World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

CHEMICAL CHARACTERIZATION AND IN VITRO LARVICIDAL ACTIVITY OF AQUEOUS AND ORGANIC EXTRACTS FROM TWO AROMATIC AND MEDICINAL PLANTS FROM NIGER AGAINST MOSQUITO LARVAE OF THE GENUS *ANOPHELES*

Abdouzakou HALIDOU [1, 2, *], Djibo ALFA KEITA [1] and Amadou Tidjani ILAGOUMA [1]

[1] Laboratory of Natural Substances and Organic Synthesis (LASNASO). Faculty of Science and Technology, Abdou Moumouni University (Niamey-Niger). BP 1062 Niamey-Niger.
[2] Laboratory of Entomology. Faculty of Science and Technology, Abdou Moumouni University (Niamey-Niger). BP 1062 Niamey-Niger.
* Corresponding Author

World Journal of Advanced Research and Reviews, 2026, 31(02), 1640–1649

Publication history: Received on 18 July 2026; revised on 25 August 2026; accepted on 27 August 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.31.2.2203

ABSTRACT

The fight against malaria-carrying mosquitoes is under threat from the emergence of resistance to synthetic insecticides. Plant-based insecticides could provide suitable alternative chemical control methods in the future. Although several plants have been reported to have anti-mosquito activity, only a few have progressed from the laboratory to practical application in the field. In most cases, the active compounds have not been identified, and most studies are limited to preliminary screening. *Cymbopogon schoenanthus* L. spreng and *Endostemon tereticaulis* poir are common weeds found in many regions of Niger and possess medicinal properties, but little is known to date about the larvicidal activity of these plants. This study forms part of efforts to promote the use of aromatic and medicinal plants in Niger. Extraction yields for aqueous and organic extracts ranged from 1.76 per cent to 24.74 per cent for *Cymbopogon schoenanthus* and from 2.14 per cent to 26.34 per cent for *Endostemon tereticaulis*. Water and methanol yielded the highest extraction yields, at 24.74 per cent and 22.42 per cent respectively for *Cymbopogon schoenanthus*, and 26.34 per cent and 19.67 per cent for *Endostemon tereticaulis*, compared with organic solvents (petroleum ether, dichloromethane, ethyl acetate and methanol). Phytochemical screening revealed the presence of sterols and triterpenes, alkaloids, coumarins, reducing compounds, saponosides and tannins in the various organic and aqueous extracts of the two plants. The results of in vitro larvicidal tests on *Anopheles* larvae showed that, amongst the crude extracts, only the ether and dichloromethane extracts of both plants and the ethyl acetate extract of *Cymbopogon schoenanthus* exhibited larvicidal activity. The ethereal extract of *Cymbopogon schoenanthus*, with an LD_{50} of 0.680 mg/mL, is more active than the ethereal extract of *Endostemon tereticaulis* (LD_{50} = 0.970 mg/mL), which is itself more active than the dichloromethane extract of *Cymbopogon schoenanthus* (LD_{50} = 1.100 mg/mL). The ether extracts of the two plants and the dichloromethane extract of *Cymbopogon schoenanthus* are less active than deltamethrin. Although the organic extracts are less active than deltamethrin (the reference chemical insecticide), they could be of great interest in the field of vector control, as, being natural substances, they are biodegradable and less polluting than chemical insecticides.

Keywords: Essential oils; *Anopheles*; *C. schoenanthus* L. spreng; *E. tereticaulis* poir

1 INTRODUCTION

Malaria, dengue, Zika virus and chikungunya are among the many mosquito-borne diseases that continue to pose a significant threat to public health, particularly in tropical and subtropical regions [1]. Of these diseases, malaria is the most widespread. According to the latest WHO report on malaria worldwide, there were approximately 263 million cases of malaria and 597,000 deaths attributed to the disease in 2023. Nearly 95 per cent of deaths occurred in the WHO African Region, where a large number of vulnerable people still lack access to the services needed to prevent, detect and treat this disease [2]. In addition to the antimalarial drugs currently used to treat malaria, vector control is a very important means of preventing the transmission of the disease. To protect against mosquitoes, several types of insecticides are used, generally synthetic ones (organophosphates, organochlorines, carbamates and synthetic pyrethroids) [3]. However, these synthetic insecticides have adverse effects not only on the environment but also on human health. In addition to these adverse effects, mosquitoes have developed resistance to commonly used insecticides. This resistance necessitates the search for new alternative compounds to combat mosquitoes [4]. As can be seen, the search for natural plant-derived substances with larvicidal activity is a major scientific challenge. Furthermore, plants used in traditional medicine or documented in the ethnopharmacological literature constitute a source of information for this type of research [5]. It is therefore necessary to investigate this flora, some species of which are aromatic, particularly those whose insecticidal properties are poorly understood. The present study aims to evaluate the larvicidal activity of aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis* on Anopheles larvae.

2 MATERIAL AND METHODS

2.1 Material

The plant material used in this study was sourced from the following plants : *C. schoenanthus* L. spreng (aerial parts) and *E. tereticaulis* poir (aerial parts). *Cymbopogon schoenanthus* was harvested in the rural commune of Simiri, in the village of Sonantché, 82 km from Niamey. *Endostemon tereticaulis* was harvested in the vicinity of the city of Niamey.

Larvicidal tests were carried out on the larvae of wild strains of *Anopheles*. Following a survey conducted in the vicinity of the city of Niamey, we selected a pool of stagnant water situated behind the Abdou Moumouni University sports ground in Niamey as the larval breeding site. *Anopheles* larvae floating on the surface of the stagnant water were collected using a plastic sieve. We placed these larvae in a plastic bucket previously filled with water from the breeding site, then transported them to the biology laboratory, where they were rinsed with well water. These larvae were reared for 24 hours in a plastic bucket containing well water, and were fed with *Anopheles* larval food before being used for biological tests.

2.2 Methods

2.2.1 Methods for obtaining aqueous and organic extracts Obtaining aqueous extracts

The aqueous extracts were prepared by decoction. We placed 50 g of plant powder and 500 mL of distilled water into a three-necked flask fitted with a condenser. We heated the contents of the flask to boiling point using a flask heater for one hour. After cooling, we filtered the mixture. Evaporation of the filtrate on a sand bath enabled us to obtain the aqueous extract.

2.2.2 Extraction of organic compounds

To obtain the ethereal, dichloromethane and ethyl acetate extracts, we placed 50 g of plant powder and 500 mL of distilled water into a 1litre Tricol flask fitted with a condenser. We heated the contents of the flask using a flask heater for 1 hour. We allowed the mixture to cool, then filtered it through cotton wool. We transferred the resulting filtrate to a 700 mL separating funnel and added petroleum ether (3 × 50 mL). We shook the mixture and then allowed it to settle. We separated the aqueous phase from the ether phase and then filtered the ether phase. We concentrated the ether extract using a rotary evaporator, then allowed the solvent to evaporate at room temperature before recovering the ether extract. We followed the same procedure with dichloromethane and ethyl acetate. Figure 1 illustrates the process for obtaining the ether, dichloromethane and ethyl acetate extracts.

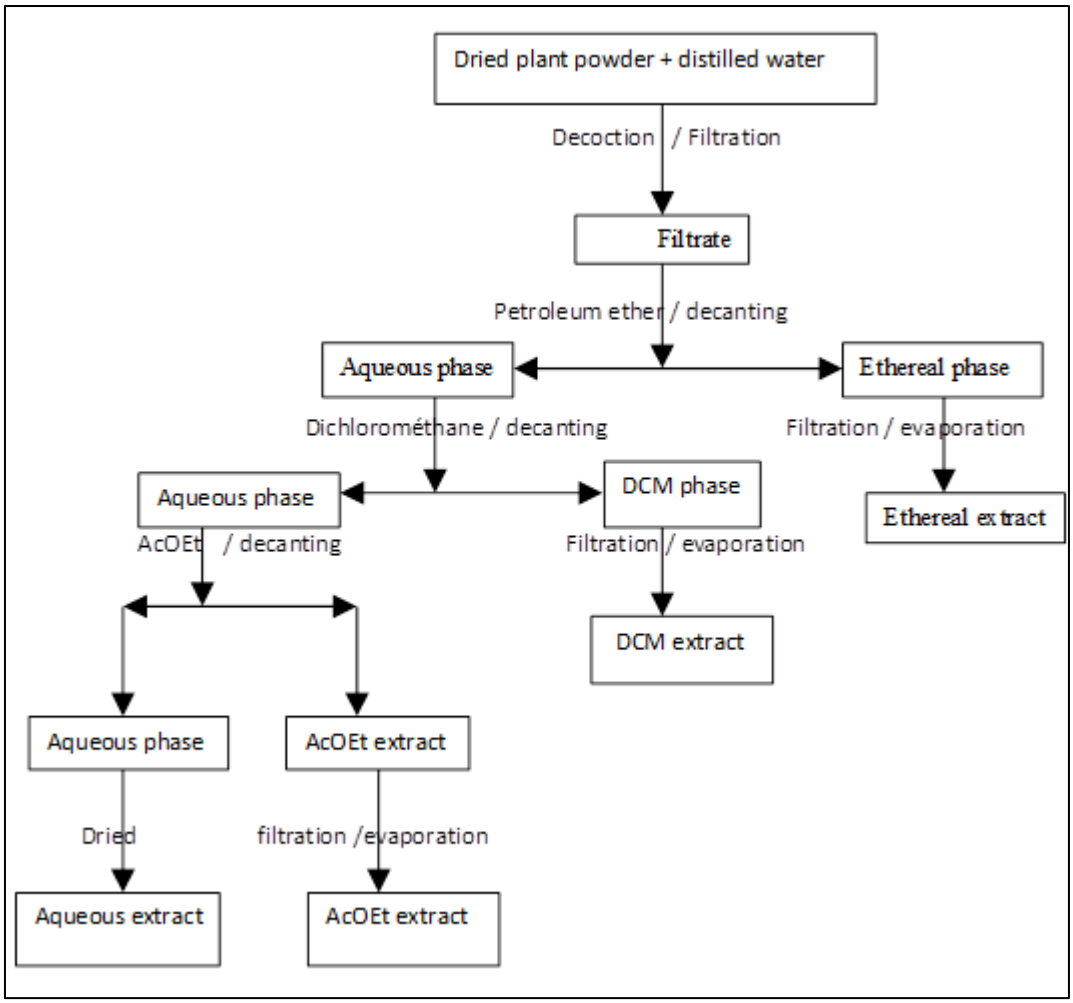

Figure 1: Method for obtaining extracts: ether, dichloromethane and ethyl acetate

For the methanolic extract, we collected the aqueous phase and then evaporated the solvent (water) using a sand bath, taking care not to scorch the product. We placed the dry extract in a 250 mL beaker and added methanol (6 × 50 mL). We then stirred the contents of the beaker using a magnetic stirrer for 15 minutes. We filtered the mixture and collected the methanolic extract after the solvent had evaporated.

2.3 Phytochemical screening of ether, dichloromethane, ethyl acetate, methanol and aqueous extracts

Phytochemical screening is a method used to identify the families of chemical compounds present in a given plant. The principle is based on the formation of insoluble complexes, precipitation reactions or colour changes [6]. The phytochemical tests carried out enabled us to screen for the following families of compounds : alkaloids, coumarins, flavonoids, sterols and terpenes, saponosides and tannins. Alkaloids, flavonoids, tannins, saponosides, coumarins and peptides (polar compounds) were investigated in the ethyl acetate, methanol and aqueous extracts. Sterols and triterpenes, which are non-polar compounds, were investigated in the ether and dichloromethane extracts. The solutions used for the screening of alkaloids, coumarins, flavonoids and saponosides were prepared by dissolving 0.5 g of the extract under investigation (ethyl acetate, methanol or aqueous extract) in 15 mL of distilled water, whereas for the screening of sterols and triterpenes, 0.02 g of the extract under investigation (ether or dichloromethane extract) was dissolved in a mixture of acetic anhydride and chloroform in equal volumes (1 mL of acetic anhydride plus 1 mL of chloroform). The characterisation methods used are based on those described by Paris and Nothis [7], Tona and al. [8] and Longaga and al. [9], with some modifications.

2.4 Testing for alkaloids

We added 1 mL of the extract solution (ethyl acetate, methanol or aqueous) to two test tubes. The first served as a control, and Meyer's reagent was added to the second. The formation of a white precipitate indicates the presence of alkaloids.

2.4.1 Search for coumarins

We added 5 mL of the extract solution (ethyl acetate, methanol or aqueous) to a test tube, then covered the opening of the test tube with filter paper treated with a diluted NaOH solution (0.1 M). The test tube was heated for 15 minutes in a water bath. The filter paper was then examined under UV light ; yellow fluorescence indicates the presence of coumarins.

2.4.2 Search for flavonoids

We added 5 mL of the extract solution (ethyl acetate, methanol or aqueous) to two test tubes. The first serves as a control, whilst into the second we added 5 mL of hydrochloric acid, 1 mL of isoamyl alcohol and three magnesium shavings. The appearance of a red or orange colour indicates the presence of a flavonoid aglycone.

2.4.3 Search for tannins

We added 5 mL of the extract solution (ethyl acetate, methanol or aqueous) to three test tubes. The first test tube serves as a control. Into the second test tube, 5 mL of Stiasny's reagent (10 mL of 40% formalin plus 5 mL of concentrated HCl) was added, and the tube was then heated for 15 minutes in a water bath. The formation of a precipitate indicates the presence of catechin tannins. In the third test tube, 1 mL of ferric chloride ($FeCl_3$) solution is added, and the tube is then heated for 15 minutes in a water bath. The development of a blue-black colour indicates the presence of gallic tannins.

2.4.4 Search for saponosides

5 ml of the extract solution (ethyl acetate, methanol or aqueous) was added to a test tube. The tube was shaken vigorously for at least five minutes. The formation of a column of foam approximately 1 cm high, persisting for at least 15 minutes, indicates the presence of saponosides.

2.5 Search for sterols and triterpenes

We transferred 5 mL of the extract solution (ether or dichloromethane) into two test tubes. The first serves as a control ; into the second, we carefully added 1 mL of sulphuric acid to the bottom of the test tube using a 1 mL pipette. If the reaction is positive, a reddish-brown or purple ring forms at the interface between the two liquids.

2.5.1 Method for preparing aqueous and organic extract solutions of *C. schoenanthus* and *E. tereticaulis* for conducting larvicidal tests.

To prepare the aqueous and organic extract solutions of *C. schoenanthus* and *E. tereticaulis*, we used water from the gîte as the solvent. The stock solutions of the aqueous and organic extracts of the two plants were obtained by dissolving 1.8 g of the extract to be studied in 180 mL of distilled water. From these stock solutions (10 mg/mL), several test solutions of the aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis* at different concentrations (0.25 mg/mL ; 0.5 mg/mL; 0.75 mg/mL; 1 mg/mL; 1.25 mg/mL; 1.5 mg/mL; 1.75 mg/mL; 2 mg/mL) were prepared by dilution. Thus, volumes of 25 mL; 50 mL; 75 mL; 100 mL; 125 mL; 150 mL; 175 mL or 200 mL of the stock solution of each crude extract, which we placed in a 100 mL volumetric flask containing approximately 60 mL of water. We made up to the mark with water and then homogenised the mixture.

2.5.2 Method for preparing deltamethrin solutions for larvicidal tests.

To prepare the stock solutions of the reference insecticide (deltamethrin), dissolve 0.05 g of deltamethrin in 5 mL of 96° ethanol. From this solution (10 mg/mL), prepare several test solutions of deltamethrin at different concentrations (0.0005 mg/mL; 0.001 mg/mL; 0.002 mg/mL; 0.004 mg/mL; 0.006 mg/mL; 0.008 mg/mL) were prepared by diluting with tap water. Volumes of 50 µL; 100 µL; 200 µL; 400 µL; 600 µL or 800 µL of the deltamethrin stock solution, which we placed in a 100 mL volumetric flask containing approximately 60 mL of water. We made up to the mark with water from the source and then mixed thoroughly.

2.5.3 Biological assays of the aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis*, and of the reference insecticide.

The larvicidal activity of the aqueous and organic extracts of the two plants was assessed on *Anopheles* larvae in accordance with a World Health Organisation protocol [10]. Using a Pasteur pipette, 20 Anopheles larvae were introduced into Petri dishes for the test. Each of these Petri dishes contained 100 mL of solution (aqueous or organic extract, or deltamethrin) at the selected concentration. In each Petri dish, the larvae were left in contact with the solution for 24 and 48 hours. Larvae considered dead are those that are immobile and have sunk to the bottom of the Petri dish. The control Petri dish is not treated in any way. Each concentration (aqueous and organic extracts or deltamethrin) was tested in triplicate. The percentage of dead larvae is calculated using the following formula :

$$\%m=\frac{number\ of\ dead\ larvae}{total\ number\ of\ larvae} \times 100$$

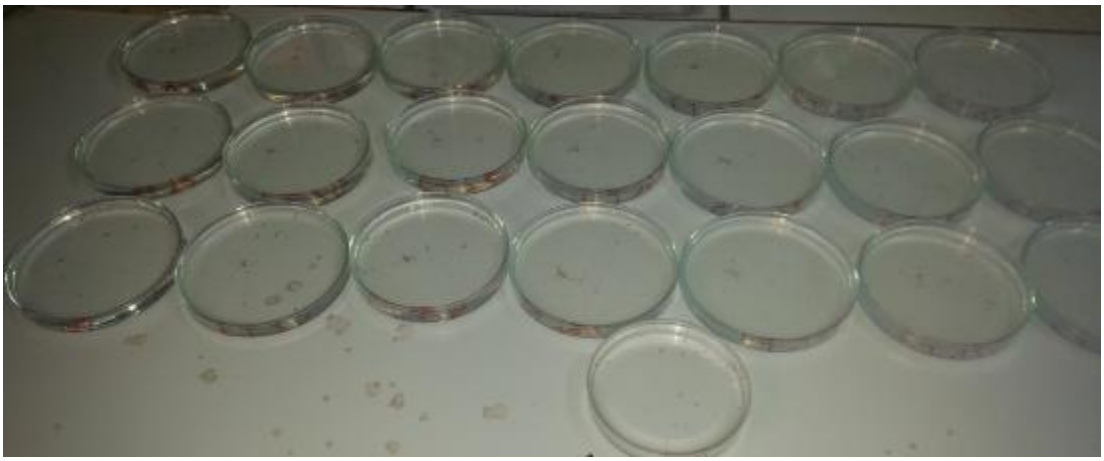

Figure 2: Test Petri dishes containing *Anopheles* larvae

The lethal dose 50 was calculated using the method described by Dragstedt and Lang (1957) and outlined by Boussahel [11].

$$\mathbf{LD_{50}} = \frac{\mathbf{50}(X_2 - X_1) + (X_1 Y_2 - X_2 Y_1)}{Y_2 - Y_1}$$

X_2 : Dose above the LD_{50} ; Y_2 : mortality rate corresponding to X_2

X_1 : Dose lower than the LD_{50} ; Y_1 : Mortality rate corresponding to X_1

3 RESULTS

3.1 Yields of aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis*

Table 1: Yields in aqueous and organic extracts

Plant species	Organs used	Extracts	Extract colour	Yields (%)
Cymbopognon schoenanthus	Aerial part	Ethereal	Yellow	1.8
		Dichloromethane	Yellow	4.2
		Ethyl acetate	Yellow	3.9
		Methanolic	Red	22.4
		Aqueous	Black	24.7
Endostemon tereticaulis	Aerial part	Ethereal	Greenish	2.1
		Dichloromethane	Greenish	6.1
		Ethyl acetate	Greenish	4.0
		Methanolic	Deep red	19.7
		Aqueous	Brown	26.3

The yields from the ether, dichloromethane, ethyl acetate, methanol and aqueous extracts of the *C. schoenanthus* and *E. tereticaulis* samples are shown in Table 1. Analysis of the results in this table shows that, for the *C. schoenanthus* sample, the yields obtained range from 1.8% to 24.7%, whilst those for *E. tereticaulis* range from 2.1% to 26.3%. Indeed, according to the results in Table 1, the highest yields are obtained with the most polar solvents (24.7 per cent with water ; 22.4 per cent with methanol) for the *C. schoenanthus* sample and (26.3 per cent with water ; 19.7 per cent with methanol) for the *E. tereticaulis* sample. This indicates that the *C. schoenanthus* and *E. tereticaulis* samples consist mainly of polar compounds.

3.2 Phytochemical screening of aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis*

Phytochemical screening revealed the presence of alkaloids, coumarins and reducing compounds in the ethyl acetate, methanol and aqueous extracts of *C. schoenanthus* and *E. tereticaulis*. Both plants also contain saponosides and catechin tannins (present in all extracts of *C. schoenanthus*) and in the methanolic and aqueous extracts of *E. tereticaulis*. *C. schoenanthus* contains neither gallic tannins nor mucilage, whereas *E. tereticaulis* contains them in its ethyl acetate, methanolic and aqueous extracts, and in its aqueous extract respectively. Neither plant contains flavonoids. Sterols and triterpenes are present in the ether and dichloromethane extracts of both plants.

Table 2: Criblage phytochimique

Plant species	Extracts	Family of chemical compounds									
		Al		Co	Cr	Fl	Mu	St/Tr	Sa	Tan	
		W	M							C	G
	Ethereal	ND	ND	ND	ND	ND	ND	+	ND	ND	ND
C. schoenanthus	Dichloromethane	ND	ND	ND	ND	ND	ND	+	ND	ND	ND
	Ethyl acetate	+	+	+	+	-	-	ND	+	+	-
	Methanolic	+	+	+	+	-	-	ND	+	+	-
	Aqueous	+	+	+	+	-	-	ND	+	+	-
E. Tereticaulis	Ethereal	ND	ND	ND	ND	ND	ND	+	ND	ND	ND
	Dichloromethane	ND	ND	ND	ND	ND	ND	+	ND	ND	ND
	Ethyl acetate	+	+	+	+	-	-	ND	-	-	+
	Methanolic	+	+	+	+	-	-	ND	-	+	+
	Aqueous	+	+	+	+	-	+	ND	+	+	+

(Al) = Alkaloids; (C) = Catechin; (Co) = Coumarin; (Cr) = Reducing compound; (Fl) = Flavonoid; (G) = Gallic acid; (M) = Meyer; (Mu) = Mucilage; (St/Tr) = Sterols and triterpenes; (Sa) = Saponins; (T) = Tannins; (W) = Wagner; (+) = present; (-) = absent; (ND) = not determined.

3.3 In vitro larvicidal activity of aqueo+us and organic extracts of *C. schoenanthus* and *E. tereticaulis*

Tables 3 and 4 show the mortality rate of *Anopheles* larvae as a function of the doses of aqueous and organic extracts (ether, dichloromethane, ethyl acetate, methanol) from *C. schoenanthus* and *E. tereticaulis*. Analysis of these results reveals that the methanolic and aqueous extracts of both plants and the ethyl acetate extract of *E. tereticaulis* have no effect on *Anopheles* larvae up to a dose of 2 mg/mL. These results show that only the ether and dichloromethane extracts of both plants and the ethyl acetate extract of *C. schoenanthus* exhibit activity against *Anopheles* larvae.

Table 3: Mortality rates of *Anopheles* larvae as a function of the doses of organic and aqueous extracts of *C. schoenanthus* after 24 and 48 hours of exposure.

Cymbopogon schoenanthus										
Doses mg/mL	Ethereal extract		Dichloromethane extract		Ethyl acetate extract		Methanolic extract		Aqueous extract	
	Larval mortality (%)									
	24H	48H	24H	48H	24H	48H	24H	48H	24H	48H
0.3	00	8,33	00	00	00	00	00	00	00	00
0.5	15	31.66	00	00	00	00	00	00	00	00
0.6	30	46.66	5	18.33	00	00	00	00	00	00
0.8	43.66	55	15	20.33	00	00	00	00	00	00
1	55	63.33	40	53.33	00	00	00	00	00	00
1.25	60.33	71.66	50	55	00	0.33	00	00	00	00

1.5	70	76.66	53.33	60	00	06.66	00	00	00	00
1.75	80	98.33	55	65	10	16.66	00	00	00	00
2	95	100	60	76.66	15	26.66	00	00	00	00

Table 4: Larval mortality rates of *Anopheles* mosquitoes as a function of the doses of organic and aqueous extracts of *E. tereticaulis* after 24 and 48 hours of exposure

Endostemon tereticaulis										
Doses mg/mL	**Ethereal extract**		**Dichloromethane extract**		**Ethyl acetate extract**		**Methanolic extract**		**Aqueous extract**	
	Larval mortality (%)									
	24H	48H	24H	48H	24H	48H	24H	48H	24H	48H
0.3	00	00	00	00	00	00	00	00	00	00
0.5	5	11.66	00	00	00	00	00	00	00	00
0.6	15	20	00	00	00	00	00	00	00	00
0.8	25	35	00	00	00	00	00	00	00	00
1	40	55	00	00	00	00	00	00	00	00
1.25	46.33	65.66	00	5	00	00	00	00	00	00
1.5	50	70	10	16.66	00	00	00	00	00	00
1.75	65	85.66	25	30	00	00	00	00	00	00
2	80	100	31.66	36.66	00	00	00	00	00	00

3.4 Lethal dose 50 of the ether and dichloromethane extracts of deltamethrin

Table 5: LD_{50} of the ether and dichloromethane extracts of deltamethrin

Nature of the substance	**Lethal dose 50 (LD_{50}) in mg/mL**
Deltamethrin	0.002
Ethereal extract of *C. schoenanthus*	0.680
Dichloromethane extract of *C. schoenanthus*	1.100
Ethereal extract of *E. tereticaulis*	0.970

Table 5 shows the various 50 per cent lethal doses (LD_{50}) of deltamethrin, essential oils and ethereal extracts from the two plants, and the dichloromethane extract of *C. schoenanthus*. Indeed, analysis of the results in Table 5 shows that the ethereal extract of *C. schoenanthus*, with an LD_{50} of 0.680 mg/mL, is more active than the ethereal extract of *E. tereticaulis* (LD_{50} = 0.970 mg/mL), which is itself more active than the dichloromethane extract of *C. Schoenanthus* (LD_{50} = 1.100 mg/mL). The ether extracts of both plants and the dichloromethane extract of *C. schoenanthus* are less active than deltamethrin, which has an LD_{50} of 0.002 mg/mL. Although the organic extracts are less active than deltamethrin (the reference chemical insecticide), they could be of great interest in the field of vector control, since, as natural substances, they are biodegradable and less polluting than chemical insecticides.

4 DISCUSSION

Liquid-liquid extraction of the aqueous extracts of *C. schoenanthus* and *E. tereticaulis* using solvents of increasing polarity yielded aqueous, methanolic, ethyl acetate, dichloromethane, and ether extracts of these two plants. The yields of the aqueous, methanolic, ethyl acetate, dichloromethane, and ether extracts ranged from 1.8% to 24.7% and from 2.1% to 26.3%, respectively, for *C. schoenanthus* and *E. tereticaulis.* The highest yields were obtained with the most polar solvents (24.7% with water ; 22.4% with methanol) for the *C. schoenanthus* sample and (26.3% with water ; 19.7% with

methanol) for the *E. tereticaulis* sample. This finding indicates that the *C. schoenanthus* and *E. tereticaulis* samples consist primarily of polar compounds. The yield of the methanolic extract of *C. schoenanthus* in our study is higher than that reported in Algeria by Bahriz and al., who obtained yields of 5.61% and 5.03% for the methanolic extract of this plant [12]. This difference in yield can be explained by the extraction technique used, the plant part used, and the location where the plant was harvested. In our study, we performed a liquid-liquid extraction using solvents of increasing polarity, whereas Bahriz and al. used a Soxhlet extraction method. Phytochemical screening of the various extracts revealed the presence of alkaloids, saponosides, tannins, flavonoids, coumarins, reducing compounds, and sterols/tri-terpenes in the various extracts from the two plants. Several studies have reported the presence of these different chemical classes in the aqueous and organic extracts of these two plants. Furthermore, research by Najmeddin and al. in Libya detected the presence of alkaloids, anthraquinones, coumarins, flavonoids, saponins, tannins, and terpenes in the aqueous and methanolic extracts of *C. schoenanthus* [13]. Research by Bouhali and al. reported the presence of total phenols and total flavonoids in the ethyl acetate extract of *C. schoenanthus* [14]. In this study, larvicidal tests were conducted on larvae of wild *Anopheles* strains. Due to environmental concerns and the development of mosquito resistance to synthetic insecticides, the recent trend has been to evaluate plants in order to obtain extracts that are safe for non-target animals and pose no residue problems, while still being capable of reducing vector populations. With this in mind, the present study evaluated the bio-insecticidal activity of aqueous and organic extracts of *C. schoenanthus* and *E. tereticaulis* against *Anopheles* larvae. In this study, all aqueous, methanolic, and ethyl acetate extracts showed no activity against *Anopheles* larvae, while the ether and dichloromethane extracts from both plants exhibited moderate, high, and very high bio-insecticidal activities. This suggests the presence of a greater number of phytochemicals soluble in nonpolar solvents within the species and plant parts tested—namely, *C. schoenanthus* and *E. tereticaulis* which are responsible for the observed bioactivities of these plants against *Anopheles* larvae [15]. The use of different solvents with varying polarities is necessary, as these can significantly influence the potency of the extracted plant compounds [16]. This phenomenon was also demonstrated by Mulla and al. during the extraction of neem, where an inverse relationship between the extract's efficacy and the solvent's polarity was observed [17]. The current results of the bioassay revealed that the ether extract was more effective than the dichloromethane, ethyl acetate, formic acid, and aqueous extracts. This finding is consistent with the work of Hidayatulfathi and al., who demonstrated a decrease in mosquito mortality as the polarity of the solvent used for the plant extract increased [18]. Furthermore, the remarkable larvicidal activity of the extracts from *C. schoenanthus* and *E. tereticaulis* could be explained by the presence of phenol, which is known to possess promising insecticidal activity [19]. Several compounds derived from various plants, such as phenolic compounds, steroids, alkaloids, essential oils, and terpenoids, have been identified as promising potential insecticides, whether in pure form or as crude extracts [20 ; 21]. Furthermore, according to the literature, the larvicidal effects of plant secondary metabolites vary depending on the plant species, the parts used, the geographic region, the mosquito species, the extraction method, and the polarity of the solvents used during extraction [22]. In Niger, several studies have been conducted on medicinal plants. These studies focused on the biological, pharmacological, and phytochemical properties of plants found in the traditional Nigerien pharmacopoeia. Data on medicinal plants have helped explain the use of *C. schoenanthus* and *E. tereticaulis* in traditional medicine by rural populations to protect themselves against malaria-carrying mosquitoes [23 ; 24 ; 25].

5 CONCLUSION

This study demonstrated that the ether extracts of *C. schoenanthus* and *E. tereticaulis* and the dichloromethane extract of *C. schoenanthus* possess significant bioinsecticidal activity against *Anopheles* larvae. Furthermore, the ether extract of *C. schoenanthus* exhibited even greater bioinsecticidal activity against *Anopheles* mosquito larvae compared to the other extracts. The LD_{50} for the larvae induced by the ether extract of *C. schoenanthus* at a concentration of 0.680 mg/mL, followed by that of the ether extract of *E. tereticaulis* with an LD_{50} of 0.970 mg/mL, and then the dichloromethane extract of *C. schoenanthus* with an LD_{50} of 1.100 mg/mL. However, further research is needed to evaluate the efficacy of these extracts under real-world field conditions. Overall, these two plants can be considered viable candidates for the development of effective, safe, biodegradable, and cost-effective botanical bioinsecticides for vector control, which could improve resistance management among vector mosquito larvae in Niger.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

All authors declare that there is no conflict of interest regarding the publication of this article.

REFERENCES

[1] Lim H, Lee SY, Ho LY, Sit NW. Mosquito larvicidal activity and cytotoxicity of the extracts of aromatic plants from Malaysia. Insects. 2023;14(6):512.

[2] WHO. 2024 World Malaria Report. 11 December 2024.

[3] Devillers J, Alout H, Barrès B, Chouin S, Corbel V, David JP, and al. Insecticide resistance in vector mosquitoes: ANSES opinion: collective expert report (reference no. 2020-SA-0029) [Internet]. 2021 [cited 6 August 2026]. Available at: https://www.documentation.ird.fr/hor/fdi:010086244

[4] Danga YSP, Nukenine EN, Younoussa L, Esimone CO. Phytochemicals and larvicidal activity of Plectranthus glandulosus (Lamiaceae) leaf extracts against Anopheles gambiae, Aedes aegypti and Culex quinquefasciatus (Diptera: Culicidae). J Pure Appl Zool. 2014;2(2):160-71.

[5] Debella A. Screening of some Ethiopian medicinal plants for mosquito larvicidal effects and phytochemical constituents. Pharmacol Online [Internet]. 2007 [cité 15 juill 2026]. Disponible sur: https://www.academia.edu/download/106271358/19.

[6] Benhabyles N, Laoufi R, Toubal S, El Haddad D, et al. Phytochemical screening and evaluation of the antioxidant activity of the leaves of *Myrtus communis* L. and *Rhamnus alaternus* L. Agrobiologia.

[7] Paris, R., & Nothis, A. Medicinal Plants, Phytotherapy. Masson, 1978.

[8] Tona L, Kambu K, Ngimbi N, Cimanga K, Vlietinck AJ. Antiamoebic and phytochemical screening of some Congolese medicinal plants. J Ethnopharmacol. 1998;61(1):57-65.

[9] Otshudi AL, Vercruysse A, Foriers A. Contribution to the ethnobotanical, phytochemical and pharmacological studies of traditionally used medicinal plants in the treatment of dysentery and diarrhoea in Lomela area, Democratic Republic of Congo (DRC). J Ethnopharmacol. 2000;71(3):411-23.

[10] content.pdf [Internet]. [cité 22 juill 2026]. Disponible sur: https://iris.who.int/server/api/core/bitstreams/e269aa3c-0225-4516-912f-0fb16747df02/content

[11] Boussahel S. Étude biochimique et histologique de l'effet de quelques extraits des plantes toxiques dans la région de Sétif [PhD Thesis] [Internet]. 2018 [cité 22 juill 2026]. Disponible sur: http://dspace.univ-setif.dz:8888/jspui/handle/123456789/2396

[12] BAHRIZ I, BENYOUCEF Z. Etude phytochimique et évaluation de l'activité antioxydante et antibactÈrienne des extraits de Cymbopogon schoenanthus (L.) Spreng. [Internet]. 2023 [cité 31 juill 2026]. Disponible sur: https://dspace.univ-ghardaia.edu.dz/jspui/handle/123456789/6065

[13] Ellali N, Habil F, Embarek S, Youssef A, Salem H, Lafi S. Antimicrobial Properties of Extracts from Cymbopogon Schoenanthus plant. AlQalam J Med Appl Sci. 2025;401-7.

[14] BOUHALI AHE, DAHMANI R. Ethnobotanical, phytochemical and biological activities of extracts from Cymbopogon schoenanthus (L.) Spreng. [Internet]. 2025 [cité 3 août 2026]. Disponible sur: http://dspace.univ-ghardaia.edu.dz/xmlui/handle/123456789/9501

[15] Gebissa N, Tolossa K, Gebresilassie A, Aklilu E, Bisrat D, Kumsa B, et al. Larvicidal effects of selected medicinal plant extracts against Anopheles arabiensis, Anopheles stephensi, and Aedes aegypti. Trop Med Health. 31 déc 2025;53(1):197. doi:10.1186/s41182-025-00879-2

[16] Shaalan EAS, Canyon D, Younes MWF, Abdel-Wahab H, Mansour AH. A review of botanical phytochemicals with mosquitocidal potential. Environ Int. 2005;31(8):1149-66.

[17] Su M, Mulla MS. Activity and biological effects of neem products against arthropods of medical and veterinary importance. J Am Mosq Control Assoc. 1999;15(2):133-52.

[18] Hidayatulfathi O, Sallehuddin S, Ibrahim J. Adulticidal activity of some Malaysian plant extracts against Aedes aegypti Linnaeus. Trop Biomed. 2004;21(2):61-7.

[19] Aydin T, Bayrak N, Baran E, Cakir A. Insecticidal effects of extracts of Humulus lupulus (hops) L. cones and its principal component, xanthohumol. Bull Entomol Res. 2017;107(4):543-9.

[20] Aivazi AA, Vijayan VA. Larvicidal activity of oak Quercus infectoria Oliv. (Fagaceae) gall extracts against Anopheles stephensi Liston. Parasitol Res. mai 2009;104(6):1289-93. doi:10.1007/s00436-008-1325-5

[21] Perumalsamy H, Kim JR, Oh SM, Jung JW, Ahn YJ, Kwon HW. Novel histopathological and molecular effects of natural compound pellitorine on larval midgut epithelium and anal gills of Aedes aegypti. Plos One. 2013;8(11):e80226.

[22] Costa MS, Cossolin JF, Pereira MJ, Sant'Ana AE, Lima MD, Zanuncio JC, et al. Larvicidal and cytotoxic potential of squamocin on the midgut of Aedes aegypti (Diptera: Culicidae). Toxins. 2014;6(4):1169-76.

[23] Yolidje I, Keita DA, Moussa I, Toumane A, Bakasso S, Saley K, et al. Enquête ethnobotanique sur les plantes utilisées traditionnellement au Niger dans la lutte contre les moustiques vecteurs des maladies parasitaires. Int J Biol Chem Sci. 2020;14(2):570-9.

[24] Laouali A, Boubacar MM, Issoufou B, Ali M. Diversité et usages des plantes médicinales à l'ouest du Niger. J Anim Plant Sci. 2020;46(1):8164-74.

[25] Abdoulahi MII, Habibou HH, Abdelkader AS, Mborbe N, Chaibou M, Rahila HG, et al. Ethno botanical, pharmacology and phytochemistry of widely used medicinal plants in Niger: a review. J Med Plants Stud. 2022;10(4):46-60.