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Ethnoveterinary use of southern African plants and scientific evaluation of their medicinal properties

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ABSTRACT

Aim of the study: Livestock keepers in many developing countries with restricted access to orthodox veterinary healthcare services commonly use traditional remedies to treat their animals when disease is encountered. This review collates the documented use of plants in South Africa for healing various ailments in domestic animals, and records bioactivity testing that has been carried out on these plants.
Materials and methods: A literature survey was conducted on the use of plants in South African ethnoveterinary medicine (EVM), as well as on biological activity investigations relating to their ethnoveterinary use where available.
Results: The ethnoveterinary application of plants, and results of screening studies of EVM plant extracts in various bioassays is presented. For diseases such as coughs, wounds, skin diseases, mild diarrhoea and reproductive disorders, EVM may be a cheap and easily accessible alternative to expensive pharmaceuticals. Studies on biological activity of EVM plants can provide indications of promising leads for extracts that can be developed into standardized medications to be used on a commercial basis. Isolation studies on active plants may yield pure active compounds that could be chemically modified to optimize medicinal value and reduce possible toxic effects.
Conclusion: In South Africa, a large proportion of the population relies on traditional remedies to treat themselves and their animals for common diseases. Only a small percentage of EVM plants have been analysed for biological activity or toxic effects, and hence research in this field offers fertile possibilities for future investigation.

1. Introduction

South Africa is home to a rich temperate flora, possessing approximately 24 000 species comprising more than 10% of the world's vascular plant flora (Germishuizen and Meyer, 2003). Plants produce a diverse array of secondary metabolites with many functions, such as defense against herbivores, diseases and parasites (Cowan, 1999; Pieters and Vlietinck, 2005). These chemicals from plants may possess complex chemical structures that are not available in synthetic compound libraries. There are estimated to be 250 000 plant species in the world, and only 5–15% of these species have been tested for potentially useful biologically active compounds (Pieters and Vlietinck, 2005). There are exciting possibilities for using plants as a source for the discovery of novel lead structures to be used in drug production, and also for the development of active plant extracts useful in treating a variety of ailments in humans and animals. There is encouraging potential for the discovery of structurally diverse metabolites with useful pharmacological activities from South African plants.

In South Africa, as in many other developing countries, the rich cultural diversity is reflected in the use of plants as medicines, and it has been estimated that up to 60% of South Africans consult traditional healers, usually in addition to making use of orthodox medical services (Van Wyk et al., 1997). In the case of animal diseases, it appears that the owners of the livestock will generally treat their own animals using medicinal plant knowledge that they themselves possess, rather than consulting traditional healers. Masika et al. (2000) estimated that 75% of rural livestock owners in the Eastern Cape (South Africa) use plants or plant-based remedies to treat animal ailments. Diseases of livestock potentially have severe economic impacts in terms of production losses following mortality and morbidity, particularly in the case of cultures where animals are equated to wealth. Such diseases also impact on the health and well-being of companion animals. The search for effective and affordable remedies to combat diseases in animals, as is the case in human medicine, is ongoing.

Ethnoveterinary medicine (EVM) comprises a complex system of beliefs, skills, knowledge and practices relating to animal husbandry and general animal care (McCorkle, 1986). The practice of

Abbreviations: EVM, ethnoveterinary medicine.

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EVM includes the use of diagnostic procedures, animal husbandry practices, surgical methods and traditional veterinary theory in addition to the use of ethnoveterinary plants to prevent and control disease (Schillhorn van Veen, 1996; Van der Merwe et al., 2001). It is therefore important to keep in mind that lack of activity in a laboratory-based *in vitro* screening system does not automatically correspond to lack of efficacy of a traditional medication.

Many aspects of EVM need to be taken into account, for example methods of preparation and administration of the remedy, as well as management practices to limit the impact of the disease. Orthodox treatments are certainly indispensable in cases such as epidemics of contagious diseases, but for common ailments, for example mild diarrhoea, skin diseases, intestinal worms and wounds, ethnoveterinary medicine may function effectively (Martin et al., 2001). Shortcomings of ethnomedicine include seasonal unavailability of plant material, inefficacy or harmfulness of treatments, as well as lack of dosing certainty and standardization of remedies (Martin et al., 2001). Means of overcoming these disadvantages need to be formulated and should be communicated to the users of EVM. The benefits of understanding, evaluating and ultimately integrating EVM into primary animal healthcare are evident.

In this paper, the current status of information on ethnoveterinary usage of plants in South Africa, as well as biological activity and toxicity investigations on South African ethnoveterinary plants, will be reviewed.

2. Use of plants for ethnoveterinary purposes in South Africa

Traditional uses of many South African plants have been documented in several books (Watt and Breyer-Brandwijk, 1962; Hutchings et al., 1996; Van Wyk et al., 1997) and journal articles. However, a complete systematic ethnobotanical recording has not yet been compiled. There is an urgent need to record indigenous knowledge on traditional plant use before it is lost to rapid urbanization and acculturation, and this includes hitherto relatively neglected areas such as ethnoveterinary medicine (Van Wyk, 2002).

In recent years, South African researchers have ventured into EVM fieldwork investigations with promising results. A Rapid Rural Appraisal (RRA) approach was used by Van der Merwe et al. (2001) to obtain information on the use of EVM plants in cattle by Setswana-speaking people in the North West Province of South Africa. The RRA data collection approach is an adaptable technique aimed at achieving understanding of a rural situation quickly and cheaply. In this method, semi-structured interviews are preferred rather than pre-prepared questionnaires, and lines of inquiry are adapted to take advantage of new insights as they become apparent (Van der Merwe et al., 2001).

Techniques including interviews, observations and guided field walks were used by Van der Merwe et al. (2001) with people in the study area involved with livestock production or who had knowledge on EVM. To give some structure to the interviews and information garnered, questions were asked around specific disease topics (such as different organ systems), general conditions, nutritional conditions, plant poisoning and other forms of poisoning (Van der Merwe et al., 2001). Informants were asked to describe the symptoms treated as well as the names of the diseases, to account for the lack of formal veterinary training. Forty-five plant species from 24 families, used for 29 indications, were recorded (Van der Merwe et al., 2001). The most important indications noted were retained placenta, diarrhoea, gallsickness, fractures, eye inflammation, general unwellness, fertility problems, gastrointestinal ailments, heartwater, helminthosis, coughing, redwater and reduction of ticks.

The treatment of livestock diseases by small-scale farmers in the Eastern Cape Province of South Africa has been documented in several reports (Masika et al., 1997; Masika et al., 2000; Masika and Afolayan, 2003). Several methods, both qualitative and quantitative, including participatory research methods such as matrix ranking, diagramming and group interviews, were used to obtain information from local livestock keepers (Masika et al., 2000). This study showed that the use of herbal remedies to treat animal diseases was widespread amongst small-scale farmers in the Eastern Cape, largely because of low cost, convenience and ease of administration (Masika et al., 2000). As was the case with the study of Van der Merwe et al. (2001), Masika et al. (2000) reported that there was a possible threat of herbal preparations being toxic. It was recommended that further research is required to optimize dosing and concentrations of EVM remedies, as well as identification of possible side effects and toxicity. According to Van der Merwe et al. (2001) it is likely that the small amounts of plant material used in medicines were the reason for the scarcity of reported toxic effects. Other issues raised by Masika et al. (2000) were those of the urgent need for documentation of rapidly disappearing local EVM knowledge, and conservation of medicinal plant resources. Over-exploitation of plants was seen to be a threat to the continued existence of EVM.

The treatment of the diseases gallsickness (anaplasmosis) and redwater (babesiosis) by livestock farmers in the Eastern Cape was among the subjects of another investigation by Masika et al. (1997). A large majority of farmers interviewed claimed to administer herbal remedies to treat these tick-borne diseases. Dold and Cocks (2001) interviewed members of 25 households, also in the Eastern Cape Province, to obtain information on the use of 53 plants as veterinary medicines by stock farmers. Most of the ailments treated concerned cattle, and the remainder pertained to goats, sheep and poultry, with distemper in dogs included as well (Dold and Cocks, 2001).

Masika and Afolayan (2003) reported that, generally, more than one plant species is combined for treating livestock in the Eastern Cape, while Van der Merwe et al. (2001) found that most remedies were used in the form of a single plant. The use of single plants as remedies in most cases was confirmed by the findings of Luseba and Van der Merwe (2006).

Luseba and Van der Merwe (2006) made use of RRA methods to collate indigenous knowledge on animal disease treatment by the Tsonga people of South Africa. These remedies were used because they were thought to be more effective for treating some diseases, and also as alternatives to expensive orthodox pharmaceuticals (Luseba and Van der Merwe, 2006).

The plants used for EVM purposes in South Africa are listed in Table 1, together with references to the original sources. Plants used for magical purposes, such as for protection against evil, have been excluded. Just over 200 species were found to be used in EVM, with extremely diverse indications being recorded.

3. Biological activity investigation of ethnoveterinary plants

The study of the ethnopharmacological properties of South African plants in general is a productive research field, and current endeavours are primarily targeted at validating traditional plant use, although some attention has been paid to the commercial potential of plants (Van Wyk, 2002). Relatively little research has been conducted on the bioactivity of plants used for ethnoveterinary purposes in particular, and published information on such bioactivities is summarized in this section, and some notes of the plant species tested have been made in Table 1.

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Table 1
Plants used in South Africa for ethnoveterinary purposes, and bioactivity of tested species

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Acanthaceae	*Hypoestes aristata* (Vahl) Soland. Ex Roem. & Schult.	Used to drench calves suffering from a condition referred to as white scours	Whole plant infusions		
Alliaceae	*Agapanthus praecox* Willd.	Diarrhoea in sheep and goats (Dold and Cocks, 2001)	Roots		
Amaranthaceae	*Exomis microphylla* (Thunb.) Aellen	Endometritis and vaginitis (Dold and Cocks, 2001)	Leaf decoction		
Amaryllidaceae	*Ammocharis coranica* (Ker-Gawl.) Herb.	Used medicinally for cattle (Gerstner, 1938)	Unspecified parts	Alkaloids, organic acid and haemolytic saponin (Watt and Breyer-Brandwijk, 1962)	
Amaryllidaceae	*Boophane disticha* (L.f.) Herb.	Redwater in cattle, constipation in cattle, used to facilitate healing of broken limbs (Dold and Cocks, 2001); abortion (Van der Merwe et al., 2001)	Bulb, root, bulb scales		
Amaryllidaceae	*Crinum delagoense* Verdoorn	Used medicinally for cattle (Gerstner, 1939)	Unspecified parts	Unknown	
Amaryllidaceae	*Crinum moorei* Hook. F.	Used medicinally for cattle (Gerstner, 1939)	Unspecified parts	Lycorine, cheryrilline, crinamidine, crinidine, dihydrocrinidine and powelline and phenols (Watt and Breyer-Brandwijk, 1962)	
Amaryllidaceae	*Haemanthus albiflos* Jacq.	Healing of broken limbs (Dold and Cocks, 2001)	Bulb		
Anacardiaceae	*Ozoroa paniculosa* (Sond.) R. & A. Fernandes	Abdominal problems in animals (Hutchings et al., 1996); diarrhoea, redwater, sweating sickness (Van der Merwe et al., 2001)	Bark, root bark	Volatile oil (Watt and Breyer-Brandwijk, 1962)	
Anacardiaceae	*Protorhus longifolia* (Bernh.) Engl.	Heartwater and diarrhoea in cows (Dold and Cocks, 2001)	Bark		
Anacardiaceae	*Rhus incisa* L.f.	Roots given to livestock as treatment for shock after an accident, bark given to cows for diarrhoea (Dold and Cocks, 2001)	Root and bark decoctions		
Anacardiaceae	*Rhus lancea* L.f.	Diarrhoea, gallsickness (Van der Merwe et al., 2001)	Roots, bark		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Anacardiaceae	*Sclerocarya birrea* (A. Rich.) Hochst.	Diarrhoea, fractures (Van der Merwe et al., 2001)	Bark		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Apiaceae	*Heteromorpha trifoliata* (Wendl.) Eckl. & Zeyh.	Zulus use bark for colic, scrofula and vermifuge for horses (Gerstner, 1938); Xhosa use roots for threadworm in horses (Watt and Breyer-Brandwijk, 1962); redwater, gallsickness (Masika et al., 2000)	Bark, roots	Falcarindiol and sarisan (antifungal) (Villegas et al., 1988)	
Apocynaceae	*Acokanthera oppositifolia* (Lam.) Codd	Heartwater in goats and sheep, redwater in cattle, snakebite, anthrax, tapeworm, swollen limbs (Dold and Cocks, 2001)	Leaves, roots		
Apocynaceae	*Secamone filiformis* (L.f.) J.H.Ross	Infectious diseases in cattle (van der Merwe, personal communication)	Aerial parts		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Apocynaceae	*Strophanthus speciosus* (Ward & Harv.) Reber	Given to cattle for snakebite (Hutchings et al., 1996)	Unspecified	Cardiac glycosides stropeside and christyoside (Watt and Breyer-Brandwijk, 1962)	
Araceae	*Zantedeschia albomaculata* (Hook.) Baill.	Medicine for cattle (Jacot Guillarmod, 1971)	Unspecified parts		
Araliaceae	*Cussonia spicata* Thunb.	Leaves applied in hot fomentations to goats paralyzed in their hind quarters (Palmer and Pitman, 1972); bark used for retained placenta in stock, leaves used to treat endometritis and/or vaginitis in cows, bark decoction for gallsickness in cattle (Dold and Cocks, 2001; Masika et al., 2000))	Leaves, bark		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)

Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Arecaceae	*Phoenix reclinata* Jacq.	Wash to treat footrot in sheep and goats (Dold and Cocks, 2001)	Roots		
Asclepiadaceae	*Sarcostemma viminale* (L.) R. Br.	Stems used to encourage lactation in cows, galactagogue in cows (Dold and Cocks, 2001); wounds and maggots (Luseba and Van der Merwe, 2006)	Stems, aerial parts		Antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Asclepiadaceae	*Secamone filiformis* (L.f.) J.H. Ross	Diarrhoea in cattle (Dold and Cocks, 2001)	Stem		
Asparagaceae	*Asparagus laricinus* Burch.	Sores, redwater, uterine infections (Van der Merwe et al., 2001)	Tubers		
Asparagaceae	*Asparagus setaceus* (Kunth) Oberm.	Used to treat livestock for shock after an accident (Dold and Cocks, 2001)	Roots		
Asparagaceae	*Asparagus suaveolens* (Burch.) Oberm.	Retained placenta in cows (Dold and Cocks, 2001); sores, redwater, uterine infections (Van der Merwe et al., 2001)	Roots, tubers		
Asparagaceae	*Protasparagus virgatus* (Bak.) Oberm.	Anthelmintics for animals and humans (Watt and Breyer-Brandwijk, 1962)	Root infusions or decoctions		
Asphodelaceae	*Aloe arborescens* Mill.	Used to drench sick calves (Hutchings et al., 1996)	Leaf decoctions	Aloin, barbaloin, aloe emodin, aloenin, polysaccharides, lectins and other compounds (Hutchings et al., 1996)	
Asphodelaceae	*Aloe cooperi* Bak.	Used to protect cattle from the ill effects of eating improper food (Watt and Breyer-Brandwijk, 1962)	Smoke from burning leaves		
Asphodelaceae	*Aloe ferox* Mill.	Typhoid, ticks and lice in poultry, redwater in cattle (Dold and Cocks, 2001); redwater, intestinal worms (Masika et al., 2000)	Leaves, juice from leaves		
Asphodelaceae	*Aloe greatheadii* var. *davyana* (Schönland) H.F.Glen & D.S.Hardy	Burns, general ailments, blood cleansing, internal parasites, eye infections (Van der Merwe et al., 2001)	Leaves, roots, whole plant		
Asphodelaceae	*Aloe maculata* All.	Used for 'blood scours' in calves and enteritis and indigestion in poultry (Hutchings et al., 1996)	Leaf infusions		
Asphodelaceae	*Aloe marlothii* Berger	Newcastle disease in chickens (Luseba and Van der Merwe, 2006); gallsickness, parasites, diarrhoea, constipation, retained placenta, dystocia, maggots (Van der Merwe et al., 2001)	Leaves		Antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007); anti-rickettsial (Naidoo et al., 2006); anti-babesial (Naidoo et al., 2005)
Asphodelaceae	*Aloe tenuior* Haw.	Retained placenta in cows, tapeworm, redwater, intestinal parasites (Dold and Cocks, 2001)	Leaves		
Asphodelaceae	*Aloe zebrine* Baker	Wounds and maggots (Luseba and Van der Merwe, 2006); Burns, general ailments, blood cleansing, internal parasites, eye infections (Van der Merwe et al., 2001)	Fresh leaves, roots, whole plant		
Asphodelaceae	*Bulbine alooides* (L.) Willd.	Redwater in cattle (Dold and Cocks, 2001)	Roots		
Asphodelaceae	*Bulbine asphodeloides* (L.) Willd.	Used to treat sick cattle and goats (Hutchings et al., 1996)	Unspecified parts		
Aspidiaceae	*Dryopteris athamantica* (Kunze) Kuntze	Retained placenta in cows by the Sotho (Jacot Guillarmod, 1971)	Rhizome decoctions		
Aspidiaceae	*Polystichum* sp.	Administered to horses with bots (Hutchings et al., 1996)	Rhizome decoctions		
Asteraceae	*Arctotus arctotoides* (L.f.) O.Hoffm.	Heartwater in goats (Dold and Cocks, 2001)	Whole plant		
Asteraceae	*Bidens pilosa* L.	Equine anthelmintics (Hutchings et al., 1996)	Unspecified	The polyacetylene phenylheptatriyne and chalcones (Graham et al., 1980; Hoffman and Hoelzl, 1988)	

Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Asteraceae	*Brachylaena discolor* DC.	Anthelmintics for calves, sheep and goats (Hutchings et al., 1996)	Dried leaf milk infusions	Onopordopicrin (Zdero and Bohlmann, 1987)	
Asteraceae	*Brachylaena elliptica* (Thunb.) DC.	Used for treating calves (Gerstner, 1939)	Roots		
Asteraceae	*Brachylaena ilicifolia* (Lam.) Phill. & Schweick.	Diarrhoea in lambs (Dold and Cocks, 2001)	Leaves		
Asteraceae	*Callilepis laureola* DC.	Used to kill maggots in cattle (Watt and Breyer-Brandwijk, 1962)	Root paste	Atractyloside and its aglycone, atractyligenin (Candy et al., 1977)	
Asteraceae	*Dicoma anomala* Sond.	Gallsickness in stock animals; powdered plants used for sores and wounds on horses (Watt and Breyer-Brandwijk, 1962)	Root decoctions	Germacranolides (Hutchings et al., 1996)	
Asteraceae	*Microglossa mespilifolia* (Less.) B.L. Robinson	Tonics for stock animals (Hutchings et al., 1996)	Infusions from leaves and stems	Epi-friedelinol and C_{17} acetylenic compounds (Bohlmann and Fritz, 1979)	
Asteraceae	*Mikania capensis* DC.	Plants used for horse sickness (Gerstner, 1939)	Unspecified		
Asteraceae	*Printzia pyrifolia* Less.	Used for treating calves (Gerstner, 1939)	Roots	Matricaria ester and *p*-coumarate (Bohlmann and Zdero, 1978a)	
Asteraceae	*Schkuhria pinnata* (Lam.) Thell.	Eye infections, pneumonia, diarrhoea, heartwater (Van der Merwe et al., 2001)	Aerial parts		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Asteraceae	*Senecio oxyriifolius* DC.	Swellings in animals (Hutchings et al., 1996)	Leaves	A tricyclic sesquiterpenoid, angeloyl and bisabolenes (Bohlmann and Zdero, 1978b	
Asteraceae	*Senecio tamoides* DC.	Anthrax and 'quarter evil' in cattle (Gerstner, 1939)	Unspecified parts		
Asteraceae	*Vernonia mespilifolia* Less.	Heartwater in goats (Dold and Cocks, 2001)	Stems		
Asteraceae	*Vernonia neocorymbosa* Hilliard	Used by Zulus to treat calves (Gerstner, 1939); root decoctions administered by Lobedu as anthelmintics to donkeys (Hutchings et al., 1996); pounded leaf and root infusions administered by Vhavenda as anthelmintics to domestic animals (Mabogo, 1990)	Roots, leaves	Squalene, vernolide and vernodalin from aerial parts, and 13-hydroxybisabol-2,10-dien-1-one and small amounts of onopordopicrin in roots (Bohlmann et al., 1983)	
Balanitaceae	*Balanites maughamii*	Diarrhoea in cattle (Luseba and Van der Merwe, 2006)	Leaves		
Boraginaceae	*Ehretia rigida* (Thunb.) Druce	Gallsickness in cattle (Hutchings et al., 1996); fractures (Van der Merwe et al., 2001)	Roots		
Capparaceae	*Capparis sepiaria* L.	Used by Xhosa for gallsickness in stock (Watt and Breyer-Brandwijk, 1962)	Root decoctions		
Capparaceae	*Capparis tomentosa* Lam.	Root ash paste applied to sore teats in cows; root infusions used for stomach ailments in animals, particularly diarrhoea in cattle (Watt and Breyer-Brandwijk, 1962; Pujol, 1990), root decoction for gallsickness in stock (Dold and Cocks, 2001)	Paste made from root ashes, root infusions and decoctions	The alkaloids stachydrine (Dictionary of Natural Products, 1996) and 3-hydroxy-4-methoxy-3-methyl-oxindole (Dekker et al., 1987).	

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Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Celastraceae	*Cassine aethiopica* Thunb.	Used by Zulus to drench worm-infested calves (Watt and Breyer-Brandwijk, 1962)	Milk or whey bark infusions		
Celastraceae	*Cassine transvaalensis* (Burtt Davy) Codd	Diarrhoea (Van der Merwe et al., 2001)	Bark		
Celastraceae	*Maytenus heterophylla* (Eckl. & Zeyh.) N.K.B.Robson	Administered by Zulus to stock animals for diarrhoea (Watt and Breyer-Brandwijk, 1962)	Bark and leaf infusions	Dulcitol, a spermidine alkaloid, celacinnine, triterpenoids, maytansine (Hutchings et al., 1996)	
Celastraceae	*Mystroxylon aethiopicum* (Thunb.) Loes.	Heartwater in cattle, worms in calves, intestinal parasites (Dold and Cocks, 2001)	Bark		
Chenopodiaceae	*Chenopodium album* L.	Decoctions made from plants mixed with *Chenopodium ambrosioides* administered to goats and sheep for anaemia (Hutchings et al., 1996)	Unspecified	Hydrocyanic acid, potassium oxalate, ascorbic acid, sitosterol, oleanic acid (Watt and Breyer-Brandwijk, 1962; Hutchings et al., 1996)	
Chenopodiaceae	*Chenopodium ambrosioides* L.	Decoctions made from plants mixed with *Chenopodium album* administered to goats and sheep for anaemia (Hutchings et al., 1996)	Unspecified	Saponins (Watt and Breyer-Brandwijk, 1962) flavonoids, quercetin, oxalic, malic and succinic acids, triterpenoid glycosides, chenopodoside A and B, amino acids, ascaridole (Hutchings et al., 1996)	
Colchicaceae	*Gloriosa superba* L.	Used to kill lice, for skin eruptions, tick infections and screw-worm on cattle (Gerstner, 1939; Roberts, 1990)	Corms	Colchicine, chelidonic acid, various alkaloids and other constituents (Hutchings et al., 1996)	
Combretaceae	*Combretum caffrum* (Eckl. & Zeyh.) Kuntze	Conjunctivitis (Masika et al., 2000)	Drops from squeezed leaves		Antibacterial, antifungal (Masika and Afolayan, 2002)
Combretaceae	*Combretum erythrophyllum* (Burch.) Sond.	Small doses administered as fattening tonics to dogs (Watt and Breyer-Brandwijk, 1962)	Roots		
Combretaceae	*Combretum paniculatum* Vent.	Fertility problems (Luseba and Van der Merwe, 2006)	Root bark		
Combretaceae	*Terminalia sericea* Burch. Ex DC.	Wounds (Luseba and Van der Merwe, 2006); diarrhoea (Van der Merwe et al., 2001)	Leaves, roots		
Convolvulaceae	*Seddera sufruticosa* Hallier f.	Fractures (Van der Merwe et al., 2001)	Roots		
Cornaceae	*Curtisia dentata* (Burm. F.) C.A.Sm.	Heartwater in cows (Dold and Cocks, 2001)	Bark		
Cucurbitaceae	*Cucumis africanus* L.f.	Used as animal medicines by the Xhosa (Hutchings et al., 1996)	Unspecified	Toxic cucurbitacins (Hutchings et al., 1996)	
Dioscoreaceae	*Dioscorea dregeana* (Kunth) Dur. & Schinz	Sores and wounds in animals and humans by Xhosa (Watt and Breyer-Brandwijk, 1962)	Water heated in scooped out tuber	An alkaloid and organic acids (Watt and Breyer-Brandwijk, 1962)	
Dioscoreaceae	*Dioscorea sylvatica* (Kunth) Eckl.	Swollen udders and uterine problems in cows (Watt and Breyer-Brandwijk, 1962)	Lotions from boiled crushed inner parts of tubers	Diosgenin (Watt and Breyer-Brandwijk, 1962)	

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Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Dracaenaceae	*Sansevieria hyacinthoides* (L.) Druce	Fresh leaf sap applied to eyes of sheep and goats for conjunctivitis (Dold and Cocks, 2001)	Leaf sap		
Ebenaceae	*Diospyros mespiliformis* Hochst. Ex A. DC.	For milk production (Luseba and Van der Merwe, 2006)	Bark		
Euphorbiaceae	*Clutia pulchella* L.	Drenches for griping pains in calves (Hutchings et al., 1996)	Milk infusions of leaves, stems and roots		
Euphorbiaceae	*Croton gratissimus* Burch. var. *gratissimus*	Pneumonia, tonic, fertility enhancement (Van der Merwe et al., 2001)	Leaves, roots		
Euphorbiaceae	*Euphorbia cooperi* N.E.Br. ex A.Berger	Blackquarter (Luseba and Van der Merwe, 2006)	Aerial parts		
Euphorbiaceae	*Jatropha curcas* L.	Drench for constipation in cattle and goats (Luseba and Van der Merwe, 2006)	Seeds		
Euphorbiaceae	*Jatropha zeyheri* Sond.	General ailments, diarrhoea (Luseba and Van der Merwe, 2006)	Roots		Antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Euphorbiaceae	*Phyllanthus burchellii* Müll.Arg. [and *Phyllanthus parvulus* Sond.]	Eye infections (Van der Merwe et al., 2001)	Aerial parts		
Euphorbiaceae	*Ricinus communis* L.	Administered as a purgative to calves refusing to suckle (Hutchings et al., 1996); constipation, internal parasites (Van der Merwe et al., 2001)	Powdered seed	Seeds contain a fixed oil, ricin, lipases and ricinine (Trease and Evans, 1983).	Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Euphorbiaceae	*Spirostachys abbrevia* Sond.	Sap applied to cattle sores to kill maggots (Hutchings et al., 1996); sweating sickness (Van der Merwe et al., 2001)	Sap, wood		
Euphorbiaceae	*Synadenium cupulare* (Boiss.) L.C. Wheeler	Eye infection, blackquarter (Luseba and Van der Merwe, 2006)	Milky latex		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Fabaceae	*Acacia decurrens* Willd.	Hastens oestrus (Masika et al., 2000)	Bark decoction		
Fabaceae	*Acacia karroo* Hayne	Diarrhoea in goats, intestinal parasites in goats, sheep, poultry and pigs (Dold and Cocks, 2001); fractures and diarrhoea (Van der Merwe et al., 2001)	Bark, leaves		
Fabaceae	*Acacia tortilis* (Forssk.) Hayne	Diarrhoea (Van der Merwe et al., 2001)	Branch tips		
Fabaceae	*Adenopodia spicata* (E. Mey.) Presl	Powdered roots used by Zulus to fatten goats (Hutchings et al., 1996); Mfengu use bark for colds in horses (Watt and Breyer-Brandwijk, 1962)	Roots, bark	Saponins (Watt and Breyer-Brandwijk, 1962)	
Fabaceae	*Calpurnia aurea* (Ait.) Benth.	Zulus use plant to destroy maggots in sores (Bryant, 1966)	Unspecified parts	Alkaloids (Hutchings et al., 1996)	
Fabaceae	*Calpurnia villosa* Harv.	The Sotho use plant infusions topically on maggot-infested sores on cattle (Gerstner, 1939)	Unspecified parts	The alkaloid oroboidine (Hutchings et al., 1996)	
Fabaceae	*Cassia abbreviata* Oliv.	Drench for worm infestations (Luseba and Van der Merwe, 2006)	Bark		
Fabaceae	*Elephantorrhiza elephantina* (Burch.) Skeels	The Xhosa use roots for diarrhoea and dysentery in cattle, horses and humans (Watt and Breyer-Brandwijk, 1962), root given to cows for mange (Dold and Cocks, 2001); heartwater, blackquarter, appetite stimulant or tonic (Luseba and Van der Merwe, 2006); diarrhoea, heartwater, coughing, pneumonia (Van der Merwe et al., 2001)	Roots, aerial parts and bulb	Tannin (Watt and Breyer-Brandwijk, 1962)	Anti-rickettsial (Naidoo et al., 2006); anti-babesial (Naidoo et al., 2005)

Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Fabaceae	*Erythrophleum lasianthum* Corbishley	Lung sickness in cattle and abortions in dogs (Hutchings et al., 1996)	Bark	Seeds and bark contain erythrophleine (Watt and Breyer-Brandwijk, 1962)	
Fabaceae	*Indigofera frutescens* L.f.	Anthelmintics in animals and humans, especially roundworm (Watt and Breyer-Brandwijk, 1962)	Root bark decoctions		
Fabaceae	*Indigofera sessilifolia* DC.	Diarrhoea in calves (Dold and Cocks, 2001)	Roots		
Fabaceae	*Macrotyloma axillare* (E. Mey.) Verdc.	Administered to cows with swollen udders after calving (Hulme, 1954)	Warm water leaf and stalk infusions		
Fabaceae	*Peltophorum africanum* Sond.	Tonic, diarrhoea (Van der Merwe et al., 2001)	Bark, root bark		Antibacterial, antioxidant, anthelmintic (Bizimenyera et al., 2005, 2006a, 2006b)
Fabaceae	*Pterocarpus angolensis* DC.	General illness, gallsickness, intestinal worms, blackquarter (Luseba and Van der Merwe, 2006)	Bark		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Fabaceae	*Schotia brachypetala* Sond.	Infectious diseases in cattle (van der Merwe, personal communication)			Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Fabaceae	*Schotia latifolia* Jacq.	Redwater in cattle (Dold and Cocks, 2001)	Bark decoction		Antibacterial, antifungal (Masika and Afolayan, 2002)
Fabaceae	*Senna italica* Mill.	Diarrhoea and gallsickness (Luseba and Van der Merwe, 2006); gallsickness, intestinal diseases, heartwater, anthrax, pneumonia (Van der Merwe et al., 2001)	Bark, roots		
Fabaceae	*Tephrosia kraussiana* Meisn.	Plants used by Zulus for protecting cattle against quarter-evil and other diseases (Doke and Vilakazi, 1972)	Unspecified parts	Roots may contain a saponin (Watt and Breyer-Brandwijk, 1962)	
Fabaceae	*Tephrosia macropoda* (E. Mey.) Harv.	Roots and seeds used for killing vermin on animals and humans (Gerstner, 1941); leaf extracts used as anthelmintics for cattle (Bryant, 1966)	Roots, seeds, leaves	Roots contain toxicarol and deguelin (Watt and Breyer-Brandwijk, 1962)	
Geraniaceae	*Monsonia emarginata* (L.f.) L'Hérit	Stomach ailments in calves, lambs and humans (Watt and Breyer-Brandwijk, 1962)	Unspecified parts	Phloroglucin tannin (Watt and Breyer-Brandwijk, 1962)	
Geraniaceae	*Pelargonium luridum* (Andr.) Sweet	Administered to sick calves (Hutchings et al., 1996)	Leaf infusions	Coumarins in roots (Wagner and Bladt, 1975)	
Geraniaceae	*Pelargonium reniforme* Curtis	Diarrhoea in goats and cows, heartwater in cattle, liver disorders in cattle and sheep (Dold and Cocks, 2001)	Root decoction		
Geraniaceae	*Pelargonium sidoides* DC.	Used as anthelmintics for calves with *Ziziphus zeyheriana* Sond. (Watt and Breyer-Brandwijk, 1962)	Decoctions of unspecified parts	Coumarins in roots (Wagner and Bladt, 1975)	
Gesneriaceae	*Streptocarpus prolixus* C.B. Cl.	Administered by the Zulus as purgatives to cows (Hulme, 1954)	Cold water leaf infusions		
Gunneraceae	*Gunnera perpensa* L.	Used to facilitate expulsion of afterbirth in animals and women (Gerstner, 1939)	Roots	Bitter principle, celastrin (Watt and Breyer-Brandwijk, 1962)	
Hyacinthaceae	*Albuca* sp.	Purgative and vermifuge for animals and humans (Gerstner, 1938)	Unspecified		
Hyacinthaceae	*Ledebouria cooperi* (Hook. F.) Jessop	Administered to cows to ensure a succession of calves of the same gender (Watt and Breyer-Brandwijk, 1962)	Unspecified		

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Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Hyacinthaceae	*Ledebouria revoluta* (L.f.) Jessop	Gallsickness in animals by the Xhosa (Watt and Breyer-Brandwijk, 1962); bulb infusion for diarrhoea in goats, leaf decoction for gallsickness (Dold and Cocks, 2001)	Bulbs, leaves		
Hyacinthaceae	*Scilla natalensis* Planch.	Administered to cattle with lung sickness (Hutchings et al., 1996)	Unspecified		
Hyacinthaceae	*Scilla nervosa* (Burch.) Jessop	Used as purges for calves (Gerstner, 1941)	Unspecified		
Hyacinthaceae	*Urginea altissima* (L.f.) Baker	Intestinal parasites in cattle, retained afterbirth (Dold and Cocks, 2001)	Bulb decoction		
Hyacinthaceae	*Urginea physodes* (Jacq.) Bak.	'Itch' in goats (Gerstner, 1941)	Unspecified		
Htacinthaceae	*Urginea sanguinea* Schinz	General ailments, intestinal diseases, internal parasites, gallsickness, heartwater, redwater, sores, retained placenta (Van der Merwe et al., 2001)	Bulbs		Anti-babesial (Naidoo et al., 2005)
Hypoxidaceae	*Hypoxis hemerocallidea* Fisch. & C.A. Mey. [and *Hypoxis rigidula* Baker]	Fertility enhancement, general ailments, heartwater, abortion (Van der Merwe et al., 2001)	Corms		
Icacinaceae	*Apodytes dimidiata* E. Mey. Ex Arn.	Purgatives for calves (Gerstner, 1938); worms in cattle (Hutchings et al., 1996)	Bark, leaves		
Iridaceae	*Crocosmia paniculata* (Klatt) Goldbl.	Used for bovine diarrhoea by the Sotho (Watt and Breyer-Brandwijk, 1962)	Unspecified		
Iridaceae	*Dietes iridioides* (L.) Sweet ex Klatt	Tonics for goats (Hulme, 1954); used by the Xhosa to prevent or treat stomach ailments in goats and sheep (Hutchings and Johnson, 1986)	Ground rhizomes		
Iridaceae	*Watsonia densiflora* Bak.	Diarrhoea in calves by the Sotho (Watt and Breyer-Brandwijk, 1962)			
Lamiaceae	*Leonotis leonurus* (L.) R. Br.	Pounded roots and leaves are added to drinking water to prevent sickness in poultry and are used for gallsickness in cattle (Hulme, 1954); eye inflammation (Masika et al., 2000)	Roots, leaves, drops from squeezed leaf used for eyes	Volatile oil and diterpenoids (labdane type lactones) for example marrubin (Dictionary of Natural Products, 1996)	
Lamiaceae	*Leonotis ocymifolia* (Burm. F.) Iwarsson	Pounded roots and leaves are added to drinking water to prevent sickness in poultry and are used for gallsickness in cattle (Hulme, 1954)	Roots, leaves		
Lamiaceae	*Leucas capensis* (Benth.) Engl.	Gallsickness in stock (Dold and Cocks, 2001)	Leaves		
Lamiaceae	*Marrubium vulgare* L.	Gallsickness in stock (Dold and Cocks, 2001)	Leaves		
Lamiaceae	*Plectranthus laxiflorus* Benth.	Drenches for animals (Watt and Breyer-Brandwijk, 1962)	Powdered aerial parts		
Lamiaceae	*Tetradenia riparia*	Used for gallsickness and fevers in cattle (Hutchings et al., 1996)	Leaves	A diterpene diol, ibozol, and related diterpenoids, large amounts of α-pyrones (Dictionary of Natural Products, 1996)	
Lamiaceae	*Teucrium africanum* Thunb.	Gallsickness in cattle, heartwater in goats and sheep, bloat in goats, anthrax (Dold and Cocks, 2001)	Leaves		
Loganiaceae	*Strychnos decussata* (Pappe)	Roundworm in cows (Dold and Cocks, 2001)	Bark infusion		
Loganiaceae	*Strychnos henningsii* Gilg.	Heartwater and diarrhoea in cattle (Dold and Cocks, 2001)	Bark infusion		

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Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Malvaceae	*Hibiscus malacospermus* E.Mey. ex Harv. & Sond.	Retained placenta, intestinal worms (Masika et al., 2000)	Root decoction		
Melianthaceae	*Bersama tysoniana* Oliv.	Used by the Xhosa for gallsickness in cattle (Watt and Breyer-Brandwijk, 1962)	Bark decoctions		
Moraceae	*Ficus ingens* (Miq.) Miq.	Administered to cows to increase milk production by Zulus (Watt and Breyer-Brandwijk, 1962) and Vhavenda (Mabogo, 1990)	Bark decoctions	Tannin (Watt and Breyer-Brandwijk, 1962)	
Moraceae	*Ficus sur* Forssk.	Zulus use leaf and bark infusions as bovine galactagogues (Hutchings et al., 1996); Vhavenda use root decoctions for retained placenta in cows (Watt and Breyer-Brandwijk, 1962)	Leaves, bark, roots	Bark may contain tannin (Hutchings et al., 1996)	
Myrsinaceae	*Rapanea melanophloeos* (L.) Mez	Heartwater in cows (Dold and Cocks, 2001)	Bark		
Myrtaceae	*Heteropyxis natalensis* Harv.	Drench for stock animals (Watt and Breyer-Brandwijk, 1962)	Powdered leaves	Essential oils from ground dried leaves contain many constituents (Hutchings et al., 1996)	
Olacaceae	*Ximenia americana* L. var. *microphylla*	Internal parasites (Van der Merwe et al., 2001)	Roots		
Oleaceae	*Olea europaea* L.	Leaves used for endometritis and vaginitis in cows, bark infusion for diarrhoea in goats, gallsickness in cattle, eye lotion for animals and humans (Dold and Cocks, 2001)	Leaves, bark		
Orchidaceae	*Eulophia speciosa* (R. Br. Ex Lindl.) H. Bol.	Emetics for animals and humans (Gerstner, 1941)	Root infusions		
Pedaliaceae	*Dicerocaryum eriocarpum* (Dcne.) J.Abels [and *Dicerocaryum senecioides* (Kltzsch.) J.Abels]	Dystocia, drench for retained placenta (Luseba and Van der Merwe, 2006; Van der Merwe et al., 2001)	Aerial parts, roots, whole plant		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Pedaliaceae	*Harpagophytum procumbens* DC.	Retained placenta (Van der Merwe et al., 2001)	Fruit		
Poaceae	*Cymbopogon marginatus* (Steud.) Stapf ex Burtt Davy	Gall sickness in animals (Jacot Guillarmod, 1971)	Unspecified		
Phytolaccaceae	*Phytolacca heptandra* Retz.	The Xhosa use roots for lung sickness in cattle (Watt and Breyer-Brandwijk, 1962)	Roots		
Phytolaccaceae	*Phytolacca octandra* L.	Lung sickness in cattle (Watt and Breyer-Brandwijk, 1962)	Root infusions	Triterpenoid saponins, known as yiamoloside B (Moreno and Rodriguez, 1981)	
Pittosporaceae	*Pittosporum viridiflorum* Sims	Gallsickness (Masika et al., 2000)	Bark decoction		
Plumbaginaceae	*Plumbago auriculata* Lam.	Diarrhoea in cows (Dold and Cocks, 2001)	Roots		
Plumbaginaceae	*Plumbago zeylanica* L.	Pneumonia (Van der Merwe et al., 2001)	Roots		
Podocarpaceae	*Podocarpus falcatus* (Thunb.) R. Br. Ex Mirb.	Distemper in dogs (Dold and Cocks, 2001)	Leaf decoction		
Podocarpaceae	*Podocarpus latifolius* (Thunb.) R. Br. Ex Mirb.	Distemper in dogs, gallsickness in cattle (Dold and Cocks, 2001; Masika et al., 2000)	Leaf, root or bark decoction		
Polygalaceae	*Polygala hottentotta* Presl	Anthrax (Jacot Guillarmod, 1971)	Unspecified parts		
Polygonaceae	*Emex australis* Steinh.	Threadworm in horses (Hutchings et al., 1996)	Leaf decoctions	Anthraquinones (Watt and Breyer-Brandwijk, 1962)	

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Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Polygonaceae	*Rumex lanceolatus* Thunb.	Used with *Euclea coriacea* A. DC. to treat gallsickness in stock animals (Jacot Guillarmod, 1971)	Unspecified parts	Chrysophanic acid, emodin and volatile oil (Watt and Breyer-Brandwijk, 1962)	
Proteaceaeae	*Protea caffra* Meisn.	Enemas given to calves with bloody diarrhoea (Hutchings et al., 1996)	Root bark decoctions		
Proteaceae	*Protea welwitschii* Engl.	Dysentery and diarrhoea in calves and humans (Watt and Breyer-Brandwijk, 1962)	Decorticated root infusions		
Ptaeroxylaceae	*Ptaeroxylon obliquum* (Thunb.) Radlk.	Anthrax remedy, for ticks in cattle (Hutchings et al., 1996)	Wood	Powdered wood is irritating and induces sneezing (Hutchings et al., 1996); timber has high oil and resin content (Watt and Breyer-Brandwijk, 1962)	
Ranuncluaceae	*Clematis brachiata* Thunb.	Vermifuge and for bots in horses (Hutchings et al., 1996)	Infusions from shoots and leaves	Contains anemonol (Watt and Breyer-Brandwijk, 1962)	
Rhamnaceae	*Berchemia zeyheri* (Sond.) Grubov	Infectious diseases in cattle (van der Merwe, personal communication)	Bark		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Rhamnaceae	*Ziziphus mucronata* Willd.	Fertility enhancement, sores, burns (Van der Merwe et al., 2001)	Roots, leaves		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Rhamnaceae	*Ziziphus zeyheriana* Sond.	Diarrhoea, internal parasites, general ailments (Van der Merwe et al., 2001)	Root-stock		
Rosaceae	*Prunus persica* (L.) Batsch.	Leaf decoction for diarrhoea in lambs and kid goats, roots for broken bones (Dold and Cocks, 2001)	Leaf decoctions, roots		
Rubiaceae	*Pentanisia prunelloides* (Klotzsch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides*	Used by Xhosa to aid expulsion of retained animal or human placenta (Watt and Breyer-Brandwijk, 1962)	Root decoctions		
Rutaceae	*Clausena anisata* (Willd.) Hook. F. Ex Benth.	Dysentery in cattle (Hutchings et al., 1996)	Bark infusions	Terpenoid hydrocarbons, alkaloids, coumarins and many other compounds (Hutchings et al., 1996)	
Rutaceae	*Zanthoxylum capense* (Thunb.) Harv.	Gallsickness in stock (Dold and Cocks, 2001)	Leaves, root decoction		
Rutaceae	*Zanthoxylum davyi* (Verdoorn) Waterm.	Administered as tonics to animals and humans (Hutchings et al., 1996)	Root decoctions		
Salicaceae	*Salix* L. spp.	Retained placenta (Masika et al., 2000)	Decoction or infusion of unspecified parts		Antibacterial, antifungal (Masika and Afolayan, 2002)
Salvadoraceae	*Azima tetracantha* Lam.	Dystocia in cows (Dold and Cocks, 2001)	Root		
Sapindaceae	*Hippobromus pauciflorus* (L.f.) Radlk.	Leaf and root infusions used to clear mucus from noses of sheep and goats (Watt and Breyer-Brandwijk, 1962); root infusions given to stock animals with coughs (Hutchings et al., 1996); leaf sap used for inflamed eyes in animals and humans (Watt and Breyer-Brandwijk, 1962; Masika et al., 2000); bark used for heartwater and diarrhoea in cattle (Dold and Cocks, 2001)	Leaf and root infusions or decoctions, leaf sap, bark	Resinous and oily substances in wood and leaves (Watt and Breyer-Brandwijk, 1962)	Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)

Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Sapindaceae	*Pappea capensis* Eckl. & Zeyh.	Used medicinally by Zulus for calves (Gerstner, 1939)	Unspecified parts		
Sapotaceae	*Englerophytum magalismontanum* Krause	Fertility enhancement (Van der Merwe et al., 2001)	Roots		
Sapotaceae	*Sideroxylon inerme* L.	Preparations administered by Zulus as tonics to calves and goats (Hutchings et al., 1996); Xhosa use bark for gallsickness in stock (Watt and Breyer-Brandwijk, 1962); bark decoction used for redwater in cattle (Dold and Cocks, 2001)	Unspecified parts; bark	Cinnamic acid, kaempferol and leucanthocyanidins from bark (Hutchings et al., 1996)	
Solanaceae	*Datura stramonium* L.	Powdered leaves are applied by Zulus to animal and human bruises and wounds to draw out inflammation and pus (Watt and Breyer-Brandwijk, 1962)	Powdered leaves	Alkaloids including hyoscyamine and hyoscine (Oliver-Bever, 1986)	
Solanaceae	*Nicotiana tabacum* L.	Eye infections (Van der Merwe et al., 2001)	Leaves		
Solanaceae	*Solanum aculeastrum* Dun.	Ringworm in cattle and horses and also for anthrax (Hutchings et al., 1996)	Fruit	Solanine (Watt and Breyer-Brandwijk, 1962)	
Solanaceae	*Solanum capense* L.	Fruit pulp used by Xhosa for warts and ringworm in animals and humans, fruit sap for sores, distemper and sore eyes in dogs (Watt and Breyer-Brandwijk, 1962)	Fruit		
Solanaceae	*Solanum hermannii* Dun.	Fruit sap and leaf paste used for sores on sheep and horses by Xhosa and Sotho (Watt and Breyer-Brandwijk, 1962)	Fruit, leaves	Solanin, solanidine, azosolanidin, quinhydrone solasonine, solasodine, solasodamine from fruit (Watt and Breyer-Brandwijk, 1962)	
Solanaceae	*Solanum incanum* L.	Sores (Van der Merwe et al., 2001)	Roots		
Solanaceace	*Solanum panduriforme* E. Mey.	Diarrhoea (Van der Merwe et al., 2001)	Fruit sap		
Solanaceae	*Solanum lichtensteinii* Willd.	Respiratory problems (Luseba and Van der Merwe, 2006)	Aerial parts		
Solanaceae	*Solanum mauritianum* Scop.	Dystocia in cows (Dold and Cocks, 2001)	Roots		
Solanaceae	*Withania somnifera* (L.) Dun.	Used to stimulate milk production in cows (Gerstner, 1941); roots used for black gallsickness in cattle (Hutchings et al., 1996); diarrhoea (Van der Merwe et al., 2001)	Unspecified parts, roots	Many compounds including choline, tropanaol, glycowithanolides, withanolides, withaferine and withasomnine (Hutchings et al., 1996 and references therein)	
Sterculiaceae	*Dombeya rotundifolia* (Hochst.) Planch.	Newcastle disease in chickens (Luseba and Van der Merwe, 2006); infectious diseases in cattle (van der Merwe, personal communication)	Leaves and flowers		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Thymelaeaceae	*Gnidia capitata* L.f.	Heartwater in cows, anthrax (Dold and Cocks, 2001)	Root decoction		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Thymelaeaceae	*Gnidia kraussiana* Meisn.	Preparations injected near the site of fractured limbs of stock animals by the Sotho (Jacot Guillarmod, 1971)	Unspecified parts	Flavone heteroside from roots, toxic diterpenoid fraction, polysaccharides daphnane orthoesters (Hutchings et al., 1996)	
Tiliaceae	*Grewia flava* DC.	Fertility enhancement (Van der Merwe et al., 2001)	Roots		

Table 1 (*Continued*)

Family	Species	Indication	Plant part used	Chemical constituents	Screened for activity
Tiliaceae	*Grewia occidentalis* L.f.	Gallsickness in stock (Dold and Cocks, 2001)	Leaves		
Tiliaceae	*Triumfetta sonderi* L.	Retained placenta (Van der Merwe et al., 2001)	Root bark		
Typhaceae	*Typha capensis* (Rohrb.) N.E. Br.	Decoctions taken or applied externally to aid expulsion of afterbirth in animals and humans (Roberts, 1990)	Unspecified parts	Quercetin 3′-dimethyl ether 4′-glucoside from leaf (Hutchings et al., 1996)	
Urticaceae	*Pouzolzia mixta* Solms	Retained placenta, bloat, vaginal discharge (Van der Merwe et al., 2001)	Roots, leaves, stems		Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007)
Verbenaceae	*Clerodendrum glabrum*	Unspecified parts are used as purgatives for calves (Hutchings et al., 1996). The Sotho and Swazi use topical leaf decoctions to prevent parasites developing in animal wounds (Watt and Breyer-Brandwijk, 1962). The Tswana use leaf infusions and bark scrapings as anthelmintics for dogs, calves and donkeys (Roberts, 1990)	Leaves, bark		
Verbenaceae	*Lantana rugosa* Thunb.	Pastes or infusions used for animal and human eye complaints (Watt and Breyer-Brandwijk, 1962)	Leaves	Volatile oil and the alkaloid lantanin (Watt and Breyer-Brandwijk, 1962).	
Verbenaceae	*Vitex zeyheri* Sond. ex Schauer	Eye infections (Van der Merwe et al., 2001)	Leaves		
Vitaceae	*Cissus quadrangularis* L.	Used by Zulus as a drench for sick horses (Watt and Breyer-Brandwijk, 1962), aerial parts used as poultice for wounds, lumpy skin disease and as tick repellent (Luseba and Van der Merwe, 2006)	Aerial parts	A steroidal mixture and triterpenoids (Hutchings et al., 1996)	Antibacterial, anthelmintic, brine shrimp toxicity (McGaw et al., 2007); antibacterial, anti-inflammatory, mutagenic (Luseba et al., 2007)
Vitaceae	*Cyphostemma natalitium* (Szyszyl.) J. V. D. Merwe	Used by Zulus for colic in cattle (Gerstner, 1939)			
Vitaceae	*Rhoicissus digitata* (L.f.) Gilg & Brandt	Cattle diseases (Hutchings et al., 1996)	Tubers		
Vitaceae	*Rhoicissus tomentosa* (Lam.) Wild & Drum.	Anthelmintics for calves (Watt and Breyer-Brandwijk, 1962)	Roots		
Vitaceae	*Rhoicissus tridentata* (L.f.) Wild & Drum.	Cattle diseases (Pujol, 1990); diarrhoea in goats and sheep (Dold and Cocks, 2001); heartwater, redwater, internal parasites, general ailments, abortion (Van der Merwe et al., 2001)	Tubers		Anti-babesial (Naidoo et al., 2005)
Zamiaceae	*Stangeria eriopus* (Kunze) Baill.	Internal parasites in livestock (Dold and Cocks, 2001)	Rootstock		
Zingiberaceae	*Siphonochilus aethiopicus* (Schweinf.) B.L. Burtt	Administered to horses as prophylactics against horse sickness (Watt and Breyer-Brandwijk, 1962)	Rhizome infusions	Volatile oil with a characteristic sesquiterpenoid, α-terpineol and other monoterpenoids (Van Wyk et al., 1997)	
Zygophyllaceae	*Tribulus terrestris* L.	Retained placenta, bloat (Van der Merwe et al., 2001)	Whole plant, aerial parts		

Many diseases affect livestock and other animals, and causal organisms of disease include protozoa, viruses, bacteria, fungi and helminth parasites. Ticks are important vectors of several economically important ailments such as heartwater, anaplasmosis, sweating sickness and babesiosis, and several plant remedies are used to rid animals of ticks. Ethnoveterinary medicine may play a significant role in the management of such diseases in a cost-effective and accessible manner, and there are an increasing number of publications in the scientific literature reporting on the ethnopharmacological activity of plants used in traditional veterinary medicine. It is essential to evaluate not only the bioactivity but also the safety of such plant treatments if their use is to be promoted and potentially developed for commercial purposes. It is expensive and ethically complex to conduct *in vivo* experiments, and large quantities of test material and specialized facilities are required; hence many studies involve *in vitro* investigations of a particular bioactivity.

The methods of preparation as well as application and dosages are critical factors to account for when evaluating a traditional remedy, but for the sake of consistency, many researchers employ standard laboratory extraction techniques using a variety of solvents to extract potential active compounds from plant material. The type of assay and appropriate selection of test organism(s) are also important in verifying a particular activity. The concept of immune support rather than direct destruction of microorganisms may be a significant mechanism of action for EVM remedies. These features and others complicate the issues associated with evaluating and assessing the rationale for EVM treatments.

Several research articles focus on the potential antibacterial activity of ethnoveterinary plants, often on the basis that bacterial diseases such as wound infections are likely to be more easily diagnosed by rural livestock owners than a viral infection for example. Luseba and co-workers (2007) tested dichloromethane extracts for antibacterial and anti-inflammatory activity in a study appraising the efficacy of South African medicinal plants used in the treatment of wounds and retained placenta in livestock. *Cissus quadrangularis* stem and *Jatropha zeyheri* root extracts were selectively inhibitory in the anti-inflammatory assay against cyclooxygenase-2 enzyme. The extracts tested were not mutagenic in the Ames test against *Salmonella typhimurium* strain TA98. In an interesting discussion, Luseba et al. (2007) claimed that although water is traditionally a commonly available solvent to prepare medicinal extracts, the activity of organic extracts need not be disregarded. In livestock wound treatment, the whole plant is often processed and applied locally, and with disorders such as retained placenta where the treatment mixtures are given orally (probably unfiltered), active ingredients may be made available (Luseba et al., 2007).

Bizimenyera et al. (2005) used a serial microplate dilution technique (Eloff, 1998) to identify antibacterial activity against *Staphylococcus aureus* (Gram-positive) and *Pseudomonas aeruginosa* (Gram-negative) in organic solvent extracts of *Peltophorum africanum* (Fabaceae). Antioxidant activity was also determined (Bizimenyera et al., 2005). Pastoralists use extracts of the root and bark to treat stomach ailments such as diarrhoea and dysentery in cattle (Bizimenyera et al., 2005), and the detected antibacterial activity, as well as antioxidant efficacy, provides some support to the traditional EVM use against bacterial infections. Masika and Afolayan (2002) tested extracts of three plant species used for livestock disease treatment, namely *Combretum caffrum*, *Salix capensis* and *Schotia latifolia*, for antibacterial and antifungal activity. They reported some activity against Gram-positive bacteria (with MIC values as low as 0.1 mg/ml). Most extracts were not active against Gram-negative bacteria but generally all of them were active against the five test fungi (Masika and Afolayan, 2002).

Gunnera perpensa (Gunneraceae) is a widely used herb for endometritis and retained placenta in cattle, and extracts of the rhizomes were investigated for antibacterial efficacy (McGaw et al., 2005). The relatively weak antibacterial activity of *Gunnera perpensa* extracts against four bacterial species did not appear to be a major factor in the reputed activity of the plant, but its known uterotonic activity was probably largely responsible (Kaido et al., 1997).

In a screening procedure of 17 plant species used to treat infectious diseases in cattle, McGaw et al. (2007) used the bacteria recommended for antibacterial testing by the NCCLS (1990), namely *Escherichia coli*, *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Hexane, methanol and water extracts were generally more active against the Gram-positive bacteria, confirming earlier reports of increased susceptibility of these organisms (Vlietinck et al., 1995). McGaw et al. (2007) reported that a third of the plant extracts screened exhibited MIC values less than 1 mg/ml, rationalising to an extent the use of these plants in EVM. The same plant extracts were also screened for anthelmintic activity using as test organism the free-living nematode *Caenorhabditis elegans* (McGaw et al., 2007), and more than a third of extracts exhibited activity. In the brine shrimp assay to evaluate cytotoxicity, some degree of toxic effect to the brine shrimp larvae was shown by 30% of extracts but the lowest LC_{50} value was a relatively high 0.6 mg/ml (McGaw et al., 2007).

Following the preliminary screening study showing high levels of antibacterial efficacy in extracts of *Ziziphus mucronata* (Rhamnaceae) (McGaw et al., 2007), further work was conducted on this plant. Compounds were isolated from leaves of the plant: 2,3-dihydroxyl-up-20-en-28-oic acid and zizyberanalic acid (Moloto, 2004). The first compound demonstrated excellent activity against *Staphylococcus aureus*, promoting claims of the efficacy of a *Ziziphus mucronata* leaf paste in treating bacterial infections in animals and humans.

Antifungal activity studies of extracts of *Terminalia* species (Combretaceae) against clinical isolates of the most common and important disease-causing fungi in animals have also revealed interesting results (Masoko et al., 2005). The test fungal pathogens represented the various morphological fungal forms, namely yeasts (*Candida albicans* and *Cryptococcus neoformans*), moulds (*Aspergillus fumigatus*) and thermally dimorphic fungi (*Sporothrix schenckii*). Acetone extracts, out of hexane, dichloromethane, acetone and methanol extracts of *Terminalia* leaves, displayed the highest antifungal activity.

Anti-babesial and anti-rickettsial *in vitro* assay systems have also been used to test EVM plant extracts. Naidoo et al. (2005) used a cell culture-based anti-babesial test, exposing *Babesia caballi* cultures to plant extracts, and demonstrating activity at 100 μg/ml in the acetone extract of *Elephantorrhiza elephantina* rhizome. This species is a popular ethnoveterinary plant. *Urginea sanguinea*, *Rhoicissus tridentata* and *Aloe marlothii* acetone extracts were not active against the babesia cultures using this assay (Naidoo et al., 2005). The anti-babesial drugs used as controls, imidocarb and diminazene, exhibited EC_{50} values of 0.08 and 0.3 μg/ml, respectively. Naidoo et al. (2006) evaluated the anti-rickettsial activity of *Elephantorrhiza elephantina* and *Aloe marlothii* in an *in vitro Ehrlichia ruminantium* culture system. *Ehrlichia ruminantium* cultures were incubated with acetone extracts of the leaves and results were compared to those obtained with oxytetracycline and untreated controls. *Elephantorrhiza elephantina* and *Aloe marlothii* both possessed anti-ehrlichial activity with EC_{50} values of 111.4 and 64.5 μg/ml and EC_{90} values of 228.9 and 129.9 μg/ml, respectively. The EC_{50} and EC_{90} values for oxytetracycline were 0.29 and 0.08 μg/ml. It was proposed that the plant extracts may be inhibitory against the *Ehrlichia* parasite by a similar mechanism to each other, which was unrelated to the mechanism of action of the tetracyclines (Naidoo et al., 2006).

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In further work on the popular ethnoveterinary plant, *Peltophorum africanum*, which is used in treating helminth diseases, the acetone extracts of the leaf, bark and root were screened for activity against *Haemonchus contortus* and *Trichostrongylus colubriformis* in the egg hatch and larval development assays (Bizimenyera et al., 2006a,b). At relatively low concentrations of 0.2 mg/ml, the extracts showed activity, which supports the use of the plant for anthelmintic purposes.

A promising area of research involves the investigation of anti-tick activity of plant extracts, entailing observation of tick repellent and toxic effects of plants. *Allium* species were investigated for repellency and toxicity against *Hyalomma marginatum rufipes* adults (Nchu, 2004). The acetone extract of *Allium porrum* revealed a high repellency index (65–79.48%), and *Allium sativum* dichloromethane extract was toxic to 100% of ticks within an hour of exposure. Essential oils from the aerial parts of *Lippia javanica* and *Tagetes minuta* were repellent toward the ticks in a concentration dependent manner (Nchu, 2004). In a growth inhibition bioassay, it was shown that *Tagetes minuta* essential oil delayed molting to adult stage of 60% of engorged nymphs of *Hyalomma marginatum rufipes* (Nchu, 2004).

Zorloni (2007) investigated 28 Ethiopian plants used for ethnoveterinary tick control purposes for repellent and toxic effects against adult *Rhipicephalus pulchellus* ticks. Promising repellency was exhibited by organic solvent extracts of many species, with *Calpurnia aurea* revealing the best tick toxicity (Zorloni, 2007). Ethyl acetate extracts of *Senna italica* subsp. *arachoides* demonstrated a concentration dependent acaricidal activity against *Hyalomma marginatum rufipes* (Thembo, 2006). Results of an *in vivo* experiment suggested that aqueous extracts of *Senna italica* subsp. *arachoides* given to guinea pigs and rabbits may hinder the feeding performance of adult *Hyalomma marginatum rufipes* ticks (Thembo, 2006). Other plants used traditionally as arthropocides in South Africa, namely *Eucalyptus globoidea* and *Lavendula angustifolia*, were reported by Mkolo (2008) to be effective tick repellents.

These studies demonstrate that South African plants have good potential for the discovery of biologically active extracts and isolated compounds with interesting effects against a range of disease-causing organisms, or disease-transmitting ticks. Only around 13% of EVM plants in South Africa have been evaluated for some sort of biological activity in ethnoveterinary studies. Much work needs to be done to evaluate more types of bioactivity as well as other plant species, particularly those that are widely used and readily available. These may then become possible sources of low-technology and low-cost treatments for diseases of livestock and other animals.

4. Conclusions

The medicinal use of plants for treating various disorders in humans and in their animals is a centuries-old tradition in many cultures. The possible benefit of plant-derived medications constitutes a rewarding area of research, particularly in countries such as South Africa which have a rich biodiversity of natural plant resources coupled with a high prevalence and variety of infectious diseases. The large majority of non-commercial, rural livestock owners in South Africa medicate their own animals with traditional remedies largely based on plants. The documentation of the use of such plants in ethnoveterinary medicine has been initiated in several areas of the country, but there is a pressing need to continue and complete this task before oral traditions of EVM are lost.

The pharmacological investigation of EVM plants is a useful endeavour which has resulted in the discovery of several plants with attractive biological activities. Methods used to test for bioactivity *in vitro* should conform to minimum standards, and where possible should be confirmed with *in vivo* tests. Alternatively, if facilities for *in vivo* studies are not available, a battery of *in vitro* assays designed to investigate potential modes of action will also provide useful information. Investigation of synergistic effects where plants are used in combinations would also be useful. The development of active plant extracts with reliable bioactivity and little or no toxicity is a practical pursuit with commercial potential. Additionally, lead structures with novel or more effective mechanisms of action are required to overcome the problems of drug resistance encountered in several disease-causing organisms.

Motivation for the study of South African ethnoveterinary plants largely resides in validating the efficacy of remedies used by rural stock owners. An essential component of this evaluation of plants should involve toxicity studies, to enable cautions to be issued of dangerous practices or toxic effects of plants. Further research is required to highlight bioactivity not due to non-specific toxic effects on microorganisms and mammalian cells. In this paper, more than 200 plant species were recorded in the available literature as being employed in EVM, and of these, a mere 27 species have been tested for bioactivity in targeted ethnoveterinary assays. More plants need to be evaluated, and more investigation of those plants already tested in one or two screening systems needs to be carried out. The unique heritage of South Africa, both in terms of its rich plant diversity and its cultural traditions of utilizing that plant wealth, needs to be studied and developed for the benefit of all its people and animals.

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