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RESEARCH ARTICLE

EFFECT OF WATER QUALITY ON THE EFFICIENCY OF *COMMIPHORA MOLMOL* RESIN, MIRAZID, AND FORMULATED AND CRYSTALLINE ACETYLSALICYLIC ACIDS IN CONTROLLING *CULEX PIPIENS*

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ABSTRACT

The mosquitoes are nuisance pests to humans and represent a global health challenge. The larvicidal activities of *Commiphora molmol* resin, mirazid, and formulated and crystalline acetylsalicylic acid (F-ASA and C-ASA, respectively) were evaluated against the 2nd and 4th instar larvae of *Culex pipiens* at 27°C, after 48 hours post-treatment in different water qualities. Water samples were collected from the tap, canal, and pool. The water pH, nitrate, salinity, and dissolved oxygen were measured. The results showed that the larvicidal activity of the tested compounds was increased by increasing their concentrations. The mortality reached 100% and 98.4% for the 2nd instar larvae at 160 ppm, 100% and 90.4% for the 4th instar larvae at 320 ppm of mirazid and *C. molmol*, respectively. The mortality induced by F-ASA and C-ASA reached 99.2% and 75.2% for the 2nd instar larvae at 1200 ppm, 100% and 92.0% for the 4th instar larvae at 2000 ppm, respectively. The efficiency of the tested materials against the 4th instar larvae was affected by the water quality; whereas their LC_{50} values were 38.3-1045.9 ppm in tap water; while at canal and pool water the LC_{50} values were 44.5-1073 and 49.8-1126.0 ppm, respectively, at 27°C and 48 hours post-treatment. The correlation coefficient between the susceptibility of *Cx. pipiens* larvae to the tested compounds and each physicochemical factor showed a positive correlation with water nitrate and dissolved oxygen. In conclusion, mirazid, *C. molmol*, F-ASA, and C-ASA can be good alternative agents for controlling mosquitos' larvae in different water qualities.

INTRODUCTION

Mosquitoes are vectors for a variety of illnesses, and millions of people are thought to be infected each year by mosquito bites around the world[1]. Due to a lack of registered vaccinations and appropriate therapies, some of these pandemic mosquito-borne diseases could be lethal[1]. As a result, more emphasis is being paid to vector mosquito management, especially since mosquitoes are expanding their range of habitation and prolonging their activity time because of global warming and human construction activities.

Culex species are the principal vectors of West Nile fever, St. Louis encephalitis, and Japanese encephalitis, which are distributed worldwide in tropical and temperate regions[1]. Lymphatic filariasis, commonly known as elephantiasis, is a neglected tropical disease set to infect 856 million people in 52 countries who require preventive chemotherapy to stop the spread of infection. The global baseline estimates of people affected by lymphatic filariasis were 25 million men with hydrocele and over 15 million people with lymphedema. At least 36 million people continue to suffer from these chronic disease manifestations[2,3]. In Egypt, the mosquito *Cx. pipiens* is the principal mosquito vector of filariasis and some arboviruses such as West Nile Virus and Rift Valley Fever virus. Synthetic insecticides have been particularly efficient in lowering mosquito-borne disease transmission, but their effectiveness has been hampered by pesticide resistance over time and unfavorable effects on non-target organisms[4]. Botanicals were discovered to have an advantage over synthetic insecticides in terms of toxicity, resistance development, and biodegradability. Botanicals have stronger activity in interrupting larval and adult vector survival, thus inhibiting insect development and multiplication as a viable alternative to synthetic insecticides[5]

Culex pipiens used most aquatic habitats for breeding, including unused wells or sakia pits, drainages, catch basins, ponds, pools, canals, irrigation channels, rice fields, swamps, irrigation basins, ditches, temporary pools, and irrigation drainage tubes in all indicator areas (rural, urbanized, and urban)[6]. Physiochemical parameters such as temperature, salinity, and pH have a significant influence on the occurrence and larval abundance of mosquito species[7]. Also, these characteristics may have some effects on mosquito vectors' susceptibility to traditionally used insecticides. Pollutants from different places, like sewage from factories and farms, can sometimes get into the places where mosquitoes lay their eggs[7].

One of the alternative biological solutions is to understand the mosquito breeding environments where understanding breeding and behavioral patterns among mosquito populations is one of the key elements to achieving the goal of mosquito control. There is limited evidence on the effects of breeding site nature on the susceptibility of mosquitoes[8]. In general, larvae have a more limited home range and lower resistance to adverse environments than adults; this can make them ideal targets for vector control in some cases. The objective of this study was to evaluate the impact of water quality on the efficacy of *Commiphora molmol*, mirazid, and formulated and crystalline acetylsalicylic acid (F-ASA and C-ASA, respectively) against the 2nd and 4th instar larvae of Cx. *pipiens*.

MATERIAL AND METHODS

Rearing technique

Cx. pipiens larvae were collected from natural breeding areas in Shiblanga village (Qualyobia governorate), colonized, and maintained continuously for many generations in the laboratory. The *Cx. pipiens* larvae were reared in water under laboratory conditions at 27±2°C under a photoperiod of 14:10 hours (light/dark) in the insectary. Immature stages of mosquitoes were reared in white enamel pans (35-40 cm in diameter and 10-12 cm in depth) filled with about 2.0 L of de-chlorinated tap water. Care was always taken to avoid overcrowding of larvae in the rearing pans. The larvae were fed on fish food (Tetramin®). The food was sprinkled once daily over the water surface of the breeding pans. The water containing larvae was poured daily into clean enamel pans to avoid scum formation on the water surface or on the walls and bottoms of the pans. Pupae were transferred from the enamel pans to a cup containing de-chlorinated tap water by means of a wire mesh spoon or a plastic pipette and placed in screened cages (35×35×40 cm in dimension) where the adults emerged. The adult mosquitoes were reared in wooden cages (35×35×40 cm) and provided with a piece of cotton soaked with 10% sucrose solution, placed on the top of the cage, and were periodically blood-fed every 3-4 days using anesthetized hamster. The eggs were collected and transferred to clean enamel pans[4].

Used compounds

Commiphora molmol resin was purchased from a local market of medicinal plants in Giza, Egypt. Mirazid, a gelatin capsule of purified oil-resin extract of *C. molmol*, was purchased from Pharco Pharmaceutical Company, Cairo, Egypt. Crystalline acetyl-salicylic acid was purchased from El Nasr Company for Chemicals in Cairo, Egypt, whereas the formulated acetylsalicylic acid (aspirin 320 mg) was purchased from the Arab Drug Company, Cairo, Egypt.

Bioassays

Different concentrations were prepared from each compound by dissolving *C. molmol* and acetylsalicylic acid in de-chlorinated tap water, whereas mirazid was dissolved in Cremephor (one capsule dissolved in 1.0 mL of ethylene glycol) and the resulting solution was diluted with water to a final volume of 100 mL and this is considered as the stock solution (0.9%). Larvicidal bioassays were accomplished under the laboratory conditions in accordance with the WHO technique for mosquitoes[9]. Twenty-five of the 2nd and 4th instar larvae were introduced separately into glass beakers containing various concentrations from 5 ppm to 160 ppm for the 2nd instars and from 10 ppm to 320 ppm for the 4th instar larvae for *C. molmol* and mirazid, whereas for acetylsalicylic acid (formulated and crystalline), the concentrations ranged from 100 ppm to 1200 ppm for the 2nd instar larvae and from 200 ppm to 2000 ppm for the 4th instar larvae in 250 mL of de-chlorinated tap water. Control treatments had a constant volume (0.1 mL) of water or ethylene glycol instead of the compound in the solvent. The treatments were carried out three times in the laboratory at 27±2°C and 75±5% relative humidity. Mortalities were recorded after 48 hours of the exposure period[10]. Dead larvae were identified when they failed to move after probing with a needle in the siphon or cervical region. Moribund larvae were those incapables of rising to the surface or showing the characteristic diving reaction when the water was disturbed.

Effect of water quality on the efficacy of tested compounds

To study the effect of water quality on the susceptibility of *Cx. pipiens* to the tested compounds, the experiments were carried out in water from three different breeding sites (tap, canal, and pool water). Twenty-five of the 2nd and 4th instar larvae per replicate were exposed to different concentrations in glass beakers containing 250 mL of water of different qualities, separately, according to WHO[10]. Each concentration of the tested compounds with an untreated control group was replicated three times. All experiments were conducted at 27±2°C and 75±5% relative humidity. The resulted mortality after 48 hours of exposure was used to determine the lethal concentration killing 50% of larvae (LC_{50}).

Chemical analysis of water

Water samples from the three different water qualities (tap, canal, and pool water) were analyzed. The physicochemical properties of water (pH, nitrate, salinity, and dissolved oxygen) were determined using a pH meter (pH 315i/SET, WTW GmbH & Co., Weilheim, Germany), a nitrate titration and spectrophotometer, a portable total dissolved solids meter, and an AD630 dissolved oxygen meter (Adwa, Hungary), respectively.

Data analysis

Data were analyzed with the one-way ANOVA and the post-hoc test “least significant difference (LSD)” at a significance level of <0.05 using SPSS (SPSS version 22, IBM, Endicott, New York, NY, USA), as well as with the Probit analysis for calculating the lethal values using the computer program PASW Statistics 2009 (SPSS). Correlation and multiple regression analysis were used to analyze the relationship between susceptibility of mosquito larvae to the tested materials and water quality. The Pearson correlation coefficient (r) formula was as follow:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Where, N: the number of pairs of scores, Σxy: the sum of the products of paired scores, Σx: the sum of "x" scores, Σy: the sum of "y" scores, Σx^2: the sum of squared "x" scores, Σy2: the sum of squared "y" scores.

The coefficient of determination (R^2) = MSS/TSS = (TSS − RSS)/TSS

Where, MSS: the model sum of squares, which is the sum of the squares of the prediction from the linear regression minus the mean for that variable, TSS: the total sum of squares associated with the outcome variable, which is the sum of the squares of the measurements minus their mean, RSS: the residual sum of squares, which is the sum of the squares of the measurements minus the prediction from the linear regression.

RESULTS

Larvicidal activities of the tested materials in the tap water

The obtained results in Table "1" showed that the larvicidal activities of *C. molmol* and mirazid were increased with increasing the concentration. The mortality reached 100% and 84.8% at 80 ppm of mirazid and *C. molmol*, and 100% and 98.4% at 160 ppm of mirazid and *C. molmol* for the 2nd instar larvae, respectively. Data showed that the 4th instar larvae of *Cx. pipiens* was more tolerant than 2nd instar larvae, whereas the mortality reached 92.0% and 72.0% in mirazid and *C. molmol* treated larvae at 160 ppm, respectively (Table 2). The larvicidal effects of F-ASA and C-ASA reached 99.2% and 75.2% (mortality) for the 2nd instar larvae of *Cx. pipiens* at 1200 ppm after 48 hours post-treatment, respectively (Table 3). The obtained results in Table "4" showed that the larvicidal effects of F-ASA and C-ASA reached 100% and 92.4% (mortality) for the 4th instar larvae at 2000 ppm, after 48 hours post-treatment, respectively. While at 1200 ppm, the mortality of the 4th instar larvae reached 62.4% and 48.8% at F-ASA and C-ASA, respectively.

Table 1: Larvicidal effects of *C. molmol* and mirazid on the 2nd instar larvae of *Cx. pipiens* at 27°C, 48 hours post-treatment.

Concentration (ppm)	Mortality (%) ± Standard error (2nd instar larvae)	
	C. molmol	Mirazid
Control	0.8 ± 0.8^{g}	0.8 ± 0.8^{f}
5	17.6 ± 2.0^{f}	23.2 ± 2.7^{e}
10	31.2 ± 1.5^{e}	36.0 ± 2.8^{d}
20	46.4 ± 2.0^{d}	64.0 ± 4.4^{c}
40	64.8 ± 2.3^{c}	88.8 ± 4.6^{b}
80	84.8 ± 3.2^{b}	100.0 ± 0.0^{a}
160	98.4 ± 1.6^{a}	100.0 ± 0.0^{a}
LC_{50} (95% FL)	20.8 (17.5-24.9)	12.6 (10.9-14.6)
*$LSD_{0.05}$	5.67	8.21

a, b, and c: Different superscript letters within the same column mean significant difference (P<0.05). FL: fiducial limit; *****: between the tested compounds for all concentrations; LSD: least significant difference.

Table 2: Larvicidal effects of *C. molmol* and mirazid on the 4th instar larvae of *Cx. pipiens* at 27°C, 48 hours post-treatment.

Concentration (ppm)	Mortality (%) ± Standard error (4th instar larvae)	
	C. molmol	Mirazid
Control	0.0 ± 0.0^{g}	0.0 ± 0.0^{f}
10	9.6 ± 1.0^{f}	15.2 ± 2.3^{e}
20	23.2 ± 2.3^{e}	28.0 ± 3.4^{d}
40	36.0 ± 4.4^{d}	49.6 ± 2.7^{c}
80	54.4 ± 4.1^{c}	69.6 ± 5.5^{b}
160	72.0 ± 4.4^{b}	92.0 ± 5.5^{a}
320	90.4 ± 3.3^{a}	100.0 ± 0.0^{a}
LC_{50} (95% FL)	66.2 (54.1-82.8)	38.3 (33.0-44.4)
*$LSD_{0.05}$	9.31	10.04

a, b, and c: Different superscript letters within the same column mean significant difference ($P<0.05$). FL: fiducial limit; *****: between the tested compounds for all concentrations; LSD: least significant difference.

Table 3: Larvicidal effects of F-ASA and C-ASA on the 2nd instar larvae of *Cx. pipiens* at 27°C, 48 hours post-treatment.

Concentration (ppm)	Mortality (%) ± Standard error (2nd instar larvae)	
	(C-ASA)	(F-ASA)
Control	0.8 ± 0.8^{f}	0.8 ± 0.8^{f}
100	8.0 ± 1.3^{ef}	12.8 ± 2.3^{e}
200	13.6 ± 2.4^{e}	20.8 ± 2.7^{e}
400	24.8 ± 3.4^{d}	37.6 ± 4.1^{d}
600	36.8 ± 3.4^{c}	60.8 ± 3.9^{c}
800	55.2 ± 3.2^{b}	80.8 ± 5.4^{b}
1200	75.2 ± 4.6^{a}	99.2 ± 0.8^{a}
LC_{50} (95% FL)	709.1 (630.6-810.6)	428.6 (283.2-736.1)
*$LSD_{0.05}$	8.71	9.49

a, b, and c: Different superscript letters within the same column mean significant difference ($P<0.05$). FL: fiducial limit; *****: between the tested compounds for all concentrations; LSD: least significant difference.

Table 4: Larvicidal effects of F-ASA and C-ASA on the 4th instar larvae of *Cx. pipiens* at 27°C, 48 hours post-treatment.

Concentration (ppm)	Mortality (%) ± Standard error (4th instar larvae)	
	C-ASA	F-ASA
Control	0.8 ± 0.8^{f}	0.8 ± 0.8^{g}
200	8.8 ± 2.3^{ef}	10.4 ± 2.7^{f}
400	20.0 ± 4.9^{de}	23.2 ± 4.5^{e}
800	32.0 ± 1.8^{d}	39.2 ± 1.5^{d}
1200	48.8 ± 3.9^{c}	62.4 ± 2.0^{c}
1600	76.0 ± 7.5^{b}	88.0 ± 3.6^{b}
2000	92.0 ± 4.9^{a}	100.0 ± 0.0^{a}
LC_{50} (95% FL)	1046.0 (867.5-1214.1)	827.4 (710.1-933.4)
*$LSD_{0.05}$	12.40	7.50

a, b, and c: Different superscript letters within the same column mean significant difference ($P<0.05$). FL: fiducial limit; *****: between the tested compounds for all concentrations; LSD: least significant difference.

Effect of water quality on the efficiency of the tested compounds in controlling mosquitos

Data represented in Table "5" showed the effect of water quality on the susceptibility of the 2nd and 4th instar larvae of *Cx. pipiens* to the tested compounds after 48 hours of exposure. Based on the LC_{50} values, the larvicidal activity of mirazid (LC_{50} = 12.6 and 38.3) was more effective than that of *C. molmol* (LC_{50} = 20.8 and 66.2 ppm) for the 2nd and 4th instar larvae of *Cx. pipiens* in tap water, followed by canal water (LC_{50} = 15.9 and 44.5), (LC_{50} = 21.5 and 72.6), and pool water (LC_{50} = 20.1 and 49.8), (LC_{50} = 26.0 and 87.0 ppm), respectively.

As indicated in Table "5" and based on LC_{50} values, the larvicidal activity of F-ASA (428.6 and 827.4) was more effective than that of C-ASA (LC_{50} = 709.1 and 1045.9) for the 2nd and 4th instar larvae of *Cx. pipiens* in tap water, followed by canal water (LC_{50} = 472.6 and 911.3), (LC_{50} = 752.6 and 1073 ppm), and pond water (LC_{50} = 521.1 and 952.6), (780.6 and 1126.0 ppm), respectively.

Table 5: Effect of the water quality on the efficiency of the tested compounds on the 2nd and 4th instar larvae of *Cx. pipiens* based on LC_{50} after 48 hours post-treatment.

Water quality	LC_{50} (ppm)							
	C. molmol		Mirazid		C-ASA		F-ASA	
	2nd	4th	2nd	4th	2nd	4th	2nd	4th
Tap water	20.8	66.2	12.6	38.3	709.1	1045.9	428.6	827.4
Canal	21.5	72.6	15.9	44.5	752.6	1073.0	472.6	911.3
Pool	26.0	87.0	20.1	49.8	780.6	1126.0	521.1	952.6

Physicochemical parameters of water

Table "6" summarized the physicochemical characters of tap, canal, and pool water. The highest pH and salinity were observed in pool water (7.8 pH and 1.55 mg/L, respectively), while the lowest pH and salinity were recorded in tap water (6.8 pH and 0.74 mg/L, respectively). Canal water showed the highest mean of nitrate concentration (38.4 mg/L), and the lowest mean were observed in tap water (11.8 mg/L). Dissolved oxygen ranged from 6.4 mg/L in pool water to 10.2 mg/L in canal water.

Correlation coefficient between the susceptibility of *Cx. pipiens* larvae to the tested compounds and each physicochemical factor showed that the susceptibility was positively correlated with the water nitrate and dissolved oxygen (Table 7).

DISCUSSION

Mosquitoes stand out among the many species of blood-sucking arthropods that bother people. Most of these species serve as vectors for infections that cause dengue fever, yellow fever, malaria, lymphatic filariasis, Japanese encephalitis, and other deadly human diseases[1, 11]. Therefore, the competent authorities and researchers seek to use the appropriate and most effective means in combating mosquitoes.

Our data revealed that the tested materials were effective against the 2nd and 4th instar larvae of *Cx. pipiens* and their mortality percentage was increased by increasing the concentration. Mirazid was more effective than *C. molmol,* and (F-ASA) was better on larval killing than (C-ASA) in both the 2nd and 4th instar larvae of *Cx. pipiens.* Similar finding has obtained by Baz[12] who showed that larvicidal activity of plant oil-resin have efficacy against *Cx. pipiens* larvae, whereas the highest larval mortalities (83.3% and 100%) were observed at 1500 ppm with acetone extracts of *C. molmol* at 24 and 48 hours post-treatment, respectively.

Massoud and Labib[13] observed that the myrrh (oleoresin) obtained from the stem of *Commiphora molmol* have insecticidal activity against mosquito larvae, where LC_{50} values in 2nd, 3rd, and 4th instar larvae of *Cx.*

Table 6: Physicochemical parameters of different water qualities.

Water quality	Physicochemical parameters			
	pH	Nitrate (mg/L)	Salinity (mg/L)	Dissolved O_2 (mg/L)
Tap water	6.8	11.8	0.7	8.9
Canal	7.6	38.4	1.2	10.2
Pool	7.8	32.8	1.6	6.4

Table 7: Correlation and multiple regression analysis of water types and susceptibility of *Cx. pipiens* larvae to tested materials.

Parameters	Correlation	Simple regression		Multiple regression values				
	r^{2*}	beta	*P*	beta	*P*	F value	*P*	R^2
pH	–0.112	–35.92	0.139	–31.11	0.126	12.037	0.0136	0.813
Nitrate (mg/L)	0.801	5.04	0.004	7.32	0.005			
Salinity (mg/L)	0.486	–60.54	0.055	–25.62	0.081			
Dissolved O_2 (mg/L)	0.283	13.71	0.013	9.50	0.013			

*r: Pearson correlation coefficient; R^2: coefficient of determination

pipiens was 0.016×10^2, 0.17×10^2 and 1.6×102 g/L, respectively. Mirazid was evaluated as a molluscicide against adult *Biomphalaria alexandrina* snails and as a larvicide against *S. mansoni* larvae (miracidia and cercariae), with LC_{50} and LC_{90} values of 19.19 and 41.26 mg/L, respectively[14]. In addition, it was reported that mirazid treatment reduced growth rate by 11%, decreased eggs and snail/week by 98%, delayed egg hatchability to 13 days, and stopped cercarial shedding completely (100 %)[14].

The efficiency of the tested materials, *C. molmol*, mirazid, F-ASA, and C-ASA as larvicides against the 2nd and 4th instar larvae of *Cx. pipiens* was affected by water quality in the current study. Mosquito larvae tested in tap water were more susceptible to the tested compounds than larvae tested in canal and pool water. The correlation coefficient between the susceptibility of *Cx. pipiens* larvae to the tested compounds and each physicochemical factor showed that the susceptibility was negatively correlated with the water nitrate and dissolved oxygen.

It is known that water quality, including its physical and chemical properties, affected positively or negatively the efficiency of the selected insecticide against the mosquito or the pest to be controlled. Many other published studies[15-17] revealed that the quality of the water plays an important role in the performance of pesticides. Water is the key to delivering insecticides to the target pest, and it must be considered the basis for a good application of the pesticide[18]. The current study proved that the efficiency of a particular pesticide differs from applied at clean water from contaminated water or pool water.

The effect of water quality on the effects of pesticide spraying is not well documented, whereas the most pesticide products, depending on the type of formulation, are applied pre-diluted in water that can originate from different resources such as reservoirs, as well as natural and artificial waterways, which may affect the quality of insecticide[15]. Some mosquito species were affected by each of the other physic-chemical characteristics such as temperature, pH, and dissolved oxygen[19]. A thorough understanding of physical, chemical, and biological variables may help to modify or monitor mosquito breeding conditions to limit their spread. Besides understanding these conditions, the government or relevant agencies should provide the basic techniques and equipment for the disposal of breeding sites, especially temporary ones, periodically and adequately[20].

In addition, one of the reasons for the selective distribution of multiple mosquito species at specific sites and the selection of optimal habitats for spawning is the association of those species with the abundance of physicochemical parameters of breeding sites. Determining the exact influence of physical and chemical factors on the presence and abundance of mosquito larvae in different habitats appears to be a complex process that largely depends on the characteristics of any given species as well as related factors such as patterns of chemical use in the environment such as pesticides[21].

In conclusion, mirazid, *C. molmol*, F-ASA, and C-ASA can be good alternative agents for synthetic insecticides in controlling mosquitoes under laboratory conditions, they are more effective in clean water than contaminated water or pool water. In addition, this study also needs to conduct some field trials to evaluate the effectiveness of these compounds to combat mosquitoes compared to the recommended pesticides

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS
Conceptualization: FFA, ADA, MMB, and YAE; methodology: ADA, MMB, RMA, and YAE; software: ADA and MMB; formal analysis: ADA, MMB, and YAE; investigation: ADA, MMB, RMA, and YAE; data curation: ADA, MMB, and YAE; writing-original draft: FFA, ADA, MMB, and YAE.; reviewing and editing: ADA, MMB, and YAE; supervision: FFA, ADA, MMB, and YAE; All authors have read and agreed to publish the final version of the manuscript.

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تأثير جودة المياه على كفاءة راتنجات نبات "*Commiphora molmol*"، والميرازيد، وحمض أسيتيل سيلسليك المُصنَّع والبلوري في مقاومة البعوض "*Culex pipiens*"

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يعتبر البعوض من أكثر الآفات المزعجة للإنسان وتمثل تحديًا صحيًا عالميًا. تم تقييم تأثير راتنجات نبات "*Commiphora molmol*"، والميرازيد، وحمض أسيتيل سيلسليك المُصنَّع والبلوري على العُمر اليرقي الثاني والرابع للبعوض "*Culex pipiens*" عند 27 درجة مئوية، بعد 48 ساعة من المعاملة فى طرز مختلفة من المياه. تم جمع عينات المياه من الصنابير والترع والبرك. وتم قياس درجة حموضة الماء والنترات والملوحة والأكسجين المذاب. وقد أظهرت النتائج زيادة نشاط المواد المختبرة كمبيدات لليرقات بزيادة تركيزاتها. وبلغت نسبة الإماتة 100% و 98.4% عند 160 جزء في المليون من الميرازيد وراتنجات نبات "*Commiphora molmol*" للعُمر اليرقي الثاني، و 100% و 90.4% عند 320 جزء في المليون من الميرازيد وراتنجات نبات "*Commiphora molmol*" للعُمر اليرقي الرابع، على التوالي. كما بلغت نسبة الإماتة 99.2% و 75.2% للعُمر اليرقي الثاني عند 1200 جزء في المليون من حمض أسيتيل سيلسليك المُصنَّع والبلوري، و 100% و 92.0% للعُمر اليرقي الرابع عند 2000 جزء في المليون، على التوالي. كما تأثرت كفاءة المواد المختبرة ضد العُمر اليرقي الرابع بجودة المياه، حيث كانت قيم "LC_{50}" تساوي 38.3-1045.9 جزء في المليون في ماء الصنبور، بينما كانت قيم "LC_{50}" في مياه الترع والبرك تساوى 44.5-1073 و 49.8-1126.0 جزء في المليون، على التوالي، عند 27 درجة مئوية وبعد 48 ساعة من المعاملة. كما بين معامل الارتباط العلاقة بين حساسية يرقات البعوض للمواد المختبرة والعوامل الفيزيائية-الكيميائية للمياه، حيث أظهرت النتائج ارتباط إيجابي مع النترات والأكسجين المذاب في الماء. والخلاصة: يمكن أن يكون الميرازيد، وراتنجات نبات "*Commiphora molmol*"، وحمض أسيتيل سيلسليك المُصنَّع والبلوري عوامل بديلة جيدة للسيطرة على يرقات البعوض فى طرز المياه المختلفة.