In vitro antiplasmodial, antileishmanial and antitrypanosomal activities of selected medicinal plants used in the traditional Arabian Peninsular region

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Abstract

Background: Worldwide particularly in developing countries, a large proportion of the population is at risk for tropical parasitic diseases. Several medicinal plants are still used traditionally against protozoal infections in Yemen and Saudi Arabia. Thus the present study investigated the in vitro antiprotozoal activity of twenty-five plants collected from the Arabian Peninsula.

Methods: Plant materials were extracted with methanol and screened in vitro against erythrocytic schizonts of Plasmodium falciparum, intracellular amastigotes of Leishmania infantum and Trypanosoma cruzi and free trypomastigotes of T. brucei. Cytotoxic activity was determined against MRC-5 cells to assess selectivity. The criterion for activity was an IC50 < 10 μg/ml (< 5 μg/ml for T. brucei) and selectivity index of > 4.

Results: Antiplasmodial activity was found in the extracts of Chrozophora oblongifolia, Ficus ingens, Lavandula dentata and Plectranthus barbatus. Amastigotes of T. cruzi were affected by Grewia erythraea, L. dentata, Tagetes minuta and Vernonia leopoldii. Activity against T. brucei was obtained in G. erythraea, L. dentata, P. barbatus and T. minuta. No relevant activity was found against L. infantum. High levels of cytotoxicity (MRC-5 IC50 < 10 μg/ml) and hence non-specific activities were noted in Cupressus sempervirens, Kanahia laniflora and Kniphofia sumarae.

Conclusion: The results endorse that medicinal plants can be promising sources of natural products with antiprotozoal activity potential. The results support to some extent the traditional uses of some plants for the treatment of parasitic protozoal diseases.

Background

Today over one billion people worldwide are at risk for tropical diseases caused by parasitic organisms. The World Health Organization (WHO) now classifies many as neglected tropical diseases, having an enormous impact on socioeconomic development and quality of life at all levels particularly in developing countries [1]. At present, a lot of research is committed to leishmaniasis, malaria, Chagas disease and sleeping sickness, not only because they are major killing diseases but also because disease control becomes more difficult due to a number of factors that limit the utility of current drugs in resource-poor settings, such as high cost, poor compliance, drug resistance, low efficacy and poor safety [2]. Hence, the search for new and preferably cheap drugs needs to be continued [3].

Natural products are still major potential sources of innovative therapeutic agents for various conditions, including infectious diseases as they represent an unmet source of chemical diversity [4]. Indeed, several antiparasitic drugs have been derived directly from natural sources, such as quinine, artemisinin and atovaquone as antimalarials and amphotericin B as antileishmanial drug.

It is estimated that two thirds of the world population still rely on traditional medical remedies, mainly plants, because of limited availability and affordability of pharmaceutical medicines [5]. This explains why a lot of current research focuses on natural molecules and plant-derived products as they can be sourced easily, are locally available
and can be selected on the basis of their ethnomedicinal use [6].

In this study, 25 plants were selected from the flora of Yemen and Saudi Arabia, and subjected to a broad panel of in vitro antiparasitic assays in an attempt to identify plant species with a promising antiprotozoal in vitro activity profile and could be subject for further investigations.

Table 1 List of plants screened and their traditional uses

| Plant species                  | Voucher specimen no. | Family       | Part used | Traditional uses                                                                 |
|-------------------------------|----------------------|--------------|-----------|----------------------------------------------------------------------------------|
| Ajuga bracteosa Wall. ex Benth.| Mo-I10a              | Labiatae     | L, F      | As antiseptic and for teeth pains, stimulant, diuretic in treatment of rheumatism, gout, palsy, amenorrhea and malaria a,b                      |
| Caralluma quadrangula (Forssk.)| Mo-H02a              | Asclepiadaceae| L         | For diabetes, stomachic ulcer and smallpox a,c                                    |
| Centaurea pseudosinica Czerep. | Mo-S11a              | Asteraceae   | L, T      | For wounds and kidney diseases a                                                  |
| Crochophora oblongifolia (Del.) A.Juss. ex Spreng. | Mo-P02a              | Euphorbiaceae| L, S      | As antiseptic for wounds, antimicrobial, cathartic, emetic and hypoglycemic and for hemorrhoids a, d                                      |
| Costus arubicus L.            | Mo-P05a              | Zingiberaceae | R         | For cancers a                                                                    |
| Cupressus sempervirens L.     | Mo-S25a              | Cupressaceae  | L         | As expectorant, astringent and for wounds, diarrhea, hemorrhoids a, c              |
| Dodonaea viscosa (L.) Jacq.   | Mo-T01a              | Sapindaceae  | L, S      | For malaria, wounds and burns, gout, rheumatism and as anesthetic, laxative and tonic a, c, e, f                                  |
| Dorsteniabamimiana Schweinf.  | Mo-P09               | Moraceae     | L, S      | For the treatment of fungul and skin diseases a, c                               |
| Enicostemma verticillare (Retz.) Baill. | Mo-I06a              | Gentianaceae | L         | For diabetes a                                                                  |
| Ficus cordata ssp. Salicifolia | 15133               | Moraceae     | L, S      | For the treatment of filariais, diarrheal infections, tuberculosis and oral infections a, c                                               |
| Ficus ingens (Miq.)           | 15187                | Moraceae     | L, S      | For Piles, diarrhea, and as diuretic a                                             |
| Ficus palmata Forssk.         | 15167                | Moraceae     | L, S      | For constipation and lungs and bladder diseases a, c                              |
| Grewia erythreaa Schweinf.    | Mo-S07a              | Tiliaceae    | L, S      | As Diuretic and haemostatic and for kidney diseases a                             |
| Iris albicans Lange           | Mo-P02a              | Iridaceae    | R         | For rheumatism and gout a                                                        |
| Kanahia laniflora (Forsk.) R. Br. | Mo-I19a              | Asclepiadaceae| L, T      | For tumors, skin diseases, scabies and itching a, c, h                           |
| Kniphofia sumareae Deflers    | Mo-I10a              | Liliaceae    | R         | For malaria a                                                                   |
| Lavandula dentata L.          | Mo-I11a              | Labiatae     | L, F      | For wounds, rheumatism, urine retention, and kidney stones and as antiseptic a, d|
| Leucas inflata Benth.         | Mo-I05a              | Labiatae     | L, F      | For kidney diseases and tooth ache a                                              |
| Pucaria inuloides DC.         | Mo-M05a              | Asteraceae   | L, F      | For wounds and as antiseptic a                                                   |
| Plectranthus barbatus Andr.   | 15732a               | Labiatae     | L, S      | For stomachache, nausea, gastritis, intestinal spasms, burns, wounds, sores, insect bites, allergies, ringworms, infections, malaria and break fevers a, f |
| Rhus retinorrhoea Steud. ex Oliv. | Mo-T22a              | Anacardiaceae| L         | General and for painful joints a                                                 |
| Tagetes minuta L.             | YT-20a               | Astersaceae  | L, S      | As antimicrobial, antihelmintic, diuretic, and antispasmodic agent a, f            |
| Tarconanthus camphoratus L.   | Mo-S15a              | Astersaceae  | L, T      | For wounds and for urinary tract infections a                                     |
| Teucrum yemense Deflers       | Mo-S17a              | Liliaceae    | L         | For kidney diseases, rheumatism and diabetes a, d                                 |
| Vernonia leopoldi Vatke        | Mo-T16a              | Astersaceae  | L, F      | For cough, colic and skin diseases a, h                                            |

F Flower, L Leaves, R Roots or rhizomes, S Stems, T Fruits.

a information has been taken from native people.
b Chandel S, Bagai U, 2010 [7].
c Al-Dubai and Al-Khulaidi (1996) [8].
d Atiqur-Rahman et al., (2004) [9].
e Mossa et al., (1987) [10].
f Ali et al., (2004) [11].
g Fleurentin and Pelt (1982) [12].
h Schopen (1983) [13].
knowledge. Voucher specimens were deposited at departments. The botanical names, plant part used and the traditional uses of the plants in the collected areas are presented in Table 1.

**Extraction of plant materials**

The air-dried and powdered plant material (50 g) was extracted with 500 ml methanol (CH$_3$OH) by using a Soxhlet apparatus for 8 hours. The obtained methanol extract was filtered and evaporated by using a rotatory evaporator and freeze dryer. The dried extracts were stored at -20°C until used. Stock solutions were prepared in 100% DMSO at 20 mg/ml just prior to screening.

**Reference drugs**

For the different tests, appropriate reference drugs were used as positive control: tamoxifen for MRC-5, chloroquine for *P. falciparum*, miltefosine for *L. infantum*, benznidazole for *T. cruzi* and suramin for *T. b. brucei*. All reference drugs were either obtained from the fine chemical supplier Sigma or from WHO-TDR.

**Biological assays**

The integrated panel of microbial screens and standard screening methodologies were adopted as previously described [14]. All assays were performed in triplicate (first test in duplicate and a single independent repeat) at the Laboratory of Microbiology, Parasitology and Hygiene at the University of Antwerp, Belgium. Plant extracts were tested at 5 concentrations (64, 16, 4, 1 and 0.25 μg/ml) to establish a full dose-titration and determination of the IC$_{50}$ (inhibitory concentration 50%). The concentration of DMSO did not exceed 0.5%. The selectivity of action was assessed by simultaneous evaluation of cytotoxicity on a fibroblast (MRC-5) cell line. The criterion for activity was an IC$_{50}$ < 10 μg/ml (< 5 μg/ml for *T. brucei*) and a selectivity index of ≥ 4.

**Antileishmanial activity**

*Leishmania* MHOM/MA(BE)/67 amastigotes were collected from the spleen of an infected donor hamster and used to infect primary peritoneal mouse macrophages. To determine *in vitro* antileishmanial activity, 3 × 10$^7$ macrophages were seeded in each well of a 96-well plate. After 2 days outgrowth, 5 × 10$^5$ amastigotes/well were added and incubated for 2 h at 37°C. Pre-diluted plant extracts were subsequently added and the plates were further incubated for 5 days at 37°C and 5% CO$_2$. Parasite burdens (mean number of amastigotes/macrohage) were microscopically assessed after Giemsa staining, and expressed as a percentage of the blank controls without plant extract.

**Antiplasmodial activity**

Chloroquine-resistant *P. falciparum* 2/K 1-strain was cultured in human erythrocytes O+ at 37°C under a low oxygen atmosphere (3% O$_2$, 4% CO$_2$, and 93% N$_2$) in RPMI-1640, supplemented with 10% human serum. Infected human red blood cells (200 µl, 1% parasitaemia, 2% haematocrit) were added to each well and incubated for 72 h. After incubation, test plates were frozen at -20°C. Parasite multiplication was measured by the Malstat method [14,15].

**Antitrypanosomal activity**

*Trypanosoma brucei* Squib-427 strain (suramin-sensitive) was cultured at 37°C and 5% CO$_2$ in Hirumi-9 medium [16], supplemented with 10% fetal calf serum (FCS). About 1.5 × 10$^5$ trypmastigotes/well were added to each well and parasite growth was assessed after 72 h at 37°C by adding resazurin [17]. For Chagas disease, *T. cruzi* Tulahuen CL2 (benznidazole-sensitive) was maintained on MRC-5 cells in minimal essential medium (MEM) supplemented with 20 mM L-glutamine, 16.5 mM sodium hydrogen carbonate and 5% FCS. In the assay, 4 × 10$^3$ MRC-5 cells and 4 × 10$^4$ parasites were added to each well and after incubation at 37°C for 7 days, parasite growth was assessed by adding the β-galactosidase substrate chlorophenol red β-D-galactopyranoside [18]. The color reaction was read at 540 nm after 4 h and absorbance values were expressed as a percentage of the blank controls.

**Cytotoxicity assay**

MRC-5 SV2 cells were cultivated in MEM, supplemented with L-glutamine (20 mM), 16.5 mM sodium hydrogen carbonate and 5% FCS. For the assay, 10$^4$ MRC-5 cells/well were seeded onto the test plates containing the pre-diluted sample and incubated at 37°C and 5% CO$_2$ for 72 h. Cell viability was assessed fluorimetrically after 4 hours of addition of resazurin. Fluorescence was measured (excitation 550 nm, emission 590 nm) and the results were expressed as % reduction in cell viability compared to control.

**Results**

Crude methanol extracts from 25 plant species belonging to 18 families that are used in Arabian traditional medicine, were evaluated in the integrated *in vitro* screen for antileishmanial, antiplasmodial and antitrypanosomal potential (Table 2). Only 7 extracts exhibited relevant activity (acceptable potency and selectivity) in one or more models (Table 2).

**Antimalarial activity**

In this study, the methanol extract of *Chrozophora oblongifolia* exhibited the greatest activity against *P. falciparum* with an IC$_{50}$ value of 5.0 μg/ml and a high SI value of 12.8. Furthermore, the extract of three other plants (*Ficus ingens*, *Al-Musayeib et al. BMC Complementary and Alternative Medicine 2012, 12:49 Page 3 of 7 http://www.biomedcentral.com/1472-6882/12/49*)
Lavandula dentata and Plectranthus barbatus) showed activity against P. falciparum with IC\(_{50}\) 8.4, 7.1 and 6.5 μg/ml respectively. These extracts exhibited moderate SI values of 3.8, 4.1 and 5.1, respectively.

Antileishmanial activity
No relevant results were found against L. infantum. A very marginal activity was observed for C. oblongifolia, Costus arabicus, Grewia erythraea, L. dentata, P. barbatus, and Vernonia leopoldii with IC\(_{50}\) values between 20.3 and 27.3 μg/ml and low SI values between 1.0 and 2.5.

Table 2 Antiprotozoal activity of the methanol extracts of the investigated plants and their cytotoxicity against MRC-5 cell lines

| Plant species                  | P. falciparum IC\(_{50}\) | L. infantum IC\(_{50}\) | T. cruzi IC\(_{50}\) (μg/ml) | T. brucei IC\(_{50}\) | MRC-5 IC\(_{50}\) |
|--------------------------------|---------------------------|-------------------------|-----------------------------|-----------------------|-------------------|
| Ajuga bracteosa                | >6.40                     | >1                      | >6.40                       | >1                    | >6.40             |
| Caralluma quadrangularis       | 27.5 ± 4.3                | >2.33                   | >6.40                       | >1                    | >6.40             |
| Centaurea pseudosinica         | 48.2 ± 9.8                | 32.5 ± 3.5              | 31.0 ± 0.7                  | 9.1 ± 0.8             | 1.76              |
| Chrozophora oblongifolia       | 5.0 ± 1.2                 | 27.3 ± 2.8              | 32.0 ± 5.8                  | >2                    | 10.8 ± 2.1        |
| Costus arabicus                | 14.5 ± 1.8                | 27.3 ± 2.1              | 13.8 ± 2.1                  | 2.79                  | 30.0 ± 4.9        |
| Capparis sepervirens           | 7.6 ± 2.4                 | 2.0 ± 0.4               | 8.3 ± 1.9                   | 1.29                  | 2.1 ± 0.2         |
| Dorstenia baritamiana          | 34.2 ± 8.7                | >6.40                   | 29.6 ± 3.9                  | >1.67                 | 22.6 ± 5.8        |
| Dodonaea viscosa               | 46.7 ± 11.8               | >1.37                   | 45.3 ± 11.8                 | >1.41                 | 11.1 ± 1.8        |
| Enicostemma verticillare       | >6.40 ± 1                 | >1                      | >6.40                       | >1                    | >6.40             |
| Ficus cordata sps.salicifolia  | 27.0 ± 6.9                | 27.3 ± 6.1              | 26.3 ± 3.2                  | 1.24                  | 8.2 ± 1.9         |
| Ficus sapessa                  | 8.4 ± 2.3                 | 32.5 ± 7.2              | 31.2 ± 4.3                  | 1.04                  | 8.0 ± 2.2         |
| Ficus palmata                  | 14.5 ± 3.8                | 2.60                    | >6.40                       | >1.67                 | 8.1 ± 2.6         |
| Grewia erythraea               | 11.7 ± 3.5                | 2.32                    | 24.1 ± 3.8                  | 3.32                  | 2.6 ± 0.9         |
| Iris albicans                  | 55.5 ± 6.2                | >1.15                   | >6.40                       | >1                    | >6.40             |
| Kamalia lanitifora             | 27.9 ± 4.9                | >6.40                   | 0.4 ± 0.2                   | 2.00                  | 9.6 ± 3.0         |
| Kniphofia sumareae             | 1.3 ± 0.6                 | 5.69                    | 32.5 ± 4.9                  | 31.4 ± 3.4            | 5.9 ± 2.8         |
| Lavandula dentata              | 7.1 ± 1.4                 | 4.17                    | 20.3 ± 3.5                  | 1.46                  | 7.9 ± 0.5         |
| Leucas inflata                 | 44.6 ± 6.3                | >6.40                   | >6.40                       | >1.41                 | 26.3 ± 1.8        |
| Plectranthus barbatus          | 6.5 ± 2.0                 | 5.06                    | 24.1 ± 2.9                  | 1.37                  | 23.3 ± 2.9        |
| Pulicaria inuloides            | 21.6 ± 3.8                | >2.96                   | 45.3 ± 8.3                  | 1.41                  | 31.7 ± 4.0        |
| Rhus retinorhsea               | 37.1 ± 4.9                | 1.43                    | >6.40                       | >2.13                 | 30.5 ± 3.9        |
| Tagetes minuta                 | 14.0 ± 2.8                | 4.57                    | 30.1 ± 4.6                  | >2.13                 | 9.2 ± 1.9         |
| Tarconanthus camphoratus       | >6.40                     | >1                      | >6.40                       | >1                    | >6.40             |
| Teucrium yemense               | 12.5 ± 2.6                | 2.18                    | 32.5 ± 6.6                  | >2.13                 | 30.5 ± 2.9        |
| Vernonia leopoldii             | 41.9 ± 7.9                | 27.3 ± 5.1              | 9.2 ± 1.2                   | 3.27                  | 8.0 ± 2.9         |
| Chloroquine                    | 0.3 ± 0.1                 | -                      | -                           | -                     | -                 |
| Miltefosine                    | -                         | 3.32 ± 0.7              | -                           | -                     | -                 |
| Benznidazole                   | -                         | 2.2 ± 0.5               | -                           | -                     | -                 |
| Suramin                        | -                         | -                      | 0.03 ± 0.02                 | -                     | -                 |
| Tamoxifen                      | -                         | -                      | -                           | -                     | 11.0 ± 2.3        |

IC\(_{50}\) values of reference drugs are expressed in μM/ml concentrations.

Antitrypanosomal activity
Our screen demonstrated that T. b. brucei is more sensitive than T. cruzi towards the investigated plant extracts (Table 2). The results revealed that the extract of G. erythraea showed activity against T. cruzi (IC\(_{50}\) 8.2 μg/ml) and T. brucei (IC\(_{50}\) 2.6 μg/ml). Additionally, L. dentata demonstrated activity against T. cruzi and T. brucei with IC\(_{50}\) values of 7.9 and 3.0 μg/ml respectively. Meanwhile, the extract of Tagetes minuta showed less activity against T. cruzi with an IC\(_{50}\) value of 9.2 (SI = 6.9) and higher activity against T. brucei with an IC\(_{50}\) value of 2.2 μg/ml and the highest SI value of >29.1. On the other hand, the methanol extract of P. barbatus, showed antitrypanosomal activity only
against *T. brucei* (IC$_{50}$ 2.6 μg/ml) with high SI value of 12.6, while the extract of *V. leopoldii* showed activity against both *T. cruzi* and *T. brucei* (IC$_{50}$ 9.2 and 8.0 μg/ml) with low SI values of 3.2 and 3.7 respectively.

**Cytotoxicity assay**

The highest cytotoxic effect against MRC-5 cells was obtained with the methanol extract of *Kanahia laniflora* (IC$_{50}$ of 0.83 μg/ml). The extracts of *Kniphofia sumarae* and *Cupressus sempervirens* also exhibited a noticeable cytotoxic effect with IC$_{50}$ values of 7.7 and 10.7 μg/ml respectively (Table 2).

**Discussion**

The scientific evaluation of medicinal plants used in the preparation of folk remedies has provided modern medicine with several effective pharmacological treatments for the treatment of diseases caused by protozoan parasites [19,20]. As a result of this, during the last two decades numerous studies from various parts of the world on antiprotozoal activity of medicinal plants have been reported [21-26].

In continuation of our search for substances of plant origin with pharmacological effects, we have screened 25 plants collected from Saudi Arabia and Yemen for their antiprotozoal, antileishmanial and antitrypanosomal activities. It is important to mention that at the best of our knowledge, this study represents the first report on antiprotozoal activities for most part of the investigated plants. Although few plants are partly investigated, existing knowledge remains in many cases very limited. Based on the activity (IC$_{50}$) and selectivity, seven plant extracts could be considered as promising and interesting enough to engage in further purification and evaluation.

During the course of screening, it was found that the methanol extract of the *C. oblongifolia*, collected from Yemen, exhibited the greatest antiprotozoal activity. Our result is in agreement with data reported recently by Abdel-Sattar et al. (2010) [27], which showed antiprotozoal activity for this species collected from Saudi Arabia (IC$_{50}$ 4.8 μg/ml) with a better selectivity (SI > 13.2). Moreover, Benoit-Vical et al. (2008) [28] reported that the water extract of *Chrozophora senegalensis* showed a remarkable in vitro antimalarial activity (IC$_{50}$ 1.6 μg/ml).

Another interesting plant was *G. erythraea*, which demonstrated considerable antimalarial and antitrypanosomal activities. Our data are in agreement with literature data of other *Grewia* species such as *G. hexaminta* and *G. bilamellata* [32,33]. Ma et al., (2006) [32] demonstrated that some triterpenoids e.g. 3α,20-lupandiol, gregwin, nitidanin and 2α,3β-dihydroxy-12-en-28-oic acid isolated from *G. bilamellata* are responsible for the antimalarial effect and showed varying degrees of in vitro activity against *P. falciparum*. The presence of such terpenoids in our *G. erythraea* may explain the biological effects seen in our screen.

Moreover, one of the most interesting plants was *L. dentata* collected from Yemen. Our antiparasitic screening revealed remarkable in vitro antiprotozoal and antitrypanosomal activity observed for *L. dentata* but with moderate SI of 4.1 and 9.8. These findings are in agreement with literature data published recently by Abdel-Sattar et al. (2010) [27] who reported the antiparasitic activity of the methanol extract of *L. dentata* growing in Saudi Arabia. The extract of *L. dentata* growing in Saudi Arabia showed better selectivity for *P. falciparum* (SI = 32.1) as compared with our results. This can be attributed to variation in the area of collection and ecological factors, which has a great impact on the quality and quantity of plants constituents. Apparently the activity of this species is mostly attributed to the presence of essential oil which was revealed to be responsible for antiparasitic and antibacterial activities [34,35].

Tempone et al., (2008) [36] investigated the antileishmanial activity of some Brazilian flora extracts, including *P. barbatus* which showed activity against *L. chagasi* with EC$_{50}$ value of 54.5 μg/mL. In earlier studies, several *Plectranthus* species showed antiprotozoal activity against *P. falciparum* 3D7 strain [37,38]. The results obtained in the present screen are in agreement with the literature data found and hence justifies the folkloric use. In addition to that, Van Zyl et al., (2008) [38] attributed the antiprotozoal activity of these *Plectranthus* species to the presence of abietane diterpenes.

Whereas the crude extract of *T. minuta* showed a remarkable antitrypanosomal activity against both trypanosome species, no effect was found against *P. falciparum*. Obviously our results of the antiprotozoal activity of *T. minuta* were not in agreement with the antimalarial effect noted recently by Lacroix et al., (2011) and Shahzadi et al., (2010) [39,40]. It was demonstrated that the ethyl acetate as well as n-hexane extract exhibited a notable antimalarial activity at 2.78 μg/ml against *P. falciparum* 3D7 strain. Apparently these findings are attributed to the presence of essential oil as well as sesquiterpene lactones.

In our screen *A. bracteosa* didn’t show any interesting antiprotozoal activity. These results are not in agreement with those recently reported by Chandel and Bagai (2010) [7]. In contrast to several reports on *Vernonia*
species e.g. V. amygdalina, V. brachycalyx, V. cinerea and V. colorata indicating in vitro and in vivo antiparasomal activity [41–43], our extract of V. leopoldii showed no antiparasomal activity. On the other hand, V. leopoldii showed a notable antitypansomal activity, which was in agreement with the results obtained by Hoet et al. (2004) [44] who attributed the antitypansomal activity to the presence of stigmastane-type steroids e.g. vernoguinosterol and vernoguinol, which were isolated from the stem bark of V. guineensis. Such compounds could also be responsible for the observed effect of V. leopoldii.

Conclusion
In conclusion, the results show that scientific studies carried out on medicinal plants having traditional claims of effectiveness can yield fruitful results. The present work led to the identification of seven plant extracts exhibiting relevant antiprotozoal potential namely C. oblongifolia, F. ingens, G. erythraea, L. dentata, P. barbatus, T. minuta and V. leopoldii. Moreover, the results in the present study support to some extent the traditional uses of some plants for the treatment of parasitic diseases. Studies aimed at the isolation and structure elucidation of antiprotozoal active constituents from some investigated plants are now in progress.

Competing interests
The author(s) declare that they have no competing interests.

Authors’ contributions
RAM and NMA carried out the study design, plant collection and extraction, part of the experimental work, data collection and interpretation, literature search and manuscript preparation. AM carried out the in vitro assays, PC and LM evaluated the data and corrected the manuscript for publication. All authors read and approved the final manuscript.

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