berger	Arnold et al. (2002)								Gelfand et al. (1985)

Table 3 (Continued)

Infrageneric taxon	Medicine	Medicine sub-category <sup>a</sup>							
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular–skeletal
<i>Aloe ferox</i> 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)
<i>Aloe fosteri</i> Pillans	Arnold et al. (2002)								
<i>Aloe globuligemma</i> Pole-Evans	Arnold et al. (2002)					Gelfand et al. (1985)			
<i>Aloe greebii</i> Schönland	Gelfand et al. (1985), Arnold et al. (2002)		Mathabe et al. (2006)			Roberts (1990)	Roberts (1990), Van Wyk et al. (1997), Smith (2003)		
<i>Aloe hereroensis</i> 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)			
<i>Aloe humilis</i> (L.) Mill.	Arnold et al. (2002)		Watt and Breyer-Brandwijk (1962)			Watt and Breyer-Brandwijk (1962)			
<i>Aloe keithii</i> Reynolds	Arnold et al. (2002)								
<i>Aloe kraussii</i> Baker								Reynolds (1950), Watt and Breyer-Brandwijk (1962)	
<i>Aloe linearifolia</i> A. Berger	Cunningham (1993), Hutchings et al. (1996), Arnold et al. (2002)								
<i>Aloe littoralis</i> Baker			Van Koenen (2001)			Van Koenen (2001)	Van Koenen (2001)		
<i>Aloe maculata</i> 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)	

<i>Aloe marlothii</i> A. Berger	Hodge (1953), Bruce (1974), Cunningham (1993), Hutchings et al. (1996), Arnold et al. (2002), Te Beest (2004)	Watt and Breyer-Brandwijk (1962), Bredekamp and Van Vuuren (1987), Roberts (1990), Hutchings et al. (1996), Glen and Hardy (2000)	Watt and Breyer-Brandwijk (1962), Bredekamp and Van Vuuren (1987), Roberts (1990), Hutchings et al. (1996), Glen and Hardy (2000)
<i>Aloe micrantha</i> Haw.	Arnold et al. (2002)		
<i>Aloe mutabilis</i> Pillans	Arnold et al. (2002)		
<i>Aloe parvibracteata</i> Schönland	Arnold et al. (2002)		Glen and Hardy (2000)
<i>Aloe pearsonii</i> Schönland	Arnold et al. (2002)		
<i>Aloe pendens</i> Forssk.	Sachedina and Bodeker (1999), Arnold et al. (2002)		
<i>Aloe perryi</i> Baker	Thoms (1929), Greenish (1929), Coimbra (1994)		
<i>Aloe plicatilis</i> (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)		
<i>Aloe rabaiensis</i> Rendle		Johnson (1999)	
<i>Aloe rupestris</i> Baker	Arnold et al. (2002), Te Beest (2004)		Hutchings et al. (1996)
<i>Aloe speciosa</i> Baker	Hodge (1953), Bruce (1974), Arnold et al. (2002)		
<i>Aloe spicata</i> 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)	
<i>Aloe striata</i> Haw.		Glen and Hardy (2000)	
<i>Aloe striatula</i> Haw.	ITFG and IITR (1996), Arnold et al. (2002)		
<i>Aloe succotrina</i> All.	Von Mueller (1881), Boulger (1889), Hodge (1953), Bornman and Hardy (1971), Bruce (1974), Arnold et al. (2002)		
<i>Aloe suprafoliata</i> Pole-Evans	Arnold et al. (2002), Lindsey et al. (2002)		
<i>Aloe tenuior</i> 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 <sup>a</sup>								
		Circulation	Digestion	Endocrine	Genito-urinary	Infection	Inflammation	Injury	Muscular-skeletal	
<i>Aloe thraskii</i> Baker	Bruce (1974), Hutchings et al. (1996), Arnold et al. (2002)									
<i>Aloe zebrina</i> 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 <sup>a</sup>	Nervous	Nutrition	Pain	Poisoning	Pregnancy	Respiratory	Sensory	Skin	Undefined illness
<i>Aloe affinis</i> A. Berger <i>Aloe africana</i> Mill. <i>Aloe arborescens</i> Mill.				Smith et al. (2005) Roberts (1990)		Watt and Breyer-Brandwijk (1962)				
<i>Aloe aristata</i> Haw. <i>Aloe asperifolia</i> 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)			
<i>Aloe ballyi</i> Reynolds									Riley and Brokensha (1988)	
<i>Aloe barberae</i> Dyer <i>Aloe boylei</i> Baker <i>Aloe broomii</i> Schönland <i>Aloe buettneri</i> A. Berger <i>Aloe burgersfortensis</i> Reynolds <i>Aloe chabaudii</i> Schönland <i>Aloe ciliaris</i> Haw. <i>Aloe cooperi</i> Baker						Hutchings et al. (1996)		Reynolds (1950)		Watt and Breyer-Brandwijk (1962), Hutchings et al. (1996)
<i>Aloe cryptopoda</i> Baker <i>Aloe dewetii</i> Reynolds <i>Aloe dichotoma</i> Masson							Van den Eynden et al. (1992), Van Damme and Van den Eynden (2000)			
<i>Aloe ecklonis</i> Salm-Dyck <i>Aloe esculenta</i> L.C. Leach						Johnson (1999) Rodin (1985), Van Koenen (2001)				
<i>Aloe excelesas</i> A. Berger <i>Aloe ferox</i> 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)
<i>Aloe fosteri</i> Pillans									Watt and Breyer-Brandwijk (1962) Van Wyk et al. (1997)	
<i>Aloe globuligemma</i> Pole-Evans									Roberts (1990), Van Wyk et al. (1997), Smith (2003)	
<i>Aloe greateheadii</i> Schönland					Watt and Breyer-Brandwijk (1962), Roberts (1990), Glen and Hardy (2000)	Reynolds (1950), Watt and Breyer-Brandwijk (1962), Glen and Hardy (2000)				

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

<sup>a</sup> 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  $\beta$ -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 ophthalmia 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 use 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 kraussii* 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 ortholophia* 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.

## Acknowledgements

Colleagues at the Royal Botanic Gardens, Kew are thanked for their assistance gathering literature.

## References

- Amusan, O.O.G., Dlamini, P.S., Msonthi, J.D., Makhubu, L.P., 2002. Some herbal remedies from Manzini region, Swaziland. *Journal of Ethnopharmacology* 79, 109–112.
- Arnold, T.H., Prentice, C.A., Hawker, L.C., Snyman, E.E., Tomalin, M., Crouch, N.R., Pottas-Bircher, C., 2002. Medicinal and Magical Plants of Southern Africa: An Annotated Checklist. National Botanical Institute, Pretoria.
- Bond, A.J., 1995. Ethnobotany and land use in Soqotra (Socotra, Sokotrā, Suqutra). MSc Thesis, University of Edinburgh.
- Boulger, G.S., 1889. The Uses of Plants: A Manual of Economic Botany. Roper & Drowleg, London.
- Bornman, H., Hardy, D., 1971. Aloes of the South African Veld. Voortrekker Pers, Johannesburg.
- Bredenkamp, G.J., Van Vuuren, D.R.J., 1987. Notes on the occurrence and distribution of *Aloe marlothii* Berger on the Pietersburg Plateau. *South African Journal of Science* 83, 498–499.
- Bruce, W.G., 1974. The origin of Natal Aloes. *Aloe* 12, 20–29.
- Bryant, A.T., 1909. Zulu medicine and medicine-men. *Annals of the Natal Museum* 2, 1–103.
- Clark, T.E., Appleton, C.C., Drewes, S.E., 1997. A semi-quantitative approach to the selection of appropriate candidate plant molluscicides. *Journal of Ethnopharmacology* 56, 1–13.
- Clarkson, C., Maharaj, V.J., Crouch, N.R., Grace, O.M., Pillay, P., Matsabisa, M.G., Bhagwandin, N., Smith, P.J., Folb, P.I., 2004. In vitro antiparasitic activity of medicinal plants native to or naturalised in South Africa. *Journal of Ethnopharmacology* 92, 177–191.
- Cocks, M., 2006. Biocultural diversity: moving beyond the realm of 'indigenous' and 'local' people. *Human Ecology* 34, 185–200.
- Coimbra, R., 1994. *Manual de Fitoterapia*, 2nd ed. Editora Cejup, Belem.
- Cook, F.E.M., 1995. Economic Botany Data Collection Standard. Prepared for the International Working Group on Taxonomic Databases for Plant Sciences (TDWG). Royal Botanic Gardens, Kew.
- Cowling, R.M., Hilton-Taylor, C., 2004. Phytogeography, flora and endemics. In: Cowling, R.M., Richardson, D.M., Pierce, S.M. (Eds.), *Vegetation of Southern Africa*. Cambridge University Press, Cambridge, pp. 43–61.
- Crouch, N.R., Symmonds, R., Spring, A., Diederichs, N., 2006. Fact sheets for growing popular medicinal plant species. In: Diederichs, N. (Ed.), *Commercialising Medicinal Plants: A Southern African Guide*. Sun Press, Stellenbosch, South Africa, pp. 100–102.
- Cunningham, A.B., 1993. African medicinal plants: setting priorities at the interface between conservation and primary healthcare. *People and Plants Working Paper*. UNESCO, Paris.
- Dold, T., Cocks, M., 2000. The iNtelezi plants of the eastern Cape: traditional and contemporary medicines. *Aloe* 37, 10–13.
- Dold, T., Cocks, M., 2001. A succulent herbal—the medicinal and cultural use of some succulent plants traded in the Eastern Cape Province of South Africa. *Cactus and Succulent Journal (U.S.)* 73, 141–145.
- Dragendorff, G., 1898. *Die heilpflanzen der verschiedenen völker und zeiten*. Verlag von Ferdinand Enke, Stuttgart.
- Dring, J.V., Nash, R.J., Roberts, M.F., Reynolds, T., 1984. Hemlock alkaloids in aloes. Occurrence and distribution of  $\gamma$ -coniceine. *Planta Medica* 50, 442–443.
- Eshun, K., He, Q., 2004. *Aloe vera*: a valuable ingredient for the food, pharmaceutical and cosmetic industries—a review. *Critical Reviews in Food Science and Nutrition* 44, 91–96.
- Flückiger, F.A., 1891. *Pharmakognosie des Pflanzenreiches*. Gaertner's Verlagsbuchhandlung, Berlin.
- Gelfand, M., Drummond, R.B., Mavi, S., Ndamera, B., 1985. *The Traditional Medical Practitioner in Zimbabwe: His Principles of Practice and Pharmacopoeia*. Mambo, Gweru.
- Githens, T.S., 1979. *Drug Plants of Africa*. University of Pennsylvania Press, Philadelphia.
- Glen, H.F., Hardy, D.S., 2000. *Flora of Southern Africa*, vol. 5, part 1. Fascicle 1: *Aloaceae* (first part): *Aloe*. National Botanical Institute, Pretoria.
- Greenish, H.J., 1929. *A Text Book of Materia Medica*, 5th ed. J&A Churchill, London.
- Grindlay, D., Reynolds, T., 1986. The *Aloe vera* phenomenon—a review of the properties and modern uses of the leaf parenchyma gel. *Journal of Ethnopharmacology* 16, 117–151.
- Hedberg, I., Staugard, F., 1989. *Traditional Medicine in Botswana: Traditional Medicinal Plants*. Ipelegeng, Gabarone.
- Hodge, W.H., 1953. The drug aloes of commerce, with special reference to the Cape species. *Economic Botany* 7, 99–129.
- Humphrey, J., 1921. *Drugs in Commerce: Their Source, Preparation for the Market, and Description*. Sir Isaac Pitman & Sons, London.
- Hutchings, A., Haxton Scott, A., Lewis, G., Cunningham, A., 1996. *Zulu Medicinal Plants: An Inventory*. University of Natal Press, Pietermaritzburg; University of Zululand/National Botanical Institute, Pietermaritzburg/KwaDlangezwa/Cape Town.
- ITFG and IITR, 1996. *Ethnoveterinary Medicine in Kenya: a Field Manual of Traditional Animal Health Care Practices*. Intermediate Technology Kenya, Nairobi; Institute of Rural Reconstruction, Nairobi.
- Johnson, T., 1999. *RC Ethnobotany Desk Reference*. C.R.C. Press, Boca Raton.
- Kambizi, L., Sultana, N., Afolayan, A.J., 2005. Bioactive compounds isolated from *Aloe ferox*: a plant traditionally used for the treatment of sexually transmitted infections in the Eastern Cape, South Africa. *Pharmaceutical Biology* 42, 636.
- Kleinschmidt, B., 2004. South African wild aloe juice enters international market. *Fruit Processing* 14, 194–198.
- Leffers, A., 2003. Gembok Bean and Kalahari Truffle. *Traditional Plant use by the Jul'hoansi in Northern-Eastern Namibia*. Gamsberg Macmillan, Windhoek.
- Lindsey, K.L., Jäger, A.K., Viljoen, A.M., 2002. Cyclooxygenase inhibitory activity of *Aloe* species. *South African Journal of Botany* 68, 47–50.
- Lukhoba, C.W., Simmonds, M.S.J., Paton, A.J., 2006. *Plectranthus*: a review of ethnobotanical uses. *Journal of Ethnopharmacology* 103, 1–24.
- Maliehe, E.B., 1997. *Medicinal Plants and Herbs of Lesotho*. Mafeteng Development Project, Maseru.
- Mander, M., Mander, J., Crouch, N., McKean, S., Nichols, G., 1995. *Catchment Action: Knowing and Growing Muthi Plants*. Share-Net, Howick; Institute of Natural Resources, Scottsville.

- Mathabe, M.C., Nikolova, R.C., Lall, N., Nyazema, N.Z., 2006. Antibacterial activities of medicinal plants used for the treatment of diarrhoea in Limpopo Province, South Africa. *Journal of Ethnopharmacology* 105, 286–293.
- Morton, J.F., 1961. Folk uses and commercial exploitation of *Aloe* leaf pulp. *Economic Botany* 15, 315–319.
- Newton, L.E., 2001. *Aloe*. In: Eggli, U. (Ed.), *CITES Aloe and Pachypodium Checklist*. Royal Botanic Gardens, Kew, pp. 121–160.
- Newton, D.J., Vaughan, H., 1996. *South Africa's Aloe ferox* Plant, Parts and Derivatives Industry. Traffic East/Southern Africa, Johannesburg.
- Oldfield, S.A., 2004. Review of significant trade: east African aloes. Document 9.2.2 Annex 4, Fourteenth meeting of the Plant Committee, Windhoek, 16–20 February 2004. Convention on International Trade in Endangered Species of Wild Fauna and Flora, Geneva.
- Pereira, J., 1855. *The Elements of Materia Medica and Therapeutics*, 4th ed. Longman, Brown Green and Longmans, London.
- Pole-Evans, I.B., 1919. Our *Aloes*: their history, distribution, and cultivation. *Journal of the Botanical Society* 5, 11–116.
- Pujol, J., 1990. *NaturAfrica: The Herbalist Handbook*. African Flora, Medicinal Plants. Jean Pujol Natural Healers Foundation, Durban.
- Raina, M.K., 1982. *Aloe*. In: Atal, C.K., Kapur, B.M. (Eds.), *Cultivation and Utilization of Medicinal Plants*. Council of Scientific & Industrial Research, Jammu-Tawi, pp. 368–374.
- Redwood, T., 1857. *A Supplement to the Pharmacopoeia being a Concise but Comprehensive Dispensatory, and Manual of Facts and Formulae, for the Use of Practitioners in Medicine and Pharmacy*. Longman, London.
- Reynolds, G.W., 1950. *The Aloes of South Africa*. The Aloes of South Africa Book Fund, Johannesburg, South Africa.
- Reynolds, T., 2004. *Aloe* chemistry. In: Reynolds, T. (Ed.), *Aloes: The Genus Aloe*. C.R.C. Press, Boca Raton, pp. 39–74.
- Reynolds, T., Dweck, A.C., 1999. *Aloe vera* leaf gel: a review updated. *Journal of Ethnopharmacology* 68, 3–37.
- Richardson, J., Smith, J.E., McIntyre, M., Thomas, R., Pilkington, K., 2005. *Aloe vera* for preventing radiation-induced skin reactions: a systematic literature review. *Clinical Oncology* 17, 478–484.
- Riley, B.W., Brokensha, D., 1988. *The Mbeere in Kenya*. Botanical identities and uses. Institute for Development, vol. II. University Press of America, Lanham.
- Roberts, M., 1990. *Indigenous Healing Plants*. Southern Book Publishers, Halfway House.
- Robertson, H.M., 1979. *The Aloe boers of the Gouritz River District*. *Quarterly Journal of the South African Library* 34, 59–69.
- Rodin, R.J., 1985. *The Ethnobotany of the Kwanyama Ovambos*. Missouri Botanic Garden, St. Louis.
- Sachedina, H., Bodeker, G., 1999. Wild *Aloe* harvesting in South Africa. *Journal of Alternative and Complementary Medicine* 5, 121–123.
- Schwegler, M., 2003. *Medicinal and Other Uses of Southern Overberg Fynbos Plants*. Mathia Schwegler, Farm Heidehof, Gansbaai.
- Sebire, R.P.A., 1899. *Les Plantes Utiles du Senegal*. *Plantes Indigenes-Plants Exotiques*. Librairie J-B Bailliere et Fils, Paris.
- Shackleton, C.N., Gambiza, J., 2007. Growth of *Aloe ferox* Mill. at selected sites in the Makana region of the eastern Cape. *South African Journal of Botany* 73, 266–269.
- Smith, A., 1888. *A Contribution to the South African Materia Medica, Chiefly from Plants in Use Among the Natives*, 2nd ed. Lovedale, South Africa.
- Smith, G.F., 2003. *First Field Guide to Aloes of Southern Africa*. Struik, Cape Town.
- Smith, G.F., Glen, H.F., 1993. Of aloes, artists and coins: *Aloe aculeata* on the 'old' 10c piece. *Aloe* 30, 17–18.
- Smith, G.F., Steyn, E.M.A., Crouch, N.R., 2005. *Aloe affinis*. *Aloaceae*. *Curtis's Botanical Magazine* 22, 95–99.
- Stafford, G.I., Pedersen, P.D., Jäger, A.K., Van Staden, J., 2007. Monoamine oxidase inhibition by southern African traditional medicinal plants. *South African Journal of Botany* 73, 384–390.
- Steenkamp, V., Stewart, M.J., 2007. Medicinal applications and toxicological activities of *Aloe* products. *Pharmaceutical Biology* 45, 411–420.
- Steenkamp, Y., Smith, G.F., 2006. Introduction. In: Germishuizen, G., Meyer, N.L., Steenkamp, Y., Keith, M. (Eds.), *A Checklist of South African plants*. Southern African Botanical Diversity Network Report No. 41. SABONET, Pretoria, pp. iv–ix.
- Simmonds, M.S.J., Howes, M.-J.R., 2006. In: Soumyanath, A. (Ed.), *Traditional Medicines for Modern Times: Antidiabetic Plants*. C.R.C. Press, Boca Raton, pp. 19–82.
- Simmonds, P.L., 1865. *Commercial Products of the Vegetable Kingdom*. T.F.A. Day, London.
- Steffens, F., 1991. *The Venda aloe stamps*. *Aloe* 28, 7–8.
- Te Beest, M., 2004. *The Impact of Medicinal Plant Use on Biodiversity. A Case Study in Hluhluwe-Umfolozi Park, KwaZulu-Natal, South Africa*. Mariska Te Beest, the Netherlands.
- Thoms, H., 1929. *Handbuch der Praktischen und Wissen-Schaftlichen Pharmazie*. Urban & Schwarsenberg, Berlin.
- Trease, G.E., Evans, W.C., 1979. *Pharmacognosy*, 11th ed. Bailliere Tindall, London.
- Van Damme, P., Van den Eynden, V., 2000. Succulent and xerophytic plants used by the Topnaar of Namibia. *Haseltonia* 7, 53–62.
- Van den Eynden, V., Vernemmen, P., Van Damme, P., 1992. *The Ethnobotany of the Topnaar*. Universiteit Gent, Gent.
- Van Koenen, E., 2001. *Medicinal, Poisonous and Edible Plants in Namibia*. Klaus Hess Verlag, Windhoek.
- Van Wyk, B.-E., 2002. A review of ethnobotanical research in southern Africa. *South African Journal of Botany* 68, 1–13.
- Van Wyk, B.-E., Gericke, N., 1999. *People's Plants. A Guide to the Useful Plants of Southern Africa*. Briza, Hatfield.
- Van Wyk, B.-E., Smith, G.F., 1996. *Guide to the Aloes of South Africa*. Briza, Pretoria.
- Van Wyk, B.-E., Van Oudtshoorn, B., Gericke, N., 1997. *Medicinal Plants of South Africa*. Briza, Pretoria.
- Van Wyk, B.-E., Wink, M., 2004. *Medicinal Plants of the World*. Timber Press, Portland.
- Von Mueller, F., 1881. *Select Extra-Tropical Plants Readily Eligible for Industrial Culture or Naturalisation, with Indications of their Native Countries and Some of their Uses*. Thomas Richards, Sydney.
- Watt, J.M., Breyer-Brandwijk, M.G., 1962. *Medicinal and Poisonous Plants of Southern and Eastern Africa*. E. & S. Livingstone, Edinburgh.
- Wills, G.S.V., 1893. *Manual of Elementary Materia Medica*, 12th ed. Simpkin, Marshall, Hamilton, Kent & Co., London.
- Wren, R.C., 1975. *Potter's New Cyclopaedia of Botanical Drugs and Preparations*, 8th ed. Health Science Press, Bradford.
- Wood, G.B., Bache, F., 1854. *The Dispensatory of the United States of America*. Lippincott, Grambo and Co., Philadelphia.