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INSECTICIDE EFFECTS OF MOROCCAN MEDICINAL PLANTS

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Abstract

Insects cause enormous damage and also contribute to the spread of parasitic diseases in Morocco such as leishmaniasis and belly tear. In addition, the search for molecules with anti-insecticidal effects is necessary. Indeed, natural products, especially those extracted from medicinal plants such as polyphenols, flavonoids and terpenoid have demonstrated important insecticidal activities. In this review, we report the work done on the insecticidal effects of medicinal plants in Morocco.

***Keywords**: Medicinal plants; Insecticide effect; Larvicidal effect; Morocco.*

Introduction

Mosquitoes cause the vector-borne diseases [1] and their impact on human public health is very considerable [2], causing millions of deaths every year [3]. There are responsible for transmitting parasitic diseases such as malaria, filaria, dengue fever [4], affecting the man and/or the animal [5] and problems of culture. Mosquito control with insecticides is very effective on culicid mosquitoes, but has several disadvantages. He has many disadvantages being harmful to the environment [6] including the phenomenon of insect resistance to insecticides [7]. Indeed, the therapeutic virtues of medicinal and aromatic plants have been experimented for centuries and the valorization of their essential oils in various applications notably as anti-inflammatory, antiseptic, antifungal, bactericidal, antitoxic, anticancer and insecticides has been reported [8-10].

In Morocco, several species have been suspected in the transmission of epidemics and the diseases transmitted by mosquitoes have an economic impact. Morocco is known for its great floristic biodiversity and richness of its phytotherapeutic heritage and provides a great botanical treasure, which can be the source of many interesting products for the development of new insecticides. In this context, several studies conducted on the insecticidal activity of plant extracts and essential oils against mosquito larvae and can be used as an alternative to synthetic insecticides for vector control programs [3,6]. In this context, this review reports the insecticide effects of Moroccan medicinal plant products.

Methodology

Different sources such as web of science, Medline, Scopus, Science-Direct and Google Scholars were used to explore the published papers on insecticide effects of Moroccan medicinal plants. In this research, the used terms are larvicidal Moroccan medicinal plants, insecticide activity of Moroccan medicinal plants. The resulting papers were identified and examined for relevance, based on their title and abstract. References lists of the papers that were retrieved were also examined to identify further papers.

Results and discussion

In Morocco, inadequate storage of uncontrolled food and agricultural crops often leads to considerable losses. These losses are mainly due to insects and phytopathogenic microorganisms. Indeed, it is insects and mites in particular, which cause the most damage to stored food and crops. The main pest species of stored commodities and crops in Morocco belong to Coleoptera such as *Sitophilus oryzae*, *Rhyzopertha dominica*, and *Tribolium castaneum*. Insects also play an important role as vectors of a number of parasitic diseases, such as leishmaniasis, malaria and bilharzia (schistosomiasis). In Morocco, these parasitic diseases continue to constitute a real danger for the population.

Moreover, the use of synthetic larvicides to control vector populations is detrimental to human and environmental health and selects for insecticide resistance. Plants can be alternative sources of effective and safe mosquito control agents.

In this context, the search for molecules with insecticidal properties is an important research topic. Indeed, the anti-insecticidal activity of Moroccan medicinal plants has been evaluated by many [6,11-29]. This activity is evaluated against several insects such as *Anopheles labranchiae, Culex pipiens, Culex pipiens, Anopheles, Tribolium castaneum, Sitophilus oryzae, Bruchusrufimanus,* and *A. obtectus*. Table 1 summarizes all published studies on insecticide activity of Moroccan medicinal plants. Several medicinal plants (*Citrus aurantium, Citrus sinensis, Ricinus communis, Tetraclinis articulata, Thymus vulgaris, Peganum harmala, Ajuga iva, Pistacia lentiscus, Nerium oleander, Ammi visnaga, Origanum majorana, Lavandula stoechas, Calotropis procera, Solanum elaeagnifolium, Cotula Cinerea, Aristolochia baetica, Raphanus raphanistrum, Thymus vulgaris, Quercus Lusitania, Mentha pulegium, Lavandula pedunculata, Cedrus atlantica, Centaurium erythraea, Launaea arborescens, Pteridium aquilinum, Juniperus thurifera, Ricinus communis*) belonging to numerous botanical families (Rutaceae, Asteraceae, Solanaceae, Apocynaceae, Lamiaceae, Apiaceae, Anacardiaceae, Euphorbiaceae, Cupressaceae, Nitrariaceae, Aristolochiaceae, Brassicaceae, Fagaceae, Pinaceae and Gentianaceae) have shown important insecticide effects.

El Akhal et al. (2015) evaluated the larvicidal activity of essential oils from two Moroccan medicinal plants (*Citrus aurantium* and *Citrus sinensis*) against *Anopheles labranchiae* (the larvae of the malaria vector). Results showed that *Citrus aurantium* and *Citrus sinensis* essential oils exhibited successively (LC_{50}=22.64 mg/L, LC_{90}=83.77 mg/L and LC_{50}=77.55 mg/L, LC_{90}=351.36 mg/L) important effects against *Anopheles labranchiae* [28]. In another study, Makrouk et al. (2000) have tested the larvicidal properties of 16 extracts of four Moroccan medicinal plants (*Calotropis procera*, *Cotulacinerea*, *Solanum sodomaeum,* and *Solanum elaeagnifolium* against *Anopheles labranchiae* mosquito larvae. Among the extracts tested, nine exhibited high larvicidal activity with LC_{50} (24 h) ranging from 28 to 325 ppm. Indeed, authors revealed that aqueous extract from *Calotropis procera*ex inhibited the most larvicidal effect (LC_{50}=24.3–29.1 mg/mL) [13].

Literature reported also *Lavandula stoechas* essential oil was tested against *Anopheles labranchiae* (the malaria vector) [21]. The findings of this work showed that the minimal dose required to achieve 100% larvicidal effect was 500 mg/L. Moreover, the lethal concentration (LC_{50} and LC_{90}) values were respectively 112.51 mg/L and 294.51 mg/L. Moreover, authors have contributed the obtained effects to major main compounds of *Lavandula stoechas* essential oil which revealed the presence of camphor (36.14%), 1,8-cineole (25.16%), camphene (11.44%) and cenchone (9.08 %) as major volatile constituents [21].

*Culex pipiens*was strongly suspected as the vector responsible for transmission of several parasitic and viral diseases. In the North center of Morocco, this species has developed resistance to synthetic insecticides. There is an urgent need to find alternatives to the insecticides as natural biocides. El akhal et al. (2014) evaluated the larvicidal activity of *Origanum majorana* essential oil (Lamiaceae) cultivated in Morocco against *Culex pipiens*. *Origanum majorana* essential oil showed remarkable inhibitory effect of *Culex pipiens* (CL_{50}=258.71 mg). This effect was correlated to the presence of α-terpinene (28.96%), γ-terpinene (18.57%), α-terpinene (12.72%) and sabinene (8.02%) as major volatile compounds [24]. On the other hand, the insecticidal activity of *Ammi visnaga* hydro-ethanolic extract was evaluated on larval stages 3 and 4 of *Culex pipiens*. *Ammi visnag a*hydro-ethanolic extract exhibited important larvicidal effects with lowest values of the lethal concentrations LC_{50}=0.42 (0.14–0.52) mg/mL and LC_{90}=0.68 (0.59–1.20) mg/mL [12]. Authors have attributed these findings to the presence of flavonoids, tannins, catechic tannins, sterols, terpenes, coumarins, mucilages and glycosides in *Ammi visnaga* hydro-ethanolic extract.

Moreover, El Akhal et al. (2015) have tested the larvicidal effect of *Nerium oleander* (Apocynaceae) ethanolic extract against *Culex pipiens.* Results showed that the ethanolic extract of *Nerium oleander* applied against the larvae of *Culex pipiens*has given the lethal concentrations LC_{50}=57.57 mg/mL and LC_{90}=166.35 mg/mL [14].

Citrus aurantium, Citrus sinensis, and *Pistacia lentiscus* essential oils were tested for their insecticide effects on *Culex pipiens* [11].Three essential oils presented important larvicidal activities with lowest lethal doses of (LD_{50}=35 ppm and LD_{90}=70 ppm), (LD_{50}=64 ppm and LD_{90}=120 ppm), and (LD_{50}=62ppm ppm and LD_{90}=160 ppm), respectively for *Citrus aurantium, Citrus sinensis,* and *Pistacialentiscus* [11].

The insecticide effects of *Citrus aurantium* and *Citrus sinensis* (Rutaceae) essential oils against the mosquito *Culex pipiens*has also evaluated by El akhal et al. (2014). Study revealed that both essential oils exhibited important larvicidal activities. Indeed, 100% mortality of larvae stages 3 and 4 of *Culex pipiens* was obtained at concentrations of 300 ppm for *Citrus aurantium* and 600 ppm for *Citrus sinensis*. Moreover, lethal doses obtained with *Citrus aurantium* are LC_{50}=139.48 ppm; LC_{90}=139.48 ppm and those obtained with *Citrus sinensis* are LC_{50}=280 ppm; LC_{90}=516 ppm [29]. The insecticide effect was attributed to the presence of limonene in both was *Citrus sinensis* and *Citrus aurantium* essential oils.

Evaluation of larvicidal activity of aqueous extracts from leaves of *Ricinus communis* and from wood of *Tetraclinis articulata* on the larvae of four mosquito species (*Culex pipiens*, *Aedes caspius*, *Culisetalo ngiareolata*, and *Anopheles maculipennis* [6]. *Ricinus communis* leaves and *Tetraclinis articulata* aqueous extracts showed strong insecticide activities against *Anopheles* with lethal doses of LC_{50}=180±33 and LC_{50}=370±58 ppm [6]. In another work carried out by El akhal el al. (2015), *Thymus vulgaris* essential oil cultivated in Morocco was tested for its insecticide effects against *Culex pipiens* larvae. The essential oil of *Thymus vulgaris* presented remarkable larvicidal properties. Indeed, the minimum levels necessary to achieve 100% mortality of larvae of *Culex pipiens* was estimated at 220 ppm for *Thymus vulgaris*. Moreover, lethal concentrations LC_{50} and LC_{90} of *Thymus vulgaris* essential oil were LC_{50}=103 ppm and LC_{90}=178 ppm [26]. These effects were attributed to the Thymol as major compound (41.4%) of *Thymus vulgaris* essential oil. Moreover, Amzouae et al., (2016) evaluated the insecticidal activity *Mentha suaveolens* (leaves and flowers) essential oils against *Bruchus rufimanus.* Results showed that the toxicity increased with the increase of the concentration and the duration of exposure. Moreover, this activity was attributed to the presence of the oxide of piperitenone [26].

Conclusions

Moroccan medicinal plants have shown remarkable insecticidal activity against several insects involved in the spread of parasitic diseases. This activity has been extensively tested by larval tally of these insects. The secondary metabolites of these plants have shown important insecticidal effects including the volatile compounds of essential oils. However, further studies regarding the isolation of bioactive molecules and their insecticides effects are required. Moreover, applications for Moroccan medicinal plants against insects involved in the dissemination (vector) of parasitic diseases, as well as those implicated in the deterioration of food is also necessary.

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Table 1: Insecticide activity of Moroccan medicinal plants.

Family	Species	Used parts	Extract	Larvae species	Effect	References
Anacardiaceae	*Pistacia lentiscus*	Feuilles	Essential oil	Larvae of Mosquitoes	DL_{50}= 62ppm	[11]
Apiaceae	*Ammi visnaga*	Aerial parts	Hydro-ethanolic extract	*Culex pipiens*	CL_{50} =0,14 - 0,52mg	[12]
Apocynaceae	*Calotropis procera*	Latex	Water filtrate	*Anopheles labranchiae*	LC_{50}= 67.7–81.1	[13]
		Latex	Ethanolic phase	*Anopheles labranchiae*	LC_{50}=127.1–146.1	[13]
		Latex	Aqueous phase	*Anopheles labranchiae*	LC_{50}= 24.3–29.1)	[13]
		Roots	Ethanolic extract	*Anopheles labranchiae*	LC_{50}=188.9–216.1	[13]
	Nerium oleander	Nd	Ethanolic extract	*Culex pipiens*	LC_{50}=57.57 mg	[14]
Aristolochiaceae	*Aristolochia baetica*	Nd	Methanol extracts	*Tribolium castaneum*	Larvicidal activity	[15]
		Aerial parts	Methanol extracts	*Tribolium castaneum*	Larvae growth was significantly inhibited	[16]
Asteraceae	*Cotula Cinerea*	Nd	Ethyl ether	*Anopheles labranchiae*	LC_{50}= 298.9–321.4	[13]
		Nd	Ethyl acetate	*Anopheles labranchiae*	LC_{50}=313.1–337.3	[13]
	Launaea arborescens	Stems leaves		*Tribolium castaneum*	Larvicidal activity	[15]
Brassicaceae	*Raphanus raphanistrum*	Aerial parts	Methanol extracts	*Tribolium castaneum*	Larvae growth was significantly inhibited	[16]
		Nd	Methanol extracts	*Tribolium castaneum*	Larvicidal activity	[15]
Cupressaceae	*Juniperus thurifera*	Leaves	Essential oil	*T. castaneum*	LD_{50}=0.6 µL/mL	[17]
			Methanol extracts	*A. obtectus*	LD_{50}=0.1 µL/mL	[17]
			Methanol extracts	*S. oryzae*	LD_{50}=2.0×10-2 µL/mL	[17]

Cupressaceae	*Tetraclinis articulata*	Wood		*Anopheles*	CL_{50}=180 ± 33	[6]
Dennstaedtiaceae	Pteridium aquilinum	Nd	Methanol extracts	Tribolium castaneum	Larvicidal activity	[15]
Euphorbiaceae	*Ricinus communis*	Young Leaves	Aqueous extracts	*Culex pipiens larvae*	LC_{50}=195 mg/L	[18]
		Roots	Aqueous extracts	*Culex pipiens larvae*	LC_{50}=224 mg/L	[18]
		Stems	Aqueous extracts	*Culex pipiens larvae*	LC_{50}=398 mg/L	[18]
		Leaves		*Anopheles*	Cl_{50}=370±58 mg/L	[6]
Fagaceae	*Quercus lusitania var*	Nd		*Culex pipiens*	LC_{50}=335 ppm	[19]
Gentianaceae	*Centaurium erythraea*	Stems leaves	Methanol extracts	*Tribolium castaneum*	Larvicidal activity	[15]
Lamiaceae	*Ajuga iva*	Nd	Methanol extracts	*Tribolium castaneum*	Larvicidal activity	[15]
		Aerial parts	Methanol extracts	*Tribolium castaneum*	Larvae growth was significantly inhibited	[16]
	Lavandula pedunculata	Aerial part	Essential oil	*Tribolium castaneum*	TL_{50}=16,00 100µl	[20]
	Lavandula stoechas	Aerial part	Essential oil	*Tribolium castaneum*	TL_{50}= 9,16 µL	[20]
		Aerial parts	Essential oil	*Anopheles Labranchiae*	CL_{50} =112,51 mg	[21]
	Mentha pulegium	Aerial part	Essential oil	*Culex pipiens*	LC_{50}=25,45 ppm	[22]
	Mentha suaveolens	Leaves Flowers	Essential oil	*Bruchus rufimanus*	LC_{50}=2,52-2,63µl/l d'air	[23]
		Leaves Flowers	Essential oil	*Bruchus rufimanus*	LC_{50}=4,48-4,04 µl/L	[23]
	Origanum majorana	Nd	Essential oil	*Culex pipiens*	CL_{50}=258.71 mg	[24]
		Nd	Essential oil	*Anopheles labranchiae*	LC_{50}=107.13 µg	[25]
	Thymus vulgaris	Leaves	Essential oil	*Culex pipiens*	LC_{50}=103 ppm	[26]
		Nd	Essential oil	*Anopheles labranchiae*	LC_{50}=351.63 µg	[25]

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Nitrariaceae	*Peganum harmala*	Aerial parts	Methanol extracts	*Tribolium castaneum*	Larvae growth was significantly inhibited	[16]
		Seeds	Methanol extracts	*Tribolium castaneum*	Larvicidal activity	[15]
Pinaceae	*Cedrus atlantica*	Aerial part	Essential oil	*Culex pipiens*	LC_{50}=782,43 ppm	[27]
Rutaceae	*Citrus aurantium*	Zest	Essential oil	*Larvae of Mosquitoes*	DL_{50}=35 ppm	[11]
		Nd	Essential oils	*Anopheles labranchiae*	LC_{50}=22.64 mg/L,	[28]
		Nd	Essential oil	*Culex pipiens*	CL_{50}=139,48 ppm	[29]
	Citrus sinensis	Nd	Essential oil	*Culex pipiens*	CL_{50}=212,04 ppm	[29]
		Nd	Essential oils	*Anopheles labranchiae*	LC_{50}=77.55 mg/L	[25]
		Zest	Essential oil	Larvae of Mosquitoes	DL_{50}=64 ppm	[11]
Solanaceae	*Solanum elaeagnifolium*	Berries	Glycoalkaloid extract	*Anopheles labranchiae,*	LC_{50}=52.9–66.9 ppm	[13]
	Solanum sodomaeum	Leaves	Glycoalkaloid extract	*Anopheles labranchiae,*	LC_{50}=110.2–131.6 ppm	[13]
		Seeds	Glycoalkaloid extract	*Anopheles labranchiae,*	LC_{50}=157.9–189.3ppm	[13]

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