ORIGINAL ARTICLE

REVIEW OF SUDANESE MEDICINAL PLANTS TESTED FOR THEIR ANTIPARSITICAL ACTIVITY

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ABSTRACT

Background: Review articles, especially in medicinal plants' research, are very important in saving time, materials and efforts, to reach the ultimate goal for application of the findings. This study is considered as the most comprehensive review in this field since it covered about 53 studies during the period 1986-2016. **Objectives:** The study is designed to define the current status of Sudanese medicinal plants' research seeking for antiparasitical activity, in order to define the gaps in this field and provide basic data for setting future strategic plans in medicinal plants' research in Sudan. **Methods:** The current review was done by collecting data on medicinal plants native to Sudan, which have been reported to possess potential antiparasitical activity. This was carried out by reviewing various research papers, review papers, short communications, MSc and PhD theses and published books, during the period 1986-2016. The sources of data were initially gathered from the major scientific databases such as science web of Knowledge, Science Direct, Pubmed and Google. **Results:** The study revealed that, at least 49 plant species belonging to 29 families were screened and tested for their antiparasitical activity in Sudan during the mentioned period. The family Fabaceae was the most screened family with 10 species. The species *Acacia nilotica* (L.) Del. received the greatest attention by researchers and has been tested in six different studies. At least 24 species of parasites belonging to 16 genera were investigated in search for antiparasitical activity. The species *Plasmodium falciparum* received the greatest attention by Sudanese researchers and has been investigated in 25 different studies out of the 53 studies reviewed. **Conclusions:** Parasitic diseases represent a major health problem in Sudan. The search for medicinal plants with antiparasitical activity is badly needed to help overcome this problem. The current study will highlight the most promising plants and define the gaps for completing the research in this highly important field.

Keywords: medicinal plants, antiparasitical, molluscicidal activity, tropical diseases.

1. INTRODUCTION

Reviews about medicinal plants are very necessary since they allow the organization and quick recovery of multidisciplinary information about medicinal plants [1]. Large reviews can be worldwide, which is practically difficult, or it can be regional reviews covering one country or more. Recently in Sudan, two reviews preceded this one, one targeted plants with antibacterial activities [2], the other targeted plants with antifungal activities [3].

Tropical parasitic diseases, such as malaria, leishmaniasis, schistosomiasis, dengue and others, represent major health concern in developing countries. They seriously affect almost exclusively poor population living there and they are responsible for severe and permanent disabilities and deformities. They can spread through insects' vectors or contact with contaminated water or soil. It is estimated that worldwide, over one billion people are victims of parasitic diseases [4].

Among tropical diseases, malaria is the most prevalent insect-borne disease, it spreads by mosquitoes (*Anopheles* spp.). Malaria is endemic in more than 100 countries around the world. Malaria affects 300-500 million people each year and results in more than 1 million deaths. In the past decades, this situation has been aggravated by the increasing spread of drug-resistant *Plasmodium falciparum* strains. Resistance of *P. falciparum* to commonly used antimalarial drugs is increasing. This has resulted in resurgence in transmission and an increase in adverse outcomes due to therapy failure. The cost of newer antimalarial drugs is unaffordable and sometimes unavailable to local communities where malaria is endemic [5,6]. According to the World Health Organization (WHO) estimates, leishmaniasis, on the other hand, is endemic in 88 countries, where 12 million people are currently affected and 350 million people are at risk. Visceral leishmaniasis (VL) is a parasitic disease caused by *Leishmania donovani* and transmitted through bites of the sand fly *Phlebotomus argentipes*. More than 90% cases of VL are reported from India, Bangladesh, Nepal, Brazil, and Sudan. The disease flourish in poor urban areas and refugee camps, and malnutrition is a well-known risk factor for visceral leishmaniasis in particular [7]. Schistosomiasis is one of the major health problems which can affect various mammals, including man and domestic livestock, caused by blood flukes of the genus *Schistosoma* [8]. It is endemic in 74 countries [9]. It is widespread in Africa, the Middle East, the northern part of South America and South East Asia. The WHO estimated that approximately 250

million people are suffering from the infection and that more than 600 million people reside in areas where schistosomiasis is transmitted [10].

Medicinal plants have been used throughout the world for the treatment of tropical diseases such as malaria, leishminasis, leprosy, etc. The discovery of antimalarial compounds from natural sources (quinine from *Cinchona* spp., and artemisinin from *Artemisia annua*) indicates a great potential of such traditional plants which are in human use since centuries, as a new source of new medicines for malaria, and for other tropical diseases.

Sudan is an African country which has tremendously suffered from all the above mentioned parasitical diseases. Sudan is very rich in medicinal plants which have been used by local people for the treatment of diseases such as schistosomiasis, malaria and leishmaniasis. In the present work the documentation of Sudanese medicinal plants investigated for their antiparasitical activity have been reported during the last three decades, in order to highlight the most promising plants and to define the gaps needed to complete the research in this highly important field.

2. MATERIALS AND METHODS

The current review was done by collecting data on medicinal plants native to Sudan, which have been reported to possess potential antiparasitical activity. This was carried out by reviewing various research papers, review papers, short communications, MSc and PhD theses and published books, during the period 1986-2016. The sources of data were initially gathered from the major scientific databases such as science web of Knowledge, Science Direct, Pubmed and Google.

The data were tabulated according to plant families and species names (both arranged alphabetically). Then vernacular names of plant species were given, which are used by local people as well as researchers in Sudan. The antiparasitical activities for each species were summarized and the references were cited. Plants Latin names were recorded as mentioned in the references reviewed, without taxonomic treatment or an attempt for updating these names, so as to keep the original information from the reference cited.

3. RESULTS

The results were presented in table (1). The first column in the table is the family name, the second column is the plant Latin name, the third column is the plant vernacular name which is more famous and used in Sudan by the local people, the fourth column is the antiparasitical activity, and the last column is the reference.

Table 1: Sudanese medicinal plants with potential antiparasitical activities

Family	Latin name	Vernacular name	Antiparasitical activity	Ref.
Amaryllidaceae	*Allium sativum* L.	Toom	The patient of cutaneous leishmaniasis showed 100% response to the treatment with the methanolic extract. While the *in vitro* activity against *Leishmania major* revealed LC_{50} of 4.94 μg/ml.	[11, 12]
	Pamianthe peruviana Stapf.		The plant extract exhibited good activity against chloroquine resistant *Plasmodium falciparum* strain (K1) and chloroquine sensitive strain (NF 54) with IC_{50} 0.6 and 1.1 μ/ml respectively. Also it showed activity against *Trypanosoma brucei rhodesiense* with IC_{50} 1.5 μg/ml and IC_{50} 11.8 μ/ml against *T. cruzi* in vitro.	[13]
Annonaceae	*Annona squamosa* L.	Gishta	The methanolic extract of the leaves showed high antiplasmodial activity with IC_{50} values of 2 and 30 μg/ml against 3D7 and Dd2 *Plasmodium falciparum* strains, respectively. While the stem bark extract showed moderate activity with IC_{50} values of 8.5 and 120 μ/ml on the above strains respectively.	[14]
Aristolochiaceae	*Aristolochia bracteolata* Lam.	Umm Glagel	The chloroformic extract showed 100% clearance of *Trypanosoma evansi* in experimentally infected rats. The plant extracts showed antimalarial activity against *Plasmodium falciparum* schizont stage in vitro with 100% mortality at concentration < 50 μ/ml.	[15]
			The methanolic extract was found of better activity when administered orally to albino rats experimentally infected with *Trypanosoma evansi* at doses 250 and 500 mg/kg body weight more than chloroformic extract.	[16]
			the seed methanolic extract was found good activity against both 3D7 and Dd2 *Plasmodium falciparum* strains in vitro with IC_{50} 10 and 5 μg/ml respectively.	[17]
Asclepiadaceae	*Solenostemma argel* (Delile) Hayne	Hargel	The aqueous leaf extract proved molluscicidal activity against adult snails of *Biomphalaria pfeifferi* with LD_{50} and LD_{95} 0.103 and 0.187 ppm respectively.	[18]

Family	Latin name	Vernacular name	Antiparasitical activity	Ref.
Asteraceae	*Ambrosia maritima* L.	Damsisa	The extracts of the aerial shoot showed antileishmanial activity in vitro against *Leishmania donovani* with IC_{50} < 8 μg/ml.	[19]
	Xanthium brasilicum Vel.	Rantouk	The methanolic extract of the whole plant gave IC_{50} 1.2, 3.9 and 2.3 μg/ml against NF54, FCM17 and locally isolated *Plasmodium falciparum* strains respectively. The extract also revealed zero parasitaemia after 5 days in experimentally infected mice with *Plasmodium yoeli*. The dichloromethane extract gave IC_{50} 0.1 μg/ml against *Trypanosoma brucei rhodesiense*. The isolated compound 8-epixanthatin 1β, 5βepoxide showed IC_{50} 0.09, 2.95, 0.16 and 1.71 μg/ml against *Trypanosoma rhodesiense*, *Trypanosoma cruzi*, *Leishmania donovani* and *Plasmodium falciparum* respectively	[20, 21]
			Methanolic and water extracts gave 100% mortality against *Trichomonas vaginalis* in vitro at concentration 500 and 1000 μg/ml after 192 hours respectively. While the chloroform extract showed 100% mortality at concentration 1000 μg/ml after 216 hours.	[22]
	Helianthus annuus L.	Abbad El Shams	The methanolic and petroleum ether extracts of the seeds gave IC_{50} of 0.1 and 0.6 μg/ml against *Plasmodium falciparum* K1 strain respectively.	[23]
	Ageratum conyzoides (L.) L.	Rehan Elguroof	The dichloromethane extract exhibited a prominent activity (IC_{50} = 0.78 μg/mL) against bloodstream forms of *Trypanosoma brucei rhodesiense*, the etiologic agent of East African Human Trypanosomiasis (East African Sleeping Sickness). This extract also exhibited noticeable activities against *Leishmania donovani* (Kala-Azar, IC_{50} = 3.4 μg/mL) as well as *Plasmodium falciparum* (*Malaria tropica*, IC_{50} = 8.0 μg/mL)	[24]
			The antiprotozoal activity of encecalol angelate isolated from the plant and unstable chromene were conducted against *T. brucei rhodesiense* as well as *T. cruzi*, *Leishmania donovani* and *Plasmodium falciparum* was investigated and found to be quite low.	[25]
Balanitaceae	*Balanites aegyptiaca* (L.) Del.	Hegleig	The aqueous extract showed activity against free living nematode *Caenorhabditis elegans* with IC_{50} 0.8 mg/ml.	[26]
			The ethanolic extract of the fruits gave 100% inhibition for *Entamoeba histolytica* and *Giardia lamblia* in vitro at 500 μg/ml after 96 hours exposure	[27]
			The aqueous extract of the fruits at doses 9 g/kg body weight reduced *Fasciola gigantica* in experimentally infected goats with 93.2%. Also the same extract at dose 200 mg/kg body weight causes reduction in total egg count, eggs burden in tissues and recovery of adult worms for *Schistosoma mansoni* in experimentally infected mice.	[28, 29]
			The in vitro study revealed significant anthelmintic effects ($p \leq 0.05$) for both crude aqueous extract (CAE) and crude methanolic extract (CME) of the seed kernel on live *Haemoncus contortus* as evident from their mortality or temporary paralysis. For in vivo studies, the CME and CAE of the plant revealed dose dependent anthelmintic effects. The three doses (100,400,800 mg/kg) of CME showed 20%, 74.7% and 79.2% reduction in eggs count per gram of faeces (EPG) on day 21 post treatments respectively. However, the dose of 100mg/kg CAE showed no significant effect while, the dose of 400mg/kg revealed 61.4% reduction in EPG on day 21 post treatments.	[30]
Bombacaceae	*Adansonia digitata* L.	Tabeldi	The ethanolic extract of the leaves gave 100% inhibition for *Entamoeba histolytica* in vitro at concentration 500 μg/ml after 72 hours exposure.	[31]
Burseraceae	*Boswellia papyrifera* (Caill. ex Del.) Hochst.	Tarag Tarag	The volatile oils collected from the plant resin were found of molluscicidal activity against both *Biomphalaria pfeifferi* and *Bulinus truncatus* snails in vitro with LD_{50} 213 and 311 ppm respectively.	[32]
Cannabaceae	*Cannabis sativa* L.	Hasheesh	Aerial part methanolic extract gave 63.6% mortality against *Giardia lamblia* in vitro at concentration 1000 ppm after 72 hours with IC_{50} 0.13 ppm.	[33]
Capparaceae	*Capparis decidua* Forssk.	Tundub	Stem methanolic extract showed 100% mortality against *Fasciola gigantica* adult worms in vitro 13 hours exposure to concentration 1200ppm	[34]
Celastraceae		Shagarat El Marfain	The crude methanolic extract showed antileishmanial activity in vitro against *Leishmania major* promastigote with IC_{50} 55 μg/ml, while the dichloromethane and ethylacetate portions from methanol extract gave	[14-35]

Family	Latin name	Vernacular name	Antiparasitical activity	Ref.
	Maytenus senegalensis (Lam.) Exell.		IC_{50} 5 and 28 μg/ml respectively. The methanolic extract was found of antiplasmodial activity against both 3D7 and Dd2 *Plasmodium falciparum* strains with IC_{50} 4 and 10 μg/ml respectively. The fractions from dichoromethane sub extract gave activity with IC_{50} 5 μg/ml against *Plasmodium* strains.	
			The qunonemethide triterpene pristimerin isolated from the plant possess activity against Dd2 *Plasmodium falciparum* strain and *Leishmania major* with IC_{50} 0.5 and 6.8 μg/ml respectively.	[36]
Combretaceae	*Terminalia laxiflora* Engl. & Diels.	Darout	The ethanolic extracts of the seeds showed cecaricidal activity against infective stage of *Schistosoma mansoni* with 100% mortality after 3 hours at concentration 5 ppm. While the leaves ethanolic extracts gave less activity LC_{90} 13.48 ppm) after 6 hours exposure.	[37]
	Combretum glutinosum Perr. ex DC.	Habeil	The stem ethanolic extract showed cercaricidal activity against cercarial stage of *Schistosoma mansoni* with LC_{90} 3071 ppm after 3 hours exposure, while the leaves extract showed LC_{90} 5 ppm after 6 hours exposure.	[37]
	Combretum hartmannianum Schweinf.	Habeil	Different part extracts revealed antiplasmodial activity against *Plasmodium falciparum* NF 54 with IC_{50} values 0.2, 0.4, 3.4 μg/ml for bark, stem and leaves respectively.	[13]
Cucurbitaceae	*Cucurbita maxima* Duchesne	Gara' asali	The petroleum ether of the seeds gave 100% mortality against *Giardia lamblia* in vitro after 48 hours' exposure with IC_{50} 49 ppm. While the methanolic extract gave 100 mortality after 96 hours with IC_{50} 36 ppm.	[38]
			The ethanolic extract of the seeds gave 100% inhibition for *Entamoeba histolytica* in vitro at concentration 500 μg/ml after 96 hours exposure.	[31]
	Lagenaria siceraria (Molina) Standl.	Bukhsa	The petroleum ether extract gave 100% mortality against *Giardia lamblia* in vitro after 72 hours' exposure with IC_{50} 96 ppm. While the methanolic extract gave 100 mortality after 120 hours with IC_{50} 9 ppm.	[38]
	Citrullus lanatus (Thunb.) Matsum. & Nakai	Betteikh El Khala	Ethylacetate, petroleum ether and butanol extracts of the fruits were active against *Giardia lamblia* with IC_{50} 0.1, 0.2 and 0.5 μg/ml respectively. The isolated cucurbiticin E and L-glycoside showed IC_{50} 2 and 5 ng/ml respectively after 5 days.	[39']
Cyperaceae	*Cyperus rotundus* L.	Sei'da	The ethanolic extract of the whole plant gave 100% inhibition for *Entamoeba histolytica* and *Giardia lamblia* in vitro at 500 μg/ml after 96 hours exposure.	[40, 41]
Euphorbiaceae	*Jatropha curcas* L.	Habb El Meluk	Crude powder and ethanolic extract of the seeds produced anticestodal activity against *Raillietina tetragona* in chicks at concentration of 500 and 100 mg/kg body weight respectively.	[42]
Fabaceae (Subfamily Caesalpinioideae)	*Bauhinia rufescens* Lam.	Kharroub	The petroleum ether extract of the leaves showed antiamoebic activity against *Entamoeba histolytica* with 78% mortality after 72 hours for the concentration 1000 ppm. While the methanolic extract gave 60% mortality after 72 hours at concentration 125 ppm.	[43]
	Senna alexandrina Mill.	Sana Mekka	The methanolic and petroleum ether extracts of the fruits gave IC_{50} of 0.1 and 0.3 μg/ml against *Plasmodium falciparum* K1 strain respectively.	[23]
	Senna obtusifolia (L.) Irwin & Barneby (*Cassia tora* L.)	Kawal	Aerial parts methanolic extract was found highly active against both 3D7 and Dd2 *Plasmodium falciparum* strains in vitro with IC_{50} 5.2 and 3.3 μg/ml respectively	[17]
Fabaceae (subfam. Faboideae)	*Sesbania sesban* (L.) Merr.	Seseban	The aqueous extract showed activity against free living nematode *Caenorhabditis elegans* with IC_{50} 8 mg/ml.	[26]
Fabaceae (Subfam. Mimosoideae)	*Albizia zygia* (DC.) J.F. Macbr.	Digen Basha Ahmar	The flavonoid 3-O-methylfisetin (3',4',7-trihydroxy-3-methoxyflavone, isolated from the plant showed high antimalarial activity against *Plasmodium falciparum* in vitro with IC_{50} 0.078 μg/ml	[44]
	Albizia anthelmintica Brongn.	Girf Eldood	The aqueous extract of the bark of 10 – 150 g/kg body weight taken orally showed anthelmintic activity (68 – 100%) against *Hymenolepis diminuta* infection in albino rats.	[45]
			The aqueous extract of the bark at doses 9 g/kg body weight reduced *Fasciola gigantica* in experimentally infected goats with 95.5%.	[28]
	Acacia senegal Del.	Hashab	The methanolic extract of the stem bark revealed 100% mortality against *Fasciola gigantica* adult worms in vitro at concentration 1000, 500 and 250 ppm after 6, 12 and 24 hours respectively.	[46]

Family	Latin name	Vernacular name	Antiparasitical activity	Ref.
			The methanol, chloroform and water extracts of the bark gave 85, 64 and 66% mortality against *Trichomonas vaginalis* in vitro while, the fruit extracts gave 56, 74 and 72% respectively.	[47]
	Acacia nilotica (L.) Del.	Sunt	Methanolic extract of the fruits and bark showed 100% mortality against *Trichomonas vaginalis* in vitro at concentration 250 μg/ml after 192 hours exposure. While the bark chloroform extract gave the same activity at concentration 1000 μg/ml.	[48]
			The extracts of the plant showed antileishmanial activity in vitro against *Leishmania donovani* with IC_{50} < 8 μg/ml.	[19]
			The ethanolic extract of the leaves and bark gave 100% inhibition for *Giardia lamblia* in vitro at 500 μg/ml after 96 hours exposure.	[49, 50]
			The ethylacetate fraction and water residue of the stem bark were found of good inhibition for the enoyl-ACP reductase (PFENR) of *Plasmodium falciparum* with IC_{50} 0.87 and 6.33 μg/ml.	[51]
			The seed methanolic extract was found highly active against both 3D7 and Dd2 *Plasmodium falciparum* strains in vitro with IC_{50} 0.9 and 4.1 μg/ml respectively. The bioassays guided isolation of ethylacetate fraction gave IC_{50} 1.5μg/ml	[17]
	Acacia seyal Del.	Talh	The methanol, chloroform and water extracts of the bark gave 97, 85 and 78% mortality against *Trichomonas vaginalis* in vitro while, the fruit extracts gave 79, 79 and 85% respectively.	[47]
	Prosopis juliflora (Sw.) DC.	Meskit	The petroleum ether extract was found with antigiardial and antiamoebic activity against *Giardia lamblia* and *Entamboeba histolytica* in vitro with mortality rate 79% and 32% at concentrations 500 and 125 ppm respectively. While the methanolic extract gave 77% and 72% mortality after 72 hours with 1000 ppm for the above protozoa respectively.	[52]
Lamiaceae	*Vitex trifolia* L.	Um dagelgel	The petroleum ether extract of the leaves possess activity against *Giardia lamblia* and *Entamoeba histolytica* with mortality rate 75 and 54% respectively for 1000 ppm concentration after 72 hours. While, the methanolic extracts showed mortality rate 72 and 62% respectively against the same parasites in the same time and concentrations.	[53]
Meliaceae	*Azadirachta indica* A. Juss.	Neem	The crude methanolic extract revealed considerable antileishmanial activity in vitro against *Leishmania major* promastigote with IC_{50} 11.5 μg/ml.	[14]
			The ethanolic extract was found neuroprotective for the induced cerebral malaria infection with *Plasmodium bergei* ANKA at doses 300, 500 and 1000 mg/kg body weight for experimentally infected mice.	[54, 55]
			The methanolic extract showed antileishmanial activity against *Leishmania major* in vitro with LC_{50} 10.2 μg/ml.	[12]
	Khaya senegalensis (Desr.) A. Juss.	Mahogany	The ethylacetate fraction and water residue of the stem bark were found of good inhibition for the enoyl-ACP reductase (PFENR) of *Plasmodium falciparum* with IC_{50} 3.35 and 11.68 μg/ml.	[51]
Menispermaceae	*Tinospora bakis* (A. Rich.) Miers.	Irg Alhagar	The methanolic extract was found very effective against *Trypanosoma evnasi* in experimentally infected rats at different concentrations 100, 250 and 500 mg/kg body weight. However, the curable dose 500 mg/kg body weight was found very toxic.	[56, 57]
			The aqueous extract of the roots showed activity against *Theilaria lestoquardi* macroschizont in vitro with IC_{50} 184569 ppm	[58]
Myrtaceae	*Eucalyptus globulus* Labill.	Ban	The crude methanolic extract showed antileishmanial activity in vitro against *Leishmania major* promastigote with IC_{50} 78 μg/ml.	[14]
Nitrariaceae	*Peganum harmala* L.	Harmel	All concentration > 250 ppm of the seeds water and methanolic extracts gave 100% mortality after half an hour exposure against cercaria of *Schistosoma mansoni* in vitro. While the methanolic extract revealed 100% mortality after 3 hours' exposure for all concentrations > 15 ppm.	[59]
Papaveraceae	*Argemone mexicana* L.	Khashkhash Mexiki	Methanolic and water extracts revealed 100% mortality against *Trichomonas vaginalis* in vitro at concentration 1000 μg/ml after 192 hours exposure. While the chloroform extract showed 100% mortality at concentration 1000 μg/ml after 216 hours.	[22]
Poaceae	*Cymbopogon nervatus* (Hochst.)Chiov.	Nal	The volatile oils extracted from the leaves were examined against both *Biomphalaria pfeifferi* and *Bulinus truncatus* snails in vitro. It gave LD_{50} 213 and 237 ppm respectively.	[32]

Family	Latin name	Vernacular name	Antiparasitical activity	Ref.
	Cymbopogon schoenanthus (L.) Spreng.	Mahareib	The methanolic and petroleum ether extracts of the aerial part gave IC_{50} of 0.5 and 0.3 μg/ml against *Plasmodium falciparum* K1 strain respectively.	[23]
Polygonaceae	*Polyganum glabrum* Willd.	Timsahiya	PGA is a pure substance isolated from the leaves, the methanol-aqueous extract was found of good anthelmintic activity against *Hymenolipes nanna* and possess molluscicidal activity against *Biomphalaria glabrata* and *Limnea truncatula*.	[60]
Ranunculaceae	*Nigella sativa* L.	Habat El Baraka	The seeds extract revealed antimalarial activity against *Plasmodium falciparum* schizont stage in vitro with 100% mortality at concentration < 50 μ/ml	[15]
			Thymoquinone isolated from the plant showed 85.5%, 91.5% and 96.8% mortality on *Entamoeba histolytica* for 25 ppm at 24 hr, 48 and 72 hr, respectively, with IC_{50} 2¥10-19, On the other hand, this natural compound showed a mortality of 82.83%, 91.76% and 96.62% mortality on *Giardia lamblia* for 25 ppm at 24 hr, 48 and 72 hr, respectively, with IC_{50} 4.8-10-5. Metrondizole powder gave 70.9% mortality at 156 ppm at the same times.	[61]
Rubiaceae	*Gardenia ternifolia* Schumch. & Thonn.	Abu Gawey	The aqueous extract of the fruits possess activity against *Theilaria lestoquardi* macroschizont in vitro with IC_{50} 6745 ppm	[62]
			The leaves methanolic extract was found highly active against both 3D7 and Dd2 *Plasmodium falciparum* strains in vitro with IC_{50} 5.2 and 3.3 μg/ml respectively	[17]
Rutaceae	*Diosma pilosa* I. Williams		The flavonoid quercetin purified from the plant was found to have strong antimalarial activity in vitro against FCR3TC *Plasmodium falciparum* strain with IC_{90} 6.9 μg/ml.	[63]
	Haplophyllum tuberculatum	Al-Haza	The plant methanolic extract was found highly active against both 3D7 and Dd2 *Plasmodium falciparum* strains in vitro with IC_{50} 1.2 and 1.5 μg/ml respectively	[17]
Salvadoraceae	*Salvadora persica* L.	Arak	Different extracts of the plant revealed antiplasmodial activity against *Plasmodium falciparum* NF 54 with IC $_{50}$ 0.6 μg/ml stem and 0.7 μg/ml leaves.	[13]
Simaroubaceae	*Harrisonia abyssinica* Oliv.	Garb-El wadi	The methanolic extract inhibited both chloroquine sensitive strain 3D7 and resistant strain Dd2 of *Plasmodium falciparum* with IC_{50} values of 4.7 and 10 μg/ml respectively.	[14]

Table (2) showed the distribution of Sudanese medicinal plants screened against each infectious parasitic disease. Malaria was the most infectious disease tested (especially the parasite *Plasmodium falciparum*).

Table 2: Distribution of Sudanese medicinal plants screened against each infectious parasitic disease.

Parasitic disease	Parasite species	Tested plants
Malaria	*Plasmodium falciparum*	*Pamianthe peruviana, Annona squamosal, Aristolochia bracteolate, Xanthium brasilicum, Helianthus annuus, Ageratum conyzoides, Maytenus senegalensis, Combretum hartmanniaum, Senna alexandrina, Cassia tora, Albizia zygia, Acacia nilotica, Khaya senegalensis, Cymbopogon schoenanthus, Gardenia lutea, Diosma pilosa, Haplophyllum tuberculatum, Salvadora persica, Harrisonia abyssinica*
	Other *Plasmodium* spp.	*Xanthium brasilicum, Maytenus senegalensis, Azadirachta indica*
Schistosomiasis	*Schistosoma mansoni*	*Balanites aegyptiaca, Terminalia laxiflora, Combretum glutinosum, Peganum harmala*
Leishmaniasis	*Leishmania major*	*Alium sativum, Maytenus senegalensis, Azadirachta indica, Eucalyptus globulus*
	Leishmania donovani	*Ambrosia maritima, Xanthium brasilicum, Ageratum conyzoides, Acacia nilotica*
Trypanosomiasis	*Trypanosoma rhodesiense*	*Pamianthe peruviana, Xanthium brasilicum, Ageratum conyzoides*
	Trypanosoma cruzi	*Pamianthe peruviana, Xanthium brasilicum, Ageratum conyzoides*
	Trypanosojma evansi	*Aristolochia bracteolata, Tinospora bakis*
Tirchomoniasis	*Trichomonas vaginalis*	*Xanthium brasilicum, Acacia senegal, Acacia nilotica, Acacia seyal, Argemone mexicana*
Giardiasis	*Giardia lamblia*	*Cannabis sativa, Cucurbita maxima, Lagenaria siceraria, Citrullus lanatus, Cyperus rotundus, Acacia nilotica, Proposis juliflora, Vitex trifolia, Nigella sativa*

Parasitic disease	Parasite species	Tested plants
Amoebiosias	*Entamoeba histolytica*	*Adansonia digitata* , *Cucurbita maxima*, *Cyperus rotundus*, *Bauhinia rufescens*, *Proposis juliflora*, *Vitex trifolia*, *Nigella sativa*
Theilariasis	*Theilaria lestoquardi*	*Tinospora bakis*, *Gardenia ternifolia*
Helminthes	Trematodes	*Balanites aegyptiaca*, *Capparis decidua*, *Albizia anthelmintica*, *Acacia senegal*
	Tape worms	*Jatropha curcas*, *Albizia anthelmintica*
	Nematodes	*Balanites aegyptiaca*, *Sesbania sesban*
Vectors	Snails	*Solenostemma argel*, *Boswellia papyrifera*, *Cymbopogon nervatus*, *Polyganum glabrum*

4. DISCUSSION

The current study revealed that, at least 49 plant species belonging to 29 families were screened and tested for their antiparasitical activity in Sudan in about 53 studies during the period 1986-2016. The family Fabaceae was the most screened family with 10 species (Subfamilies: Mimosoideae 6 spp.; Caesalpiniodeae 3 spp.; Faboideae 1 sp.), followed by Asteraceae (4 spp.), then Combretaceae and Cucurbitaceae (3 spp. each), Amarillydaceae, Meliaceae, Poaceae and Rutaceae (2 spp. each), then 21 families with only one species has been screened, those including: Annonaceae, Aristolochiaceae, Asclepiadaceae, Balanitaceae, Bombacaceae, Burseraceae, Cannabaceae, Capparaceae, Celastraceae, Cyperaceae, Euphorbiaceae, Lamiaceae, Menispermaceae, Myrtaceae, Nitrariaceae, Papaveraceae, Polygonaceae, Ranunculaceae, Rubiaceae, Salvadoraceae and Simaroubaceae. These findings were presented in Figure (1).

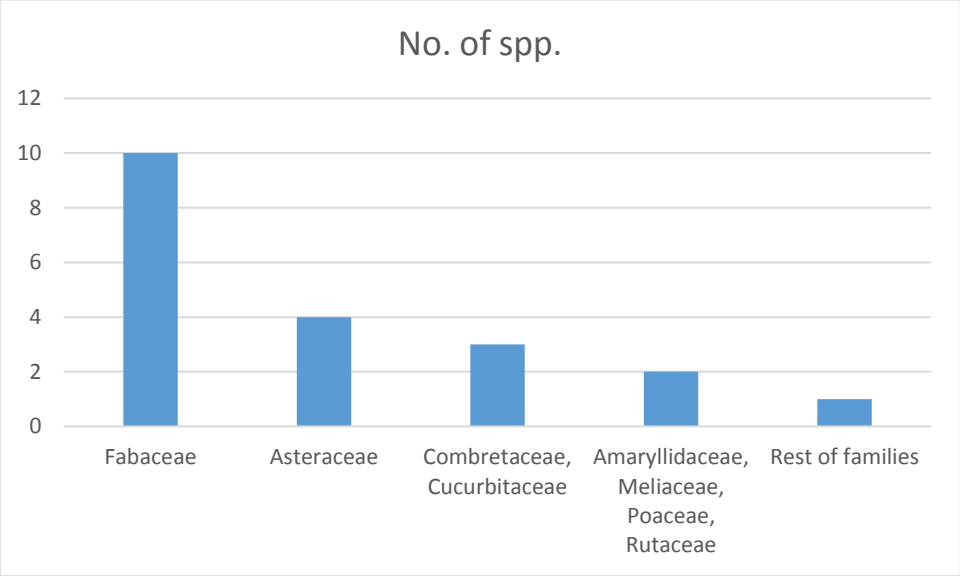

Figure 1: Plant families Vs number of species tested for antiparasitical activity.

The species *Acacia nilotica* (L.) Del. received the greatest attention by researchers and has been tested in six different studies, followed by the species *Balanites aegyptiaca* (L.) Del. which is tested in five different studies. This attention might be due to the importance and seldom use of these two species in Sudanese traditional medicine.

The present study also revealed that at least 24 species of parasites belonging to 16 genera were investigated in search for antiparasitical activity from medicinal plants in Sudan during the period 1986-2016. The species *Plasmodium falciparum* received the greatest attention by Sudanese researchers and has been investigated in 25 different studies out of the 53 studies reviewed, followed by the species *Giardia lamblia* which has been investigated in 10 studies, then *Entamoeba histolytica* in 8 studies, and *Leishmania major* in 6 studies, then both *L. donovani* and *Trichomonas vaginalis* in 5 studies, and all of the three species *Trypanosoma brucei rhodsiense*, *Fashiola gigantica* and *Schistosoma mansoni* in 4 studies, then the three species *Trypanosoma cruzi*, *T. evansi* and *Biomphlaria pfeifferi* in 3 studies, and only one species, *Theilaria lestoquardi* in 2 studies, while the rest of species were investigated in only one study. These findings were presented in Figure (2).

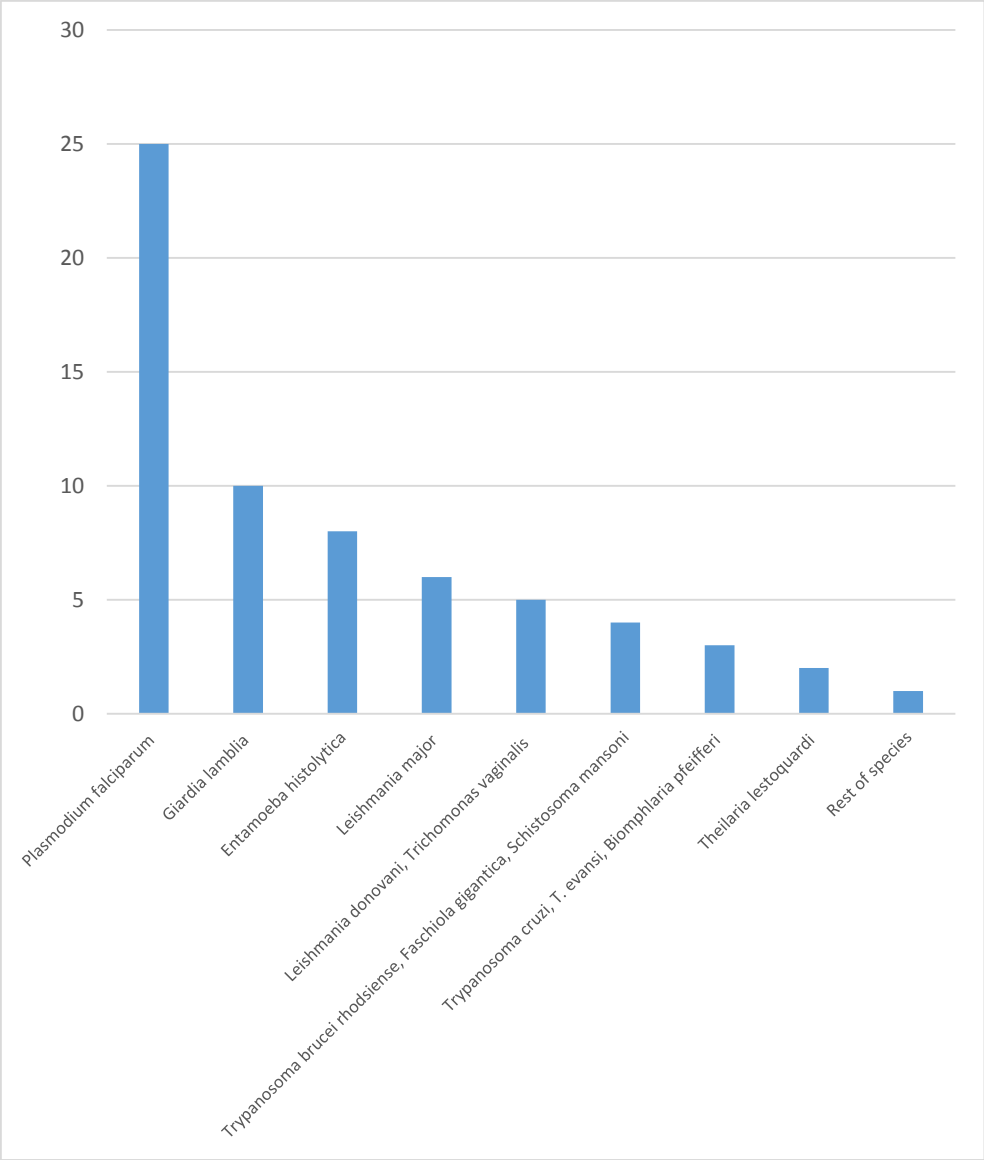

Figure 2: The figure presents the number of studies per parasitic species.

This attention might be because in Sudan malaria is one of the major public health and socio-economic problems. It is the most important cause of morbidity and mortality, especially among children and pregnant women. The entire population of the country is at risk of getting the disease. Malaria is widely endemic all over the country with various levels of endemicity. It ranges from hypo-endemic in northern Sudan, meso-endemic in central Sudan to holo-endemic in the south, depending on rainfall fluctuation. All *Plasmodium* different species have been observed in Sudan [64].

In Sudan, there has been a serious increase in endemicity and prevalence of both *Schistosoma mansoni* and *S. haematobium* infections since 1990s as a result of expansion in water resource projects, population movements, and unsuccessful control measures. For instance, the prevalence in Gezira reaches up to 70% of *S. mansoni* and reaches 15% of *S. haematobium* [65].

5. CONCLUSION

Parasitic diseases represent a major health problem in Sudan. The search for medicinal plants with antiparasitical activity is badly needed to help overcome this problem. The current study will highlight the most promising plants and define the gaps for completing the research in this highly important field.

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