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Antiparasitic activities of medicinal plants: An overview

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Abstract

Several of the parasites have become resistant to chemotherapy, so alternatives are urgently required. Natural products still play an important role in therapy: between 1981 and 2006, 1,184 new drugs were registered of which 28% were natural products or their derivatives. Another 24% of the new drugs had pharmacophores (functional groups with pharmacological activity) derived from natural products. In this review, PubMed, Google Scholar, Web of Science, EBSCO, Science Direct, and Scopus were searched for medicinal plants with antiparasitic, antiprotozoal, molluscicidal and insecticidal activity to encourage identification of the active ingredients, determination of clinical efficacy, studying of pharmacokinetic characteristics, investigation of the mode of action and safety.

Keywords: Medicinal plants; Pharmacology; Antiparasitic; Antiprotozoal; Molluscicidal; Insecticidal

1. Introduction

Parasitic diseases are one of the major public health problems [1]. Roughly 300 helminth species and 70 protozoa species have already were infecting humans, being the cause of death of about 200,000 people per year [2]. The most important GI parasites in humans consist of both helminths and protozoans. The main helminth include *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, and *Necator americanus* [3]. Approximately 1.5 billion people (24% of the world's population) are infected with at least one of these helminths during their life span; they are among the most common infectious disease agents reported in humans [4]. The estimated number of *A. lumbricoides* infections exceeds a billion, while *T. trichiura* account for 795 million and *N. americanus* account for 740 million infections [5]. Protozoan parasites infect about one-third of the human population worldwide. *Giardia lamblia*, *Entamoeba histolytica*, and *Cryptosporidium* spp. are the most common GI protozoan parasites reported in humans [6-7]. Natural products still play an important role in therapy: between 1981 and 2006, 1,184 new drugs were registered of which 28% were natural products or their derivatives. Another 24% of the new drugs had pharmacophores (functional groups with pharmacological activity) derived from natural products [8]. Several of the parasites have become resistant to chemotherapy, so alternatives are urgently required [9-16]. Medicinal plants possess antiparasitic effect by many modes of action, included uncoupling the oxidative phosphorylation leads to disturbance in energy generation mechanism, cause paralysis due to its effect on central nervous system of parasites, binding glycoprotein on the cuticles of the worms, cause digestion of nematode cuticle, disturb the Ca^{+2} homeostasis in the parasites and inhibition of the enzymes of glycogenolysis and glycolysis [17-23]. This review discuss the plants with antiparasitic effect to encourage further investigation of plants or plant derivatives as potential origins for novel therapies for parasitic infections.

1.1. Medicinal plants with antiparasitic effect

1.1.1. Achillea santolina

The volatile oil of *Achillea santolina* produced insecticidal and insect repellent activities on both domestic flies and honeybees. The ethanolic extract did not produce any insecticidal or repellent activity against larvae of potato tuber

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worm, on worker groups of honeybee and on domestic flies by applying three different methods [24-24]. Mustafa and Al-Khazraji investigated the effects of *Achillea santolina* extracts on the second instar of larval stage of *Culex pipiens molestus* Forskal. They found that the extracts of *Achillea santolina* caused high mortality to the larvae after 7 days of treatment [26]. Tammam *et al* examined the phytotoxic potential of *Achillea santolina* L. on *Vicia faba* L. and *Hordeum vulgare* L. *Achillea santolina* extract exhibited inhibitory effect on plumule and radicle lengths with a maximum inhibition at 16% concentration. The growth of radical was enhanced in broad bean and barley treated with 1 and 2% concentrations of *Achillea santolina* extract, respectively. Leaf area was significantly reduced in both crops and the percent reduction was greater in broad bean than in barley. There was a highly significant decrease in soluble protein contents in broad bean plants and a significant increase in barley plants treated with *Achillea santolina*. The number of *de novo* synthesized proteins in barley plants were more than those induced in broad bean plants [27].

1.1.2. Ailanthus altissima

The chloroform extract of *Ailanthus altissima* stem bark was tested for their antischistosomal and hepatoprotective effects. The effect of schistosomal infection and treatment with extracts on the activities of aspartate and alanine aminotransferases, acid phosphatase, 5'nucleotidase, glucose-6-phosphatase, lactate dehydrogenase, alkaline phosphatase and succinate dehydrogenase were estimated, the effect on free radical production in the form of lipid peroxides and on the levels of certain antioxidants namely, catalase, glutathione, vitamins C and E were evaluated. In addition, the efficiency of the tested extracts on reducing the worm burden and ova counts in the infected mice was studied. The results revealed that infection with *S. mansoni* increased lipid peroxides and decreased all antioxidant levels. On the other hand, the activities of acid phosphatase and 5`nucleotidase were higher while those of glucose-6-phosphatase, lactate dehydrogenase, alkaline phosphatase and succinate dehydrogenase were lower with respect to control. However, treatment with *Ailanthus altissima* ameliorated the disturbed lipid peroxides, antioxidants and enzymes' levels to nearly the control values [28]. Extracts and isolated compounds from seedlings of *Ailanthus altissima*, were assessed for antiplasmodial activity *in vitro*. Two quassinoids, ailanthone and 6 alpha-tigloyloxychaparrinone, isolated from the active extracts showed activity against both chloroquine-resistant and chloroquine-sensitive strains of *Plasmodium falciparum in vitro* [29]. Extracts *of Ailanthus altissima* (Mill.) Swingle have been tested for activity against *Plasmodium falciparum in vitro* and against *P. berghei* infections in mice. The activity of the chloroformic extract *in vitro* (IC_{50} 5 µg/m) and *in vivo* (ED_{50} 82.94 mg kg/d after oral administration), the activity was due, principally to the presence of the quassinoid ailanthone (IC_{50} *in vitro* 0.015µg/ ml ED_{50} *in vivo* 0.76 mg kg/d) [30]. The potential acaricidal properties of an *Ailanthus altissima* bark extract were assessed against two common species of animal ectoparasitic mites, *Psoroptes cuniculi* and *Sarcoptes scabiei var. cuniculi*, *in vitro*. *Ailanthus altissima* bark extract was obtained by ethanol thermal circumfluence and tested at four concentrations (1.0, 0.5, 0.25 and 0.125 g/ml) on mites collected from rabbits. Compared to the fenvalerate treatment group, the *Ailanthus altissima* bark exhibited significant acaricidal properties for both mite species. The extract at concentrations of 1.0, 0.5 and 0.25 g/ml killed all tested *S. scabiei* within 7 h, however, only 1.0 and 0.5 g/ml of extract killed all the treated *P. cuniculi*. The median lethal time (LT_{50}) values at 1, 0.5 and 0.25 g/ml were 0.60, 0.78, 1.48 h for *S. scabiei* and 0.74, 1.29, 3.33 h for *P. cuniculi*. The median lethal concentration (LC_{50}) for *P. cuniculi* was approximately 1.6 times that for *S. scabiei var. cuniculi* at 4 h. The extract showed stronger toxicity against *S. scabiei* than against *P. cuniculi*. Mortality rates increased with increasing concentration of extract administered and with increasing time post-treatment, indicating that the acaricidal activity of *Ailanthus altissima* bark extract is both time-dependent and dose-dependent [31]. The essential oil of *Ailanthus altissima* bark repelled *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), *Oryzaephilus surinamensis* (Linnaeus) (Coleoptera: Silvanidae), *Sitophilus oryzae* (Linnaeus) (Coleoptera: Curculionidae) and *Liposcelis paeta* Pearman (Psocoptera: Liposcelididae) adults, with the repellency value reaching IV grade or stronger during the whole exposure period. *Ailanthus altissima* bark oil also possessed strong contact toxicity on *S. oryzae* adults which gradually enhanced with increased exposure time and the corrected percentage mortality reached 76.5% after 72h treatment. Furthermore, *Ailanthus altissima* bark oil had high fumigant activity against *O. surinamensis* and *S. oryzae* adults with the corrected percentage mortality 99.3 and 81.9% within 24 h, respectively [32]. Methanol extracts of various plant parts of *Ailanthus altissima* were tested against the root knot nematode *Meloidogyne javanica*. Extracts of bark (ABE), wood (AWE), roots (ARE), and leaves (ALE) from *Ailanthus altissima* were investigated against freshly hatched second-stage juveniles (J2). AWE was the most active extract, with EC_{50}/3d) of 58.9 mg/l, while ALE, ARE, and ABE did not show nematicidal activity. The chemical composition of the extracts of *Ailanthus altissima* was determined by gas chromatography-mass spectrometry, and (E,E)-2,4-decadienal, (E)-2-undecenal, (E)-2-decenal, hexanal, nonanal, and furfural were the most prominent constituents. (E,E)-2,4-Decadienal, (E)-2-decenal, and furfural showed the highest nematicidal activity against *M. javanica* , with EC_{50}/1d) = 11.7, 20.43, and 21.79 mg/l, respectively, while the other compounds were inactive at the tested concentrations [33]. The mollusicidal effects of *Ailanthus altissima* cultivated in the hilly and mountainous areas on Oncomelania hupensis against *O. hupensis* snails was studied. The LC_{50} of *Ailanthus altissima* in 24, 48, and 120h reached the middle noxious level against *O. hupensis* snails [34-35].

1.1.3. Allium cepa

Allium cepa also exerted anti-parasitic activity for many helminthes and protozoa such as, *Trichinella spiralis*, and *leishmania* [36-37]. It also minimized the pathological and biochemical effects of many parasites such as cryptosporidia and toxoplasma [38-42].

1.1.4. Allium sativum

Some experimental studies have been performed to explain the mechanism of anthelmentic action of *A. sativum* extract in 12 different human and non-human parasites. It was used in the treatment of roundworm (*Ascaris)* and hookworm (*Ancylostoma caninum* and *Necator americanus*)**.** Sulfur compounds of the plant, such as Allicin, diallyl trisulphide (DAT) and ajoene can reduce developing different protozoan parasites such as *Giardia lamblia*, *Leishmania major* and *Leptomonas colosoma* [43-48]. *Allium sativum* and its constituents were also active against amoeba. 30 µg/mL of allicin was totally inhibited the growth of amoeba cultures**.** However**,** 5 µg/ml allicin inhibited 90% the virulence of trophozoites of *E. histolytica* as determined by their inability to destroy monolayers of tissue-cultured mammalian cells *in vitro* [49-50]. 30 µg/mL was very efficiently inhibited the growth of other protozoan parasites such as *Giardia lamblia, Leishmania major, Leptomonas colosoma,* and *Crithidia fasciculate* [50]. The methanolic extract of *A. sativum* bulbs was screened for *in vitro* and *in vivo* antileishmanial activity against *Leishmania major* strain (NLB 145) and *L. donovani* strain (NLB 065). BALB/c mice and golden hamsters (*Mesocricetus auratus*) were used in *in vivo* studies of *L. major* and *L. donovani*. The extract showed IC_{50} values of 34.22 µg/ml and 37.41 µg/ml against *L. major* and *L. donovani* promastigotes respectively, compared to 1.74 µg/ml against *L. major* and 1.18 µg/ml against *L. donovani* for Amphotericin B. The multiplication indices for *L. major* and *L. donovani* amastigotes in macrophages treated with 100 µg/ml of the extract were significantly decreased [51]. Cytotoxic potential of *A. sativum* on *L. major* (MRHO/IR/75/ER) promastigotes was determined using the MTT assay in order to find 50% inhibitory concentration (IC_{50}) of this herbal extract. *A. sativum* showed a dose-dependent cytotoxic effect in *L. major* with almost 100% death at a concentration of 93 µg/ml [52]**.** The therapeutic efficacy of (garlic 10% in petrolatum) was compared with (sulphur l0% in petrolatum) in 106 patients with scabies in three primary health care centers. It was found that the efficacy of sulphur 10% in petrolatum was (100%), while the efficacy of garlic 10% in petrolatum was (83.33%) [53-54].

1.1.5. Ammi majus

Mustafa and Al-Khazraji investigated the effects of the extracts *Ammi majus* against larval stage of *Culex pipiens* molestus Forskal. *Ammi majus* L. caused high mortality to the larvae after 7 days of treatment [55-56].

1.1.6. Anagyris foetida

Anagyris foetida was tested for its insecticidal effects, the oils and powders of *Anagyris foetida* possess insecticidal activity [57-58].

1.1.7. Antirrhinum majus

The iridoid glucoside, antirrhinoside, is constitutively distributed throughout Antirrhinum majus L. in a manner consistent with its possible role as an allelochemical. However, the insect herbivory of iridoid glucoside, antirrhinoside was studied. Two generalist herbivores, *Lymantria dispar* L. (gypsy moth) and *Trichoplusia ni* Hübner (cabbage looper) were chosen for feeding trials on excised whole leaves of A. majus and in artificial diet assays. In leaf excision feeding trials, fourth instar gypsy moth rejected, without sampling, the leaves of A. majus regardless of what node the leaf was excised from. In contrast, fourth instar cabbage looper readily fed on the excised leaves, and antirrhinoside was not found in their bodies or feces (frass) as determined by thin layer and high-pressure liquid chromatography. In the leaf and diet assays, a second major leaf iridoid in A. majus, antirrhide, was found in both cabbage looper and gypsy moth frass. In diet feeding assays, the growth of gypsy moth and cabbage looper were not inhibited by methanol extracts, iridoid fractions, or pure antirrhinoside at concentrations of 0.6% in diet, but cabbage looper growth was enhanced. At an antirrhinoside concentration of 3.3% in diet, gypsy moth growth was reduced, whereas cabbage looper growth again increased significantly relative to the control. It is likely that antirrhinoside functions as defense against herbivory for one generalist insect herbivore but also, at low concentrations, enhances the growth of another [59-60].

1.1.8. Apium graveolens

Apium graveolens seeds have been proven to possess nematocidal activity against *Caenorhabditis elegans* and *Panagrellus redivivus*, and mosquitocidal effects against *Ae. aegypti* fourth-instar larvae [61-64]. *Apium graveolens*, was investigated for anti-mosquito potential, including larvicidal, adulticidal, and repellent activities against *Aedes aegypti*. The ethanol extracted *A. graveolens* possessed larvicidal activity against fourth instar larvae of *Ae. aegypti* with LD_{50} and LD_{95} values of 81.0 and 176.8 mg/l, respectively. The abnormal movement observed in treated larvae indicated that the

toxic effect of *A. graveolens* extract was probably on the nervous system. In testing for adulticidal activity, celery extract exhibited a slightly adulticidal potency with LD_{50} and LD_{95} values of 6.6 and 66.4 mg/cm2, respectively. It showed repellency against *Ae. aegypti* adult females with ED_{50} and ED_{95} values of 2.03 and 28.12 mg/cm2, respectively. It also provided biting protection time of 3 h when applied at a concentration of 25 g%. Topical application of the ethanol-extracted *A. graveolens* did not induce dermal irritation. No adverse effects on the skin or other parts of the body of human volunteers were observed during 3 months of the study period or in the following 3 months, after stopping the treatment [65]. Sedanolide and two senkyunolides were found to be active against nematode, mosquito larvae and fungi [66].

1.1.9. Arachis hypogaea

The amoebicidal activity of ethanol extracts of *Arachis hypogaea* L. was evaluated *in vitro*. Acanthamoeba were isolated from keratitic patients, cultivated on 1.5% non-nutrient agar, and then incubated with different concentrations of peanut ethanolic to evaluated their cysticidal activity. The results showed that all extracts had significant inhibitory effect on the multiplication of Acanthamoeba cysts as compared to the drug control (chlorhexidine) and non-treated control, and the inhibition was time and dose dependent. The ethanol extract of A. *hypogaea* had a remarkable cysticidal effect with minimal inhibitory concentration (MIC) of 100 mg/ml in all incubation periods, while the concentrations of 10 and 1 mg/ml were able to completely inhibit growth after 48 and 72 h respectively. The concentrations 0.1 and 0.01 mg/ml failed to completely inhibit the cyst growth, but showed growth reduction by 64.4-82.6% in all incubation periods [67]. The toxicity of peanet stilbenoids was evaluated on adult mosquito and mosquito larvae. Six stilbenoids showed the highest activity and high lipophilicity activity. The lipophilicity characteristics seem to play a role in the toxicity of natural peanut stilbenoids to adult mosquito. Peanut stilbenoids with higher lipophilicity rapidly induced parentheses followed by death [68-69].

1.1.10. Artemisia campestris

Ethanolic extract from *Artemisia campestris* var *glutinosa* showed weak larvicidal ctivity against mosquito Culex Linnaeus (Diptera, Culicidae) larvae [70-72].

1.1.11. Arundo donax

Crude aqueous-methanol extracts of the leaves of *Arundo donax* and its chloroform, petroleum spirit and ethyle acetate fraction were tested against *H. contortus*. *Arundo donax* (25-50 mg/ ml) exerted anthelmintic effects ($P \geq 0.05$). 56.7% mortality of *H. contortus* was recorded by 10 hours post-exposure with crude aqueous methanol extracts of *Arundo donax* 50 mg/ ml. There was 100% mortality of worms in Levamisole (used as a reference drug) within 2 hours post-exposure. However , the anthelmintic effects of the plant were dose and time dependent. The ranking of efficacy of the *Arundo donax* fractions against *H. contortus* were ethyl acetate, chloroform aqueous followed by petroleum spirit fraction. Dose and time dependent ovicidal effects were recorded for the plant extracts. In egg hatch test , *Arundo donax* exhibited ovicidal activity with LC50 = 200.1 µg/ ml ; whereas, crude powder of *Arundo donax* resulted in 50.5% reduction in fecal egg count in sheep naturally infected with gastrointestinal nematodes [73-74]. *Arundo donax* extracts had anthelmintic properties (around 55% efficacy) against gastrointestinal parasites (Ascaris sp., Oesophagostomum sp. and Paramphistomum sp.) of cattle [75].

1.1.12. Asclepias curassavica

The MIC value of the hydro alcoholic extract (95%) of dried sap of plant, was found to be >250 µg/ml against *Entamoeba histolytica*. The plant showed no insecticidal effect [76-78].

1.1.13. Ballota nigra

Ballota nigra contained diterpenes, these compounds with well known insecticide and antifeedant activities. The whole plant of *Ballota nigra* L. is used in repellent fumigation against insects [79-81]. Root and stem flavonoids, terpenes and phenols present in ethanol, chloroform, and ethyl acetate soluble fraction; these were found to be the most active inhibiting fractions against all the tested strains of bacteria, fungi, and leishmania. While in leaves flavonoids, terpenes, and phenols were present in ethanol, chloroform, and n-butanol fractions which were the most active fractions against both types of microbes and protozoan (leishmania) in *in vitro* study [82].

1.1.14. Bauhinia variegata

The molluscicidal activity of *Bauhinia variegata* leaf was studied against vector snail *Lymnaea acuminata*. The toxicity of the plant was time and concentration-dependent. Among organic extracts, ethanol extracts of the plant were more toxic. The toxicity of *B. variegata* leaf ethanolic extract was (96h LC_{50}- 14.4 mg/L). The 24h LC_{50} of column purified

fraction of *B. variegata* was 20.3 mg/L. Saponin and quercetin were characterized and identified as active molluscicidal component [83-85].

1.1.15. Betula alba

Disuccinylbetulin, diglutaryldihydrobetulin, and disuccinyldihydro betulin of *Betula alba* inhibit the growth of *Leishmania donovani*, they reduced the intracellular parasite burden in macrophages infected with wild-type *L. donovani.* They targeting enzyme type IB topoisomerase of the parasite [86]. The *in vitro* antiplasmodial IC_{50} values of betulinic acid against chloroquine resistant and sensitive *Plasmodium falciparum* were found to be 19.6 µg/ml and 25.9 µg/ml respectively. Betulinic acid was also tested for *in vivo* activity in a murine malaria model (*P. berghei*). It was found that the top dosage employed (250 mg/kg/day) is ineffective in reducing parasitaemia [87-88].

1.1.16. Bidens tripartita

Ethanol extract of the dried whole plant (20 µg/ml) was active against *Plasmodium falciparum* [89-90].

1.1.17. Brassica nigra

Alcohoilc extract of the seeds of *Brassica nigra* Linn. was investigated for their anthelmintic activity against *Pheretima posthuma* and *Ascardia galli*. The effects of various concentrations (10-100 mg/ml) of extract were tested on the paralysis and time of death of the worms. Alcoholic extracts exhibited significant activity at high concentration (100mg/ml) [91-92].

1.1.18. Bryophyllum calycinum

The crude extracts contained tannins which produced anthelmentic activity. The chloroform, methanolic and aqueous extract of the plant root cause paralysis and deaths of worms and showed significant anthelmentic activity [39-95]. The antileishmanial effect of the plant extracts and its flavonoids components was evaluated *in vivo* in murine model of cutaneous leishmaniasis. Quercetin 3- O-α-L-arabinopyranosyl, α-L-rhamnopyranoside, quercetin 3-O-α-L- rhamno pyranoside and free quercetin were able to control the lesion growth caused by *Leishmania amazonensis* and significantly reduce the parasite load. These flavonoids were as effective as the crude aqueous extract which indicated that the antileishmanial effect could be attributed to flavonoids [96-97].

1.1.19. Caccinia crassifolia

The root methanolic extract showed antiplasmodial activity against the chloroquine-resistant and chloroquine-sensitive strains of *Plasmodium falciparum* with IC_{50} >64µg/ml and cytotoxic activity against human breast carcinoma cells (MCF7) and the Madin–Darby bovine kidney cells (MDBK), with IC_{50} >50µg/ml [98].

1.1.20. Caesalpinia crista

The isolated diterpenes especially as cassane, norcaesalpinin E and norcassane showed antimalarial activity, norcaesalpinin E showed the most potent activity, its effect was more potent than chloroquine [99-100]. The antimalarial effects of caesalpinins and nor-caesalpinins were also tested for their inhibitory activities against growth of *Plasmodium falciparum* FCR-3/A2 *in vitro*. All of them displayed different activities in a dose dependent manner. Caesalpinin K and norcaesalpinin F showed the most potent inhibitory activity with an IC_{50} value of 120 and 140 nM, respectively, and were less than that reported for chloroquine (IC_{50}, 283-291 nM) [101-102]. The bark extract of *Caesalpinia crista* (50 mg/ml) was evaluated for anthelmintic activity using adult earthworms, which exhibited paralysis with the adding of aqueous extract, the effect was compared with 3% piperazine citrate. There was no final recovery in the case of worms treated with aqueous extract in comparison with piperazine citrate. *Caesalpinia crista* also exerted anthelmintic activity against trichostrongylid nematodes of sheep [103]. The *Caesalpinia crista* seed kernel extract and fractions showed microfilaricidal, and female-sterilizing efficacy when used against *L. sigmodontin* and microfilaricidal, and female-sterilizing efficacy against *B. malayi* in animal models [104].

The antiascarid activity of *Caesalpinia crista* seeds was evaluated in chickens of the Fumi breed, suffering from artificially induced *Ascaridia galli* infection. Eggs per gram (EPG) counts were determined in the droppings of chickens prior and after treatment with powdered *Caesalpinia crista* at doses of 30, 40 and 50 mg/kg of body weight along with its extracts in water and methanol in amounts representing 50 mg/kg of crude powder. The crude drug at the dose rates of 40 and 50 mg/kg and its methanol extract induced a significant ($P < 0.001$) effect on post-treatment days 10 and 15, while, the 30 mg/kg dose was efficacious ($P < 0.05$) on day 15 only. However, the aqueous extract did not show significant results. These results suggest that a 50 mg/kg dose of *Caesalpinia crista* seed powder, its equivalent methanolic extract and piperazine (200 mg/kg) are equieffective in treating the ascarid infection of poultry. The crude

Caesalpinia crista powder appears to be potent and safer than its methanol extract on the basis of the side effects observed [105]. Wadkar *et al* also found that *Caesalpinia crista* exerted anthelmintic activity against *Phertima posthuma* and *Ascardia galli* [106]. *Caesalpinia crista* also showed anthelmintic effects against *Haemonchus contortus* and their eggs in adult motility assay and egg hatch test. *In vivo* anthelmentic activity was evaluated in sheep naturally infected with mixed species of gastrointestinal nematodes by administering crude powder (CP) and crude aqueous methanolic extract (AME) in increasing doses (1.0–3.0 g/kg). The plant exhibited dose- and time-dependent anthelmintic effects by causing mortality of worms and inhibition of egg hatching. LC_{50} for *Caesalpinia crista* was 0.134 mg/ml in egg hatch test. *In vivo*, it gave 93.9 % reduction in eggs per gram of faeces [107]. The *Caesalpinia crista* petroleum ether, ethanolic and aqueous extracts of dried leaves and fixed oil from the seeds at various concentrations were evaluated against the fourth instar larvae of *Culex quinquefasciatus*. Hundred per cent mortality was observed in 1% concentration of petroleum ether and ethanolic extract of leaf, whereas it was 55% in 2.5% concentration of aqueous extract and 92.6% in 2.5% concentration of fixed oil [108].

1.1.21. Calendula officinalis

The methanolic and ethanolic extract of leaves of *Calendula officinalis* was prepared in three different concentrations 5, 10 and 15 mg/ml for investigation of anthelmintic activity *in vitro* against Indian adult earth worm, *Pheretima posthuma*. The results suggested that both the extracts showed significant anthelmintic activity as compared to the standard drug (albendazole 10 mg/ml), and it was also noticed that higher concentrations depicted better anthelmintic activity *in vitro* [109-110]. Glycosides of oleanolic acid isolated from marigold (*Calendula officinalis*) inhibited the development of L3 *Heligmosomoides polygyrus* larvae, the infective stage of this intestinal parasitic nematode. In addition, both oleanolic acid and its glycosides reduced the rate of L3 survival during prolonged storage, but only oleanolic acid glucuronides affected nematode infectivity [111]. The effects of saponins of *Calendula officinalis* on the infectivity of *Heligmosomoides polygyrus* was evaluated in mice. The immune activation provoked by third-stage larvae exposed to *Calendula officinalis* glucuronides and the pattern of glycosylation of larval antigens which appeared to be crucial for induction of cytokine production in mice were examined; higher concentrations of IL-6, IFN-γ, IL-10 and TNF-α were observed in serum or intestine one week post infection. Three weeks later, in the chronic phase of infection, cells in culture were able to produce IL-6, IFN-γ, TNF-α and IL-17. Re-stimulation of cells with *H. polyigyrus* antigen resulted in reduced production of IL-6, and TNF-α. The pattern of cytokine production co-existed with reduced expression of terminal glucose, α-linked mannose, N-acetyl-galactosamine, β-galactose, N-acetyl-glucosamine and α-fucose in several protein bands. Galactose, as a new terminal carbohydrate residue appeared in 20-24kDa protein bands. The number of immunogenic epitopes in parasitic antigens was reduced; only three protein bands of 56, 26 and 12kDa were recognized by IgG [112].

1.1.22. Calotropis procera

Different extracts of *Calotropis procera* leaves were evaluated for *in-vitro* anthelmintic activity against Indian earthworms *Pheritima posthuma.* The perusal of the anthelmintic activity data reveals that 70% hydroethanolic extract at the concentration of 12.5 mg/ml showed paralysis and death in 18.58 and 29.05m. respectively. Similarly *n*-butanol and chloroform extract at the concentration of 12.5 mg/ml showed both paralysis in 21.03 and 48.26 and death in 26.53 and 51.25m. respectively. The effect was positively correlated with concentration [113-114]. The anthelmintic effect of crude aqueous (CAE) and methanolic extracts (CME) of *Calotropis procera* flowers was evaluated by *in vitro* and *in vivo* models in comparison with levamisole. The *in vitro* studies demonstrated the anthelmintic effects ($P<0.05$) of (CAE) and (CME) of *Calotropis procera* flowers on *Haemonchus contortus* as evaluated by mortality or temporary paralysis. For the *in vivo* studies, *Calotropis procera* flowers were administered as a crude powder (CP), CAE and CME to sheep naturally infected with a mixed sample of gastrointestinal nematodes. The percentage reduction in egg count (ECR) was recorded as 88.4 and 77.8 % in sheep treated with CAE and CP at a dose of 3000 mg/kg body weight respectively. CME was the least effective producing only a 20.9 % reduction in ECR on day 7 after the treatment. The anthelmintic activity of *Calotropis procera* against nematodes, was less than that exhibited by levamisole (97.8 %-100 %) [115]. The antischistosomal activity of *Calotropis procera* extracts was evaluated gainst *Schistosoma mansoni* in mice exposed to 80 ± 10 cercariae per mouse. They were treated orally (250-500 mg/kg for three consecutive days) by aqueous stem latex and flowers of *C. procera*, *Calotropis procera* latex and flower extracts were toxic (50–70% mortality) even in a small dose (250 mg/kg). *C. procera* (stem latex and flowers) extracts revealed significant *S. mansoni* worm reductions by 45.31 and 53.7% respectively. Extracts also produced significant reductions in tissue egg load (34–38.5%) and positively affected oogram pattern [116]. The ethanolic extracts of the different parts of *Calotropis procera* showed IC_{50} values ranging from 0.11 to 0.47 mg/ml against *P. falciparum* MRC20-chloroquine-sensitive, and from 0.52 to 1.22 mg/ml against MRC76- chloroquine -resistant strains, flower and bud extracts being the most active. Although 220-440 times less effective than chloroquine [117]. The saponins-rich fraction of *Calotropis procera* (cpsf) did not demonstrate an *in vitro* antitrypanosomal activity. Furthermore, the (cpsf) treatments did not significantly ($P>0.05$) keep the parasites lower than the infected untreated rat groups. At the end of the experiment, all *T. evansi* infected rats developed anemia whose severity was not significantly ($P>0.05$) and was ameliorated by the cpsf treatment [118]. The efficacy of

Calotropis procera against *Theileria annulata* infection in cattle was investigated. The efficacy of *C. procera* against *Theileria annulata* infection was higher (92.5%), compared with 75% of buparvaquone on 21 day post treatment. The result of liver and kidney function tests after treatment with *C. procera* showed no toxicity at the dose rate of 0.3 mg/Kg orally (8 doses on alternate days) [119]. Ethanolic extract of the leaves of *Calotropis procera* was fractionated using aqueous methanol with petroleum ether, chloroform and ethyl acetate. The residue of ethanol extract (marc) was extracted with 5M HCl, basified and then extracted with chloroform. These were labeled as CP1-01 to CP1-05 for the plant. The fractions obtained from the plant were found to be selectively active against brine shrimp larvae. These fractions were also subjected to antimalaria parasites bioassay. Fractions CP1-01, CP1-04 and CP1-05 were found to be active against the tested organisms, withCP1-04 being the most active [120]. The latex of *C.procera* (0-1-1%) has shown larvicidal efficacy against all three important vector species *viz*,. *Ae. aegypti*, *An. stephensi* and *Cx. quinqefaciatus*, vectors of dengue, malaria and Lymphatic filariasis respectively. The latex dissolved in methyl alcohol and acetonitrile showed highest larvicidal efficacy among all the experimental solvents [121]. In studying the comparative effectiveness of larvicidal potential of methanol extracted latex of *Calotropis procera* with temephos, a synthetic larvicide which is widely used in all vector control programme against *Aedes aegypti* mosquitoes, it appeared that methanolic extracted latex gave 100% mortality after 1 hour exposure, while water extracted latex gave 60% mortality after 3 hours exposure [122]. The toxic effects of *Calotropis procera* were evaluate upon egg hatching and larval development of *Aedes aegypti*. The whole latex was shown to cause 100% mortality of 3rd instars within 5 min. It was fractionated into water-soluble dialyzable (DF) and non-dialyzable (NDF) rubber-free materials. Both fractions were partially effective to prevent egg hatching and most of individuals growing under experimental conditions died before reaching 2nd instars or stayed in 1st instars. On the other hand, the fractions were very toxic to 3rd instars causing 100% mortality within 24h. When both fractions were submitted to heat-treatment, the toxic effects were diminished considerably suggesting low thermostability of the toxic compounds. Polyacrylamide gel electrophoresis of both fractions showed the presence of proteins in both materials. When submitted to protease digestion prior to larvicidal assays NDF lost most of its toxicity but DF was still strongly active. It may be possible that the toxicity involved protein and non protein molecules [123]. The crude ethanol extract of *Calotropis procera* leaves have been screened for its larvicidal activities against *Musca domestica*. The third instar larvae of housefly were treated with the different concentrations of the extract by dipping method for 48 h. The LC_{50} values of the extract of *C. procera* leaves was found to be 282.5 mg/l [124].

1.1.23. Canna indica

Anthelmintic activity of benzene and methanol extracts of various parts of *C. indica* was evaluated on *Pheritima posthuma*. Results showed that the methanolic extract of rhizomes of the plant took less time to cause paralysis of the earthworms [125]. The molluscicidal activity of ethanol , methanol, ether, chloroform and column purified fraction of *Canna indica* root extracts as well as root powder against the snail *Lymnaea acuminata* was studied. The molluscicidal activity of *C. indica* root was found to be time and dose dependent. The 24, 48, 72, 96 h LC_{50} of the column-purified root of *C. indica* was 6.54, 5.04, 4.07 and 1.84 mg/l respectively. Accordingly, *C. indica* may be used as potent molluscicides since the concentrations used to kill the snails were not toxic for the fish *Colisa fasciatus*, which shares the same habitat with the snail *L. acuminate* [126-127]. Sublethal *in vivo* 24 h exposure to (40% and 80% of 24 h LC_{50}) active fractions of *Canna indica* root alone or in combination with other plant-derived, significantly inhibited the activity of acetyl cholinesterase, acid/alkaline phosphatase, Na+K+ATPase and lactic dehydrogenase in the nervous tissue of *Lymnaea acuminata*. The inhibition kinetics of these enzymes indicates that active fractions of both the plants caused a competitive inhibition of AChE, LDH, ALP, ACP and Na^+K^+ATPase [128].

1.1.24. Capparis spinosa

Both the alcoholic and aqueous extracts of C. spinosa displayed significant antihelminthic properties at high concentrations. Both extracts showed antihelminthic activities in a dose-dependent manner giving short time of paralysis and death with 400 mg/ml concentration. The alcoholic extract induced paralysis of the earthworm L. terrestris in 6.16 minutes and death in 9.1 minutes, while the aqueous extract showed paralysis and death in 21.83 and 34.5 minutes respectively. In the mean time, albendazole (20 mg/ml) caused paralysis of the earthworm in 8.6 minutes and death in 32.23 minutes [129-130].

1.1.25. Carum carvi

The anti-plasmodial activity of 47 plant essential oils and 10 of their constituents were screened for *in vitro* activity against *Plasmodium falciparum*. Five of these essential oils (sandalwood, caraway, monarda, nutmeg, and *Thujopsis dolabrata var. hondai*) and 2 constituents (thymoquinone and hinokitiol) were found to be active against *P. falciparum in vitro*, with 50% inhibitory concentration (IC_{50}) values equal to or less than 1.0 microg/ml. Furthermore, *in vivo* analysis using a rodent model confirmed the anti-plasmodial potential of percutaneously administered caraway oil against rodent *P. berghei*. Notably, caraway oils showed no efficacy when administered orally, intraperitoneally or

intravenously. Caraway oil dissolved in carrier oil, applied to the skin of hairless mice caused high levels in the blood, with concentrations exceeding its IC_{50} values [131-132]. The essential oil of Caraway was found to possess strong contact toxicity against *Sitophilus zeamais* and *Tribolium castaneum* adults, with LD_{50} values of 3.07 and 3.29 µg/adult respectively, and also showed strong fumigant toxicity against the two grain storage insects with LC_{50} values of 3.37 and 2.53 mg/l respectively. (R)-Carvone and D-limonene showed strong contact toxicity against *S. zeamais* (LD_{50}= 2.79 and 29.86 µg/adult) and *T. castaneum* (LD_{50} = 2.64 and 20.14 µg/adult). (R)-Carvone and D-limonene also possessed strong fumigant toxicity against *S. zeamais* (LC_{50} = 2.76 and 48.18 mg/l) and *T. castaneum* adults (LC_{50} = 1.96 and 19.10 mg/l). Plant essential oils from 26 plant species were tested for their insecticidal activities against the Japanese termite, *Reticulitermes speratus* Kolbe, using a fumigation bioassay. Responses varied with source, exposure time, and concentration. Among the essential oils which showed strong insecticidal activity were the essential oils of caraway [133]. The molluscicidal activity of the seed powder of *Carum carvi* was studied against the snail *Lymnaea acuminata*. The molluscicidal activity was found to be both time and concentration dependent. The toxicity of *C. carvi* (96 h LC_{50}) was 140.58 mg/l. Ethanol extract was more toxic than other organic extracts. The toxicity of the ethanol extract of *C. carvi* (24h LC_{50} was 130.61 mg/l). The 96 h LC_{50} of column purified fraction of seed powder of *C. carvi* was 5.40 mg/l [134].

1.1.26. Cassia occidentalis

The anthelmintic activity of ethanolic extract of *Cassia occidentalis* was evaluated using adult earthworm *Pheritima posthuma.* Various concentrations (25, 50, 75 mg/ml) of all extracts were tested and the results were expressed in terms of time for paralysis and time for death of worms. Dose dependent activity was observed in all extracts *Cassia occidentalis* [135-136]. *In vitro* egg hatch assay and larval development tests were conducted to determine the possible anthelmintic effects of crude aqueous and hydro-alcoholic extracts of the leaves of *Cassia occidentalis*. The aqueous extract of *Cassia occidentalis* induced complete inhibition of egg hatching at concentration less than or equal to 1 mg/ml. Aqueous and hydro-alcoholic extracts of *Cassia occidentalis* shown statistically significant and dose dependent egg hatching inhibition. The plant extracts have shown remarkable larval development inhibition. Aqueous extracts of *Cassia occidentalis* induced 96.36% inhibition of larval development [137]. Antimalerial effects of *Cassia occidentalis* was documented by many studies [138-139]. The ethanolic, dichloromethane and lyophilized aqueous extracts of *Cassia occidentalis* root bark were evaluated for their antimalarial actvity *in vivo*, in 4-day, suppressive assays against *Plasmodium berghei* ANKA in mice, no toxic effect or mortality was observed in mice treated, orally, with any of the extracts as a single dose of 500 mg/kg body weight, or as the same dose given twice weekly for 4 weeks (to give a total dose of 4 g/kg). No significant lesions were observed, by eye or during histopathological examinations, in the hearts, lungs, spleens, kidneys, livers, large intestines or brains of the mice. At doses of 200 mg/kg, the ethanolic and dichloromethane extracts produced significant chemosuppressions of parasitaemia (of > 60%). The lyophilized aqueous extract was less active than the corresponding ethanolic extract [140]. The larvicidal potential of ethanol extract of *Cassia occidentalis* was tested against the larvae of *Anopheles stephensi*. The ethanol extract of *Cassia occidentalis* was found most effective with LC_{50} value was 60.69%-92.21%. The smoke toxicity was more effective against the *Anopheles stephensi*. Smoke exposed gravid females oviposited fewer eggs when compared to those not exposed [141]. The leaves of *Cassia occidentalis* were used to protect cowpea seeds (*Vigna unguiculata*) against *Callosobruchus maculatus*. The biological activity of the leaves, the seeds and oil of *C. occidentalis* was evaluated against *C. maculatus*. At the rate of 10 % (w/w), both fresh and dry leaves as well as whole and ground seeds had no contact toxicity on the cowpea beetle. In contrast, seed oil increased mortality of *C. maculatus* eggs and first larval instar at the concentration of 10 ml/kg cowpea [142]. The larvacidal effect of methanolic extract of *Cassia occidentalis* leaf, at various concentrations was evaluated against malarial vector (mosquito larva). The plant extract exhibited larvacidal activity at different time intervals (24 hrs and 48 hrs). The mosquito larva of LC_{50} and LC_{90} values of *Cassia occidentalis* for I instar larvae were 60.69%, 119.74%, for the II instar were 64.76%, 121.60%, for the III instar were 67.78%, 123.35%, for the IV instar were 70.56%, 122.81% and for pupa were 92.21%, 162.52% respectively [143]. *Cassia occidentalis* ethanolic leaves extract was evaluated for its effectiveness to suppress wood damage by workers termite (Isoptera: Rhinotermitidoe). Bioassay was conducted in plastic containers. Extract was prepared into different concentration (0.5, 1.0 and 1.5 g) and inoculated into separate plastic containers containing 20 g of disinfested wood sample which correspond to 2.5, 5.0 and 7.5% w/w, respectively. Forty workers termite were introduced into these containers. Mortality of the insect was assessed after 24h interval. The result showed that *C. occidentalis* ethanolic extracts in all concentrations caused mortality of the workers termite within the shortest duration of application when compared with the untreated wood. 100% mortality of workers termite was observed on wood treated with *C. occidentalis* extract at all level of application after 120h of treatment [144].

1.1.27. Celosia cristata

The chloroform, methanol and aqueous extract of *Celosia cristata* leaves (100 mg/ml and 200 mg/ml) were used to determine the paralysis and mortality of earthworms, Pheretima *posthuma* in comparison with albendazole (100 mg/ml and 200 mg/ml). Worms placed in both aqueous and methanol extracts of *C. cristata* showed significant paralysis and

leads mortality in dose dependent manner. Chloroform extract showed no significant activity against the worms. The results revealed that the aqueous extract had higher significant anthelmintic activity than methanol extract [145-146].

1.1.28. Chenopodium album

The anthelmintic activity of the plant (50, 25 and 12.5 mg/ml) was recorded against adult Indian earthworm, *Pheretima posthuma* [147-148]. *In vitro* anthelmintic activity of crude aqueous methanolic extract (AME) of *Chenopodium album* whole plant was studied using mature *Haemonchus contortus* and their eggs in adult motility assay and egg hatch test respectively. *In vivo* anthelmintic activity was evaluated in sheep naturally infected with mixed species of gastrointestinal nematodes by administering crude powder (CP) and AME in increasing doses (1.0-3.0 g/kg). Extracts exhibited dose- and time-dependent anthelmintic effects by causing mortality of worms and inhibition of egg hatching. LD_{50} for *Chenopodium album* was found to be 0.449 mg/ml in egg hatch test. *In vivo*, maximum reduction in eggs per gram (EPG) of faeces was recorded as 82.2% at 3.0 g/kga of *Chenopodium album* AME [149].

Insecticidal effect was exerted by the petroleum ether, carbon tetrachloride and methanol extract of *Chenopodium album* against malaria vector, *Anopheles stephensi* Liston. It influenced the early life cycle of *Anopheles stephensi* by reducing the percentage of hatching, larval, pupal and adult emergence and also lengthening the larval and pupal periods. The growth index was also reduced significantly [150]. The biological effect of polar and non-polar secondary metabolites from the aerial parts (leaves and inflorescences) of *Chenopodium album* against *Oryzaephilus surinamensis* was studied. The results show that the aqueous extract of *C album* was effective with low percentage survival of adult and larval stages [151].

1.1.29. Chrysanthemum cinerariaefolium

The main use of pyrethrum at present is in household formulations to kill houseflies, cockroaches and mosquitoes. Insects react very quickly when dosed with pyrethrum, and this quick knock-down effect is a very valuable property for household insecticides as the user sees the onset of paralysis within 2–3 minutes. Pyrethrum acts on a very wide spectrum of insect species – more so than with most individual synthetic insecticides. It is also a very powerful repellent to mosquitoes. The process of piercing the skin using saliva injected as a lubricant, finding and piercing a blood capillary followed by sucking of blood into the insect is a very precise and complicated process and coordination is lost when even a few molecules of pyrethrum are present. Synergised pyrethrum formulations are particularly effective against the mosquitoes and midges, which bite humans, and to date there have been no reports of resistance developing in these species to this biopesticide. Pyrethrins are very quickly degraded in sunlight leaving no toxic residues and are ideal for use as pre-harvest sprays to remove insect pests on edible crops – up to 24 hours before harvest [152-153].

The efficacies of pyrethrum and albendazole against experimental sheep gastrointestinal nematode infection were compared. Sheep were infected orally with 10,000 larvae (Haemonchus spp. (60.1%), Oesophagostomum spp. (13.9%), Trichostrongylus spp. (13.2%), Cooperia spp. (8.3%), Nematodirus spp. (3.5%), Strongyloides spp. (0.8%) and Ostertagia spp. (0.2%). Faecal egg count reduction in albendazole treated sheep was 100% by day 4 following treatment, compared to 37.03%, 31.3%, 38.9% and 51.8% on days 4, 6, 8 and 10 in pyrethrum treated sheep. These effects were statistically significant on days 8 and 10 posttreatment ($p< 0.05$) [154].

1.1.30. Cichorium intybus

It appeared that the animals grazing on chicory have a lower incidence of gastrointestinal nematode infestations, the total number of abomasal helminths was found to be lesser in the lambs grazing on this plant. The anthelmintic activity of the plant attributed to the condensed tannins and sesquiterpene lactones [155-156]. The effects of condensed tannins (CT) and an extract containing crude sesquiterpene lactones (CSL) from chicory (*Cichorium intybus*) on the motility of the first- (L1) and third-stage (L3) larvae of deer lung worm *Dictyocaulus viviparus* and the L3 larvae of gastrointestinal nematodes was studied *in vitro*, using the larval migration inhibition (LMI) assay. The CT and CSL had a profound effect on the motility of the larvae displayed by their ability to inhibit larval passage through nylon mesh sieves. Incubation of lungworm L1 larvae in rumen fluid (collected from deer fed pasture) containing 100, 400 and 1000 microg CT/ml, inhibited 12, 28 and 41% of the larvae from passing through the sieves, respectively, while the incubation of L3 larvae with rumen fluid (pH 6.6) containing the same concentrations inhibited 26, 37 and 67% of L3 larvae from passing through the sieves, respectively. Gastrointestinal larvae seem more susceptible to CT than lungworm larvae especially at higher concentrations. CT inhibited 27, 56 and 73% of gastrointestinal larvae from passing through the sieves when used at a concentration of 100, 400 and 1000 microg/ml, respectively. CT were more effective ($P<0.001$) at reducing the motility of lungworm L1 and L3 larvae when added to the rumen fluid than when added to the abomasal fluid (pH 3.0). Addition of 2 microg polyethylene glycol/microg CT eliminated the inhibitory effect of CT against L1 and L3 larvae especially during incubation in rumen fluid, confirming the effect as due to CT. The CSL extract also showed similar

inhibitory activity against L1 and L3 lungworm and L3 gastrointestinal larvae in both fluids, indicating that this extract was not affected by the pH of the fluid, and was more effective against L3 than L1 lungworm larvae. Condensed tannins appeared to be more effective than CSL at inactivating L1 and L3 lungworm and L3 gastrointestinal larvae in rumen fluid, but CSL were particularly effective against L3 lungworm larvae in abomasal fluid [157-158].

To determine whether the individual sesquiterpene lactone compounds of *Cichorium intybus* [lactucin (LAC), 8-deoxylactucin (DOL), and lactucopicrin (LPIC)] differ in anthelmintic activity, their effects were studied on the hatching of a predominantly *Haemonchus contortus* egg population. The dominant constituents in the Puna and Forage Feast extracts were DOL and LAC, respectively; LPIC concentrations in the two extracts were similar. Extracts from both cultivars inhibited egg hatching at all concentrations tested ($P<0.001$), but there were significant differences in egg responses to the two extracts ($P<0.001$). With Puna, egg hatching decreased sharply in a linear fashion when the combined LAC, DOL, and LPIC concentrations ranged from 0 to 5.0 mg/ml. A biphasic effect on egg hatching occurred with the Forage Feast extract. The fraction of eggs that hatched decreased gradually to 65% as the sesquiterpene lactone concentrations increased from 0 to 6.7 mg/ml. Treatment with higher concentrations resulted in a sharp decline in egg hatchability. Concentrations of sesquiterpene lactones required for 50% lethality were determined by probit dose-effect analysis to be 2.6 mg/ml (95% confidence interval: 2.4-2.8 mg/ml) for the Puna extract and 6.4 mg/ml (95% confidence interval: 5.9-7.2mg/ml) for the Forage Feast extract ($P<0.0001$). These concentrations provided 1.3 and 1.5mg/ml of DOL and 0.8 and 3.9 mg/ml of LAC for Puna and Forage Feast extracts, respectively. However, the results showed that LAC has minimal effect on egg hatching [159].

The bitter compounds in the plant, namely, lactucin, lactucopicrin, and the guaianolide sesquiterpenes, isolated from aqueous root extracts of chicory were concluded to be the antimalarial components of the plant. Lactucin and lactucopicrin completely inhibited the HB3 clone of strain Honduras-1 of *Plasmodium falciparum* at concentrations of 10 and 50 μg/ml, respectively [160-161].

1.1.31. Citrullus colocynthis

Albino mice were intraperitionally infected with 100 X 10^6 promastigotes of *Leishmania donovani* (MHOM/ IQ/ 982/BRCI) strain. The inoculation of albino mice caused elevation of liver and spleen weight after 7-15 days. The mice treated with 20-100 mg/kg from *Citrullus colocynthis* showed decreased average liver and spleen weight in comparison to the positive control. The most important histopathologcal results in the positive control included scattered necrosis, lymphatic infiltration, proliferation of macrophages and a variable number of leishman bodies were observed. 80-100 mg/kg of *Citrullus colocynthis* return liver section to normal histology [162-163].

Larvicidal activity of crude hexane, ethyl acetate, petroleum ether, acetone, and methanol extracts of the leaf of five species of cucurbitaceous plants, *Citrullus colocynthis, Coccinia indica, Cucumis sativus, Momordica charantia*, and *Trichosanthes anguina*, were tested against the early fourth instar larvae of *Aedes aegypti* L. and *Culex quinquefasciatus* (Say) (Diptera: Culicidae). The larval mortality was observed after 24 h of exposure. All extracts showed moderate larvicidal effects; however, a high larval mortality was found in petroleum ether extract of *Citrullus colocynthis* against the larvae of *A. aegypti* (LC_{50}=74.57 ppm) and against lymphatic filariasis vector, *C. quinquefasciatus* (LC_{50}=88.24ppm) [164].

The larvicidal activity of crude acetone, hexane, ethyl acetate, methanol, and petroleum ether extracts of the leaf of *Citrullus colocynthis* (Linn.) Schrad were assayed for their toxicity against the early fourth instar larvae of *Culex quinquefasciatus* (Diptera: Culicidae). The larval mortality was observed after 24 h exposure. The highest larval mortality was found in whole plant petroleum ether extract of *Citrullus colocynthis*. Bioassay-guided fractionation of petroleum ether extract led to the separation and identification of fatty acids; oleic acid and linoleic acid were isolated and identified as mosquito larvicidal compounds. Oleic and linoleic acids were quite potent against fourth instar larvae of *Aedes aegypti* L. (their LC_{50} were 8.80, 18.20 and LC_{90} 35.39, 96.33 ppm respectively), *Anopheles stephensi* Liston (LC_{50} 9.79, 11.49 and LC_{90} 37.42, 47.35 ppm respectively), and *Culex quinquefasciatus* Say (LC_{50} 7.66, 27.24 and LC_{90} 30.71, 70.38 ppm respectively) [165].

Methylene chloride, n-hexane, chloroform and ethanol extracts of *Citrullus colocynthis* fruits were tested against *Aphis craccivora*. The highest insecticidal effect (LC_{50}: 11003 ppm) was obtained from the ethanol extract. The residue remaining after evaporation of ethanol extract was re-extracted by different solvents with increasing polarity. Each fraction was tested against *Aphis craccivora*. The butanol extract showed the maximum insecticidal effect. The effective compound was identified as 2-O-β-D-glucopyranosylcucurbitacin E [166].

Citrullus colocynthis was evaluated as new therapeutic approach for scorpion envenomation mainly *Androctonus australis* hector venom (Aah). Local action (paw edema) and systemic effects (inflammatory, metabolic parameters, oxidative stress and hyperglycemia) were studied in pretreated mice with *Citrullus colocynthis* (50 mg/kg), 30 min before injection of sublethal dose of *Androctonus australis* hector venom (10 µg/20 g). Results showed that injected *Citrullus colocynthis* extract before envenomation is able to protect animals against the toxicity of the venom. It significantly reduced paw edema, cell migration, exudation, hyperglycemia, and MDA. *Citrullus colocynthis* decreased also some inflammatory markers (MPO and EPO activities, CRP and C3) and maintain the level of CPK, ASAT and ALAT. *Citrullus colocynthis* appeared to be a potential tool that can reduce pathophysiological effects induced after envenomation (inflammation and oxidative stress) [163].

1.1.32. Citrus species

Methanolic extract of *Citrus medica* was evaluated for anthelmintic activity against Indian adult earthworm *Pheritima posthuma*. Various concentrations of extract were tested and results were expressed in terms of time for paralysis and time for death of worms. Piperazine citrate (10 mg/ml) was used as a reference standard and distilled water as a control group. Dose dependent anthelmintic activity was possessed by the methanolic extract of *Citrus medica* [167].

Petroleum ether extracts of *Citrus medica* leaves also possessed dose dependant anthelmintic activity against the Indian adult earthworms (*Pheretima posthumad*). The effect which could be attributed to inhibition of glucose uptake in the parasites and depletion of its glycogen synthesis. It also activated nicotinic cholinergic receptor in the worms resulting in either persistent depolarization or hyperpolarization [168].

The anthelmintic activity of petroleum ether extract of the peels of *Citrus sinensis* was studied against Indian adult earthworms, *Pheretima posthuma,* it exhibited a dose dependent inhibition of spontaneous motility (paralysis), and evoked responses to pin-prick, and the effects were comparable with that of piperazine citrate [169].

The effect of aqueous extract of this *Citrus medica* on viability of the protoscolices of *Echinococcus granulosus in vitro*, in a concentration of 90 mg/ml, the aqueous extract was effective in killing all protoscolices after four days of incubation [170].

Alcoholic extracts of the rind of *Citrus medica* showed *in vitro* anthelmintic activity against human Ascaris lumbricoides [171].

The larvicidal potential of hexane and petroleum ether extracts of *Citrus limetta* peels was assessed against dengue fever vector, *Aedes aegypti*, and malarial vector, *Anopheles stephensi*, by evaluating the toxicity effects on early fourth instars. Both the extracts were found effective against both the species. The bioassay with hexane extracts resulted in LC_{50} values of 132.45 and 96.15 ppm against *A. stephensi* and *A. aegypti*, respectively; while the petroleum ether extracts from the *C. limetta* peels showed LC_{50} values of 244.59 and 145.50 ppm, respectively. It revealed that the hexane extracts possessed 1.9-fold more larvicidal potential against *A. stephensi* and 1.5-fold more efficacy against *A. aegypti* as compared to the extracts obtained using petroleum ether as solvent. The data further revealed that the extracts were 1.4-1.7 times more effective against *A. aegypti* as compared to *A. stephensi* [172].

The mosquito repellent activity of extracts from Peels of five citrus fruit species, *Citrus sinensis*, *Citrus limonum*, *Citrus aurantifolia*, *Citrus reticulata* and *Citrus vitis*, were studied using five different concentrations, 5%, 10%, 15%, 20% and 25% (volume by volume). Topical application of the extract concentrations on human volunteers revealed that 20% and 25% repelled mosquitoes 2 hours and 5 hours, respectively. Short-lived and mild skin itching and sneezing reactions were observed as side effects [173-174].

1.1.33. Clerodendrum inerme

Leaf extracts were evaluated for their nematicidal efficacy against root-knot nematodes. In the juvenile mortality assay against egg masses, leaf extracts of *C. inerme* significantly inhibited the development [175-176].

The aqueous extract of *Clerodendron inerme* (*C. inerme*) plant leaves was evaluated against laboratory strain *Aedes aegypti* larvae. The extract elucidated 100% inhibition of adult emergence at 2% concentration of extract, and concentrations above 4% led to prolongation of larval developmental period without moulting leading to death during larval stage. Mortality during larval stage was found to be dose-dependent elucidating 100% mortality at 16% concentration. It is apparent that the extract interferes in the developmental process affecting larval developmental period and disruption of larval-pupal moult [177].

Laboratory and field investigations have been made to evaluate the combined effect of *Clerodendron inerme* and *Acanthus ilicifolius* on three species of mosquito vectors, *Anopheles stephensi, Aedes aegypti* and *Culex quinquefasciatus.* Different concentrations of *Clerodendron inerme* and *Acanthus ilicifolius* have been tested on the various stages of species of mosquito vectors*.* They were active against different larval stages of mosquitoes. The lethal effect on mosquito larvae may be due to the active plant compounds on the gut lining of the mosquito larvae. The larval density was decreased after the treatment with the *Clerodendron inerme* extracts at the breeding sites (drinking water and ditches water) [178].

The dry powder of *Clerodendrum inerme* leaves was tested (10 to 60 mg) against freshly moulted fourth instar larvae of dengue mosquito vector *Aedes aegypti*. The results revealed that there was no larval mortality in the treated larvae and they moulted to pupae after 60h from the start of the experiment and the process was completed by 72h. Control larvae also required 60–72h to pupate. There were no visible behavioural changes in the treated larvae, except for the fact that they were not as active as those of control ones after 24h of treatment. During pupal stage also, the pupae in treated flasks were not as active as control groups. Flasks containing 40, 50 and 60 mg powder showed pupal mortality after about 18-20h. At the end of 72h, the percent pupal mortality in the same treated groups was 48, 74 and 96 respectively. Flasks containing 20 and 30 mg of powder exhibited less than 10% pupal mortality. In order to determine the quantity of powder required to cause larval mortality, the quantity of powder was increased from 100 to 200 mg with 20 mg increment between the treatments. The results showed dose-dependent larval mortality. As much as 85% larval mortality was seen when the powder quantity was increased to 160 mg. It was further noted that the fourth instar larvae that moulted to pupae died during the early pupal stage. The final analysis of results revealed 100% mortality in all the experimental flasks, which included larval as well as pupal mortality. Microscopic examination of dead larvae revealed that the larval cuticle had started sclerotization, which appeared to be a characteristic feature of the pupal cuticle. The dead pupae on the other hand, showed less sclerotization of the cuticle compared to untreated ones, and in majority of the pupae, the head capsule remained attached to the pupal head [179]. It was stated that petroleum ether extract of *Clerodendrum inerme* gave 3h protection against mosquitoes at 9% concentration [180].

The Petroleum ether, Chlorofrom, Ethyl acetate, Ethanol and water fractions of the powdered leaves of *Clerodendrum inerme* were tested for their efficacy against the stored grain insect pest *Corcyra cephalonica* (Stainton) (Lepidoptera Pyralidae). Seven different doses (0.05, 0.1, 0.15, 0.5, 1.0, 1.5, and 2.0 g) per 20.0 g of rice were tested against this common insect pest of rice to evaluate their effect on its life cycle and mortality. Three higher doses were further tested for their effect on physiological parameters like total haemocyte count (THC), total protein content and glycogen level along with starved insects. *C. inerme* exhibited biopesticidal activity as evidenced by the high mortality rate in treated insects. There was also a significant reduction in the THC (39-53%), protein (30-38%) and glycogen (40-61%) content in *C. inerme* treated larvae with respect to their controls [181].

The efficacy of *Clerodendron inerme* leaf extract was evaluated against *Pieris brassicae*. Larva, pupa and adult of *P. brassicae* have been treated with the aqueous extract of *C. inerme* leaf of different concentration. The results show that extract was quite effective against all the three stages in general, and pupa in particular. A typical extract with 12.5% concentration showed a mortality rate of 20% for larvae which rises to 55% for pupa. The mortality rate generally increases with increase in the concentration, reached to its maximum at 10% to 17.5% of concentration and then decreased or became constant for different developmental stages [182].

1.1.34. Clitoria ternatea

The ethanolic extract of *Clitoria ternatea* (100mg/ml) bring paralysis within 15-20 min and bring death within 28-30 min to the Indian earthworm *Pheritima posthuma* [183-184]. However, the anthelmintic activity of ethanolic extracts of flowers, leaves, stems and roots of *Clitoria ternatea* were also evaluated on adult Indian earthworms *Pheretima posthuma.* Results showed that roots of the *Clitoria ternatea* took less time to paralyze and death of the earthworms. Roots were further extracted successively with petroleum ether, chloroform, ethyl acetate and methanol and these extracts were screened for anthelmintic activity. Results showed that methanol extract of *Clitoria ternatea* root is the more potent [185].

The *in vitro* comparative study of anthelmintic activity of aqueous and ethanolic extracts of leaves of *Clitoria ternatea* was carried out against *Eisenia foetida* at three different concentrations (100, 50, 25 mg/ml). The study involved the determination of time of paralysis and time of death of the worms. At the concentration of 100 mg/ml both the ethanolic and the aqueous extracts showed very significant anthelmintic activities as compared to the standard drug, levamisole (0.55 mg/ml). In case of aqueous extract the time of paralysis and death time was observed as 18 ± 1.57 min and 53.33 ± 0.33 min, and in case of ethanolic extracts 12.33 ± 0.80 min and 32.33 ± 0.71min respectively [186].

The mosquito larvicidal activity of *Clitoria ternatea* was investigated against three major mosquito vectors *Aedes aegypti, Culex quinquefasciatus*, and *Anopheles stephensi*. Among the methanol extracts of *Clitoria ternatea* leaves, roots, flowers, and seeds, the seed extract was effective against the larvae of all the three species with LC_{50} values 65.2, 154.5, and 54.4 ppm, for *A. stephensi, A. aegypti,* and *C. quinquefasciatus* , respectively. Among three tested plant species, *Clitoria ternatea* was showing the most promising mosquito larvicidal activity [187].

1.1.35. Corchorus capsularis

The mosquitocidal activities of *Corchorus capsularis* against a common malarial vector, *Anopheles stephensi* and a dengue vector *Aedes aegypti* was studied. The larvicidal activity exerted by ethyl acetate was more prominent than acetone and methanol extracts in all concentrations tested against *Ae. aegypti* larvae. Evaluation of the lethal concentration values (LC_{50} and LC_{90}) of acetone, ethyl acetate and methanol extract of the plant against *An. stephensi* and *Ae.aegypti* revealed that LC_{50} of 197.34ppm and LC_{90} of 358.59ppm was recorded for acetone extract against the *An. stephensi*; furthermore, the larvae of *Ae. aegypti* showed the LC_{50} and LC_{90} values of 222.45 and 383.06ppm respectively, with the treatment with the acetone extract of *Corchorus capsularis*. Minimum LC_{50} values were observed among the experimental larval groups treated with methanol extract of *Corchorus capsularis* were 176.19ppm and 182.06ppm against *An. stephensi* and *Ae. Aegypti* respectively. With regard to the ovicidal activity of acetone, ethyl acetate and methanol extract, it was apparent that 300 -450 ppm concentrations resulted with no hatchability on *An. stephensi* and 375-450pp concentrations in *Ae. aegypti*. The authors refered to the possible utilization of *Corchorus capsularis* to control mosquito menace to a greater extent [188].

The efficacy of emulsified petroleum ether extract of *Corchorus capsularis* seed was studied against three stored product pests (*Callosobruchus chinensis*, *Sitophilus oryzae* L and *Tribolium castaneum* Herbst) in adult phase. The residual film technique method was conducted to determine the LC_{50} value of the mentioned plant extract against three stored product pests. LD_{50} (µg /cm) of *Corchorus capsularis* against *C. chinensis* was 74.26 (50.26 **-** 109.74) after 24 hrs and 6.67 (0.49 - 90.07) after 48hrs. LD_{50} against *S. oryzae* was 84.61 (61.98-115.50) after 24 hrs and 32.87 (16.03-67.39) after 48hrs. While, LD_{50} against *T. castaneum* was 547.08 (477.38 - 626.97) after 24 hrs and 452.51 (380.30 - 538.42) after 48hrs [189].

However, On the other hand, in studying of the role of jute leaf (*Chorchorus capsular*) phytochemicals on feeding, growth and reproduction of *Diacrisia casignetum* Kollar (Lepidoptera: Arctiidae), it appeared that the larval and post larval developmental duration was shorter on mature jute leaf fed insects whereas adult longevity was higher in it ($P < 0.05$) relative to young and senescent leaf fed insects. Fecundity of *D. casignetum* was also highest on mature leaves followed by young and senescent leaves. The growth and development of *D. casignetum* were related to the nutrient content relative to the secondary metabolites of these three types of jute leaves. Higher levels of nutritional factors (total carbohydrates, proteins, lipids, nitrogen and amino acids including water content) and lower levels of anti-nutritional factors (secondary metabolites) in mature jute leaves have influenced lower developmental time along with higher growth rate, fecundity and accumulated survivability of *D. casignetum* than the young and senescent leaves [190-191].

1.1.36. Cordia myxa

The anti-leishmanial activity of the mucilage extract of *Cordia myxa* was examined against promastigotes of *L. infantum* (MCAN/IR/96/LON49) and *L. major* (MRHO/IR/75/ER) (1×10^6 cells/ ml). They were seeded in a 96-well microtiter plate, in the presence of the serial concentrations (0, 0.61, 1.22, 2.44, 4.88, 9.75, 19.5, 39, 78, and 156 mg/ ml w/v) of the extract and then incubated at 24°C, for 72 hours. Antileishmanial activity was assayed by light microscopy and (3-(4,5-dimethylthiazol-2-yl)-2,5 diphenyl tetrazolium bromide) MTT method. The concentration inhibiting parasite growth by 50% (IC_{50} value) was calculated with a sigmoid dose-response curve. Mucilage extract of *Cordia myxa* was active against promastigotes form of *L. major* and *L. infantum*, with an IC_{50} of 26 ± 2.2 mg/ml and an IC_{50} of 35 ± 2.2 mg/ml, respectively. The survival percentage of *L. major* and *L. infantum* promastigotes after 72 hours treatment appeared concentration dependent. Percentage of survival *Leishmania major* after 72 hours reached 17.68% in a concentration of 156 mg/ml, while the percentage of survival of *L. infantum* promastigotes after 72 hours reached 16.68% in a concentration of 156 mg/ml [192-193].

Cordia myxa were tested for antiplasmodial activity. Antimalarial effects were quantified with respect to inhibition of parasite growth, as measured by the production of *Plasmodium* lactate dehydrogenase. Alkaloids extract of *Cordia myxa* showed good antiplasmodial activity, IC_{50} was 6.2 µg/ml, while dichloromethane extract of *Cordia myxa* showed moderate antiplasmodial activity IC_{50} was 4.2 µg/ml, followed by aqueous and methanol extracts [194].

The crude alkaloid compounds for *Cordia myxa* leaves was tested against *Culex pipines* at (10, 7.5, 5, 2.5, 0) mg /ml. It possessed significant effect on some biological aspects of *Culex pipines*. The results showed that of eggs and larval stages

(1st, 2nd, 3th, 4th) was (13.38 , 0, 0, 0, 0) respectively in 10 mg /ml. At the same concentration, it also reduced productivity from 320 egg / female to 0 egg / female [195].

1.1.37. Coriandrum sativum

Commercial essential oils from 28 plant species were tested for their nematicidal activities against the pine wood nematode, *Bursaphelenchus xylophilus*. The best nematicidal activity against *B. xylophilus* was achieved with essential oils of coriander (*Coriandrum sativum*) [196].

In vitro anthelmintic activities of crude aqueous and hydro-alcoholic extracts of the seeds of *Coriandrum sativum* were investigated on the egg and adult nematode parasite *Haemonchus contortus*. The aqueous extract of *Coriandrum sativum* was also investigated for *in vivo* anthelmintic activity in sheep infected with *Haemonchus contortus*. Both extracts of *Coriandrum sativum* inhibited hatching of eggs completely at a concentration less than 0.5 mg/ml. ED_{50} of aqueous extract of *Coriandrum sativum* was 0.12 mg/ml while that of hydroalcoholic extract was 0.18 mg/ml. There was no statistically significant difference between aqueous and hydroalcoholic extracts ($p>0.05$). The hydroalcoholic extract showed better *in vitro* activity against adult parasites than the aqueous one. For the *in vivo* study, sheep were artificially infected with *Haemonchus contortus*, crude aqueous extract of *Coriandrum sativum* was given at 0.45 and 0.9 g/kg dose levels. Efficacy was tested by faecal egg count reduction (FECR) and total worm count reduction (TWCR). On day 2 post treatment, significant FECR was detected in groups treated with higher dose of *Coriandrum sativum* ($p<0.05$) and albendazole ($p<0.001$). Significant ($p<0.05$) TWCR was detected only for higher dose of *Coriandrum sativum* compared to the untreated group. Reduction in male worms was higher than female worms. Treatment with both doses of *Coriandrum sativum* did not help the animals to improve or maintain their PCV, while those treated with albendazole showed significant increase in PCV ($p<0.05$) [197].

The antiparastic efficacy of *Coriandrum sativum* essential oils was studied by two *in vitro* assays on *Haemonchus contortus* using egg hatch test (EHT) and larval development test (LDT). *Coriandrum sativum* essential oils exhibited a dose-dependent effect in the EHT, inhibiting 81.2% of *H. contortus* larvae hatching, at a concentration of 2.5 mg/ml. The effective concentration to inhibit 50% (EC_{50}) of egg hatching was 0.63 mg/ml. In LDT, *Coriandrum sativum* at concentration of 10 mg/ml inhibited 97.8% of *H. contortus* larval development [198].

The *in vitro* effect of fractions from *Coriandrum sativum* (coriander) on promastigotes and amastigotes of *L. infantum* was studied in addition to its toxicity against the murine monocytic cells RAW 264.7. All fractions were effective against *L. infantum* promastigotes and did not differ from the positive control pentamidine ($p>0.05$). However, the *Coriandrum sativum* methanol fraction, was the most effective against amastigotes and did not differ from the positive control amphotericin B ($p>0.05$) [199].

The biological activity of essential oil of *Coriandrum sativum* seeds was tested against adult *Tribolium confusum* Duval (Coleoptera: Tenebrionidae) and *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) in a series of laboratory experiments. The mortality of 1-7 day old adults of the insect pests increased with concentration from 43 to 357 µl/l air and with exposure time from 3 to 24 h. In the probit analysis, LC_{50} values showed that *C. maculatus* (LC_{50} = 1.34 µl/l air) was more susceptible than *T. confusum* (LC_{50} = 318.02 µl/l air) to seed essential oil of *Coriandrum sativum* [200].

The essential oil (EO) of the fruits of *Coriandrum sativum* was evaluated for its larvicidal and repellent activities against *Aedes albopictus* Skuse (Diptera: Culicidae). *Coriandrum sativum* EO exerted toxic activity against *A. albopictus* larvae: LC_{50} was 421 ppm, while LC_{90} was 531.7 ppm. Repellence trials highlighted that *Coriandrum sativum* EO was a good repellent against *A. albopictus*, RD_{50} was 0.0001565 µl/cm^2 of skin, while RD_{90} was 0.002004 µl/cm^2. At the highest dosage (0.2 µl/cm^2 of skin), the protection time achieved with *Coriandrum sativum* essential oil was higher than 60 min [201].

The leaf oil had significant toxic effects against the larvae of *Aedes aegypti* with an LC_{50} value of 26.93 ppm and an LC_{90} value of 37.69 ppm, and the stem oil has toxic effects against the larvae of *A. aegypti* with an LC_{50} value of 29.39 ppm and an LC_{90} value of 39.95 ppm [202].

The seed oil had significant toxic effects against the larvae of *Aedes aegypti* with an LC_{50} value of 21.55 ppm and LC_{90} value of 38.79 ppm. The major components in the essential oil of coriander play an important role as immunotoxicity on the *A. aegypti* [203-204].

1.1.38. Coronilla scorpioides

Screening of *Ae. aegyptii* larvicidal activity of 110 selected Egyptian plants proved that *Coronilla scorpioides* exhibited highest larvicidal activity, calculated as 22.53 ± 2.01 mg% for aqueous extracts and 18.53 ± 1.95 mg% for methanol extract [205].

1.1.39. Coronilla varia

A group of 3-nitropropanoyl-D-glucopyranoses was also isolated from active fractions of the crude extracts of the root. These compounds were toxic when administered orally to 3rd instar *Costelytra zealandica* larvae [206-207].

1.1.40. Crocus sativus

The effectiveness of *Crocus sativus* and its apoptotic activity against *Leishmania major* (MRHO/IR/ 75/ER) promastigotes was studied using MTT assay to find viability of *L. major* promastigotes and the results were explicated as IC_{50} (50% inhibitory concentration). ED_{50} (50% effective doses) for *L. major* amastigotes were also analyzed. Annexin-V FLUOS staining was performed to study the cell death properties of saffron by using FACS analysis. Qualitative analysis of the DNA fragmentations was accomplished by agarose gel electrophoresis, and light microscopy was used to observe morphological changes of promastigotes. The results revealed that *L. major* promastigotes and amastigotes are sensitive to saffron at different concentrations and time dependent manner, with apoptotic features including DNA laddering, cytoplasmic shrinkage, and externalization of phosphatidylserine. IC_{50} and ED_{50} of this extract after 48 h of incubation was 0.7 and 0.5 mg/ml respectively [208-209].

Safranal isolated from *Crocus sativus* extract exhibited insecticidal and pesticidal effect. This fact could present saffron as safe and effective herbal insecticide and pesticide which was more environment friendly than other synthetic insecticides [210].

1.1.41. Cyminum cuminum

The electrophysiological, behavioural (repellency, irritancy) and toxic effects of the of *Cuminum cyminum* essential oils was studied against *Anopheles gambiae* strain (Kisumu). Aldehydes elicited the strongest responses and monoterpenes the weakest responses in electroantennogram (EAG) trials. However, EAG responses did not correlate consistently with results of behavioral assays. In behavioral and toxicity studies, several of the single compounds exhibited repellency, irritancy or toxicity in *An. gambiae*; however, the activity of essential oils did not always correlate with activity expected from the major components. The biological activity of essential oils appeared complex, suggesting interactions between individual compounds and the insect. Data also indicated that the three effects appeared independent, suggesting that repellency mechanism (s) may differ from mechanisms of irritancy and toxicity [211-212].

Fumigant activity of essential oil vapours distilled from cumin was recorded against the eggs of two stored-product insects, the confused flour beetle, *Tribolium confusum*, and the Mediterranean flour moth, *Ephestia kuehniella*. The exposure to vapours of essential oils resulted in 100% mortality of the eggs at a concentration of 98.5 µl cumin essential oil/l air [213-214].

1.1.42. Cupressus sempervirens

The ethanol extract of the powdered cones of *Cupressus sempervirens* , collected from Oxford, Mississippi, exhibited potent antiparasitic activities. Bioassay-guided fractionation using a centrifugal preparative thin-layer chromatography led to isolation of many diterpenes, 6-deoxytaxodione (11-hydroxy-7, 9 (11), 13-abietatrien-12-one), taxodione, ferruginol and sugiol. 6-deoxytaxodione (11-hydroxy-7, 9 (11), 13-abietatrien-12-one) and taxodione, displayed potent antileishmanial activity with half-maximal inhibitory concentration (IC_{50}) values of 0.077 µg/ml and 0.025 µg/ml, respectively, against *Leishmania donovani* promastigotes, compared to those of the standard antileishmanial drugs, pentamidine (IC_{50} 1.62 µg/ml) and amphotericin B (IC_{50} 0.11 µg/ml) [215-216].

1.1.43. Cymbopogon schoenanthus

The anthelmintic potential of *Cymbopogon schoenanthus* essential oil was evaluated in lambs experimentally infected with *Haemonchus contortus*. Two-month-old lambs with mean body weight (BW) of 22.5 kg were experimentally infected with a multidrug-resistant *Haemonchus contortus* strain. Infected animals were dosed orally with *Cymbopogon schoenanthus* essential oil. Eighteen animals were allocated into three groups of six animals, and each received one of the following treatments: Group 1 - control (10 ml of water), Group 2 - *Cymbopogon schoenanthus* essential oil (180 mg/kg bw); and Group 3 - *Cymbopogon schoenanthus* essential oil (360 mg/kg bw). Animals received the oil once a day for 3 consecutive days. Lambs were evaluated clinically for blood biochemistry before and at 1, 5, 10, 15, 20 days after

treatment. No statistically significant reduction in fecal egg count, packed cell volume or total worm count was observed after treatments. Also, no statistical difference among group means for blood levels of urea, creatinine, albumin, alkaline phosphatase, aspartate aminotransferase and gamma glutamyl transferase was found. Larval development assay (LDA) and egg hatch assay (EHA) were performed from feces of treated animals at 1, 5, 10 and 15 days after essential oil administration. An inhibition in LDA was observed 1 day after the 3-day treatment in larvae from feces of animals treated with 360 mg/kg essential oil [217-218].

Cymbopogon schoenanthus essential oils were evaluated against developmental stages of trichostrongylids from sheep naturally infected (95% *Haemonchus contortus* and 5% *Trichostrogylus* spp.) using egg hatch assay (EHA), larval development assay (LDA), larval feeding inhibition assay (LFIA), and larval exsheathment assay (LEA). *Cymbopogon schoenanthus* essential oil showed a good activity against ovine trichostrongylids It had LC_{50} value of 0.045 mg/ml in EHA, 0.063 mg/ml in LDA, 0.009 mg/ml in LFIA, and 24.66 mg/ml in LEA [219].

The insecticidal activity of crude essential oil extracted from *Cymbopogon schoenanthus* and its main constituent (piperitone), was assessed on different developmental stages of *Callosobruchus maculatus*. Piperitone was more toxic to adults with LC_{50} value of 1.6 microl/l vs. 2.7 microl/l obtained with the crude extract. Piperitone inhibited the development of newly laid eggs and of neonate larvae, but was less toxic than the crude extract to individuals developing inside the seeds [220].

Cymbopogon schoenanthus essential oils from Benin Republic in west Africa displayed about 100% mortality rate against adult *Anopheles gambiae* [221].

The efficacies of essential oils of nine plant species, which were traditionally used to avoid mosquito bites in Benin, were investigated. These oils were tested on suceptible "kisumu" and resistant "ladji-Cotonou" strains of *Anopheles gambiae*. The results showed that *Cymbopogon schoenanthus* was a potential promising plant sources alternative to pyrethroids, for the control of the *Anopheles malaria* vector in Benin. The efficacy of essential oil was possibly attributed to its chemical composition in which major and/or minor compounds have been shown insecticidal activities on various pests and disease vectors such as Anopheles [222].

The effect of camelgrass (*Cymbopogon schoenanthus*) oil on Anopheles mosquito and its larvae was tested to evaluate its repellence property. Different quantity of the oil extract viz: 10ml, 5ml and 1ml was introduced into two set of twelve beakers each containing twenty larvae and adult mosquito. Mortality rate was recorded at certain time interval. Application of the oil extract on adult mosquitoes and larvae caused 100% mortality. The maximum mortality time taken was 15 minutes for the adult mosquito and 18 minutes for the larvae. The minimum mortality time taken was 3 minute. The rapid mortality recorded in respect to both larvae and adult of anopheles mosquito indicated high insecticidal and larvicidal properties of the chemical compounds present in the oil of the grass species [223].

The efficacy of 3% citronella candles and 5% citronella incense were evaluated in protecting subjects from bites of Aedes spp under field conditions. The study was conducted in a deciduous woodlot in Guelph, Ontario, Canada. Eight subjects, dressed identically, were assigned to one of 8 positions on a grid within the study area. Two citronella candles, 2 citronella incense, 2 plain unscented candles, or no candles (i.e., non-treated controls) were assigned to 2 positions on the grid each evening. Subjects conducted 5-min biting counts at each position and performed 16 biting counts per evening. On average, subjects received 6.2 ± 0.4, 8.2 ± 0.5, 8.2 ±0.4, and 10.8 ± 0.5 bites/ 5 min at positions with citronella candles, citronella incense, plain candles, and no candles, respectively. Although significantly fewer bites were received by subjects at positions with citronella candles and incense, than at non-treated locations, the overall reduction in bites provided by the citronella candles and incense was only 42.3 and 24.2%, respectively [224].

The insecticidal properties of the aerial part of *Cymbopogon schoenanthus* was studied experimentally. Cabbage plants were sprayed with the aqueous extracts of *Cymbopogon schoenanthus* leaves as treatment, and the damage levels of *Plutella xylostella* was assessed. *In vitro*, the emulsified essential oil concentrations were used in a contact test on the larvae in order to assess the mortality effects. The larvae survival time was only 22 seconds with *Cymbopogon schoenanthus* emulsified oil treatment (2 g/l), whilst it exceeded 44,100 seconds (over 12 hours) for the dimethoate. The nutrition test showed that at 48 h period, a significant effectiveness against larvae was observed with emulsified oil treatment 2 g/l (60% mortality) versus 10% of mortality for dimethoate. The authors concluded that *Cymbopogon schoenanthus* can validly be used as alternative in *P. xylostella* management. The results of the field experiments showed no significant difference between the treatments and the control in terms of marketable cabbages harvested [225].

1.1.44. Cynodon dactylon

Anthelmintic activity of petroleum ether, methanol, and water extracts of *Cynodon dactylon* was evaluated on adult Indian earthworm *Pheretima posthuma* with the using of albendazole as a standard drug. The aqueous extract of *Cynodon dactylon* exerted anthelmintic activity in comparison with the standard drug [226-227].

The of mosquito repellents activity of volatile oils of *Cynodon dactylon* was studied against (*A. aegypti*). The distillates of the fruits of *Cynodon dactylon* was effective for 3 hours. The mixture of *C. papaya* and *Cynodon dactylon* was effective for 2.5 hours compared to that of *C. papaya* (2.5 hours) alone or *Cynodon dactylon* (1.5 hours) alone [228].

1.1.45. Cyperus rotuntdus

Hexane extract of tuber of plant *Cyperus rotundus* was tested for repellent activity against mosquito vector *Anopheles culicifacies*, *Anopheles stephensi* and *Culex quinquefasciatus*. Results showed that the tuber extracts were effective for repellency of the entire mosquito vector even at a low dose [229].

Cyperus rotundus was more effective insecticidal than carbamate and has almost the same efficacy as that of organophosphate. Result showed that all the test ants died after 10s, while organophosphate ranked second with 9 ants dead after 10s, and the carbamate ranked third with seven ants dead after 12s [230].

The ovicidal and larvicidal efficacy of essential oils of the tubers of *Cyperus rotundus* was studied on eggs and fourth instar larvae of *Aedes albopictus*. The eggs and larvae were exposed to serial concentration of the oils ranging from 5-150 ppm and observed for 24 h. Oils showed remarkable ovicidal and larvicidal activities indicated by EC_{50} values of <5 ppm and LC_{50} and LC_{90} values of <20 ppm [231].

Activity-guided investigation of *Cyperus rotundus* tubers led to the isolation of patchoulenone, caryophyllene alpha-oxide, 10,12-peroxycalamenene and 4,7-dimethyl-1-tetralone. The antimalarial activities of these compounds were in the range of EC_{50} 10^{-4} to10^{-6} M, with the novel endoperoxide sesquiterpene, 10,12-peroxycalamenene, exhibiting the strongest effect at EC_{50} 2.33×10^{-6} M [232-233].

1.1.46. Dalbergia sissoo

The petroleum ether, carbon tetrachloride, benzene and ethanol extracts of leaves of *D. sissoo* were assessed for anthelmintic activity against Indian earthworms (*Pheretima posthuma*) at different concentrations of 10, 25, 50, and 100 mg/mL, and compared wth piperazine citrate. All the extracts revealed anthelmintic activity against the eartworms and the carbon tetrachloride extract exhibited most ptent activity with the paralysis time of 19.14±2.78 min and death time of 48.15±3.23 min at the concentration of 100 mg/mL, while piperazine citrate showed 5.23±0.72 and 20.45±2.33 min, respectively at the concentration of 10 mg/ml [234-235].

The anthelminthic activity of ethanolic extract of bark of *Dalbergia sissoo* was investigated against Indian earthworms *Pheretima posthuma* and nematode *Ascardi galli*. Various concentrations (10, 20, 50 mg/ml) tested and compared with piperazine citrate (15 mg/ml) and Albendazole (20 mg/ml) as standard reference and normal saline as control. The result sowed that of *Dalbergia sissoo* possessed strong anthelminthic activity [236].

Adult immersion test was employed to study the acaricidal activity of leaf extracts of *Dalbergia sissoo* (sheesham) against resistant ticks. Mortality and fecundity of ticks exposed to leaf aqueous (SLA) and ethanolic (SLE) extracts were evaluated at concentrations of 0.625, 1.25, 2.5, 5.0 and 10.0% and controls (distilled water and 10% ethanol). Higher acaricidal activity was recorded in SLA with a lower LC_{50} (95% CL) value of 1.58% (0.92-2.71%) than SLE [5.25% (4.91-5.63%)]. A significant decrease in egg mass weight and reproductive index was recorded in treated ticks along with an increase in percent inhibition of oviposition. A complete inhibition of hatching was recorded in eggs laid by ticks treated with higher concentrations of SLA, whereas, SLE exhibited no effect on hatching percentage [237].

The molluscicidal effects of the crude aqueous and ethanolic extracts of *Dalbergia sissoo* fruits, leaves, roots and stem bark were studied against egg masses of *Biomphalaria pfeifferi*, the snail intermediate host of *Schistosoma mansoni* in Nigeria. Viable 0–24 hr-old embryonated egg masses were separately exposed to five different concentrations (7.81–2000 mg/l) of extracts for 24 hrs, washed in dechlorinated tap water and incubated at room temperature for a maximum of 4 weeks. The LC_{50} and LC_{90} values of test extracts for egg masses were calculated by probit analysis. The activities of the tested extracts were concentration-dependent. However, only the ethanolic extract of the fruits demonstrated significant activity (24 hr-LC_{90} value < 100 mg/l: 89.29 mg/l). Mortalities of eggs were manifested at the gastrula/exogastrula and or the prehatch snail stage of development. The percentage of dead embryos at the prehatch

snail stage decreased while the deaths of embryos at the gastrula/exogastrula stage increased, with increasing concentration of extract [238].

The larvicidal, growth inhibitor and repellent actions of *D. sissoo* oil was studied against *Anopheles stephensi, Aedes aegypri* and *Culex quinquefasciacus*. pure oil was applied at 0.4-5ml/m^2 on a water surface. This showed larvicidal activity directly proportional to dosages. One hundred percent mortality of *Culex quinquefasciacus* immatures was observed within 24 hrs at 4ml/m^2, followed by (90%) and *Anopheles stephensi* (60%), and pupation was totally inhibited. The oil also showed strong repellent action when 1ml oil was applied on exposed parts of human volunteers. They were protected from mosquito bites for 8-11h. The protection (91.6±2%) was recorded with *D. s* sissoo oil as compared to that with commercial available Mylol oil (93±1.2%) consisiting of di-butyl and dimethyl phthalates [239].

1.1.47. Datura metel

Different percentage of methanolic extract of *Datura metel* seeds were tested against *Helicoverpa armigera* (Hubner). The 1.5 and 2 % of methanolic extract showed significant adverse effects larval survival, weight and duration, pupal period, % of pupation and adult emergence [240-241].

1.1.48. Datura stramonium

The ethanolic extracts of leaves of *Datura stramonium* were evaluated for larvicidal and mosquito repellent activities against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*. The LD_{50} values for larvicidal activity were found to be 86.25, 16.07 and 6.25 ppm against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* respectively. The ethanolic leaves extract of *Datura stramonium* provided complete protection time (Mosquito repellency) of 2.73, 71.66, 117.7 mins against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* at 1% concentration [242].

1.1.49. Dianthus caryophyllus

The larvicidal effect exhibited by essential oils of *Dianthus caryophyllus* was studied against late third to early fourth instar mosquito larvae of Culex pipiens. The essential oils of D. caryophyllus revealed moderate larvicidal activity, displaying a LC_{50} value above 50 mg/l. Among the pure components, the most toxic were eugenol, (E)-anethole, and α-terpinyl acetate, with LC_{50} values 18.28, 16.56, and 23.03 mg/l, respectively [243-244].

The essential oil from flowers of carnation (*Dianthus caryophyllum*) exerted pronounced repellent effect both against ticks (nymphs of Ixodes ricinus) and yellow fever mosquitoes (*Aedes aegypti*). Phenylethanol was found the most potent repellents ingredient [245].

1.1.50. Digitalis purpurea

Studying of insecticidal activity of alcoholic extract of *D. purpurea* against *T. castaneum* Revealed that percentage mortality of *T. castaneum* was 60%, at 100 mg/2 ml of alcoholic extract of *D. purpurea* [246-247].

1.1.51. Dodonaea viscosa

Insecticidal activity of the ethanolic extracts of the leaves of *Dodonaea viscosa* was studied. Four insect models were used: *Epilachna paenulata, Spodoptera littoralis, Myzus persicae*, and *Rhopalosiphum padi*, which are pests of crops of economic importance. Bioguided fractionation and supercritical fluid extraction led to the isolation of active insecticidal compounds. Lupeol, stigmasterol, stigmast-7-en-3-ol, and a labdane diterpene were isolated and showed differential activity against the insects [248].

The larvicidal activity of *Dodonaea viscose* leaf, stem and root using aqueous, methanol and chloroform solvents was studied against *Artemia salina* larvae. Artemia salina cysts were incubated in saline water and the eggs were hatched in 24 hours. The hatched nauplii (larvae) were then used (48h growth) for larvicidal activity assay. One gram of dried extract is dissolved in 10ml of saline water (master dilution). Four different concentrations (0.5, 1, 1.5 and 2) were prepared from the master dilution. Ten nauplii were transferred to each test sample and incubated in room temperature for 24h. After 24 hours the susceptibility of the nauplii were observed. Among different parts of Dodonaea viscose, the leaf extract alone showed significant level of lethality. The aqueous extract of leaf showed 100 % lethality against the larvae at the concentration of 1 %. Aqueous extract of root extract of the plant showed 100 % lethality of larvae at the concentration of 1.5 and only the methanol extract of stem at the concentration of 2 % showed 100 % lethality of larvae [249-250].

1.1.52. Dolichos lablab

Arcelins, the protein isolated from seed flour of the Indian wild bean, Lablab purpureus showed insecticidal activity against Callosobruchus maculates [251-252], Rhyzopertha dominica and Oryzaephilus surinamensis. L. purpureus proteins at 2% in the diet resulted in retarded insect development. However, a 5% dose of the L.purpureus fraction resulted in complete mortality of all larvae Rhyzopertha dominica and Oryzaephilus surinamensis [253].

1.1.53. Echium italicum

Echium italicum showed good insecticidal activity, its extract caused 100 % mortality against within six days against Yellow Fever mosquito [254].

The insecticidal efficacy of aqueous extract of *Echium italicum* L was investigated against Indian meal moth (IMM). Three concentrations of extract were used: 1%, 2% and 5%. Controls for each set of treatments contained 10 g of untreated wheat kernels and 10 larvae from one type's stage/Petri dish. The number of dead larvae/Petri dish was counted daily after 1, 2, 3 and 4 days after treatment (DAT). Biological effects of plant extracts were calculated using the Abbott formula. The extract showed insecticidal activity (dead larvae) in low concentration 1% extracts [255-256].

1.1.54. Equisetum arvense

E. arvense water extract showed anti-leishmanial effects*.* The number of *L. tropica* decreased gradually by using 0.5 to 2.5 µg/ml concentrations of *E. Arvense* extract, Moreover, the extracts effect on number and time of generation, an inverse relationship could be established between concentration of the extract and growth mean of the parasite. Inhibitory concentration of 50% of promastigotes (IC_{50}) was 1.5 µg/ml, whereas at logarithmic phase (96 hrs of cultivation). The *Equisetum arvense* dissolve in cold and hot water found to cause reduction in protein, carbohydrates and total nucleic acid contents in *Leishmania tropica* promastigotes that were treated with IC_{50} of the tested extracts [257-258].

1.1.55. Eryngium creticum

Antileishmanial activity of *Eryngium creticum* extract was tested *in vitro* on a culture of Leishmania donovani promastigotes. IC_{50} of dichloromethane extract of the aerial parts of Eryngium creticum against L. donovani was 38µg/ml, while IC_{50} of methanolic extract of the aerial parts of Eryngium creticum was 35µg/ml [259-260].

1.1.56. Eucalyptus species

In studying anti- schistosomal effect, the Scanning Electron Microscope observation showed that of essential oil produced sever damage in schistosoma worm's typography [261-262].

The antitrypanosomal effect the leaves, stem and root barks extracts of Eucalyptus camaldulensis was investigated in Trypanosoma brucei infected mice. 200-600 mg/kg body weight/day of the hexane, ethyl acetate, methanol and water extracts for 21 consecutive days. One control group was treated with 3.5mg/kg bodyweight of berenil while the other control group was left untreated. The methanol extract of E. camaldulensis (leaf) produced complete cure for the animals in the different dose groups and survived as long as those treated with the standard drug, berenil, although the clearance time was faster for the standard drug. Sub inoculation of healthy mice with the blood and Cerebrospinal Fluid (CSF) of the cured mice did not result in infection, thus indicating a complete and permanent cure. Bioassay-guided fractionation of the crude methanol extract of E. camaldulensis leaf gave 10 fractions, only fractions 8 and 9 exhibiting minimal antitrypanosomal activities that were not comparable to those of the crude extract and the standard drug ($p \leq 0.05$) [263].

The effect of methanolic and aqueous extracts of Eucalyptus camaldulensis was studied on the promastigotes of Leishmania major. The stationary phase promastigotes of L. major was incubated in the methanolic and aqueous extractions *in vitro*. Tartar emetic was used as the positive control drug. After 72 h of incubation the activity of the extracts was measured, using MTT method. The IC_{50} values were 586.2 ± 47.6 and 1,108.6 ± 51.9 µg/ml for methanolic and aqueous extracts, respectively, whereas it was 32.5 ± 6.8 µg/ml for tartar emetic [264].

The effect of different extracts of Eucalyptus camaldulensis (total extract, diethyl ether, chloroform, ethyl acetate, and water fractions) on T. vaginalis was investigated in culture medium. Crude extract of E. camaldulensis showed 80% growth inhibition (GI) in a concentration of 12.5 mg/ml during 24 h. Diethyl ether extract in a concentration of 25 mg/ml showed 100% GI during 24 h. With ethyl acetate extract, 100% GI was detected with the minimum concentration

of 12.5 mg/ml in the first 24 h. Water extract in a concentration of 50 mg/ml showed 80% and 100% GI after 48 and 72 h, respectively [265].

Eucalyptus essential oil showed a wide biological activity against insects, nematodes, weeds and mites. The use of eucalyptus oil as a natural pesticide is of immense significance in view of the environmental and toxicological implications of the indiscriminate use of synthetic pesticides and vercoming/reducing the problem of increasing pest resistance [266].

The larvicidal activity of Eucalyptus camaldulensis was studied against Anopheles stephensi. The leaf extract and volatile oil exerted significant larvicidal activity with LC_{50} values of 89.85 and 397.75 ppm, respectively. Clear dose-response relationships were established with the highest dose of 320 ppm essential oil extract resulted almost in 100% mortality in the population [267].

Vapors of essential oils extracted from E. camaldulensis and its major components were found to be toxic to Aedes aegypti adults, the yellow fever mosquito. An aliquot of oil was placed in a cylindrical test chamber and the number of knocked-down mosquitoes was recorded as function of time. Knockdown time 50% was then calculated. A correlation was observed between the content of 1,8-cineole in the Eucalyptus essential oils and the corresponding toxic effect. The correlation between KT_{50} values and calculated vapor pressures of the essential oil components showed that the fumigant activity of simple organic compounds in insects is correlated with their volatility [268].

The mosquito larvicidal activity of leaf essential oils of Eucalyptus camaldulensis and their constituents was investigated against two mosquito species, Aedes aegypti and Aedes albopictus, Essential oil ofthe leaves of E. camaldulensis had an excellent inhibitory effect against both A. aegypti and A. albopictus larvae. The 12 pure constituents extracted from the eucalyptus leaf essential oils were also tested individually against two mosquito larvae. Among the six effective constituents, alpha-terpinene exhibits the best larvicidal effect against both A. aegypti and A. albopictus larvae [269].

Eucalyptus essential oil can act directly as a natural insect repellent. Eucalyptus essential oil can protect plants against rice weevils, pine processionary moths and mushroom flies [266].

Essential oils extracted from the dried fruits of Eucalyptus camaldulensis, and essential oils of many other plants were tested for their repellency against the adult females of Culex pipiens. The essential oils showed repellency in varying degrees, eucalyptus, basil and anise being the most active [270].

The insecticidal effects of hot and cold aqueous *Eucalyptus microtheca* leaves extracts were studied on mosquito *culex pipiens*. Hot water extract was more effective on immature stages of insect. Eggs mortality rate of the hot and cold extracts was 51% and 47.3% respectively at a concentration of 20 mg/ml. Larval mortalities rate was significantly increased in hot and cold water extracts as compared with control. The hot and cold extracts caused 31.5 % and 28.6% pupal mortality at concentration of 20 mg/ml, respectively [271].

The accumulative and non accumulative effects of aqueous and organic extracts of the leaves of *Eucalyptus microtheca* was investigated on larvae of *Culex quinqefasciatus*. The petroleum ether extract was the most effective, however, all extracts increased the duration of larval stage and caused morphological changes of larva [272].

1.1.57. Eupatorium cannabinum

The methanol and chloroform fraction of *Eupatorium cannabinum* were effective for the control of *Callosobruchus chinensis*. They possessed maximum repellent activity 90% at 250ppm concentration [273].

The toxicity of Eupatorium cannabinum L. against the second and fourth instar larvae of *Culex quinquefasciatus* and *Aedes aegypti* was studied using four different concentrations from 20 to 50 ppm. Acetone extract of Eupatorium cannabinum caused dose dependent larval motility against second and fourth instar larvae of *Aedes aegypti* and *Culex quinquefasciatus*. The purified fraction was much more effective than the crude extract, the IC_{50} values for the 100 ppm of purified fraction against second and fourth instar larvae of *Aedes aegypti* were 40.11 and 34.10 ppm respectively [274-275].

1.1.58. Euphorbia hirta

The growth of Entamoeba histolytica was inhibited by polyphenolic extract of the whole plant, the minimum active concentration was less than 10 pg/ml [55]. Bioassay-guided fractionation of the methanolic extracts of *Euphorbia hirta*

aerial parts led to the isolation of flavonol glycosides afzelin, quercitrin and myricitrin. All these compounds showed proliferation inhibition of *Plasmodium falciparum*., with IC_{50} values of 1.1, 4.1, 5.4 µg/ml, respectively [276-277].

The anthelmintic efficacy of the aqueous crude extract of *Euphorbia hirta* Linn was studied in 20 Nigerian dogs naturally infected with nematodes. Two groups were treated with aqueous crude extracts of *E. hirta* using intramuscular and oral routes for 3 consecutive days and was repeated after 2 weeks. Two weeks after treatment, blood and faecal samples were collected to evaluate haematological values and faecal egg counts. Aqueous crude extracts of *E. hirta* produced a significant increase ($P< 0.05$) in PCV, RBC, Hb conc., WBC and lymphocyte counts. The faecal egg counts also showed a remarkable and significant reduction in the levels of the identified helminths. The reduction in faecal egg counts was more pronounced with the extract administered through the oral route when compared with the intramuscular route. The effects of the plant extracts were broad spectrum in action [278].

The larvicidal effect of many extracts of *Euphorbia hirta*, was evaluated against the early fourth instar larvae of *Aedes aegypti* L. and *Culex quinquefasciatus*. The results revealed that LC_{50} of petroleum ether extract of *E. hirta*, was 272.36 ppm against *A. aegypti* and 424.94 against *C quinquefasciatus* [279].

The aqueous stem bark and leaf extracts of *Euphorbia hirta* showed potent molluscicidal activity. 40% and 80% of LC_{50} of aqueous stem bark and leaf extracts significantly ($P<0.05$) alter the levels of total protein, total free amino acid, nucleic acids (DNA and RNA) and the activity of enzyme protease and acid and alkaline phosphatase in various tissues of the vector snail *Lymnaea acuminata* in time and dose dependent manner [280].

1.1.59. Ficus carica

The aqueous and methanolic extracts were active against the earthworms *Pheretima posthuma* causing paralysis and death [281-282].

Within a 2h incubation period, cysteine proteinases from fig (*Ficus carica*), caused marked damage to the cuticle of rodent gastrointestinal nematode *Heligmosomoides polygyrus* adult male and female worms, reflected in the loss of surface cuticular layers [283].

The milky sap of Ficus carica was significantly toxic against early fourth-stage larvae of *Aedes aegypti* with a lethal concentration LC_{50} value of 10.2 mg/ml and an LC_{90} value of 42.3 mg/ml. Two furocoumarins, 5-methoxypsoralen and 8-methoxypsoralen, were isolated from the milky sap of Ficus carica, their LC_{50} value 9.4 and 56.3 mg/ml, respectively [284].

1.1.60. Ficus religiosa

Ficus religiosa bark methanolic extract showed 100% lethality for *Haemonchus contortus* worms using *in vitro* testing [285-286].

The stem and bark extracts of *F. religiosa* proved lethal to *Ascaridia galli in vitro* [287].

1.1.61. Foeniculum vulgare

The larvicidal activity of the essential oils and its major constituents were evaluated, against third instar larvae of *Ae. aegypti* for 24 h. Pure compounds, such as limonene isomers, were also assayed. The lethal concentrations LC_{50}, C_{90} and LC_{99} were determined by probit analysis using mortality rates of bioassays. A 99% mortality of *Ae. aegypti* larvae was estimated at 37.1 and 52.4 µl/l of fennel essential oils from Cape Verde and Portugal, respectively [288-289].

The repellent activity of (+)-fenchone and (E)-9-octadecenoic acid was tested against *Aedes aegypti* females using skin and patch tests in comparison with the commercial repellent agent (N,N-diethylm-toluamide (DEET) and (Z)-9-octadecenoic acid). In a skin test with female mosquitoes (+)-fenchone and (Z)-9-octadecenoic acid (0.4mg/cm^2) exhibited moderate repellent activity 30 min after treatment [290].

The larvicidal activity of essential oils was investigated against malaria vector called *Anopheles stephensi*. Of oils of three plants, *F. vulgare* oil was the most effective against *A. stephensi* with LC_{50} and LC_{90} values of 20.10 and 44.51 ppm, respectively [291].

The essential oil of the leaves, flowers, and roots of *F. vulgare* exerted larvicidal activity against fourth-instar larvae of the mosquito *Culex pipiens molestus*. Terpineol and 1,8-cineole content of *F. vulgare* were the most effective contents against *Culex pipiensmolestus* bites offering complete protection for 1.6 and 2 h, respectively [292].

1.1.62. Fraxinus ornus

The potential protective effects of *Fraxinus ornus* against experimental infection with *Eimeria tenella* was investigated in broiler chickens. Treatment with lasalocid or *Fraxinus ornus* at a lesser extend incorporated into the ration revealed significant reduction in the oocyst excretion whereas this effect was not significant when *Fraxinus ornus* was incorporated into drinking water. The caecal lesion score was also depressed *Fraxinus ornus* and lasalocid supplementation but not significantly. In addition, the dietary *Fraxinus ornus* supplementation induced a significant growth promoting effect on un-infected broilers [293-294].

1.1.63. Fritillaria imperialis

In evaluation of insecticidal activity of Turkish plants, crude extracts of *Fritilluria imperialis* possessed significant insecticidal activity against the milkweed. Insecticidal activity of crude extracts of *Fritilluria imperialis* recorded as 90% or greater mortality within six days against Milkweed bug [295-296].

1.1.64. Fumaria parviflora

The anthelmintic activity of *Fumaria parviflora* was evaluated against the gastrointestinal nematodes of sheep [*H. contortus , O. circumcincta, Trichostrongylus Spp., S. papillosus, Oe. columbianum* and *Chabertia ovina*] through egg hatch and larval development tests *in vitro* and faecal egg counts reduction test *in vivo*. *In vitro* studies revealed that aqueous and ethanolic extracts at the concentration of 3.12, 6.3, 12.5, 25.0 and 50.0 mg/ml exhibited ovicidal and larvicidal effects [$P<0.05$] against the eggs and larvae of gastrointestinal nematodes. The highest effective dose [ED_{50}] value of *Fumaria parviflora* extract was recorded on the eggs of *Chabertia ovina* [14.45 mg/ml] with aqueous extract; whereas, the higher LC_{50} value of *Fumaria parviflora* extracts was recorded against the larvae of *Strongyloides papillosus* [16.60]. *In vivo* studies revealed that experimental animal groups treated with the doses of 200 mg/kg of either aqueous or ethanolic extracts of *Fumaria parviflora* exhibited higher [$P<0.05$] reduction rate on faecal egg counts [FEC]. The highest reduction rate on FEC of treated animal groups recorded was 77.6 and 70.05% with ethanolic and aqueous extracts, respectively at the dose of 200 mg/kg on the day 14 post treatment [297-298].

Extracts or ingredients of six different plant species were tested against exsheathed infective larvae of *Haemonchus contortus* using a modified methyl-thiazolyl-tetrazolium [MTT] reduction assay. Pyrantel tartrate was used as reference anthelmintic. The ethanolic extracts of the whole plant of *Fumaria parviflora* showed an anthelmintic efficacy of up to 93%, relative to pyrantel tartrate [299].

Helminth-free lambs were infected artificially with 10.000 third stage larvae of *Haemonchus contortus* or 20,000 third stage larvae of *Trichostrongylus colubriformis*. Thirty days post-infection the lambs were treated orally with a single dosage of 3 mg/kg body weight of aqueous ethanol extract of the whole plants of *Fumaria parviflora*. Of many medicinal plant treatments, only the ethanol extract of *Fumaria parviflora* caused a strong reduction of the faecal egg counts [100%] and a 78.2 and 88.8% reduction of adult *H. contortus* and *T. colubriformis* on day 13 post-treatment. The extract was as effective as the reference compound, pyrantel tartrate [300].

The antifasciolic effect of powdered plant drugs including *Nigella sativa* seeds, *Fumaria parviflora* aerial parts and *Caesulpinia crista* seeds was investigated in buffaloes. The trial results showed that *Fumaria parviflora* possessed significant efficacy against fascioliasis. Its highest doses produced highly significant [$P<0.001$] decrease in EPG counts on 15th days. Among the 3 plants used in the trial, the maximum antifasciolic efficacy, judged on the basis of % EPG count reduction was shown by *Fumaria parviflora* [93.2 ±0.5%]. No visible side effects were produced by any of these plant drugs. Single oral treatment with 25 mg/kg of *Nigella sativa* seeds or 60 mg/kg of *Fumaria parviflora* aerial parts and 40 mg/kg of *Caesulpinia crista* seeds exerted highly significant antifasciolic efficacies on the day 15 after treatment [301].

The nematicidal activity of nonacosane-10-ol and 23a-homostigmast-5-en-3β-ol, isolated from the n-hexane fraction of the roots of *Fumaria parviflora* was investigated against eggs and juveniles of Meloidogyne incognita *in vitro* at the concentrations of 50, 100, 150, and 200 µg/ml. Over 120 h of incubation, the cumulative percent mortality and hatch inhibition of both ranged from 20 to 100% and from 15 to 95.0%, respectively [302].

The antiprotozoal effect of the ethanol extracts of five Fumaria species [*Fumaria densiflora,* F*umaria cilicica, Fumaria rostellata, Fumaria kralikii,* and *Fumaria parviflora*] was investigated against *Plasmodium falciparum* [malaria] and *Trypanosoma brucei rhodesiense* [human African trypanosomiasis] at 0.81 and 4.85 µg/ml concentrations. The results revealed that anti -*Plasmodium falciparum* effect of *Fumaria parviflora* was 18.70% at concentration of 4.85 µg/ml and anti- *T. brucei rhodesiense* was 5.60 at concentration of 0.81 µg/ml and 11.25 at concentration of 4.85µg/ml [303].

N-octacosan 7β ol was isolated from the methanolic extract of whole plant of *Fumaria parviflora*. The *in vitro* antileishmanial evaluation of isolated compound against *Leishmania donovani* promastigotes was investigated by growth kinetics assay, reversibility assay, analysis of cellular morphology, adverse toxicity and determination of 50% growth inhibitory concentration [GI_{50}]. N-octacosan-7β-ol [OC], possessed significant anti-*Leishmania donovani* promastigotes activity with GI_{50} = 5.35 [304].

1.1.65. Gossypium species

The N-hexane, ethyl ether and ethanol extracts of leaves of *Gossypium herbaceum* was investigated for anthelmintic activity using earthworms (Pheretimaposthuma). Various concentrations (10,20,40,60,80 &100 mg/ml) of plant extracts were tested in the bioassay. The ethyl ether and ethanol extracts exhibited significant anthelmintic activity at highest concentration (60, 80 and 100 mg/ml) compared to standard drug

(Albendazole 10 mg/ml). The result showed that ethyl ether extract possessed potent vermicidal activity and found to be effective as an anthelmintic compared to ethanolic extract [305-306].

The anti-leishmanial activity of methanolic extracts of Gossypium hirsutum was studied on *Leishmania major* promastigotes by colorimetric assay in comparison to a trivalent antimony compound (tartar emetic). The plant extracts and tartar emetic inhibited the growth of promastigote stage of *L.major* after 72 hours of incubation. Tartar emetic as positive control gave a 50% inhibitory concentration (IC_{50}) of 4.7µg/ml, while the IC_{50} values of G. hirsutum was 3.6 µg/ml [307-308].

The lethal effect of *Gossypium hirsutum* extract on *Toxoplasma gondii* tachyzoites were studied *in vitro*. Tachyzoites of *T. gondii* RH strain were treated with concentrations of 10, 50, 100, and 200 mg/ml of *Gossypium hirsutum* extracts within 10, 30, and 45 min. The lowest mortality rate of *Gossypium hirsutum extract* at concentration of 10 mg/ml was 4.63±2.1 [309].

Gossypol was effective in the immobilization of *Tryponosoma cruzi* , T. brucei and *Plasmodium falciparum* [310-314].

Gossypol and its enantiomers were showed a potent *in vitro* anti-amoebic effect against several strains of *Entamoeba histolytica* [314-316].

Anti-amoebic effect of gossypol was studied in golden hamsters with experimental hepatic amoebic abscess. Hamsters with experimental amoebic hepatic abscess were fed acetic acid gossypol (0–45 mg/kg) or metronidazole (30 or 45 mg/ kg) for 5 or 10 days. The experimental amoebic hepatic abscess size and the *in vitro* cell density reached by trophozoite cultures from the experimental amoebic hepatic abscesses were scored. Gossypol and metronidazole reduced the experimental amoebic hepatic abscess. The smallest effect of gossypol was obtained with 5–45 mg/kg (23–31% score reduction) administered for 5 days whereas the most effective treatment corresponded to 30 mg/kg gossypol for 10 days (90% score reduction) [317].

The plant leaves were extracted by different solvents and the extracts were tested to control different larval stages of mosquito species, *Ae. aegypti* and *An. stephensi*. LC_{50} values of water, ethanol, ethyl acetate and hexane extracts for *Ae. aegypti* were 211.73±21.49, 241.64±19.92, 358.07±32.43, 401.03±36.19 and 232.56±26.00, 298.54±21.78, 366.50±30.59, 387.19±31.82 for 4th instar of *An. stephensi,* respectively. The water extract displayed lowest LC_{50} value followed by ethanol, ethyl acetate and hexane. Owing to the comparatively better activity of water extract, its efficacy was further evaluated for mosquito larvicidal activity, which exhibited LC_{50} values of 133.95±12.79, 167.65±11.34 against 2nd and 3rd instars of *Ae. aegypti* and 145.48±11.76, 188.10±12.92 against 2nd and 3rd instars of *An. stephensi*, respectively. Crude protein was tested against 2nd, 3rd and 4th instars of *Ae. aegypti* and *An. stephensi*. It revealed further decrease in LC_{50} values as 105.72±25.84, 138.23±23.18, 126.19±25.65, 134.04±04 and 137.88±17.59, 154.25±16.98 for 2nd, 3rd and 4th instars of *Ae. aegypti* and *An. stephensi,* respectively [318].

1.1.66. Haplophyllum species

The oil of Haplophyllum tuberculatum was investigated for its insecticidal and repellent activity against *Aedes aegypti*. The oil was repellent to the yellow fever mosquito *Ae. aegypti* using the "cloth patch assay" down to a concentration of 0.074 mg/cm^2; however, the oil had low toxicity against first instar larvae and adults of Ae. aegypti in a high throughput larval bioassay and adult topical assay [319-320].

The methanol extract of flowering aerial parts of *Haplophyllum linifolium* (Haplophyllum hispanicum) resulted very active against epimastigotes of *T. cruzi*, with a 65% of growth inhibition at 250 µg/ml. The obtained results indicated that the arylnaphtalene lignans contribute to the anti-protozoal activity of the plant [321].

The effect of two arylnaphthalene lignans, diphyllin apioside and diphyllin acetylapioside isolated from *Haplophyllum linifolium* (Haplophyllum hispanicum) was evaluated against epimastigotes of *T. cruzi* in axenic cultures. The results, showed that the diphyllin derivatives arylnaphthalene lignans, diphyllin apioside and diphyllin acetylapioside were only endowed with a mild *in vitro* antitrypanosome activity, with IC_{50} values of 62.9 and 60.1 µM, respectively, but they appeared toxic to normal mammal cells at the same concentration. Furthermore, the plant methanolic extract exhibits a potent topical toxicity, causing necrosis of the skin, when applied chronically [322].

Haplophyllum tuberculatum was evaluated as a plant molluscicide. The mortality rate of *Biomphalaria alexandrina* snails were monitored after treatment with three extracts of the plant aerial parts; petroleum ether, chloroform and ethanol. Chloroform extract that recorded the most potent effect was further evaluated through measuring the toxicity pattern against *B. alexandrina* snails, egg laying capacity, cercarial shedding, phenol oxidase enzyme and the levels of steroid sex hormones. Histopathological examination of hepatopancreas and ovotestis of treated snails were also done for confirmation. Treatment of snails by chloroform extract showed reduction in egg laying capacity, decrease in cercarial shedding, diminution in phenol oxidase enzyme, disturbance in steroid sex hormones and sever alternation of the histopathological picture of snails tissue [323].

1.1.67. Hedera helix

Saponins of ivy, Hedera helix possessed antileishmanial activity *in vitro* on promastigote and amastigote forms of Leishmania infantum and Leishmania tropica. Monodesmosides were found to be as effective on promastigote forms as the reference compound (pentamidine). Against amastigote forms only hederagenin exhibited a significant activity which was equivalent to that of the reference compound (N-methylglucamine antimonate) [324].

In vitro anthelmintic activity of crude extracts of the ripe fruits of Hedera helix was investigated on eggs and adult nematode parasites Haemonchus contortus. Aqueous extract of H. helix was also evaluated for *in vivo* anthelmintic activity at dose of 1.13 and 2.25 g/kg in sheep artificially infected with H. contortus. ED_{50} for egg hatch inhibition was 0.12 and 0.17 mg/ml for aqueous and hydro-alcoholic extracts, respectively. There was no statistically significant difference in the activity of the two extract types ($p>0.05$). Hydro-alcoholic extract showed better *in vitro* activity against adult parasites compared to the aqueous extract. Significant faecal egg count reduction (FECR) was detected in groups treated with both doses of H. helix ($p<0.05$) on day 2 post-treatment. On day 7 post-treatment significant reduction was detected only for higher dose of H. helix ($p<0.05$) while on day 14 post-treatment there was no significant FECR in both groups treated with H. helix. The percentage of larvae recovered from culturing faeces obtained from groups of sheep treated with lower and higher doses of H. helix was 47.52% and 36.07%, respectively, which was significantly lower than ($p<0.05$) that recovered from the control group (60%). Significant ($p<0.05$), dose dependent total worm count reduction (WCR) was observed for groups of sheep treated with H. helix. Increasing the dose of H. helix improved the efficacy against the male than the female parasites [325-326].

The *in vivo* activity of an alcoholic extract of *Hedera helix* (20% and 70% alcoholic extract) was studied in experimental ulcer of zoonotic Cutaneous leishmaniasis (CL) in Balb/c mice. The results revealed that the main lesion size did not decrease significantly, and the small lesions did not completely disappear after treatment by H. helix alcoholic extract. Amastigotes counts (mean ± SD) of the skin lesions decreased in placebo control and 20% concentration groups, but in negative control and 70% concentration groups the number of parasites did not reduce [327].

Three extracts were prepared from *Hedera helix* and tested for both *in vitro* and *in vivo* anthelminthic activity. Saponic complex 60% (CS 60), purified saponic complex 90% (CSP 90) and alpha hederin were evaluated *in vitro* using *Fasciola hepatica* and *Dicrocoelium* spp. The same extracts were assayed for their effects on *Dicrocoelium* in naturally infected sheep. After an exposure of 24 hours *in vitro*, both *Fasciola hepatica* and *Dicrocoelium* spp were killed by alpha-hederin at concentrations of 0.005 and 0.001 mg/ml respectively. When sheep naturally infected with *Dicrocoelium* were treated po, with CS 60 and CSP 90, the worms were eliminated after three doses, one of 500 and two of 800 mg/kg [328].

1.1.68. Helianthus annuus

The anti-plasmodial effect of the ethanol extract of the leaves of Helianthus annus (2g and 4g / kg bw/ day for 3 days) was investigated in *Plasmodium berghei* infected Swiss albino mice. The chemo- suppression of the infection was found to be 98.1 and 98.3 for 2g and 4g / kg bw respectively [329-330].

Among many plants, *Helianthus annus* showed good to moderate antiplasmodial activity. *H. annus* seeds showed 50% inhibitory concentration (IC_{50}) of 0.1µg/ml (methanol extract) and 0.6 µg/mL (petroleum ether extract) against *Plasmodium falciparum* K1 strain [331].

1.1.69. Herniaria glabra:

Sisalana oil and herniarin, a constituent of *Herniaria glabra* exhibited heavy knockdown effect coupled with high insecticidal activity against the larvae of semilooper [332-334].

1.1.70. Hibiscus cannabinus

The anthelmintic activity of Hibiscus cannabinus leaf extract was investigated against adult earthworm, Pheritima posthuma. The methanolic extract of the crude Hibiscus cannabinus leaf at concentrations of 10, 20, 30 and 40mg/ml were tested by the determination of paralysis time and death time. Methanolic extract of the Hibiscus cannabinus leaves showed good anthelminthic activity in comparison with albendazole [335-336].

1.1.71. Hibiscus rosa-sinensis

The *in vitro* and *in vivo* anticestodal effects of methanol extract of *Hibiscus rosa-sinensis* L. leaf was investigated against *Hymenolepis diminuta*. *H. diminuta* worms were exposed to 10, 20 and 40 mg/ml concentrations of methanol leaf extract and the effects were judged on the basis of physical motility/mortality of worms. In *in vivo* study, *H. diminuta* infected rats were treated individually with 200, 400 and 800 mg/kg doses of leaf extract for 5 days. The effects were judged on the basis of reduction in eggs per gram (EPG) of faeces and worm counts. In *in vitro* test, the treatment with 40 mg/ml concentration of extract revealed prominent anticestodal effect and caused paralysis of worms in 3.00 ± 0.53 h and mortality in 4.08 ± 0.21 h. However, *in vivo* study revealed that 800 mg/kg dose of extract possessed the highest anticestodal effect and caused 66.55 % reduction in EPG count and 75.00 % reduction in worm count in the treated animals [337-338].

1.1.72. Hyoscyamus niger

Methanol extract of *Hyoscyamus niger* aerial parts had positive effects on destroying the Anopheles spp larvae and the most effective extract for destroying the mosquitoes Anopheles spp larvae, was the flower extract of henbane (LC_{50} = 0/26 ppm) [339-340].

1.1.73. Inula graveolens

In studying of insecticidal activity of *Inula graveolens*, oil caused 0, 10, 16.66 and 33.33% mortality of adult *Mayetiola destructor* at concentration of 15. 30, 60 and 90 µg/l of air, respectively [341-342].

1.1.74. Iris pallida

Iridal, a triterpenoidic compound was tested *in vitro* on *Plasmodium falciparum* chloroquine-resistant and -sensitive strains and *in vivo* on *P. vinckei*. The IC_{50} obtained *in vitro* on human malaria strain was ranged from 1.8 to 26.0 microg/ml and the ED_{50} *in vivo* was 85 mg/kg/day by intraperitoneal route [343-344].

Iridals also showed antitrypanosomal activity with the using of *in vitro* screening assays [345].

1.1.75. Jasminum officinale

Jasminum officinale were tested for the larvicidal efficacy against the third instar larvae of *Culex quinquefasciatus* at concentrations of 62.5, 125, 250, 500, 1000, 2000, 4000 and 8000 mg/l. Mortality was recorded after 24 and 48 h. The crude flower extracts of *Jasminum officinale*, the hexane and chloroform extract of possessed 14 and 13.3% mortality at 4000 mg/l after 24 h, and 18.66 and 18% mortality at 4000 mg/l after 48 h. $LC_{50\ was}$ 3136.68 after 24 h and 6231.08 after 48 h [346-347].

The crude chloroform, methanol and aqueous flower extracts of *Jasminum officinale*, were tested for the larvicidal efficacy against the third instar larvae of *Aedes aegypti* at concentrations of 62.5, 125, 250, 500, 1000, 2000, 4000 and

8000 mg/l. Mortality was recorded after 24 and 48 h. The crude methanolic flower extracts of *Jasminum officinale* caused 20% mortality after 48 h at concentration of 8000 mg/l [348].

1.1.76. Jasminum sambac

The larvicidal activities of ethanolic extracts (100, 200, 500ppm) of four Philippine plant species (*Citrus microcarpa, Chromolaena odorata, Nephelium lappaceum,* and *Jasminum sambac*) were evaluated against third instar larvae of dengue mosquito, *Aedes aegypti*. The ethanolic extract of *Jasminum sambac* induced 11.3, 13.3 and 26.7 % mortality at the concentration of 100, 200, 500ppm after 72 hours respectively [349-350].

1.1.77. Juglans regia

The extracts of *Juglans regia* stem bark were investigated for anthelmintic activity on adult Indian earthworm, *Pheretima posthuma*. The stem bark of *Juglans regia* was extracted with different solvents (petroleum ether, benzene, chloroform, acetone, methanol, ethanol and distilled water). Benzene, methanol and ethanol extracts exhibited significant anthelmintic activity as comparable to that of standard drug piperazine citrate [351-352].

The anthelmintic activity of different extracts of *Juglans regia L* leaf were tested against adult Indian earthworms *Pheretima posthuma.* The methanolic leaf extract of *Juglans regia L* demonstrated paralysis as well as death of worms in a less time as compared to piperazine citrate especially at concentration of 50 mg/ml. Water extract showed significant activity, while, petroleum ether extract being the least active among all the extracts [353].

Petroleum ether, chloroform, ethyl acetate, and methanol eaf extracts of the walnut, *Juglans regia* were evaluated under laboratory conditions for their acaricidal activity on the mites *Tetranychus cinnabarinus* (Boisduval) and *Tetranychus viennensis* Zacher (Acari: Tetranychidae). Extracts had both contact and systemic toxicity to these mites. The crude extracts with petroleum ether resulted in the highest mite mortality (79.04- 0.52%) in a slide dip bioassay. Mites mortalities of the chloroform, ethyl acetate, methanol, or distilled water extracts were significantly lower than petroleum ether. The mean lethal concentrations (LC_{50}) of the petroleum ether, chloroform, ethyl acetate, methanol, and distilled water extracts to the two mite species were 0.73-0.04, 1.66-0.28, 4.96- 0.35, 7.45-0.67, and 9.91-0.32 mg/ml, respectively [354].

The antileishmanial activity of Juglans regia hydroalcoholic extract was tested on the growth of the promastigotes of Leishmania major. The results showed that both J. regia and L. inermis extracts reduced the promastigotes number significantly ($P<0.01$) [355].

The effects of topical application of the ointment-based extract (2 and 4% of 50% ethanol extract) of *Juglans regia* was studied on *Leishmania major* (MRHO/ IR/75/ ER) induced infection in mice. The results showed significant post-treatment decrease in the lesion size and parasite count in infected animals, compared to control groups [356].

1.1.78. Juniperus communis

The methanolic extracts of *Juniperus communis* was evaluated for schistosomicidal and molluscicidal activities. *Schistosoma mansoni* Sambon worms and *Biomphalaria alexandrina* (Ehrenberg) snails were used. The screening results showed that the extract possessed schistosomicidal activity ($LC_{50} \approx 91$ µg/ml, in 3 days). *J communis* extract possess potent molluscicidal activity ($LC_{50} = 22.9$ ppm, after one day) [357-358].

1.1.79. Kochia scoparia (Bassia scoparia)

Petroleum ether, chloroform, and methanol extracts of *Kochia scoparia*, were bioassayed for acaricidal activities against *Tetranychus urticae* Koch, *Tetranychuscinnabarinus* (Boisduval), and *Tetranychus viennensis* Zacher (Acari: Tetranychidae). Extracts had both contact and systemic toxicity to these mites. Extracts with chloroform resulted in the highest mite mortality (78.86%). Mite mortalities from the concentrated extracts by methyl acetate or distilled water were significantly lower than those by chloroform. The mean lethal concentrations (LC_{50}) of the extracts by chloroform, methyl acetate, and distilled water to the mites were 0.71 ± 0.06, 2.08 ±0.16 and 8.75 ± 0.062 mg/ml, respectively [359-360].

The petroleum ether, chloroform, ethyl acetate, acetone, and methanol extracts of three medicinal plants (*Dryopteris crassirhizoma, Kochia scoparia,* and *Polygala tenuifolia*) were screened for antiparasitic properties agaianst *Dactylogyrus intermedius* in goldfish using *in vivo* anthelmintic efficacy assay. The methanolic extracts of K. scoparia showed antiparasitic properties with EC_{50} values of 31.28 mg/l [361].

The effect of extracts obtained from 17 plants used in traditional Chinese medicine were tested *in vitro* against epimastigote form of Trypanosoma cruzi, *Kochia scoparia*, Sophora flavescens and Ligustrum lucidum showed effects with inhibition values between 25% and 60% [362].

1.1.80. Lantana camara

Lantanilic acid, camaric acid and oleanolic acid isolated from the methanolic extract of the aerial parts of *Lantana camara* possessing nematicidal activity. These compounds exhibited 98%, 95% and 70% mortality respectively against root-knot nematode *Meloidogyne incognita* at 0.5% concentration [363]. However, lantanoside, linaroside and camarinic acid showed 90, 85, and 100% mortality, respectively, at 1.0% concentration against root-knot nematode *Meloidogyne incognita* [364].

The anti-filarial activities of two *Lantana camara* extracts were tested *in vitro* on the bovine model parasite, *Onchocerca ochengi* as well as *Loa loa* microfilariae. Extracts showed 100% activity at 500 µg/ml against *Onchocerca ochengi* adult worms and microfilariae. The highest activity against *Onchocerca ochengi* was observed with the hexane extract of *Lantana camara* leaves, with IC_{50} of 35.1 µg/ml for adult females and 3.8 µg/ml for the microfilariae. This extract was more active against *Onchocerca ochengi* microfilariae than *Loa loa* microfilariae. Lantadene A extracted from the methylene chloride extract of *Lantana camara* leaves, showed IC_{50s} of 7.85 µg/ml for adult males, 10.38 µg/ml for adult females, 10.84 µg/ml for *Onchocerca ochengi* microfilariae and 20.13 µg/ml for *Loa loa* microfilariae [365].

The extract of stem portion of *Lantana camara* possessed antifilarial activity. The crude extract at 1 g/kg for 5 days by oral route killed 43.05% of the adult *Brugia malayi* parasites and sterilized 76% of surviving female worms in the rodent model of *Mastomys coucha*. A 34.5% adulticidal activity along with sterilization of 66% of female worms were exerted by the chloroform fraction. Remarkable antifilarial activity was observed in the adult *B. malayi* transplanted gerbil model where up to 80% of the adult worms killed at the same dose and all the surviving female parasites were found sterilized. The extract was also effective against a subcutaneous rodent filariid *Acanthocheilonema viteae* maintained in *Mastomys coucha*, where it exerted strong microfilaricidal (95.04%) and sterilization (60.66%) efficacy with mild macrofilaricidal action. Two compounds, oleanonic acid and oleanolic acid, isolated from hexane and chloroform fractions showed LC_{100} at 31.25 and 62.5 mug/ml, respectively, on *B. malayi in vitro* [366].

The aqueous extract from the leaves of *Lantana camar* was evaluated against filarial vector mosquito *Culex quinquefasciatus* and dengue vector *Aedes aegypti*. The aqueous extract (1000, 500, 250, 125 and 62.5 ppm) was tested against I, II, III and IV instar larvae of *C. quinquefasciatus* and *A. aegypti*. The LC_{50} values of *Lantana camara* against I, II, III and IV instar larvae of *C. quinquefasciatus* were 35.48, 46.74, 67.64 and 95.51ppm and against *A. aegypti* 35.19, 38.26, 65.98 and 91.90 ppm [367].

The decoctions of *Lantana camara* inhibited the process of *Haemonchus contortus* larval exsheathment, which may be related to tannin action because the addition of PVPP reversed the inhibitory effect [368].

The larvicidal activity of aqueous extract of dried leaf powder of *Lantana camara* was studied against the larvae of mosquito. *Lantana camara* was an ideal candidate as a larvicide, 80mg/100ml concentration of the aqueous extract was required for 100% mortality in six hours [369].

The extracts (10, 50 and 100 mg/ml) of the leaves of *Lantana camara* were investigated for their anthelmintic activity against *Pheretima posthuma.* Ethanolic extract exhibited significant anthelmintic activity at highest concentration (100 mg/ml) [370].

Lantana camara methanolic leaves extract at a concentration of 0.04 g/ml exerted the highest larvicidal activity towards the *Musca domestica* (housefly) larvae [371].

The larvicidal activity of *Lantana camara* was investigated against the larvae of common species of mosquitoes in Philippines. After the 24 hours of observation, researchers found that all the methanolic extracts of *Lantana camara* leaves were not significantly effective against the larvae, causing only 0-20% mortality [372].

The insecticidal effect of essential oil of *Lantana camara* was studied against the 3rd instar larval stage of *Aedes aegypti*. The essential oil (2500 to 10000 ppm) caused larval mortality of 20-50% on 3rd instar larvae at 24 hrs and 90-100% during 7th day [373].

The insecticidal activity of essential oil of the leaves of *Lantana camara* was investigated against mosquito vectors. LD_{50} values of the oil were 0.06, 0.05, 0.05, 0.05 and 0.06 mg/cm^2, while LD_{90} values were 0.10, 0.10, 0.09, 0.09 and 0.10 mg/cm^2 against *Ae. aegypti, Cx. quinquefasciatus, An. culicifacies, An. fluvialitis* and *An. stephensi* respectively. KDT_{50} values of the oil were 20, 18, 15, 12, and 14 min and KDT_{90} values were 35, 28 25, 18, 23 min against *Ae. aegypti, Cx. quinquefasciatus*, *An. culicifacies, An. fluviatilis* and *An. stephensi*, respectively on 0.208 mg/cm^2 impregnated paper. Studies on persistence of essential oil of *Lantana camara* on impregnated paper revealed that it has more adulticidal activity for longer period at low storage temperature [374].

Essential oils *Lantana camara* were also tested for insecticidal effect against *Sitophilus granarius* adults. Essential oils isolated at different times showed different activities on *S. granarius*. April essential oil, after 24 hours of exposure, exerted the highest activity. Similar results were obtained for February and June essential oils after 48 hours of exposure, while, December essential oil showed good fumigant activity after 96 hours of exposure [375].

Lantana flower extract provided 94.5% protection from Aedes albopictus and *Ae. aegypti*. One application of Lantana flower extract can provide more than 50% protection up to 4 h against the bites of Aedes mosquitoes [376].

The repellent properties of different fractions isolated from *Lantana camara* flowers were evaluated against Aedes mosquitoes. The results showed that the maximum protection time (3.45 h) was induced by a fraction eluted by chloroform. One application of this fraction gave 100% protection for 2 h and protected 75.8% at 7 h against the bites of Aedes mosquitoes [377].

The repellent activity of creams formulated with methanol crude extract, hexane fraction, and ethyl acetate fractions of *Ocimum gratissimum* and *Lantana camara* leaves in single and combined actions against female *Aedes aegypti*. All formulations (single and mixture) were applied at 2, 4, 6, and 8 mg/cm^2 in the exposed area of human hands. All the formulations presented good protection against mosquito bites without any allergic reaction in the human volunteers. The repellent activity was dependent on the strength of the extracts and fractions. Methanol crude extracts combination and hexane fractions mixtures from both plants showed synergistic effect [378].

The application of *Lantana camara* oil to the upper surface of the human forearms at the rates between 0.08 to 3.33 mg/cm^2 of skin possessed a significant repellent activity against mosquitoes (*Aedes aegypti*) [379].

1.1.81. Lawsonia innermis

The chloroform, ethanol and water extracts of the leaves of *Lawsonia inermis* (10, 20, 50 and 100mg/ml) were investigated for anthelmintic effect using adult *Eicinia fetida*. *Lawsonia innermis* extracts produced paralytic effect much earlier and the time to death was shorter [380-381].

The anti- *Strongyloides* effect of *Lawsonia inermis* (stems 70% methanolic etract) was studied *in vitro*, larvae and free living females were incubated with different concentrations of *Lawsonia* (1, 10, 100 mg/ml), for different incubation periods (24, 48, 72 and 96 h). *Lawsonia inermis* in a concentration of 10 mg/ml for 24 h affected the parasite cuticular surface in the form of transverse and longitudinal fissures and transverse depression in comparison to no cuticular change with flubendazole (100 mg/ml) [382].

The antimalarial activity of henna extract was studied *in vitro*. The antimalarial activity of petroleum ether extract was 27 mg/l and ethyl extract was 33 mg/l against both FcB1-Columbia and FcM29-Cameroon strains of *P. falciparum* [383].

A chemically characterized extract and it's major constituent were investigated for *in vitro* antiplasmodial activity on chloroquine sensitive NF-54 strain. The ethyl acetate extract of leaves (IC_{50} 9.00 ± 0.68 µg/ml) and fraxetin (IC_{50} 19.21 ± 1.04 µM) were the most effective in *in vitro* assays and they were further selected for *in vivo* in *Plasmodium berghei* infected mice. The administration of the ethyl acetate extract of leaves and fraxetin to the infected mice resulted in significant ($p < .05$) suppression of parasitaemia as evidenced by a 70.44 ± 2.58% to 78.77 ± 3.43% reduction. Two-fold increase in mean survival time, a significant ($p < .05$) reduction in lipid peroxidation and an elevation in glutathione, catalase and superoxide dismutase were also observed in treated mice. The post-infection treatment also augmented the endogenous antioxidant enzymes compared with infected control [384].

The synergistic anti-leishmanial effect of *Peganum harmala* and *Lawsonia inermis* was studied using MTT assay. A significant ($p< 0.01$) inhibition of promastigotes of *L. tropica* was possessed by both extracts at low and moderate concentrations, the combined extracts revealed a synergistic inhibitory effect in comparison with each one [385].

Constituents of *Lawsonia inermis* showed antileishmanial (*Leishmania tropica*) effects. Luteolin was the most potent anti-antileishmanial compound with an IC_{50} value of 4.15 µg/ml [386].

The antileishmanial effect of *Lowsonia inermis* methanolic extracts (0.07, 0.15, 0.31, 0.62, 1.25, 2.5, 5, 10 mg/ml) was studied on *Leishmania major* promastigotes using the MTT assay. *Lowsonia inermis* methanolic extract inhibited the growth of promastigote forms of *L. major in vitro* after 72 h of incubation, and showed IC_{50} of 1.25 mg/ml [387].

The *in vitro* antileishmanial activity of the hydroalcoholic extract of *Lawsonia inermis* was tested on the growth of the promastigotes of *Leishmania major*. The results showed that *Lawsonia inermis* extracts reduced the promastigotes number significantly ($p< 0.01$) [388].

The 90% ethanolic extract of *Lawsonia inermis* leaves was investigated for anticoccidial effects against caecal coccidiosis in broilers. *Lawsonia inermis* leaves extract at a dose of 300 ppm as feed supplement showed good anticoccidial effects, it significantly reduced the lesions and mortality as compared with salinomycin [389].

The antitrypanosomal activity of *Lawsonia inermis* leaves was investigated *in vitro* and *in vivo*. the crude methanolic extract of *Lawsonia inermis* leaves had *in vitro* activity against *Trypanosoma brucei* at concentration of 8.3 mg/ml while *in vivo* study revealed that the methanolic extract of *Lawsonia inermis* leaves ameliorated the disease condition but did not affect the level of parasitaemia and pack cell volume [390].

The ameliorative effect of methanol leaf extract of *Lawsonia inermis* (125, 250 and 500 mg/kg, orally) was studied in rats infected intraperitoneally with 10^6 *Trypanosoma congolense* per ml of blood. The extract significantly ($p< 0.05$) reduced levels of parasitaemia at 250 mg/kg, increased PCV ($p > 0.05$) and significantly decreased EOF and MDA. The authors concluded that, in addition to an antitrypanosomal effect of of *Lawsonia inermis* against *T. congolense* in rats, it attenuated the trypanosomosis pathology probably via protection of the erythrocyte membrane against trypanosome-induced oxidative damage to the erythrocytes [391].

The lousicidal activity of synthesized Ag NPs was studied against human head louse, *Pediculus humanus capitis* De Geer (Phthiraptera: Pediculidae), and sheep body louse, *Bovicola ovis* Schrank (Phthiraptera: Trichodectidae). The average percent mortality for synthesized Ag NPs was 33, 84, 91, and 100 at 10, 15, 20, and 35 min, respectively against *B. ovis*. The maximum activity was observed in the aqueous leaf extract of *Lawsonia inermis*, 1 mM $AgNO_3$ solution, and synthesized Ag NPs against *P. humanus capitis*. The findings revealed that Ag NPs possessed the highest anti-lousicidal activity [392].

The larvicidal activity of *Lawsonia inermis* (4, 40, 400 and 4000 ppm) was studied against, the malaria vector, *Anopheles stephensi.* The highest toxic effect of *Lawsonia inermis* was found at 4000 ppm and the lowest at 4 ppm against larval stages I and II. The same result was found against larval stages III and IV. The LC_{50} and LC_{90} were 413.8, 3366.3, 696.9 and 3927.7 ppm respectively against larval stages I, II, III and IV stages [393].

The larvicidal effects of the methanolic extracts of 11 medicinal plants were investigated against malaria vector, *Anopheles stephensi*. The methanolic extract of aerial parts of *Lawsonia inermis* showed high larvicidal activity with LC_{50} value of 69.40 ppm [394].

1.1.82. Lithospermum officinale

Shikonin also showed antiparasitic activity against *Culex pipiens* and *Aedes aegypti* and exhibited the highest toxicity for intracellular persisting *Leishmania major* [395-397].

1.1.83. Luffa acutangula

The larvicidal effect of extract of *Luffa acutangula* was studied against the late third larval age group of *Culex quinquefasciatus*. The larval mortality was observed after 24 h exposure. The LC_{50} values of the extract of *Luffa acutangula* was 839.81 ppm [398-399].

The anthelmintic activity of the of aerial parts extract of *Luffa acutangula* was studied by *in vitro* test using earth worm *Pheretima posthuma* test. The methanol extracts of aerial part of *Luffa acutangula* showed moderate anthelmintic activity. At 10 mg/ml concentration, it induced paralysis and death after >90 minutes [400].

1.1.84. Lycopus europaeus

The antiparasitic effects of methanolic extracts of the aerial parts of *Lycopus europaeus* (at the concentrations of 227, 113.5, 56.75, 28.37, 14.1 and 7.09 mg/ml after 0, 1, 3, and 6 hours exposure time) were studied on the growth of *T. gallinae* trophozoites. Both extracts decreased the viability of *T. gallinae*, they showed 60% growth inhibition at the highest concentration immediately after exposure. The lowest concentration of *Lycopus europaeus* extract that showed 100% growth inhibition was 28.37 mg/ml that affected trophozoites after 6 hours [401-402].

1.1.85. Mangifera indica

The stem bark extract of *Mangifera indica* was evaluated for antiplasmodial activity against *Plasmodium yoelii nigeriensis.* The extract exhibited a schizontocidal effect during early infection, and also demonstrated repository activity [403-404].

The inhibitory activity of mangiferin (50 and 100 mg/kg/die) on *Cryptosporidium parvum* was evaluated in a neonatal mouse model in comparison with that of paromomycin (100 mg/kg/die). Results showed that mangiferin at 100 mg/kg/day possessed significant anticryptosporidial activity similar to that showed by the same dose (100 mg/kg/day) of paromomycin. However, both mangiferin and paromomycin were not able to completely inhibit intestinal colonization of *C. parvum* but only to reduce it 80% compared to the untreated control [405].

In vivo treatment of *Toxocara canis*- infected BALB/c mice for 18 days with 50 mg/kg Vimang, reduced eosinophil migration into the bronchoalveolar space and peritoneal cavity. Also, eosinophil generation in bone marrow and blood eosinophilia were inhibited in infected mice treated with Vimang. This reduction was associated with inhibition of IL-5 production in serum and eotaxin in lung homogenates. The effects of Vimang were more selective than those observed with dexamethasone. The results supported its potential use as an alternative therapeutic drug for the treatment of eosinophilic disorders including those caused by nematodes and allergic diseases [406].

The anthelmintic effects of oral administration of Vimang (an aqueous extract of *Mangifera indica* stem bark) (500mg/ kg bw per day) and mangiferin (the major polyphenol present in Vimang) (50 mg/ kg bw/ day) were studied in mice experimentally infected with the *Trichinella spiralis*. Treatment with Vimang or mangiferin throughout the parasite life cycle led to a significant decline in the number of parasite larvae encysted in the musculature, however, the treatment were not effective against adults in the gut. Treatment with Vimang or mangiferin led to a significant decline in serum levels of specific anti-*Trichinella* IgE, throughout the parasite life cycle. Vimang or mangiferin, daily for 50 days orally in rats, inhibited mast cell degranulation as evaluated by the passive cutaneous anaphylaxis test (sensitization with infected mouse serum with a high IgE titre, then stimulation with the cytosolic fraction of *T. spiralis* muscle larvae) [407].

1.1.86. Marrubium vulgare

The anthelmintic activity of *Marrubium vulgare* aqueous and ethanolic leaves extracts (0.78, 1.55, 3.1, 6.2, 12.5, 25, and 50 mg/ml) was evaluated against digestive strongyles in naturally infected bovine using the egg hatch assay and larval mortality assay. The high effects were observed with 50 mg/ml, but the lowest reduction on parasite eggs hatchability was observed in cultures exposed to 0.78 mg/ml of both extracts. Both aqueous and ethanolic extracts of *Marrubium vulgare* (at 50 mg/ml) exhibited 45.8±1.99% and 51±2.53% larval mortality rate, respectively, at 24h [408-409].

Mortality of the 4th instar larvae of the mosquito *Culex pipiens* exposed to different doses of methanolic extract of *Marrubium vulgare* was varied with exposure time. The maximum mortalities (31, 40, 59%) were recorded for the concentration of 200, 500 and 900 mg/ml respectively, after 72 h of exposure [410].

The molluscicidal activity of *Marrubium vulgare* essential oils was investigated in adult and eggs *of Biomphalaria alexandrina*. The LC_{50} and LC_{90} of *Marrubium vulgare* essential oil against adult snails was 50 and 100 ppm/3hrs, respectively. Moreover, *Marrubium vulgare* showed LC_{100} ovicidal activity at 200 ppm/24 hrs [411].

1.1.87. Matricaria recutita

In vitro anthelmintic activity of *Matricaria recutita* was investigated on egg-hatching inhibition and loss of motility of adult worms of *Haemonchus contortus* from sheep. The results showed that both methanolic (IC_{50} = 1.559 mg/ml) and aqueous (IC_{50} = 2.559 mg/ml) extracts had the greatest effect on egg hatching and motility of worms (100% after 8 h post exposure at 8 mg/ml). Furthermore, methanolic and aqueous extracts contained more total polyphenols, total flavonoids and condensed tannins than chloroformic and hexanic extracts. ABTS and DPPH assays showed that methanolic extracts had the highest anti-oxidant potency (IC_{50} = 1.19 µg/ml and 1.18 µg/ml, respectively). The total phenolic, total flavonoid and condensed tannin values were correlated with inhibition of egg hatching [412-413].

The activity of *Matricaria chamomilla* essential oil was evaluated *in vitro* against axenic amastigotes of *Leishmania braziliensis* at concentrations lower than or equal to 250µg/ml. The essential oil of *Matricaria chamomilla* also showed activity against intracellular amastigotes of *L. panamensis* and *L. braziliensis* (EC_{50} of 2.87 and 10.30µg/ml, respectively [414].

Chamomile essential oil possessed lousicidal, ovicidal and repellant activity against lice and flies infesting water buffaloes. LC_{50} values was 22.79% [415].

1.1.88. Mirabilis jalapa

The anthelmintic activity of aerial parts extracts (20%, 40%, 60%, 80%) of *Mirabilis jalapa* was studied using *Pheretima posthuma* as a test worms. The methanolic extract of *Mirabilis jalapa* caused paralysis in 12.6 min and death in 13.5 min. The reference drug albendazole showed the same effect at 2.3 min and 3.24 min respectively [416-417].

The larvicidal activity of crude benzene, chloroform, ethyl acetate, and methanol leaf extracts of *Mirabilis jalapa* was investigated against the larvae of three important vector mosquitoes (*An. stephensi, Ae. aegypti* and *Cx. Quinquefasciatus*). The highest larvicidal activity was possessed by the leaf methanol extract of *Mirabilis jalapa* against *An. stephensi*, *Ae. aegypti* and *Cx. quinquefasciatus* with LC_{50} and LC_{90} values of 57.55, 64.58, 84.53 ppm and 104.20, 120.28, 159.25 ppm, respectively. The mortality rate was positively correlated with concentration [418].

1.1.89. Musa paradisiaca

The anthelmintic activity from corm ethanol extracts of *Musa paradisiaca* cv. *puttabale* was investigated using *Pheretima posthuma* as an experimental model. The results showed that the ethanol extract at the concentration of 100 mg/ml showed significant anthelmintic activity in time of paralysis: 42.33±1.45 min compared with control (142.67± 1.45 min) and death time was 54.00±0.58 min compared with control (168.00± 1.53 min) [419-420].

Aqueous extract as well as methanol extracts of *Musa paradisiaca* exhibited anthelmintic activity by inhibiting hatching of eggs of nematodes. The egg hatch test was conducted on nematodes ova to investigate the *in vitro* ovicidal effects. Lethal LC_{50} values of crude aqueous and crude aqueous-methanol extracts of *Musa paradisiaca* leaves were 0.0207 and 0.4813, respectively [421].

The *in vitro* antiparasitic effect of *Musa paradisiaca* stem and leaf aqueous, methanolic and/or dichloromethane extracts was studied against Haemonchus contortus using egg hatch assay, larval development assay, L3 migration inhibition assay and adult worm motility assay. The highly significant ($P< 0.0001$) ability to stop larval development (inhibition > 67% for each extract) and the negative effect of the dichloromethane extract of leaf on adult worm motility (43% of inhibition of motility after 24 hours of incubation) compared to the negative controls, suggest anthelmintic properties of *Musa paradisiaca* stem and leaf against H. contortus [422].

The leishmanicidal activity of Musa paradisiaca was studied using promastigotes and amastigotes of *L. chagasi*. Two fractions of the aqueous ethanolic extract of Musa paradisiaca showed IC_{50} value of 1.70 and 1.83 µg/ml against promastigotes and 14.18 and 16.54 µg/ml against amastigotes [423].

The leishmanicidal activity of triterpenes and sterols isolated from Musa paradisiaca fruit peel was studied against L. infantum chagasi promastigotes and amastigotes. Five isolated compounds (three triterpenes: cycloeucalenone, 31-norcyclolaudenone; and 24-methylene-cicloartanol and a mixture of two sterols: beta-sitosterol and stigmasterol) showed statistically similar activity against promastigote compared to pentamidine with the exception of cycloeucalenone, furthermore, all compounds acting against amastigotes, excluding 31-norcyclolaudenone [424].

The antiparasitic effect of banana roots (*Musa paradisiaca*) was evaluated in rabbits infected with coccidiosis. Rabbits received control with no intervention, rabbit pellets mixed with sulphadimidine sodium, or rabbit pellets mixed with dried crushed banana roots, over a two-weeks period. A significant decrease in oocysts output was recorded in both banana root treatment and sulphadimidine sodium treatment ($p\leq 0.05$) [425].

1.1.90. Myrtus communis

Extract of *Myrtus communis* caused death of *T. vaginalis* at pH 4.65, but failed to do so at pH 6.00 [426].

The anti-*Toxoplasma* effect of *Myrtus communis* extracts was evaluated *in vitro*. *T. gondii* RH strain tachyzoites were exposed to extract of *Myrtus communis* in cell-free medium and cell culture. The extract showed cidal effects on

tachyzoites in cell-free medium. But, in cell culture, EC_{50} and selectivity of *Myrtus communis* extract was significantly lower than pyrimethamine [427-428].

The anti-*Acanthamoeba* effect of crude aqueous and ethanolic extracts of *Myrtus communis* (1.25, 2.5, 5, and 10 mg/ml) was evaluated at three different times (24, 48 and 72 hr) on trophozoites and cysts of *Acanthamoeba in vitro*. The percentage of viablity of trophozoites and cysts after adding ethanolic extract of *Myrtus communis* was 0% and 8.62%, respectively. At 10 mg/ml concentration of aqueous extract of *Myrtus communis,* 0% trophozoites and 31.10% cysts lived after 72 h [429].

Antileishmanial effects of essential oil and methanolic extract of *Myrtus communis* were studied on promastigote and amastigote forms of *Leishmania tropica*. Furthermore, their cytotoxic activities were investigated against J774 cells were Myrtus communis, particularly the essential oil, significantly ($P<0.05$) and dose-dependently inhibited the growth rate of promastigote and amastigote forms of *L. tropica* based on a dose-dependent response. The IC_{50} values for essential oil and methanolic extract was 8.4 and 28.9 µg/ml against promastigotes, and 11.6 and 40.8 µg/ml against amastigote forms, respectively. The essential oil and methanolic extract possessed no significant cytotoxicity in J774 cells. However, essential oil indicated a more cytotoxic effect as compared with the methanolic extract of Myrtus communis [430].

The scolicidal effect of the methanolic extract of *Myrtus communis* was studied against protoscolices of hydatid cyst. The result showed that high scolicidal effect (100%) was possessed by Myrtus communis at 100 and 50 mg/ml concentrations. LC_{50} in 10, 20 and 30 min were 11.64 mg/ml, 7.62 mg/ml, and 6.47 mg/ml respectively [431].

The extract of Myrtus communis at different concentrations (50, and 100 mg/ml) increased the activity of caspases 3 and 9 and caused programmed cell death in hydatid cyst protoscolices [432].

The fumigant toxicity of leaf essential oil of *Myrtus communis* was assessed against *Trogoderma granarium*. The essential oil was active against different life stages of *T. granarium*. Adult stage was the most sensitive of all developmental stages to essential oil vapours. Whereas, larvae were the most tolerant with 94% and 100% mortality obtained after exposure of larvae to 562.5 µl/l air for 24 and 48h respectively. At 48h exposure period, LC_{50} and LC_{90} were 221 µl/l air and 487 µl/l air respectively [433].

1.1.91. Nerium oleander

The aqueous leaf extract of *Nerium oleander* possessed ovicidal and larvicidal properties when tested against *Culex tritaeniorhynchus* and *Culex gelidus* [434].

The crude hexane and aqueous extract of *Nerium oleander* flowers were investigated for larvicidal activity against the filarial vector, *Culex quinquefasciatus*. Mortality was observed for 24 and 48 hours. Hexane flower extract exhibited highest larvicidal activity with a LC_{50} value of 102.54 ppm and 61.11ppm after 24 and 48 hours respectively [435].

The insecticidal activity of the extract of Nerium oleander, was studied against the larval stages 3 and 4 of *Culex pipiens*. The LC_{50} and LC_{90} of the ethanolic extract of Nerium oleander were 57.57 mg/ml and 166.35 mg/ml, respectively [436].

The larvicidal activity of water, chloroform, acetone and diethyl ether extracts of Nerium oleander leaves, was tested against *Culex pipiens*. The toxicity of the four extracts, using the LC_{50}, at 10 °C was higher than that at 35 °C. Diethyl ether extract of *Nerium oleander* leaves was the most potent extract, with LC_{50} of 10500 mg/l. The diethyl ether extract significantly decreased the larval duration, pupal duration, percentage of pupation, percentage of adult emergence, longevity of females, fecundity, and oviposition activity index, whereas the growth index and the percentage of development per day of larvae and pupae were significantly increased compared to non-treated insects [437].

The larvicidal activity of *Trigonella foenum* and *Nerium oleander* leaf extracts was studied against different mosquito larvae, the larvicidal effect of the combination of both plant extracts was also studied. The results showed that the leaf extract of *Trigonella foenum* and *Nerium oleander* possessed larvicidal activity (3% concentration showed 50 and 20% mortality after 72 hrs exposure, respectively), and the combination of the extracts, showed higher larvicidal activity (3% concentration of the combination showed 100% mortality after 48 hrs exposure) [438].

The insecticidal effect of ethanolic extract of the leaves of *Nerium oleander* was studied against 2nd instar larvae of the medically important false stable fly *Muscina stabulans*. LC_{50} of the extract was 113.66 ppm. It delayed larval and pupal duration, suppressed oviposition and decreased adult longevity of the survivors [439].

1.1.92. Nicotiana tabacum

The antiparasitic effect of crude aqueous methanol *Nicotiana tabacum* leaves extract was evaluated against oxfendazole-resistant *Haemonchus contortus* in sheep by using hatch assay, adult motility test and fecal egg count reduction test. The extract caused dose and time dependent antinematicidal activity with LC_{50} values of 0.566 and 1.91 mg/ml in egg hatch assay and adult motility test, respectively. There was, however, no significant difference ($P>0.05$) in fecal egg count reduction (87.5 vs 88.6%) in sheep at low (2g/kg bw) and high (4g/kg bw) doses. Administration of *Nicotiana tabacum* leaves extract at low dose (2 g/kg bw) did not exhibit side effects in animals [440-441].

The anthelmintic activity of *Nicotiana tabacum* leaves extracts (crude aqueous and methanol extract) was studied using *in vitro* and *in vivo* models. Both the extracts caused paralysis and/or mortality of worms noted at 6 h post-exposure *in vitro*. In *in vivo* study, both extracts were administered in increasing doses (1.0-3.0 g/kg) to sheep naturally infected with mixed species of gastrointestinal nematodes. A maximum reduction of 73.6% in eggs per gram of faeces was recorded on day 5 post-treatment with crude methanolic extract (3.0 g/kg) while the same dose of crude aqueous extract showed a 49.4% reduction [442].

The *in vitro* anthelminthic effect of aqueous and alcoholic extract (25, 50 and 75 mg/ml) of *Nicotiana tabacum* was studied against *Marshallagia marshalli* compared with levamisole. The aqueous extract at 25 and 50 mg/ml dilution possessed the same anthelminthic effects ($P<0.05$), but 75 mg/ml of the aqueous extract and 25, 50 and 75 mg/ml of alcoholic extract possessed more anthelminthic effect ($P<0.05$) [443].

The ovicidal, adulticidal effects of *Nicotiana tabacum* leaf extract, garlic (*Allium sativum*) bulb extract, soft soap and their binary mixtures were investigated against *Tetranychus urticae*. The results showed that the tobacco leaf extract, the soft soap and the garlic extract soap mixture were the most toxic against adult females. Although the garlic bulb extract had the lowest toxic effect, its mixtures with the soft soap and tobacco extract showed higher toxicity against the adults. Furthermore, the tobacco application at the tested dose significantly reduced the *T. urticae* fecundity [444].

The acaricidal activity of acetone and aqueous extracts of the leaves of *Nicotiana tabacum* and deltamethrin were tested against *Rhipicephalus* (*Boophilus*) *microplus* fresh larvae using larval packet test. The LC_{50} and LC_{99} were highest for aqueous leaf extract at 728.97 and 6094.438 ppm, respectively [445].

A mosquito repellent paints was formulated from the extract of tobacco leaves. The results showed that 5% concentration of tobacco extract killed half of the mosquito population in 2 hours, the concentration of tobacco extract between 3-5% killed half the mosquito population in 4 hours, while 1-3% and 0-1% concentration of tobacco extract killed half the mosquito population during 6 and 24 hours, respectively [446].

The effect of leaf and seed extract of *Nicotiana tabacum* in the management of larvae, pupae and adults of *Anopheles gambiae*was was assessed at five different concentrations (0.1%, 0.2%, 0.3%,0.4% and 0.5%) at ambient temperature (28±2 ^{0}C) and relative humidity (75±5%). Both extracts of *Nicotiana tabacum* elicited 100% mortality in larvae, pupae and adults of *An. gambiae* at the highest concentration. LC_{50} values revealed that leaf extract showed more toxicity than the seed extract. The LC_{50} values of leaf and seed extract of *Nicotiana tabacum* also increased with the developmental stages of the mosquitoes with the lowest and highest observed in larval (leaf: 0.153µg/ml; seed: 0.188µg/ml) and adult (leaf: 0.219 µg/ml; seed: 0.290 µg/ml) stage respectively. Median LC_{50} values were recorded in pupae of *An. gambiae* (leaf: 0.176 µg/ml; seed: 0.213µg/ml) [447].

The crude methanolic leaf extract of *Nicotiana tabacum* was evaluated for larvicidal activity against *Aedes aegypti* at concentrations of 62.5, 125, 250, 500 and 1000 ppm. *Nicotiana tabacum* exhibited high larvicidal activity with LC_{50} values of 313.58 and 122.99 ppm respectively after 24 and 48 hours [448].

The larvicidal effect of *Nicotiana tabaccum* leaves extracts was investigated against the larvae of *Anopheles* and *Culex* mosquitoes. Tobacco leaf extract caused 100% mortality rate at 80 and 100% concentrations [449].

The effectiveness of tobacco extract nanoemulsion was studied against *Aedes aegypti* larvae. Bioassay of larvicidal nanoemulsion revealed that the decrease in LC_{50} values was directly proportional to the decrease in particle size. The lowest LC_{50} values were obtained by the an average particle size of 631 nm. The larvicidal activity of tobacco was attributed to its nicotine and some toxic content [450].

Bio-oil extracted from tobacco leaves using fast pyrolysis at temperature of 500, 600, and 700^{o}C was made into bio-mass based repellent. The repellent efficacy was 38.09%; 45.82%; 46.41% and 57.07%, respectively, at concentrations

of (0%, 0.5%; 1.5% and 3%). The active compounds of repellency were nicotine, d-limonene, indole, and pyridine [451-452].

The crude 95% ethanol extracts of tobacco leaves containing nicotine as an active ingredient was tested as pesticide. The emulsion formulation was studied against aphids (*Aphis glycines* Mats.) in the experiment field. It killed all of the aphids [453].

1.1.93. Ocimum basilicum

The antileishmanial activity of *Ocimum basilicum* leaves extract against *Leishmania tropica* was investigated. *Ocimum basilicum* showed good antileishmanial activity with LC_{50} value of 21.67 µg/ml [454-455].

Trypanocidal activity of *Ocimum basilicum* essential oils was investigated against *Trypanosoma cruzi* epimastigote and bloodstream trypomastigote forms. Treatment with *Ocimum basilicum* essential oils inhibited parasite growth, they caused ultrastructural alterations mainly in the nucleus [456].

Oils from some *Ocimum* spp. possessed repellent and larvicidal activity against houseflies, blue bottle flies, and mosquitoes. The effective concentration of the oil to kill the larvae ranged from 113-283 ppm. The repellent properties could be attributed to camphor, d-limonene, myrcene and thymol, while eugenol and methylchavicol could be responsible for the larvicidal activity [457].

The chloroform extract of *Ocimum basilicum* at concentrations between 6% and 10% exhibited 70% and 100% mortality of ticks, *Rhipicephalus microplus* compared to control. The LC_{50} and LC_{90} values of the chloroform extract after 24 h were 5.46% and 7.69%, respectively [458].

Ocimum basilicum essential oil killed the larvae of *Culex quinquefasciatus* (100%) at 120 ppm, the LC_{50} of the essential oil was 60 ppm, while a commercial insecticide containing pyrethrins and malathion required 32 ppm for a complete kill and about 15 ppm for 50% kill. A mixture of the oil at 20 ppm and the insecticide at 16 ppm gave 100% kill, suggesting that the oil of *Ocimum basilicum* possessed synergistic powers [459].

The extracts of *Ocimum basilicum* were screened for their repellent effect against *Culex pipiens* mosquito. The petroleum ether, acetone and methanol extracts of *Ocimum basilicum* showed repellency of 98.1, 84.6 and 77.4% respectively, at dose of 6.7mg/cm^2. [460]

The insecticidle effect of *Ocimum basilicum* leaves powder and ethanolic extract was evaluated against the 3rd larval Instar of *Anopheles arabiensis*. The results showed that the LC_{50} of the extract was 58mg/l and LC_{90} was 143 mg/l [457].

The essential oils of *Ocimum basilicum* possessed remarkable adulticidal properties on *Anopheles funestus* ss (LC_{50} = 84ppm), one hour after exposure. The effectiveness was decreased significantly with time (LC_{50} = 84; 171.7, 397 respectively, one hour, 5 days and 10 days after exposure piece of nets to the product) [461].

1.1.94. Olea europaea

The anti-cryptosporidium effect of *Olea europaea* leaf extract was studied in four different groups of experimentally infected neonatal mice. There was a 100% reduction in cryptosporidium oocyst excretion in stool and copro-DNA of *Olea europaea* leaf extract - treated infected mice after 2 weeks of drug administration [462-463].

The antimalarial activity of *Olea europaea* (crude extract and fractions 200, 400 and 600 mg/kg) was investigated against *Plasmodium berghei* infected mice. The crude extract significantly reduced parasitemia ($P < 0.001$) and prolonged survival time ($P < 0.001$), in a dose-dependent manner. Parasitemia was significantly reduced ($P < 0.001$) by all fractions in all doses used, with the rank order of n-butanol (51%) > chloroform > aqueous (21%) fractions [464].

The scolicidal effects of *Olea europaea* leaf extract (75-300 mg/ml, for 5-30 min) on hydatid cyst protoscolices were studied *in vitro* and *ex vivo*. The mean of the mortality of protoscoleces was 100% after 10 min of incubation with the concentration of 300 mg/ml of *Olea europaea* leaves extract, and the mean of the mortality of protoscoleces after 20 min of incubation with the concentration of 150 mg/ml of *Olea europaea* leaves extract was also 100%. After injection of *Olea europaea* leaves extract directly into the hydatid cyst (*ex vivo*), the mean of the mortality of protoscoleces was 100% after 12 and 25 min of incubation with 300 and 150 mg/ml of the extract [465].

2. Conclusion

Medicinal plants were used traditionally for the treatment of different parasitic diseases. They possessed preventive and curative effects against wide range of parasitic species. The current paper reviewed the antiparasitic, antiprotozoal, molluscicidal and insecticidal effects of the medicinal plants to encourage identification of the active ingredients, determination of clinical efficacy, studying of pharmacokinetic characteristics, investigation of the mode of action and safety.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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