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In vitro antiplasmodial activity of medicinal plants native to or naturalised in South Africa

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Abstract

The increasing prevalence and distribution of malaria has been attributed to a number of factors, one of them being the emergence and spread of drug resistant parasites. Efforts are now being directed towards the discovery and development of new chemically diverse antimalarial agents. The present study reports on the in vitro antiplasmodial activity of 134 plant taxa native to or naturalised in South Africa, representing 54 families, which were selected semi-quantitatively using weighted criteria. The plant extracts were tested for in vitro activity against a *Plasmodium falciparum* strain D10 using the parasite lactate dehydrogenase (pLDH) assay. Of the 134 species assayed, 49% showed promising antiplasmodial activity ($IC_{50} \leq 10$ μg/ml), while 17% were found to be highly active ($IC_{50} \leq 5$ μg/ml). Several plant species and genera were shown for the first time to possess in vitro antiplasmodial activity. These results support a rational rather than random approach to the selection of antiplasmodial screening candidates, and identify a number of promising taxa for further investigation as plant-based antimalarial agents.

Keywords: Malaria; Antiplasmodial; *Plasmodium falciparum*; Ethnomedicinal plants; South Africa

1. Introduction

Despite intensive efforts to control malaria, the disease continues to be one of the greatest health problems facing Africa. It is estimated that there are at least 300 million clinical cases of malaria per annum, making it one of the top three killers among communicable diseases (WHO, 2003). Although a number of advances have been made towards the understanding of the disease, relatively few antimalarial drugs have been developed in the last 30 years (Ridley, 2002). Since the treatment and control of malaria depends largely on a limited number of chemoprophylactic and chemotherapeutic agents, there is an urgent need to develop novel, affordable antimalarial treatments. This urgency has been further highlighted by the increasing prevalence of drug resistant strains of the malaria parasite *Plasmodium falciparum*, which have contributed to the escalating disease burden.

Historically, the majority of antimalarial drugs have been derived from medicinal plants or from structures modelled on plant lead compounds. These include the quinoline-based antimalarials as well as artemisinin and its derivatives. Medicinal plants are commonly used in South African traditional healthcare to treat a range of ailments, including malaria and its associated symptoms (Watt and Breyer-Brandwijk, 1962). Of the 24,300 higher plant taxa recorded in the *Flora of Southern Africa* (FSA) region, approximately 15% are used for medicinal purposes (Arnold et al., 2002) and have been documented in various publications and electronic databases. The importance of the region's diverse medicinal plants lies not only in their chemotherapeutic value in traditional healthcare but also in their potential as sources of new chemical entities for drug discovery.

South Africa boasts remarkable biodiversity and rich cultural traditions of plant use. Scientific understanding of medicinal plants is, however, largely unexplored and pharmacological investigation of the South African flora only gained momentum recently (Van Wyk, 2002).

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In light of this and the pressing need for new antimalarial agents, the South African Department of Arts, Culture, Science and Technology (now the Department of Science and Technology) awarded an innovation fund to five South African institutions to evaluate local medicinal plants for antimalarial activity. The aim of this collaborative project was to discover novel, effective plant-based medicines for the treatment of malaria. In this article, we report on the in vitro antiplasmodial activity of 134 species of plants and identify potential sources of new antimalarial drugs.

2. Materials and methods

2.1. Selection and collection of plant material

A survey of relevant literature (30 books) on medicinal plant use in East and Southern Africa revealed approximately 700 taxa associated with malaria and/or fever. All taxa (623) occurring, indigenous or naturalised within the *FSA* region, were flagged as potential candidates for a targeted antiplasmodial screen. They were subsequently ranked following the application of weighted criteria, principally ethnobotanical and chemotaxonomic. Similar methodology has previously been applied to the selection of plant molluscicidal candidates from the *FSA* region (Clark et al., 1997). In the present study, this semi-quantitative approach objectively optimised the selection process and arguably maximised the likelihood of identifying positive antiplasmodial leads. Scores were based on each taxon's association with malaria and/or fever, the documented chemotherapeutic (antiplasmodial) potential of the plant family, use in traditional medicine, occurrence in the regional malaria-endemic area, and popularity in the local ethnomedicinal plant trade. Extra weighting was provided to plants indigenous to the *FSA* region. From the ranked list, 475 taxa attained total scores of seven or more, of which 134 species were collected throughout South Africa and subsequently investigated. Notably, the top-ranked taxon possessed a total score of 17 out of a possible maximum 20 points. The relevance and suitability of the selection approach and the scoring system will be reported on in due course in a separate publication. Voucher specimens were identified and deposited at the National Herbarium (Pretoria).

2.2. Preparation of extracts

Plant samples were separated into different components and dried in an oven at 30–60 °C. The drying time and temperature varied depending on the nature of the plant part. Dried plant material was ground to a coarse powder using a hammer mill and stored at ambient temperature prior to extraction. For each extraction procedure, 100–500 g of powdered plant material was sequentially extracted, typically with cold dichloromethane (DCM), DCM/methanol (MeOH) (1:1), MeOH and purified water. Organic extracts were concentrated by rotary vacuum evaporation below 45 °C and then further dried in vacuo at ambient temperature for 24 h. The aqueous extracts were concentrated by freeze-drying. All dried extracts were stored at −20 °C and the yields of the extracts, in terms of starting plant material, were recorded.

2.3. In vitro antiplasmodial activity

A chloroquine-sensitive strain (D10) of *Plasmodium falciparum* was continuously cultured according to the methods described by Trager and Jensen (1976), and parasite lactate dehydrogenase (pLDH) activity was used to measure parasite viability (Makler et al., 1995). The in vitro assays were performed as previously described by Clarkson et al. (2003). The IC_{50} values were obtained from the dose–response curves, using non-linear dose–response curve fitting analyses with GraphPad Prism v.3.00 software. Chloroquine diphosphate (Sigma) served as the positive control and was made up in Millipore water and serially diluted in medium to the required concentrations. All crude plant extracts were stored at −20 °C prior to testing and stock solutions were made up a day before the experiment and stored at −20 °C. Crude plant extracts were first dissolved in MeOH or dimethylsulphoxide (DMSO), depending on their solubility, sonicated for 10 min and then diluted in Millipore water to prepare a 2 mg/ml solution. The 2 mg/ml solution was further diluted in medium to give 200 μg/ml stock solutions. The highest concentration of solvent that the parasites were exposed to was 0.5%, which was shown to have no measurable effect on parasite viability. Extracts were tested in nine serial twofold dilutions (final concentration range: 100–0.2 μg/ml) in 96-well microtitre plates. All tests were performed in duplicate and no attempt was made to determine 50% inhibitory concentration (IC_{50}) values in excess of 100 μg/ml.

3. Results and discussion

For the purpose of this study, an IC_{50} value of ≤10 μg/ml was classified as promising activity, and ≤5 μg/ml was considered to be highly active. These two concentrations were chosen with the reasoning that inhibition of parasite growth at the low concentrations would indicate selective activity as opposed to higher concentrations where non-specific toxicity is often observed. A total of 134 plant taxa, representing 54 families, were tested for in vitro antiplasmodial activity (Table 1). Sixty-six species showed promising antiplasmodial activity with IC_{50} values of ≤10 μg/ml, of which 23 were found to be highly active with IC_{50} values of ≤5 μg/ml (Table 2). Due to the large volumes of data generated in this study, only the highly active extracts are highlighted (Table 2) and further discussed.

Although a substantial amount of phytochemical research has been carried out on *Catha edulis* (Vahl) Forssk. ex Endl.

Table 1
In vitro antiplasmodial activity of the plant extracts against *Plasmodium falciparum* D10

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
Acanthaceae	*Asystasia gangetica* T. Anderson	BP00901	Twigs	DCM/MeOH (1:1)	0.3	16
				Water	7.6	> 100
		BP00901	Leaves	DCM/MeOH (1:1)	0.9	7
				Water	1.1	> 100
	Justicia flava (Vahl) Vahl	BP00960	Whole plant	DCM/MeOH (1:1)	0.6	31
				Water	3.7	> 100
Amaranthaceae	*Achyranthes aspera* L.	BP01260	Whole plant	DCM/MeOH (1:1)	0.6	9.9
				Water	0.8	> 100
Amaryllidaceae	*Crinum macowanii* Baker	BP00907	Bulbs	DCM/MeOH (1:1)	0.7	26
				Water	1.1	25
Anacardiaceae	*Lannea discolor* (Sond.) Engl.	BP01389	Fruit	DCM	0.4	25
				MeOH/DCM	0.6	> 100
				Water	1.1	> 100
Annonaceae	*Annona senegalensis* Pers. subsp. *senegalensis*	EN00334	Leaves	DCM	0.7	35
				DCM/MeOH (1:1)	0.9	45
	Artabotrys brachypetalus Benth.	BP00210	Leaves/twigs	DCM/MeOH (1:1)	0.9	> 100
				Water	1.3	> 100
	Artabotrys monteiroae Oliv.	BP01273	Twigs	DCM/MeOH (1:1)	1.2	8.7
				Water	4.8	> 100
		BP01273	Leaves	DCM/MeOH (1:1)	1.3	22
				Water	0.7	23
Apiaceae	*Alepidea amatymbica* Eckl. & Zeyh.	EN00994	Whole plant	DCM/MeOH (1:1)	0.7	12.5
				Water	1.7	> 100
	Berula erecta (Huds.) Coville	BP00957	Whole plant	DCM/MeOH (1:1)	0.3	6.6
				Water	2.7	> 100
	Centella asiatica (L.) Urb.	BP00955	Leaves	DCM/MeOH (1:1)	0.4	8.3
Apocynaceae	*Carissa edulis* Vahl	EN00097	Stems	DCM	0.6	33
				DCM/MeOH (1:1)	0.9	60
	Carissa edulis Vahl	EN00097	Stems	MeOH	0.5	100
				Water	1.5	> 100
		EN00097	Seeds	DCM	0.7	> 100
				DCM/MeOH (1:1)	0.9	> 100
				MeOH	0.9	> 100
				Water	0.6	> 100
		EN00097	Leaves	DCM	1.1	100
				DCM/MeOH (1:1)	0.8	> 100
				MeOH	0.9	> 100
				Water	1.3	> 100
	Diplorhynchus condylocarpon (Müll. Arg.) Pichon	EN00300	Roots	DCM	0.6	> 100
				DCM/MeOH (1:1)	0.9	24
				Water	0.8	> 100
	Rauvolfia caffra Sond.	EN00232	Fruit	DCM	0.8	26.5
				DCM/MeOH (1:1)	0.3	55
				Water	1.1	> 100
		EN00232	Roots	DCM	1.3	88
				DCM/MeOH (1:1)	0.9	67
				Water	1.2	90
	Gomphocarpus fruticosus (L.) Aiton. f.	BP01151	Fruit	DCM/MeOH (1:1)	0.6	26
Araliaceae	*Cussonia spicata* Thunb.	BP00031	Leaves	DCM	1.6	45
				DCM/MeOH (1:1)	0.9	13
				MeOH	1.0	27.5
				Water	1.8	90
		EN00867	Fruit	DCM/MeOH (1:1)	0.4	14
				Water	1.2	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
	Schefflera umbellifera (Sond.) Baill.	EN00060	Leaves	DCM	0.6	3.7
				DCM/MeOH (1:1)	0.6	19.5
				MeOH	0.9	49.5
	Schefflera umbellifera (Sond.) Baill.	EN00060	Leaves	Water	1.2	> 100
		EN00060	Roots	DCM	1.1	7.5
				DCM/MeOH (1:1)	0.9	5.8
				MeOH	0.7	> 100
				Water	1.0	> 100
		EN00060	Stems	DCM	0.8	42
				DCM/MeOH (1:1)	0.9	15
				MeOH	0.6	35
				Water	0.9	100
				Water	1.2	> 100
		BP01151	Leaves/twigs	DCM/MeOH (1:1)	1.2	25
				Water	0.9	> 100
	Xysmalobium undulatum (L.) Aiton. f.	BP01179	Whole plant	DCM/MeOH (1:1)	1.4	6
				Water	1.8	> 100
Asparagaceae	*Asparagus virgatus* Baker	BP01029	Whole plant	DCM/MeOH (1:1)	0.7	8
				Water	0.2	> 100
Asphodelaceae	*Aloe ferox* Mill.	BP00469	Whole plant	DCM/MeOH (1:1)	0.7	8
				Water	1.1	> 100
		EN00588	Fruit	DCM	0.4	20
				DCM/MeOH (1:1)	0.8	14
				Water	0.6	18
		EN00588	Stems	DCM	0.8	30
				DCM/MeOH (1:1)	0.8	15.5
				Water	0.9	> 100
		EN00588	Roots	DCM	0.7	13
				DCM/MeOH (1:1)	0.8	8.5
				Water	0.5	> 100
	Aloe ferox Mill.	EN00588	Leaves	DCM	0.8	21
				DCM/MeOH (1:1)	0.4	> 100
				Water	0.7	> 100
	Aloe maculata All.	BP01314	Whole plant	DCM/MeOH (1:1)	0.6	12.4
				Water	3.0	> 100
	Aloe marlothii A. Berger	BP00049	Leaves	DCM	0.8	74
				DCM/MeOH (1:1)	0.6	90
				MeOH	0.6	> 100
				Water	0.8	71
		BP00049	Whole plant	DCM	0.4	3.5
				DCM/MeOH (1:1)	0.7	18
				Water	1.0	> 100
	Ageratum conyzoides L.	BP01233	Whole plant	DCM/MeOH (1:1)	1.4	27
				Water	0.9	> 100
Asteraceae	*Artemisia afra* Jacq. ex Willd.	EN00148	Leaves	DCM	0.7	5
				DCM/MeOH (1:1)	0.9	7.3
				MeOH	0.9	8
				Water	0.6	> 100
	Bidens pilosa L.	EN00001	Leaves	DCM	0.4	8.5
				DCM/MeOH (1:1)	0.8	11
				MeOH	0.6	5
				Water	1.6	70
	Conyza albida Spreng.	BP01221	Whole plant	DCM/MeOH (1:1)	0.7	2
				Water	1.1	> 100
	Conyza podocephala DC.	BP00378	Whole plant	DCM/MeOH (1:1)	0.6	6.8
				Water	1.3	> 100
	Conyza scabrida DC.	BP00443	Flowers	DCM/MeOH (1:1)	0.3	7.8
				Water	0.4	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
	Conyza scabrida DC.	BP00443	Leaves	DCM/MeOH (1:1)	0.6	11.5
				Water	2.2	> 100
		BP00443	Twigs	DCM/MeOH (1:1)	0.7	11
				Water	1.1	> 100
	Helichrysum nudifolium (L.) Less.	EN01023	Whole plant	DCM/MeOH (1:1)	0.5	6.8
				Water	2.4	> 100
	Osteospermum imbricatum L.	EN00874	Stems	DCM/MeOH (1:1)	1.2	7.3
				Water	0.7	> 100
	Pentzia globosa Less.	EN00506	Leaves	DCM	0.7	12.5
				DCM/MeOH (1:1)	0.6	19.5
				Water	1.2	53
		EN00506	Stems	DCM	0.9	9.5
				DCM/MeOH (1:1)	0.9	15.5
				Water	0.6	> 100
		EN00393	Roots	DCM	1.1	8
				DCM/MeOH (1:1)	0.8	14
				Water	0.8	> 100
	Psiadia punctulata (DC.) Oliv. & Hiern ex Vatke	CS00005	Twigs	DCM	0.3	9
				Water	0.9	> 100
		CN00044	Leaves	DCM	1.2	14
				DCM/MeOH (1:1)	1.4	22.5
				Water	0.6	> 100
		BP00278	Whole plant	DCM/MeOH (1:1)	1.2	18
				Water	0.9	> 100
	Senecio oxyriifolius DC.	BP01037	Whole plant	DCM/MeOH (1:1)	0.7	13
				Water	2.6	> 100
	Spilanthes mauritiana (Pers.) DC.	EN00075	Stems	DCM	0.8	38
				DCM/MeOH (1:1)	0.9	5.3
	Spilanthes mauritiana (Pers.) DC.	EN00075	Stems	MeOH	0.8	64
				Water	2.6	> 100
	Tarchonanthus camphoratus L.	BP00263	Whole plant	DCM/MeOH (1:1)	0.6	6
				Water	0.9	> 100
		EN00389	Leaves	DCM	0.9	7.5
				DCM/MeOH (1:1)	1.2	13
				Water	1.8	> 100
		EN00389	Roots	DCM	1.1	60
				DCM/MeOH (1:1)	0.8	24
				Water	0.7	> 100
	Tridax procumbens L.	BP00892	Whole plant	DCM/MeOH (1:1)	0.4	17
				Water	1.9	> 100
	Vernonia colorata (Willd.) Drake subsp. *colorata*	BP01279	Twigs	DCM/MeOH (1:1)	0.4	14.1
				Water	0.6	> 100
		BP01279	Leaves	DCM/MeOH (1:1)	1.5	4.7
				Water	1.0	87.7
	Vernonia fastigiata Oliv. & Hiern	EN00118	Leaves	DCM	1.0	10
				DCM/MeOH (1:1)	0.8	15
				MeOH	0.6	30
				Water	0.9	> 100
	Vernonia hirsuta (DC.) Sch. Bip. ex Walp.	EN01012	Whole plant	DCM/MeOH (1:1)	0.7	14
				Water	1.2	> 100
	Vernonia myriantha Hook. f.	EN00044	Roots	DCM	0.9	61
				DCM/MeOH (1:1)	0.8	37.5
				MeOH	0.8	28
				Water	2.3	70
		EN00044	Leaves	DCM	0.6	3
				DCM/MeOH (1:1)	0.8	13.5

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
	Vernonia myriantha Hook. f.	EN00044	Leaves	Water	2.1	> 100
	Vernonia natalensis Sch. Bip. ex Walp.	EN00331	Whole plant	DCM	1.5	19.5
				DCM/MeOH (1:1)	0.7	24
				Water	1.1	> 100
	Vernonia oligocephala (DC.) Sch. Bip. ex Walp.	EN00314	Roots	DCM	0.7	> 100
				DCM/MeOH (1:1)	0.7	20
				Water	2.1	> 100
		EN00314	Leaves	DCM	1.2	3.5
				DCM/MeOH (1:1)	0.8	5.5
				Water	2.2	> 100
Bignoniaceae	*Kigelia africana* (Lam.) Benth.	EN00217	Leaves	DCM	0.7	51
				DCM/MeOH (1:1)	0.8	87
				Water	1.7	> 100
	Tecomaria capensis (Thunb.) Lindl.	BP01302	Leaves	DCM/MeOH (1:1)	0.1	11.6
				Water	3.1	10.9
		BP01302	Twigs	DCM/MeOH (1:1)	0.1	81.9
				Water	2.0	10.2
Capparaceae	*Capparis tomentosa* Lam.	EN00222	Leaves	DCM	0.5	65
				DCM/MeOH (1:1)	0.9	> 100
				Water	0.7	> 100
		EN00222	Stems	DCM	0.4	41.5
				DCM/MeOH (1:1)	0.7	> 100
				Water	0.9	> 100
		EN00222	Roots	DCM	0.4	38
				DCM/MeOH (1:1)	0.8	> 100
				Water	1.2	> 100
Celastraceae	*Catha edulis* (Vahl) Forssk. ex Endl.	EN00159	Seeds	DCM	0.3	46
	Catha edulis (Vahl) Forssk. ex Endl.	EN00159	Seeds	DCM/MeOH (1:1)	0.4	10
				MeOH	0.4	78.5
				Water	0.3	> 100
		EN00159	Roots	DCM	0.6	0.63
				DCM/MeOH (1:1)	0.8	4.8
				MeOH	0.6	23.5
				Water	1.2	> 100
		EN00159	Leaves	DCM	0.9	0.77
				DCM/MeOH (1:1)	1.1	6.9
				MeOH	1.0	7.7
				Water	1.4	> 100
	Maytenus senegalensis (Lam.) Exell.	EN00218	Roots	DCM	2.3	15.5
				Water	1.2	> 100
		EN00218	Stems	DCM	2.7	42
				DCM/MeOH (1:1)	1.3	48.3
				Water	0.4	> 100
	Maytenus undata (Thunb.) Blakelock	EN00029	Leaves	DCM	0.5	> 100
				DCM/MeOH (1:1)	0.7	21
				MeOH	0.7	60
				Water	1.1	> 100
		EN00029	Stems	DCM	0.5	85
				DCM/MeOH (1:1)	0.6	24
				MeOH	0.5	38
				Water	2.1	> 100
		EN00029	Roots	DCM	0.6	23
				DCM/MeOH (1:1)	0.8	36
				MeOH	0.6	40
				Water	2.1	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
Chrysobalanaceae	*Parinari curatellifolia* Planch. ex Benth.	EN00065	Leaves/flowers	DCM	0.8	17
				DCM/MeOH (1:1)	0.7	40
				MeOH	0.7	46.5
				Water	1.6	81
		EN00065	Roots	DCM	0.6	5.3
				DCM/MeOH (1:1)	1.2	22.5
				MeOH	0.9	30.5
				Water	1.9	63.5
Clusiaceae	*Hypericum aethiopicum* Thunb.	BP00365	Leaves/flowers	DCM/MeOH (1:1)	0.7	1.4
				Water	1.4	90
Colchicaceae	*Gloriosa superba* L.	BP01040	Whole plant	DCM/MeOH (1:1)	0.8	17
				Water	3.7	> 100
Combretaceae	*Combretum zeyheri* Sond.	BP01239	Twigs	DCM/MeOH (1:1)	0.4	15
				Water	1.2	> 100
Cucurbitaceae	*Momordica balsamina* L.	FP00062	Whole plant	DCM/MeOH (1:1)	0.9	18
				Water	2.1	> 100
		MM00075	Stem	DCM/MeOH (1:1)	0.7	5.3
				Water	0.8	> 100
		MM00075	Leaves	DCM/MeOH (1:1)	0.7	6
				Water	2.3	> 100
	Zehneria scabra (L.f.) Sond. subsp. *scabra*	BP01065	Whole plant	DCM/MeOH (1:1)	0.9	5.6
				Water	3.8	> 100
Ebenaceae	*Euclea natalensis* A.DC.	EN00760	Stems	DCM/MeOH (1:1)	1.4	5.3
				Water	2.7	> 100
		EN00760	Roots	DCM/MeOH (1:1)	0.9	5.1
				Water	1.3	> 100
	Euclea undulata Thunb.	BP01105	Leaves	DCM/MeOH (1:1)	1.7	11
				Water	1.1	> 100
	Euclea undulata Thunb.	BP01105	Twigs	DCM/MeOH (1:1)	1.2	4.6
				Water	0.4	> 100
Euphorbiaceae	*Bridelia micrantha* (Hochst.) Baill.	BP01316	Twigs	DCM/MeOH (1:1)	0.5	59.3
				Water	1.1	6.9
	Clutia hirsuta E. Mey. ex Sond.	BP01193	Whole plant	DCM/MeOH (1:1)	1.0	15
				Water	2.3	50
	Croton gratissimus Burch. var. *subgratissimus* (Prain) Burtt Davy	BP00929	Leaves	DCM	0.7	3.5
				DCM/MeOH (1:1)	1.2	11.5
				MeOH	1.1	29
				Water	2.3	95
	Croton menyhartii Pax	BP01213	Leaves	DCM/MeOH (1:1)	2.0	1.7
				Water	2.0	> 100
		BP01213	Twigs	DCM/MeOH (1:1)	0.8	15
				Water	0.7	> 100
	Euphorbia heterophylla L.	BP01249	Whole plant	DCM/MeOH (1:1)	1.3	40
				Water	4.8	> 100
	Euphorbia tirucalli L.	RP00008	Leaves	DCM	0.8	12
				DCM/MeOH (1:1)	1.2	23.5
				MeOH	0.7	> 100
				Water	2.3	83
	Flueggea virosa (Roxb. ex Willd.)	BP00207	Leaves/twigs	DCM/MeOH (1:1)	0.3	19
	Voigt subsp. *virosa*			Water	1.4	11.4
	Ricinus communis L. var. *communis*	EN00768	Leaves	DCM/MeOH (1:1)	1.0	27.5
				Water	0.6	> 100
		EN00768	Stems	DCM/MeOH (1:1)	0.9	8

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
				Water	1.3	> 100
		EN00768	Fruit	DCM/MeOH (1:1)	0.5	90
				Water	0.6	> 100
Fabaceae	*Acacia nilotica* (L.) Willd. ex Delile	BP01209	Twigs	DCM/MeOH (1:1)	0.4	13
	Acacia nilotica (L.) Willd. ex Delile	BP01209	Twigs	Water	6.8	32
	Acacia tortilis (Forssk) Hayne	BP01203	Whole plant	DCM/MeOH (1:1)	0.7	4.8
				Water	0.1	> 100
	Crotalaria burkeana Benth.	EN00126	Leaves	DCM	0.7	30
				DCM/MeOH (1:1)	1.3	50
				MeOH	1.5	> 100
				Water	0.8	> 100
		EN00126	Roots	DCM	0.5	9.5
				DCM/MeOH (1:1)	0.9	13
				MeOH	1.3	> 100
				Water	1.1	> 100
	Elephantorrhiza elephantina (Burch.) Skeels	BP01010	Roots	DCM/MeOH (1:1)	0.4	28
				Water	1.5	> 100
		BP01010	Leaves	DCM/MeOH (1:1)	0.1	26
				Water	1.2	> 100
	Parkinsonia aculeata L.	BP01144	Twigs	DCM/MeOH (1:1)	0.3	9
				Water	0.8	> 100
	Piliostigma thonningii (Schumach.) Milne-Redh.	BP01294	Leaves	DCM/MeOH (1:1)	0.9	32
				Water	1.0	> 100
		BP01294	Fruit	DCM/MeOH (1:1)	0.3	32.4
				Water	4.1	59
		BP01294	Twigs	DCM/MeOH (1:1)	0.3	25.9
				Water	0.8	> 100
	Pseudarthria hookeri Wight & Arn. var. *hookeri*	BP01217	Leaves	DCM/MeOH (1:1)	1.3	100
				Water	4.8	> 100
	Pterocarpus angolensis DC.	EN00083	Stems	DCM	0.7	15
				DCM/MeOH (1:1)	1.1	60
				MeOH	0.9	71
	Pterocarpus angolensis DC.	EN00083	Stems	Water	1.8	> 100
		EN00083	Roots	DCM	0.9	10.6
				DCM/MeOH (1:1)	0.9	25.5
				MeOH	1.5	33.5
				Water	2.0	80
	Senna didymobotrya (Fresen.) Irwin & Barneby	BP01078	Leaves	DCM/MeOH (1:1)	1.7	40
				Water	3.8	> 100
		BP01078	Twigs	DCM/MeOH (1:1)	0.7	9.5
				Water	1.6	> 100
		BP01078	Pods	DCM/MeOH (1:1)	0.3	18
				Water	2.5	> 100
	Senna petersiana (Bolle) Lock	BP01290	Leaves	DCM/MeOH (1:1)	2.7	> 100
				Water	6.2	> 100
		BP01290	Twigs	DCM/MeOH (1:1)	0.3	13
				Water	0.7	> 100
Flacourtiaceae	*Flacourtia indica* (Burm. f.) Merr.	EN0029	Roots	DCM	0.7	86.5
				DCM/MeOH (1:1)	1.3	78
				Water	0.9	> 100
Gentianaceae	*Anthocleista grandiflora* Gilg	NB00028	Leaves	DCM	1.4	> 100
				DCM/MeOH (1:1)	1.2	> 100
				Water	2.6	90
	Pelargonium alchemilloides (L.) L'Hér.	BP01018	Whole plant	DCM/MeOH (1:1)	0.7	15

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
				Water	5.5	100
Goodeniaceae	*Scaevola plumieri* (L.) Vahl	BP01075	Twigs	DCM	0.9	11
				Water	15.3	> 100
Hyacinthaceae	*Eucomis autumnalis* (Mill.) Chitt.	NB00025	Bulbs	DCM	1.8	70
				DCM/MeOH (1:1)	2.2	9.5
				Water	3.6	> 100
Illecebraceae	*Pollichia campestris* Aiton	BP00559	Twigs	DCM/MeOH (1:1)	0.5	6.8
				Water	0.7	> 100
		BP00416	Whole plant	DCM/MeOH (1:1)	2.3	25
				Water	3.2	> 100
		EN00124	Leaves	DCM	1.7	23
				DCM/MeOH (1:1)	1.6	17
				MeOH	0.9	70
				Water	2.2	> 100
		EN00124	Fruit	DCM	0.3	14
				DCM/MeOH (1:1)	0.3	27
				MeOH	0.5	68
				Water	0.4	> 100
Kirkiaceae	*Kirkia wilmsii* Engl.	BP01242	Leaves	DCM/MeOH (1:1)	1.3	3.7
				Water	2.5	> 100
Lamiaceae	*Hyptis pectinata* (L.) Poit.	BP00243	Leaves/stems/fruit	DCM/MeOH (1:1)	0.8	17.5
				Water	0.7	> 100
	Leonotis leonurus (L.) R.Br.	EN00809	Roots	DCM/MeOH (1:1)	0.8	15
				Water	1.1	> 100
		BP00444	Twigs	DCM/MeOH (1:1)	0.9	5.4
				Water	1.0	> 100
		BP00444	Leaves	DCM/MeOH (1:1)	0.8	5.4
				Water	1.3	> 100
	Leonotis nepetifolia (L.) R.Br.	BP01247	Whole plant	DCM/MeOH (1:1)	0.6	15
				Water	0.9	> 100
	Leonotis ocymifolia (Burm. f.) Iwarsson	BP01257	Leaves	DCM	1.3	17
				DCM/MeOH (1:1)	0.9	12
				MeOH	0.6	6.1
				Water	0.8	> 100
	Leonotis ocymifolia (Burm. f.) Iwarsson	BP01257	Fruit	DCM	0.3	38
				DCM/MeOH (1:1)	0.6	20
				MeOH	0.3	40
				Water	0.4	> 100
		BP01257	Roots	DCM	0.8	17
				DCM/MeOH (1:1)	0.9	28
				MeOH	1.2	> 100
				Water	2.6	> 100
	Leonotis ocymifolia (Burm. f.) Iwarsson var. *raineriana* (Vis.) Iwarsson	EN01257	Whole plant	DCM/MeOH (1:1)	0.8	28
				Water	1.5	> 100
	Leucas martinicensis (L.) R.Br.	BP01204	Whole plant	DCM/MeOH (1:1)	0.8	13.3
				Water	0.7	> 100
	Ocimum americanum L. var. *americanum*	BP01210	Whole plant	DCM/MeOH (1:1)	0.1	4.2
				Water	0.8	> 100
	Salvia repens Burch. ex Benth.	BP00998	Whole plant	DCM/MeOH (1:1)	1.0	10.8
				Water	1.3	> 100
	Tetradenia riparia (Hochst.) Codd	EN00341	Leaves	DCM	0.9	> 100
				DCM/MeOH (1:1)	0.7	> 100
				Water	2.6	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
Lecythidaceae	*Barringtonia racemosa* (L.) Roxb.	BP00919	Leaves	DCM/MeOH (1:1)	1.2	18
				Water	4.0	70
		BP00919	Twigs	DCM/MeOH (1:1)	0.5	5.7
				Water	1.7	> 100
Maesaceae	*Maesa lanceolata* Forssk.	BP01226	Twigs	DCM/MeOH (1:1)	0.7	5.9
				Water	0.2	> 100
Meliaceace	*Ekebergia capensis* Sparrm.	BP00442	Fruit	DCM/MeOH (1:1)	0.4	10
				Water	0.6	> 100
		BP00442	Twigs	DCM/MeOH (1:1)	0.5	18
	Ekebergia capensis Sparrm.	BP00979	Twigs	Water	0.8	> 100
	Trichilia emetica Vahl subsp. *emetica*	BP00958	Leaves/twigs	DCM/MeOH (1:1)	3.4	3.5
				Water	2.2	> 100
	Turraea floribunda Hochst.	BP01265	Leaves	DCM/MeOH (1:1)	0.5	8.8
				Water	2.8	> 100
Myrtaceae	*Syzigium cordatum* Hochst. ex Sond. var. *cordatum*	BP01268	Twigs	DCM/MeOH (1:1)	1.8	14.7
				Water	1.3	48.3
		BP01268	Leaves	DCM/MeOH (1:1)	0.7	22.8
				Water	0.9	23.6
Myrsinaceae	*Rapanea melanophloeos* (L.) Mez	BP01031	Leaves	DCM/MeOH (1:1)	2.0	44
				Water	1.2	> 100
		BP01031	Twigs	DCM/MeOH (1:1)	1.0	40
				Water	0.9	> 100
Olacaceae	*Ximenia caffra* Sond. var. *caffra*	EN00110	Leaves	DCM	0.7	43.5
				DCM/MeOH (1:1)	0.9	55
				MeOH	0.7	100
				Water	2.3	> 100
		EN00110	Roots	DCM	0.5	> 100
				DCM/MeOH (1:1)	0.7	> 100
				MeOH	1.0	> 100
				Water	1.9	> 100
Oleaceae	*Olea europaea* L. subsp. *africana* (Mill.) P.S. Green	BP01236	Leaves	DCM/MeOH (1:1)	0.7	12
				Water	0.7	> 100
		BP01236	Twigs	DCM/MeOH (1:1)	1.2	13
				Water	1.1	> 100
Pittosporaceae	*Pittosporum viridiflorum* Sims	EN00049	Whole plant	DCM	1.5	3
				DCM/MeOH (1:1)	0.9	10
				MeOH	0.6	27.7
	Pittosporum viridiflorum Sims	EN00049	Whole plant	Water	1.4	> 100
		EN00049	Leaves/flowers	DCM	0.8	28
				DCM/MeOH (1:1)	0.6	47
				MeOH	0.8	70.5
				Water	1.7	> 100
Plantaginaceae	*Plantago major* L.	EN00499	Whole plant	DCM	0.9	21.5
				DCM/MeOH (1:1)	1.2	45
				Water	1.9	> 100
Plumbaginaceae	*Plumbago zeylanica* L.	EN00208	Roots	DCM	0.8	43
				DCM/MeOH (1:1)	1.3	34
				MeOH	1.1	77.3
				Water	2.4	> 100
		EN00208	Leaves	DCM	1.0	3
				DCM/MeOH (1:1)	0.7	4.8
				MeOH	0.9	5.5
				Water	1.9	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
Poaceae	*Cymbopogon validus* (Stapf) Stapf ex Burtt Davy	BP01227	Whole plant	MeOH/DCM (1:1)	0.9	5.8
				Water	0.8	> 100
	Setaria megaphylla (Steud.) T. Durand & Schinz	BP01200	Whole plant	MeOH/DCM (1:1)	0.8	4.5
				Water	0.9	> 100
Polygonaceae	*Rumex crispus* L.	EN00569	Leaves	DCM	1.2	36.8
				DCM/MeOH (1:1)	1.5	60
				Water	0.9	> 100
		EN00569	Roots	DCM	0.9	14
				DCM/MeOH (1:1)	0.7	32
				Water	1.8	> 100
	Rumex sagittatus Thunb.	BP01201	Whole plant	DCM/MeOH (1:1)	0.5	18
				Water	0.1	100
Ptaeroxylaceae	*Ptaeroxylon obliquum* (Thunb.) Radlk.	EN00646	Roots	DCM	0.6	19
				DCM/MeOH (1:1)	0.9	17
				Water	1.3	> 100
		EN00646	Leaves	DCM	0.8	19.5
				DCM/MeOH (1:1)	0.5	22.8
				Water	0.6	> 100
		EN00646	Stems	DCM	0.7	11.5
				DCM/MeOH (1:1)	0.8	5.5
				Water	1.2	> 100
Ranunculaceae	*Clematis brachiata* Thunb.	BP00192	Leaves/stems/flowers	DCM/MeOH (1:1)	0.8	20
				Water	3.0	> 100
	Ranunculus multifidus Forssk.	BP00962	Whole plant	DCM/MeOH (1:1)	0.2	2.3
				Water	2.7	> 100
Rhamnaceae	*Ziziphus mucronata* Willd.	BP00005	Leaves	DCM	0.8	12
				DCM/MeOH (1:1)	1.3	> 100
				MeOH	0.4	> 100
				Water	0.8	> 100
Rhizophoraceae	*Bruguiera gymnorhiza* (L.) Lam.	BP01275	Twigs	DCM/MeOH (1:1)	0.6	11.7
				Water	0.9	> 100
		BP01275	Leaves	DCM/MeOH (1:1)	1.2	15.3
				Water	2.6	> 100
	Rhizophora mucronata Lam.	BP01274	Leaves	DCM/MeOH (1:1)	0.7	24
				Water	4.5	25
		BP01274	Twigs	DCM/MeOH (1:1)	0.6	5.6
				Water	2.2	> 100
Rubiaceae	*Burchellia bubalina* (L.f.) Sims	BP00936	Twigs	DCM/MeOH (1:1)	0.4	18
				Water	1.3	> 100
		BP00936	Leaves	DCM/MeOH (1:1)	0.8	50
	Cephalanthus natalensis Oliv.	BP01299	Leaves	DCM/MeOH (1:1)	0.2	24.3
				Water	3.6	> 100
		BP01299	Twigs	DCM/MeOH (1:1)	0.1	16.5
				Water	1.4	> 100
	Vangueria infausta Burch. subsp. *infausta*	BP00004	Fruit	DCM/MeOH (1:1)	0.9	23
				Water	0.7	> 100
Rutaceae	*Agathosma apiculata* G. Mey.	BP01123	Whole plant	DCM/MeOH (1:1)	1.1	5.2
				Water	1.9	> 100
	Agathosma puberula (Steud.) Forc.	EN00697	Roots	DCM	0.8	33
				DCM/MeOH (1:1)	0.7	19
				Water	1.4	> 100
		EN00697	Stems	DCM	0.9	15
				DCM/MeOH (1:1)	0.8	15
				Water	1.6	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
	Clausena anisata (Willd.) Hook. f. ex Benth var. *anisata*	BP01125	Twigs	DCM/MeOH (1:1)	0.6	18
				Water	1.0	> 100
		BP01125	Leaves	DCM/MeOH (1:1)	1.0	55
				Water	2.9	> 100
	Diosma sp.	EN00735	Roots	DCM	0.4	10
				DCM/MeOH (1:1)	0.8	80
				Water	1.2	> 100
	Macrostylis squarrosa Bartl. & H.L. Wendl.	EN00758	Stems	DCM/MeOH (1:1)	0.6	10
				Water	0.7	> 100
Sapindaceae	*Cardiospermum halicacabum* L.	BP01286	Whole plant	DCM/MeOH (1:1)	1.5	20
				Water	2.8	> 100
	Dodonaea viscosa Jacq.	EN00791	Leaves	DCM/MeOH (1:1)	0.5	15.5
				Water	0.7	> 100
	Hippobromus pauciflorus (L.f.) Radlk.	BP01229	Leaves	DCM/MeOH (1:1)	0.4	34
	Hippobromus pauciflorus (L.f.) Radlk.	BP01229	Leaves	Water	0.2	60
		BP01229	Twigs	DCM/MeOH (1:1)	0.6	5.9
				Water	0.9	> 100
Sterculiaceae	*Hermannia depressa* N.E.Br.	BP01081	Whole plant	DCM/MeOH (1:1)	0.4	6.9
				Water	4.1	70
	Waltheria indica L.	BP01241	Whole plant	DCM/MeOH (1:1)	0.7	> 100
				Water	2.2	> 100
Strychnaceae	*Strychnos madagascariensis* Poir.	EN00286	Stems	DCM	0.8	70
				DCM/MeOH (1:1)	0.9	31.5
				Water	2.6	85
		EN00286	Leaves	DCM	0.5	65
				DCM/MeOH (1:1)	0.8	40
				Water	1.3	74
		EN00286	Roots	DCM	0.7	56
				DCM/MeOH (1:1)	0.9	> 100
				Water	1.2	> 100
	Strychnos potatorum L.f.	EN00219	Leaves	DCM	0.9	60
				DCM/MeOH (1:1)	1.3	> 100
	Strychnos pungens Soler.	EN00186	Leaves	DCM	0.7	12.6
				DCM/MeOH (1:1)	0.8	80.4
				MeOH	0.8	80
				Water	2.3	39
Thymelaeaceae	*Gnidia cuneata* Meisn.	EN00716	Leaves	DCM	0.7	31.1
				DCM/MeOH (1:1)	0.9	51
				Water	1.4	45.5
		EN00716	Stems	DCM	0.6	15.9
				DCM/MeOH (1:1)	0.8	40.5
				Water	1.5	> 100
	Gnidia kraussiana Meisn. var. *kraussiana*	BP01008	Tuber	DCM/MeOH (1:1)	0.7	16
				Water	4.4	> 100
		BP01008	Leaves/twigs	DCM/MeOH (1:1)	0.4	10.8
				Water	1.3	> 100
Tiliaceae	*Triumfetta welwitschii* Mast. var. *hirsuta* (Sprague & Hutch.) Wild	BP01238	Leaves	DCM/MeOH (1:1)	1.0	3.6
				Water	1.7	> 100
Verbenaceae	*Clerodendrum glabrum* E. Mey. var. *glabrum*	BP01207	Twigs	MeOH/DCM (1:1)	0.1	19
				Water	3.5	> 100
	Lantana camara L.	BP01216	Leaves/twigs	DCM/MeOH (1:1)	1.3	11
				Water	4.8	> 100

Table 1 (*Continued*)

Family	Plant species	Voucher number	Plant part	Solvent	% Yield	IC_{50} (μg/ml)
	Lippia javanica (Burm. f.) Spreng.	BP00200	Roots	DCM	0.8	3.8
				DCM/MeOH (1:1)	1.3	27
				MeOH	0.7	24
				Water	0.6	> 100
		BP00200	Stems	DCM	0.6	4.5
				DCM/MeOH (1:1)	1.7	21.8
				MeOH	0.8	29.8
				Water	1.0	> 100

(Celastraceae) (Brenniesen and Geisshusler, 1985; Carlini, 2003), *Conyza albida* Spreng. (Asteraceae) (Pacciaroni et al., 2000; Stamatis et al., 2003), *Lippia javanica* (Burm. f.) Spreng. (Verbenaceae) (Neidlein and Staehle, 1974; Van Wyk et al., 1997) and *Ocimum americanum* L. var. *americanum* (Lamiaceae) (Vieira et al., 2003), there are no reports on their antiplasmodial activity. Several representatives of genera investigated here (viz. *Croton* (Euphorbiaceae) (Prozesky et al., 2001), *Acacia* (Fabaceae) (El Tahir et al., 1999b), *Hypericum* (Clusiaceae) (Decosterd et al., 1991; Gu et al., 1988), *Triumfetta* (Tiliaceae) (Muñoz et al., 2000) and *Vernonia* (Asteraceae) (Abosi and Raseroka, 2003; Kraft et al., 2003; Oketch-Rabah et al., 1998; Alves et al., 1997)) have previously been shown to have antiplasmodial

Table 2
Native or naturalised South African plants with high antiplasmodial activity, and comments on prior reports

	IC_{50} (μg/ml)	Comments
Taxon		
Acacia tortilis	4.8	*Acacia nilotica* (L.) ex Delile has shown in vitro activity (El Tahir et al., 1999b)
Aloe marlothii	3.5	In vitro activity previously reported (Van Zyl and Viljoen, 2002), although 16-fold lower than observed in this study
Artemisia afra	5.0	In vitro activity previously reported; active constituents do not appear to be artemisinin-type compounds (Kraft et al., 2003)
Bidens pilosa[a]	5.0	Watt and Breyer-Brandwijk (1962) reported negative antimalarial findings, but more recent tests yielded positive in vitro results (Brandão et al., 1997; Krettli et al., 2001)
Catha edulis	0.6	No previous reports of antiplasmodial activity
Conyza albida[a]	2.0	No previous reports of antiplasmodial activity
Croton gratissimus	3.5	*Croton pseudopulchellus* Pax has shown in vitro activity (Prozesky et al., 2001)
Croton menyhartii	1.7	*Croton pseudopulchellus* Pax has shown in vitro activity (Prozesky et al., 2001)
Euclea undulata	4.6	No previous reports of antiplasmodial activity
Hypericum aethiopicum	1.4	*Hypericum japonicum* Thunb. (Gu et al., 1988) and *Hypericum calcyinum* L. (Decosterd et al., 1991) have shown in vivo and in vitro activity
Kirkia wilmsii	3.7	No previous reports of antiplasmodial activity
Lippia javanica	3.8	Reported to be a mosquito repellent (Govere et al., 2000), but no previous reports of antiplasmodial activity
Ocimum americanum[a]	4.2	Used as a mosquito repellent (Seyoum et al., 2002), but no previous reports of antiplasmodial activity
Pittosporum viridiflorum	3.0	No previous reports of antiplasmodial activity
Plumbago zeylanica	3.0	In vitro activity previously reported (Simonsen et al., 2001)
Ranunculus multifidus	2.3	No previous reports of antiplasmodial activity
Schefflera umbellifera	3.7	In vitro activity previously reported (Tetyana et al., 2002)
Species		
Setaria megaphylla	4.5	No previous reports of antiplasmodial activity
Trichilia emetica	3.5	*Trichilia emetica* and other members of genus have shown in vitro activity (MacKinnon et al., 1997; El Tahir et al., 1999b; Prozesky et al., 2001)
Triumfetta welwitschii	3.6	*Triumfetta semitrilobata* Jacq. has shown in vitro and in vivo activity (Muñoz et al., 2000)
Vernonia colarata	4.7	Several *Vernonia* species have shown activity in vitro and in vivo (Alves et al., 1997; Oketch-Rabah et al., 1998; Abosi and Raseroka, 2003; Kraft et al., 2003)
Vernonia myriantha	3.0	Several *Vernonia* species have shown activity in vitro and in vivo (Alves et al., 1997; Oketch-Rabah et al., 1998; Abosi and Raseroka, 2003; Kraft et al., 2003)
Vernonia oligocephala	3.5	Several *Vernonia* species have shown activity in vitro and in vivo (Alves et al., 1997; Oketch-Rabah et al., 1998; Abosi and Raseroka, 2003; Kraft et al., 2003)

[a] Naturalised in South Africa.

activity. In addition to identifying further species within these genera that display activity, our findings are substantiated by earlier reported antiplasmodial activity elsewhere in the genera. Similarly, the results for *Plumbago zeylanica* L. (Plumbaginaceae) (Simonsen et al., 2001), *Bidens pilosa* L. (Asteraceae) (Brandão et al., 1997; Krettli et al., 2001), *Trichilia emetica* Vahl (Meliaceae) (El Tahir et al., 1999a; Prozesky et al., 2001), *Schefflera umbellifera* (Sond.) Baill. (Araliaceae) (Tetyana et al., 2002) and *Artemisia afra* Jacq. ex Willd. (Asteraceae) (Kraft et al., 2003) agree with previous reports on their antiplasmodial activity. The activity of *Aloe marlothii* A. Berger (Asphodelaceae) has been reported on before ($IC_{50} > 50\,\mu g/ml$), although it was considerably lower than that observed in this study (Van Zyl and Viljoen, 2002). A number of the genera investigated, namely, *Euclea* (Ebenaceae), *Kirkia* (Kirkiaceae), *Pittosporum* (Pittosporaceae), *Ranunculus* (Ranunculaceae) and *Setaria* (Poaceae) were shown for the first time to display high antiplasmodial activity. To the best of our knowledge, this is the first report of the antiplasmodial activity in the families Ebenaceae, Kirkiaceae and Pittosporaceae.

It is interesting to note that the majority of the aqueous extracts, which would be the preferred method of preparing the plants when used in traditional medicines, did not show any activity. Moreover, they would contain very little if any of the lipophilic compounds extracted with the organic solvents (DCM and MeOH), which showed the greatest activity. A possible explanation for the poor hit rate of aqueous extracts is that they were not prepared according to the traditional methods, which often involves boiling for several hours. Furthermore, in the traditional context it is not uncommon for several plant taxa to be administered as mixtures. In this case, synergism could exist between the various phytochemicals or different constituents could help extract and keep active lipophilic compounds in an aqueous solution. In the course of this study the above-mentioned factors were not taken into consideration and only the in vitro antiplasmodial activity of individual plant extracts was determined.

A number of the plants selected did not display in vitro antiplasmodial activity, despite strong associations with malaria and its treatment. A possible explanation could be that the plants act as antipyretics or immune stimulants to relieve the symptoms of the disease, rather than having direct antiparasitic activity (Phillipson et al., 1993). Alternatively, precursors of the active components may be present in the extracts but have to be modified, usually in vivo, before activity is exhibited. Furthermore, factors such as chemotypes, environmental parameters, harvesting and storage conditions could collectively influence the plant secondary metabolites prior to and following harvesting, which in turn would be reflected in the bioactivity. Despite these possible sources of variability, a number of the plant species that were found to be active in this study have previously been shown to possess in vitro, and in some cases in vivo, antiplasmodial activity. In the course of this study, several taxa at the genus and family levels were shown for the first time to display in vitro antiplasmodial activity and warrant further investigation as potential sources of antiplasmodial agents. Additional in vitro and in vivo work aimed at understanding the mechanisms of action of the active plant species and isolating and characterising the bioactive constituents is underway in our laboratories and will be reported on in due course.

4. Conclusions

Not only has this study highlighted promising taxa for further antimalarial investigation, it has provided compelling evidence for the rational exploration of indigenous and naturalised South African medicinal plants as a source of antiplasmodial agents. Considering that most regional plant taxa have not been investigated chemically or pharmacologically, they remain a potential source of leads for drug development. This is particularly important for diseases lacking effective chemotherapeutic agents, such as malaria.

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