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(Review Article)

Iraqi medicinal plants with insecticidal activity

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Abstract

Insects occupy fundamental places in the world's ecosystems. Some insects carry the causative agents of many diseases. The use of synthetic insecticides has been restricted recently, mainly due to harmful environmental effects, and increasing insecticidal resistance. Herbal medicines can possess insecticide effects via many mechanisms. The current review was designed to highlight the medicinal plants with insecticide and insect repellent activities with special focus on their mechanism of action.

Keywords: Insects; Medicinal Plants; Insecticide; Insect Repellent

1. Introduction

Insects occupy fundamental places in the world's ecosystems. Some insects carry the causative agents of many diseases such as malaria, Chagas' disease, Lyme disease, bubon¬ic plague, and dengue fever. They also carry the parasites and bacteria causing animals diseases and damage food crops (locusts), trees (gypsy moths), and homes (termites). Vari¬ous synthetic insecticides are developed to manage insects and insect-related damage and disease (1). However the use of a wide range of synthetic insecticides has been restricted recently, due to the high cost, non-biodegradable nature, harmful envi¬ronmental effects, and increasing insecticidal resistance (2).

All types of parasites including insects continuously develop resistance against treatments (3-9). Herbal medicines have been used for thousands of years as sources of bioactive and therapeutic substances with industrial and agricultural purposes. Botanical sources are an efficient alternative source for synthetic insecticides with wide range of insecticidal effects , they provide a simple and sustainable method of insect control (10). Herbal medicines can possess insecticide effects via many mechanisms including acetylcholine esterase inhibitors, GABA-gated chloride channel antagonists, voltage-dependent sodium channel blockers, Acetylcholine receptor agonists /antagonists and chloride channel modulation (11-13). In the current review, databases including PubMed, Web Science, Science Direct, Researchgate, Academia.edu and Scopus were searched to investigate the medicinal plants with insecticide and insect repellent activities with special focus on their mechanism of action.

2. Medicinal plants with insecticide and insect repellent activities

2.1. *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 worm, on worker groups of honeybee and on domestic flies by applying three different methods (14-15).

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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 (16).

2.2. *Ailanthus altissima*

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 72 h 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(17-18).

2.3. *Allium sativum*

Allium sativum lectins are promising candidate molecules for the protection against insect. Lectins show its effect right from sensory receptors of mouth parts by disrupting the membrane integrity and food detection ability. Subsequently, enter into the gut lumen and interact with midgut glycosylated proteins like alkaline phosphatase (ALP), aminopeptidase-N (APN), cadherin-like proteins, polycalins, sucrase, symbionin and others. These proteins play critical role in life cycle of insect directly or indirectly(19-20).

Aqueous and methanol extracts showed highest insecticidal activity (mortality rate of 81% and 64% respectively) against the larvae of Spodoptera litura (S. litura) at a concentration of 1 000 ppm(21).

2.4. *Anagyris foetida*

Anagyris foetida was tested for its insecticidal effects, the oils and powders of *Anagyris foetida* possess insecticidal activity against insects (22-23).

2.5. *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 (24-25).

2.6. *Artemisia campestris*

Ethanolic extract from *Artemisia campestris* var glutinosa showed weak larvicidal ctivity against mosquito Culex Linnaeus (Diptera , Culicidae) larvae (26-28).

2.7. *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(29-31).

2.8. *Caesalpinia crista*

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 (32-33).

2.9. *Calotropis procera*

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 LC50 values of the extract of C. procera leaves was found to be 282.5 mg-1 (34-35).

2.10. *Capsicum Species*

Capsaicin is used on vegetation such as crops and trees, buildings, and garbage containers. It is registered to repel vertebrate pests such as rabbits, squirrels, deer, voles, raccoons, cats, dogs, and skunks. It is applied to foliage of plants to deter feeding by insects such as spider mites, lace bugs, and other invertebrates. Capsaicin is used as an insecticide in addition to its use as a repellent (36-37).

The insecticidal activities of red pepper (Capsicum annuum L.) fruit powder were investigated against Rhyzopertha dominica and Sitophilus granaries. This powder was mixed with 20g wheat grains as direct admixtures at different rates viz, 0, 0.5, 0.85, 1.5, 3 and 5% (w/w) to assess for mortality and reduction of Fl progeny. The results revealed that red pepper in low concentrations did not cause complete mortality on two insects after 14 days. It caused complete reduction in Fl progeny of S. granarius and R. dominica at highest tested dosages (38).

Capsicum annuum and Capsicum frutescens fruit and seed powders were evaluated in the laboratory for the control of Callosobruchus maculatus (F.) in stored cowpea and Sitophilus zeamais in stored maize. Capsicum frutescens seed powder and Capsicum annuum seed powder dust were toxic to C. maculatus and S . zeamais at the rate of 5.0g, 7.5g per 50g cowpea and 50g maize within 48hrs and 96hrs respectively (39).

Capsicum frutescens L. (fruit and seed) and C. annuum Miller (fruit and seed) were examined as fumigant insecticides on cowpea bruchid. The powders were applied at rates 0.0 (control), 2g and 3.0g/20g of cowpea seeds either directly for contact with the insect pest or in plastic containers to assess fumigant toxicity of their volatiles. Results of contact toxicity assay showed that powders of C. frutescens and C. annum seeds were highly effective against the adult C. maculatus evoking 100% mortality within 2 days of application at 3g/20g of cowpea seeds. There was no progeny development of the bruchid in samples treated with *Capsicum Species.* The survival of the bruchid from eggs to adults when treated with the plant powders showed that there was significantly ($P<0.05$) more % progeny development in the control (69.32%) compared to others (40).

The mosquito repellent effect of extracts of Capsicum frutescens was studied against A. aegypti mosquitoes. The plant parts were dried in the shade and ground to powder. The volatile constituents of the powders were isolated by dry distillation, and the distillates used in repellency tests on A. aegypti mosquitoes. The distillates of the fruits of C. frutescens were effective for 2.5 hours. The mixture of C. frutescens and C. papaya was effective for 4 hours, whilst that of C. frutescens and C. dactylon was effective for 3 hours. The mixture of all three extracts was effective for 4 hours, i.e. giving the same duration of protection as the mixture of C. frutescens and C. papaya. Mixtures of highly repellent extracts are likely to give high repelling products although the repellency of the mixture is not likely to be a simple additive product of the repellencies of the constituent extracts (41).

The insecticidal activity of different concentrations of methanol extract of fruits and leaves of C. frutescens was investigated against 2nd and 3rd instar larvae of A. aegypti. The mortality of the larvae was found to be concentration dependent. Among larvae, 2nd instar larvae were shown to be more sensitive than 3rd instar larvae. The fruit extract has shown more killing effect than leaf extract (42-43).

2.11. *Carum carvi*

The essential oil of Caraway was found to possess strong contact toxicity against Sitophilus zeamais and Tribolium castaneum adults, with LD50 values of 3.07 and 3.29 μg/adult respectively, and also showed strong fumigant toxicity against the two grain storage insects with LC50 values of 3.37 and 2.53 mg/l respectively. (R)-Carvone and D-limonene showed strong contact toxicity against S. zeamais (LD50= 2.79 and 29.86 μg/adult) and T. castaneum (LD50 = 2.64 and 20.14 μg/adult). (R)-Carvone and D-limonene also possessed strong fumigant toxicity against S. zeamais (LC50 = 2.76 and 48.18 mg/l) and T. castaneum adults (LC50 = 1.96 and 19.10 mg/l) (38). 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 (*Carum carvi*) (44-45).

2.12. *Cassia occidentalis*

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 LC50 and LC90 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 (46).

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 (47-48).

2.13. *Chenopodium album*

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(49-50).

2.14. *Chrysanthemum cinerariaefolium*

Pyrethrum is first insecticide recorded in history at the time of China's Chou Dynasty, some 2000 years ago. The flower was traded along the Silk Route into Europe where it was widely grown. The Dalmatian region was the predominant pyrethrum-producing region from the late 19th century through to the advent of World War I, when the predominant product was referred to as "Dalmatian Flea Powder". Japan became the major supplier after 1918 and remained so until 1940. Kenya began production after the introduction of Chrysanthemum cineariaefolium in 1928 and, by 1940, had replaced Japan as the dominant world supplier of pyrethrum extract. Neighbouring East African countries, particularly Tanzania, Rwanda, and Uganda also developed infrastructure to support pyrethrum cultivation and have produced significant amounts of pyrethrum from time to time. Small commercial plantings for production of pyrethrum extract were made in Albania, Algeria, Angola, Argentina, Australia (Canberra and NSW prior to Tasmania), Bermuda, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Congo, Cyprus, Ecuador, Egypt, Republic of Ireland, England, Ethiopia, Fiji, France, Greece, Guatemala, India, Italy, Jamaica, Madagascar, Mexico, Morocco, New Zealand, Nigeria, Palestine, Persia, Peru, Philippines, Puerto Rico, United States, St. Helena, Spain, Sudan, Sweden, Switzerland, Trinidad, Turkey, Russia, South Africa and Zimbabwe(51-52).

The plant products were available for use even though the chemistry of active ingredients was unknown. In 1924, German chemist Herman Staudinger (1881-1965) and a Croatian scientist, Lavoslav Ružička (1887- 1976), winner of the 1939 Nobel Prize in Chemistry, identified chemical structure of the active pyrethrin ingredients, pyrethrin I and pyrethrin II(53).

Pyrethrin is mainly concentrated in the flower heads, 93.7 % of pyrethrin is accumulated in achenes, and minor quantities in disc florets (2.0 %), ray florets (2.6 %), and receptacles (2.6 %). The term pyrethrin is referred to the six insecticide active ingredients: pyrethrin I, cinerin I, jasmolin I, pyrethrin II, cinerin II and jasmolin II. Pyrethrin I, cinerin I and jasmolin I are closely related insecticidal esters of chrysanthemic acid, while pyrethrin II, cinerin II and jasmolin II are insecticidal esters of pyrethric acid. The three chrysanthemic acid esters are commonly referred as pyrethrins I, and pyrethric acid esters as pyrethrins II. Among these compounds pyrethrin I and pyrethrin II are the most predominant and active(54-57).

It is used for the control of a wide range of insects and mites in public health and on domestic and farm animals and for the control of chewing and sucking insects and spider mite on fruit, vegetables, field crops, ornamentals, glasshouse crops, and house plants. Pyrethrin also acts as a repellent. It has a quick knock-down effect on a wide range of insect species, causing paralysis within a few minutes. It acts as contact poison and affects the central nervous system of insects. The commonly accepted mechanism of action of pyrethroids is the prolongation of the open state of voltage-dependent sodium channels in nervous tissue. These altered sodium channels result in repetitive firing or depolarizing block of the neuron, depending on how long the channel open state is prolonged. Other channel and receptor systems in neuronal tissues have been proposed to play a role in the generation of compound-specific clinical symptoms in mammals, including calcium channels and GABAA receptors(55, 58).

In studying the mechanism of biosynthesis of pyrethrins, the results of experiments using 13C-labeled glucose as the biosynthesis precursor indicated that the acid and alcohol moieties are biosynthesized via the 2-C-methyl-D: -erythritol 4-phosphate (MEP) and oxylipin pathways, respectively. Further study on the effects of wound-induced signals in leaves showed that biosynthesis is enhanced in response to both volatile and nonvolatile signals(16). In other study the acid was found produced by the same route, but the authors mentioned that the alcohol moiety was possibly biosynthesized from linolenic acid(59).

Tissue cultures of *Chrysanthemum cinerariaefolium* were used to study the production of pyrethrin insecticides, and their precursor chrysanthemic acid. Callus cultures and root-differentiated cultures did not contain pyrethrins whereas shoot differentiated callus was found to produce the pyrethrins. Chrysanthemic acid was isolated by extraction from callus cultures, and feeding 14C-labelled chrysanthemic acid to a cell suspension of *Chrysanthemum cinerariaefolium* established that the acid accumulates largely as a glucoside ester(60).

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(61-62).

2.15. *Citrullus colocynthis*

Methylene chloride, n-hexane, chloroform and ethanol extracts of *Citrullus colocynthis* fruits were tested against Aphis craccivora. The highest insecticidal effect (LC50: 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(63).

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)(64-65).

2.16. *Clerodendron inerme*

The aqueous extract of *Clerodendron inerme* 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 (66).

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) (67).

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 (68). It was stated that petroleum ether extract of Clerodendrum inerme gave 3h protection against mosquitoes at 9% concentration (69).

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 (70).

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 (71-72).

2.17. *Clitoria ternatea*

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 LC50 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(73-74).

2.18. *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 (LC50 and LC90) of acetone, ethyl acetate and methanol extract of the plant against An. stephensi and Ae.aegypti revealed that LC50 of 197.34ppm and LC90 of 358.59ppm was recorded for acetone extract against the An. stephensi; furthermore, the larvae of Ae. aegypti showed the LC50 and LC90 values of 222.45 and 383.06ppm respectively, with the treatment with the acetone extract of *Corchorus capsularis*. Minimum LC50 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(75-76).

2.19. *Cordia myxa*

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(77-78).

2.20. *Coriandrum sativum*

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: LC50 was 421 ppm, while LC90 was 531.7 ppm. Repellence trials highlighted that *Coriandrum sativum* EO was a good repellent against A. albopictus, RD50 was 0.0001565 µl/cm2 of skin, while RD90 was 0.002004 µl/cm2. At the highest dosage (0.2 µl/cm2 of skin), the protection time achieved with *Coriandrum sativum* essential oil was higher than 60 min(79).

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(80).

The seed oil had significant toxic effects against the larvae of Aedes aegypti with an LC50 value of 21.55 ppm and LC90 value of 38.79 ppm. The major components in the essential oil of coriander play an important role as immunotoxicity on the A. aegypti(81-82).

2.21. *Cuminum cyminum*

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(83-84).

2.22. *Cupressus sempervirens*

Ethanolic, acetone and petroleum ether extracts of leaves from the Egyptian *Cupressus sempervirens* were tested against 3rd instar larvae of the mosquito Culex pipiens. The obtained results indicated that petroleum ether extracts were more efficient than ethanolic and acetone extracts. The toxicity, based on LC50 values, were: ethanolic (LC50 263.6ppm) > acetone extract (LC50 104.3ppm) > petroleum ether extracts (LC50 37.8 ppm). A remarkable reduction in both the pupation percent and adult emergence was obtained. Moreover, all extracts exerted a delayed toxic effect on the pupae and adults after treatment of larvae. Furthermore, various degrees of morphogenic abnormalities were observed in the immature and adult stages(85-86).

2.23. *Cymbopogon schoenanthus*

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 LC50 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(87).

Cymbopogon schoenanthus essential oils from Benin Republic in west Africa displayed about 100% mortality rate against adult Anopheles gambiae(88).

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(89-90).

2.24. *Cynodon dactylon*

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 (91-92).

2.25. *Cyperus rotundus*

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(93).

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(94).

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 EC50 values of <5 ppm and LC50 and LC90 values of <20 ppm(95-96).

2.26. *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 LD50 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 these insects at 1% concentration(97-98).

2.27. *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 *Dianthus caryophyllus* also exerted moderate larvicidal activity, displaying LC50 value above 50 mg/l. Among the pure components, the most toxic were eugenol, (E)-anethole, and α-terpinyl acetate, with LC50 value of 18.28, 16.56, and 23.03 mg/l, respectively(99).

The essential oil from flowers of carnation (*Dianthus caryophyllum*) exerted pronounced repellent effect both against both ticks (nymphs of Ixodes ricinus) and yellow fever mosquitoes (Aedes aegypti). Phenylethanol was found the most potent repellents ingredient(100-101).

2.28. *Digitalis purpurea*

Studying of insecticidal activity of alcoholic extract of *Digitalis purpurea* against *T. castaneum* revealed that the percentage mortality of T. castaneum was 60%, at 100 mg/2 ml of alcoholic extract of *Digitalis purpurea* (102-103) .

2.29. *Dodonaea viscosa*

Insecticidal activity of the ethanolic extracts of the leaves of *Dodonaea viscosa* was studied by using four insect models (*Epilachna paenulata, Spodoptera littoralis, Myzus persicae, and Rhopalosiphum padi*), which were 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 insecticidal activity against the insects(104-105).

2.30. *Dolichos lablab*

Arcelins, the protein isolated from seed flour of the Indian wild bean, *Dolichos lablab* showed insecticidal activity against Callosobruchus maculates(106)

Lablab purpureus proteins at 2% in the diet resulted in retarded *Rhyzopertha dominica* and *Oryzaephilus surinamensis* development. However, 5% dose of the *Dolichos lablab* fraction resulted in complete mortality of all larvae of *Rhyzopertha dominica* and *Oryzaephilus surinamensis*(107-108).

2.31. *Echium italicum*

Echium italicum showed good insecticidal activity, its extract caused 100 % mortality within six days against Yellow Fever mosquito(109).

The insecticidal efficacy of aqueous extract of *Echium italicum* was investigated against Indian meal moth (IMM). Three concentrations of extract were used: 1%, 2% and 5%. The number of dead larvae/Petri dish was counted daily after 1, 2, 3 and 4 days after treatment. The extract showed insecticidal activity (dead larvae) in low concentration 1% extracts(110-111).

2.32. *Eucalyptus Species*

The larvicidal activity of Eucalyptus camaldulensis was studied against Anopheles stephensi. The leaf extract and volatile oil exerted significant larvicidal activity with LC50 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(112).

Vapors of essential oils extracted from Eucalyptus 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 KT50 values and calculated vapor pressures of the essential oil components showed that the fumigant activity of simple organic compounds in insects was correlated with their volatility(113).

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 of the leaves of Eucalyptus camaldulensis had an excellent inhibitory effect against both Aedes aegypti and Aedes 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 exhibited the strongest larvicidal effect against both Aedes aegypti and Aedes albopictus larvae(114).

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(115).

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(116).

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(117-118).

2.33. *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(119-120).

The toxicity of *Eupatorium cannabinum* 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 more effective than the crude extract, the IC50 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 (121).

2.34. *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(122-123).

2.35. *Gossypium hirsutum*

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. LC50 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 LC50 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 LC50 values of 133.95±12.79, 167.65±11.34 against 2nd and 3rd in stars 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 LC50 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 in stars of Ae. aegypti and An. stephensi, respectively(124-125).

2.36. *Haplophyllum tuberculatum*

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/cm2; 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(126-127).

2.37. *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(128-129).

2.38. *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(130-131).

2.39. *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. LC50 was 3136.68 after 24 h and 6231.08 after 48 h(132).

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(133-134).

2.40. 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 (135-136).

2.41. *Lantana camara*

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(137).

The insecticidal activity of essential oil of the leaves of *Lantana camara* was investigated against mosquito vectors. LD50 values of the oil were 0.06, 0.05, 0.05, 0.05 and 0.06 mg/cm2, while LD90 values were 0.10, 0.10, 0.09, 0.09 and 0.10 mg/cm2 against Ae. aegypti, Cx. quinquefasciatus, An. culicifacies, An. fluvialitis and An. stephensi respectively. KDT50 values of the oil were 20, 18, 15, 12, and 14 min and KDT90 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/cm2 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(138).

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(139).

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(140).

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(141).

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/cm2 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(142).

The application of *Lantana camara* oil to the upper surface of the human forearms at the rates between 0.08 to 3.33 mg/cm2 of skin possessed a significant repellent activity against mosquitoes (Aedes aegypti)(143-144) .

2.42. *Nerium oleander*

The aqueous leaf extract of *Nerium oleander* possessed ovicidal and larvicidal properties when tested against Culex tritaeniorhynchus and Culex gelidus(145).

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 LC50 value of 102.54 ppm and 61.11ppm after 24 and 48 hours respectively(146).

The insecticidal activity of the extract of *Nerium oleander*, was studied against the larval stages 3 and 4 of Culex pipiens. The LC50 and LC90 of the ethanolic extract of *Nerium oleander* were 57.57 mg/ml and 166.35 mg/ml, respectively(147).

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 LC50, at 10 °C was higher than that at 35 °C. Diethyl ether extract of *Nerium oleander* leaves was the most potent extract, with LC50 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(148).

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)(149).

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. LC50 of the extract was 113.66 ppm. It delayed larval and pupal duration, suppressed oviposition and decreased adult longevity of the survivors(150-151).

2.43. ***Ocimum basilicum***

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(152).

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 LC50 and LC90 values of the chloroform extract after 24 h were 5.46% and 7.69%, respectively (153).

Ocimum basilicum essential oil killed the larvae of Culex quinquefasciatus (100%) at 120 ppm, the LC50 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(154).

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/cm2.(155)

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 LC50 of the extract was 58mg/l and LC90 was 143 mg/l (152).

The essential oils of *Ocimum basilicum* possessed remarkable adulticidal properties on Anopheles funestus ss (LC50 = 84ppm), one hour after exposure. The effectiveness was decreased significantly with time (LC50 = 84; 171.7, 397 respectively, one hour, 5 days and 10 days after exposure piece of nets to the product)(156-157).

2.44. ***Reseda lutea***

The activity of many Turkish medicinal plants was investigated against mosquitoes in vitro. ED50 of mosquito larvicidal activity of *Reseda lutea* extracts was 0.15 mg/ml against Aedes aegypti and 0.07 mg/ml against Aedes gambiae(158-159).

2.45. ***Schinus molle***

The volatile oil extracted from the vegetative aerial parts of *Schinus molle* showed insecticidal effects against bed bugs. The concentration of 2 μg/cm2 (250 μg/125 cm2) in 24 h exposure time produced 100% mortality(160). The essential oils of *Schinus molle* had larvicidal activity against *C. quinquefasciatus*(161).

2.46. ***Tagetes erecta***

The crude acetone extract of defatted inflorescences of Tagetes patula and the semipurified fractions (n-hexane, dichloromethane, ethyl acetate, n-butanol, and aqueous) (750, 500, 300, 100, and 50 mg/l) were assayed for larvicidal activity against Aedes aegypti. All fractions except the aqueous fraction showed insecticidal activity after 24 h exposure of larvae to the highest concentration. However, ethyl acetate fraction showed the highest activity with more than 50% reduction in larval population at 50 mg/l, the insecticidal activity could be attributed to the higher concentration of patuletin present in this fraction(162).

2.47. ***Tribulus terrestris***

The effect of *Tribulus terrestris* extract on the mortality of all larval stages of (Culex pipiens) was studied in vitro. The results showed that the ethyl extract of the leaves showed larvicidal activity, the high rate of mortality was recorded within the 1st larval instar 97.3% and 100% at a concentration of (0.5 mg/ml) after 24 and 72 hours of exposure respectively. The leaf extracts modified the morphology of the larval development stage(163).

The methanolic extracts of leaves and seeds of *Tribulus terrestris* was tested against 3rd instar larvae and adults of mosquito, Anopheles arabiensis. The seeds extract showed high insecticidal activity compared to the leaves extract. The extracts exhibited remarkable effects on the fecundity, fertility and sterility index of adult females resulted from treated larvae, but the seeds extract was more effective than leaves extract. The repellent action of the extracts varied depending on the plant parts and the dose of extract. The seeds extract was more effective in exhibiting the repellent action (100%)

against the tested mosquito as compared with the leaves extract (79.5%) at the dose of 1.0 and 2.0 mg/cm2, respectively(164).

2.48. *Tropaeolum majus*

The efficiency of *Tropaeolum majus* leaf and flower extracts on the Culex quinquefasciatus was studied in vitro. Crude extract of both leaf and flower showed significant larval mortality. 100% and 96% mortality were achieved within 72 h in 2% crude extracts of leaf and flower respectively. After 72 h treatment LC50 value was assessed as 0.56% and 0.78% in the case of leaf and flower extracts respectively. A significant relationship was established between exposure time and concentration of extracts in imposing mortality to the mosquito larvae(165).

2.49. *Urtica pilulifera*

The cumulative biological effect of aqueous extract of *Urtica pilulifera* (4-16 mg/ml) was studied on mosquito Culex pipiens. The cumulative effect of the extract significantly affected the hatchability of eggs, mortality rate and elongation the duration of the larvae and pupae of C. pipiens. The highest incubation period of eggs was found to be 5 days at a concentration of 16 mg/ml. Also the total growth period from the egg to adult reached 21.5 days with the concentration of 12 mg/ ml. The adult emergence and the most vital biological activities of the emerging females including fecundity (fertility) were obviously affected. Complete emergence inhibition (100%) was recorded at concentrations 14 and 16 mg/ml. The highest rate of adult emergence was recorded at the concentration of 4 mg/ml which was 93.52%. The preoviposition period of the females which developed from the treated eggs was tested, and it was found that at the concentrations 12 and 14 mg/ml, the females were sterile. The lowest and highest mean scores of deposited eggs were 32% and 58.39% at concentrations of 8 and 4 mg/ml, respectively. The percentage of egg hatching was extremely reduced at all concentrations and the extract caused morphological deformations in different developmental stages(166).

3. Conclusion

Databases collected from PubMed, Web Science, Science Direct, Researchgate, Academia.edu and Scopus showed that 47 Iraqi medicinal plants possessed insecticide and insect repellent activities. These include: *Achillea santolina, Ailanthus altissima, Allium sativum, Anagyris foetida, Antirrhinum majus, Artemisia campestris, Ballota nigra, Caesalpinia crista, Calotropis procera, Capsicum Species, Carum carvi, Cassia occidentalis, Chenopodium album, Chrysanthemum cinerariaefolium , Citrullus colocynthis, Clerodendron inerme, Clitoria ternatea, Corchorus capsularis, Cordia myxa, Coriandrum sativum, Cuminum cyminum, Cupressus sempervirens, Cymbopogon schoenanthus, Cyperus rotundus, Datura stramonium, Dianthus caryophyllus, Digitalis purpurea, Dodonaea viscose, Dolichos lablab, Echium italicum, Eucalyptus Species, Eupatorium cannabinum, Fritillaria imperialis, Gossypium hirsutum, Haplophyllum tuberculatum, Herniaria glabra, Inula graveolens, Jasminum officinale, Jasminum sambac, Lantana camara, Nerium oleander, Ocimum basilicum, Reseda lutea, Tagetes erecta, Tribulus terrestris, Tropaeolum majus, Urtica pilulifera.* The review focused on active extract or ingredients, the effective concentrations and their mechanism of action, to encourage their usage as alternatives for the synthetic drugs because they provide a simple and sustainable method of insect control.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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