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A comparative study between biological and chemical control against domestic mosquito larvae

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Abstract. *Habiba G, Imen K, Rabeh C, Lina L. 2022. A comparative study between biological and chemical control against domestic mosquito larvae. Biodiversitas 23: 6456-6462.* Mosquitoes are the first cause of transmission of viral diseases to both humans and animals, as they can transmit some viral diseases. These insects have attracted the attention of specialists, especially in the field of control, because they have controlled their spread in urban areas. Traditionally, they have resorted only to insecticides to eliminate them, and aquatic organisms have long been used to assess the health of aquatic systems. Extensive use of pesticides in agricultural and public health programs has caused many environmental problems and toxic effects on aquatic animals, especially non-target organisms. Hence, this method has negative effects. Later, another method appeared called "biological control", which is based on natural predators. The current study aims to compare the use of biological and chemical control in eliminating mosquito larvae without causing any damage to the ecosystem. Therefore, two studies were conducted. The first is biological control by placing water mites with local mosquito larvae and measuring mite mortality, while the second study deals with chemical control. The rust solution was tested on mosquito larvae at different doses of 0.5mL/L, 2.5mL/L, and 4.5 mL/L. The results proved the effectiveness of biological control compared to chemical control. Finally, these findings will greatly contribute to both the agricultural and medical fields that infect this insect, as well as enrich the literature for future research in mosquitoes.

Keywords: Acetamipride, *Culex pipiens*, ecotoxicity, *Piona uncata*, rustile, Tonga Lake

INTRODUCTION

Risks of some insecticides were evaluated on non-target species: diflubenzuron and novaluron chitin synthesis inhibitors insecticides, on the structure and biochemical composition of cuticles and stress biomarkers in crustacean species *Penaeus kerathurus* and *Palaemon adspersus* (Morsli et al. 2015; Berghiche et al. 2016; Lechekhab and Soltani 2018) and thiametoxin, a neonicotinoid insecticide, on growth and biomarker responses (Cheghib et al. 2020). Insects are one of the most important classes of the arthropod phylum that have attracted tremendous interest among ecologists in terms of either their large numbers and biological diversity or their economic importance. Among the insects that scientific research has found abundant (Hubálek 1999). We can name the mosquito family, which is the main vector of viral diseases for humans and animals (Benelli 2016; Pagano et al. 2020). In addition, some types of mosquitoes can even transmit certain viral diseases to humans. For example, "*Aedes aegypti*" mosquitoes female can transmit the yellow fever virus, while other types of mosquitoes can transmit dengue viruses, together with some viruses that cause brain and animal infections. Generally, insects live with us on our planet in huge numbers and have great capabilities and potential (Eggleton 2020). Mosquitoes have caught specialists' attention, particularly in the field of control.

However, the first and most important step of the control process is to identify the level of numerical density and diagnose the dominant species because having the proper information about the insect is the key to providing an accurate scientific recommendation. In other words, effective control against mosquitoes depends on the species' life cycle, and this life cycle cannot be known until the species is diagnosed (James et al. 2018). Moreover, to reduce the spread of insect pests, scientists have begun to look for effective ways to control them by suppressing them, preventing their access to the host, or by creating unsuitable conditions for their reproduction and eliminating them (El-Shafie 2019). Chemical control has become the primary means of controlling this pest for its ease of use and rapid effect, despite the many challenges that can arise along the way in controlling mosquito larvae (Jonsson et al. 2008). With the discovery of chlorinated hydrocarbons, a new era has begun in the use of controlled chemicals, beginning with the compound DDT (Dichloro-Diphényle-Trichloro-éthane), which contributed to the control of larvae and adult mosquitoes, leading to the elimination of malaria from many parts of the world (Fillinger 2011; Shüné 2022). There are also organophosphate pesticides that have better specifications compared to organic pesticides (Cuervo-Parra et al. 2016; Buxton et al. 2020). This is due to the shortcomings of the method adopted in chemical control, and this is clearly shown in the health risks it causes, such as skin inflammation, eye and respiratory infections, environmental pollution, and the resistance of insects to pesticides and the destruction of predators and other non-target organisms (Gill and Garg

2014; Özkara et al. 2016).

Therefore, scientists resorted to another method of control called "biological control," which relied on natural predators such as *Gambusia affinis* and freshwater mites which are considered to be the first predators, the most important of which are the families: Pionidea and Arrunirida (Costa et al. 2017). They are closely related to other biological components of the ecosystem; they parasitize insect larvae such as mosquitoes, worms, and shellfish. The very first research was carried out on water mites in Algeria (Malla and Goyal 2016). In our case, we conducted a comparative study of the biological control of domestic mosquitoes using aquatic mites and investigated the predation rate of mites against mosquito larvae during four larval stages. In addition, a chemical control study using the chemical pesticide "Rustile" on domestic mosquito larvae was conducted. Finally, from the results obtained from the biological control, mites were found to be natural predators of mosquito larvae, which confirmed their effectiveness in the biological control of mosquitoes. Finally, we found that moths are natural predators of mosquito larvae and that chemical pesticides also have a toxic effect on these larvae.

MATERIALS AND METHODS

Presentation of the sampling sites

Annaba

It is located in the northeast of Algeria and overlooks the coastal strip with an extension of over 80 km. It is 600 km from the Algerian capital and about 100 km from the Tunisian border in the extreme east of the country. Its total area is 1439 km^2, and it is geographically bordered by the Mediterranean Sea to the north, the province of El Tarf to the east, the province of the Skikda to the west, and Guelma to the south (Ghanim 2020). Annaba is a port city, reflecting the city's French colonial architecture (Aldrich 2005). It is the fourth largest city in Algeria in terms of population, after Algiers, Oran, and Constantine, with a population of approximately 650,000 inhabitants, known as Annabes (also called Pons and Bonoise). Annaba is one of the oldest cities in Algeria, founded in 1295 BC, and known under successive names such as Ubon, Hippo Regius, Hiboun, Buna, Bled El Enab, Bonn, and finally, Annaba (Jones 2021).

Tonga lake

Our study was conducted within the PNEK (El Kala National Park), which is located in the extreme northeast of Algeria, covering about 80,000 hectares. It was first founded on July 23 by the N0: 83-462 and built as a biosphere reserve by UNESCO (L'Organization des Nations Unies pour l'éducation, la science et la culture). On December 17, 1990, it was the most important wetland in North Africa (Elafri 2017). This reserve is bordered to the north by the Mediterranean sea; to the south by the foothills of the Medgerda Mountains; to the east by the Algerian-Tunisian border (Figure 1), and to the west by the end of the alluvial plain of Annaba and the hills of Jebel al-Kursi (Loucif et al. 2020; Bayley et al. 2021). This region has international importance as it is located in the Mediterranean region. Lake Tonga has been included in the Ramsar List since 1983. It is located between 36° and 51°N and 08° and 30°E and occupies a huge coastal depression that covers an area of 2600 hectares, a length of 7.5 km, and a width of 4 km. Mount Argob Arrashed (167 meters long) to the north and northwest; a dividing line separating the two basins of Lake Tonga and Opera to the west, and the Algerian-Tunisian boundary to the east (Raachi 2007).

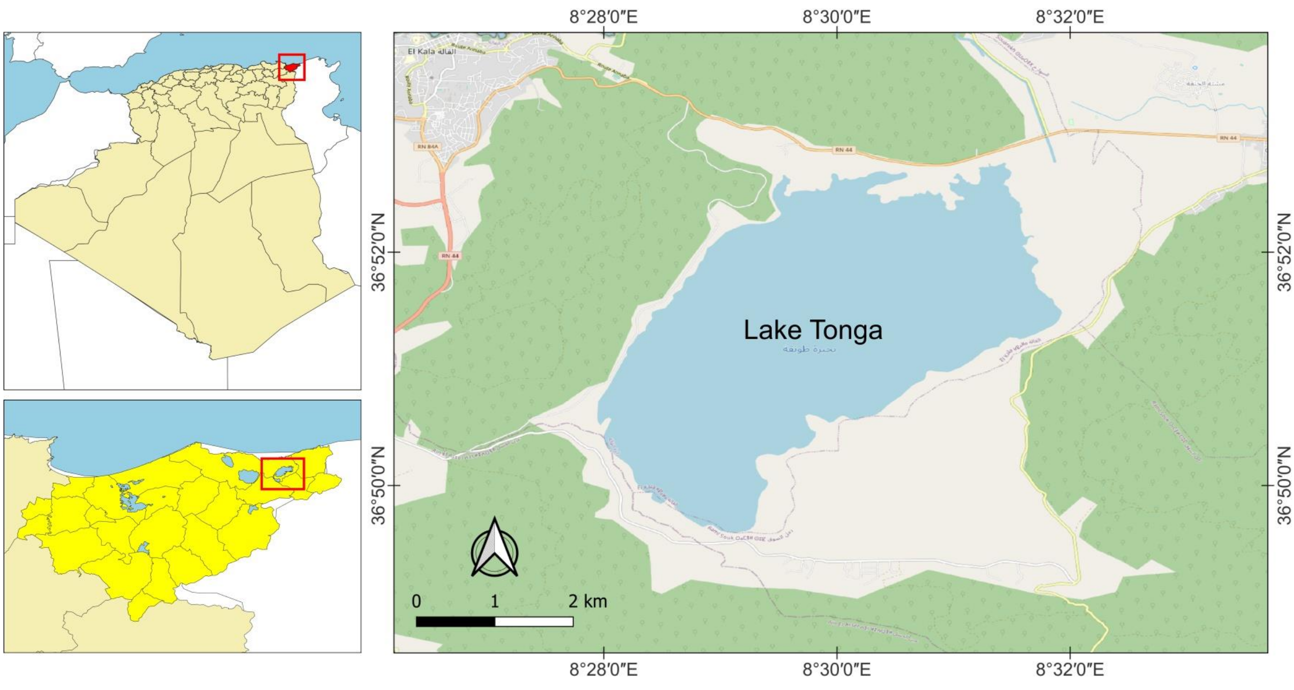

Figure 1. Geographical position of Lake Tonga, Algeria (P.N.E.K 2011)

Biological materials

Culex pipiens

Mosquitoes are gray, small insects with long, thin wings (about 7 mm long). The wings are translucent, and the body is covered with black scales (Figure 2). It spreads worldwide and can be found throughout the year, especially during the warm seasons, but it decreases during the cold ones (Sarwar 2020). The life cycle of this insect consists of four stages: egg, larva, pupa, and adult. Their life cycle lasts from 10 to 14 days, passing through four larval stages before reaching the pupal stage. With morphological changes occurring at each stage. Despite their lack of motor apparatus, this does not mean that they are immobile, but rather that they move with contractile movements (Hall and Martin-Vega 2019). They feed on plankton and organic particles ingested through mill-like mouthparts. Mosquitoes are among the organisms that have received much attention from environmental scientists as the main enemies of humans and animals since they can carry many diseases. In order to reduce the spread of insect pests, scientists began to look for effective ways to combat them by eliminating them. At first, they relied on chemical control, but the problem of pest control is getting worse day by day due to the shortcomings of chemical control (Alyokhin 2015; Pappas 2017). Therefore, scientists resorted to another method, biological control, which relied on natural predators (Cuervo-Parra et al. 2016).

Water mites Piona uncata

Hydracarans are chelicerate arthropods of the class Arachnida and family Pionidae. They are purely aquatic mites with soft and brightly colored integuments. One of the most striking things about Hydracarans is their shining colors, often orange, yellow, and red (Figure 3), probably due to noxious secretions from their dermal glands (Dunlop 2019). The microscopic size ranges from 0.5 mm to 5 mm. The body is single-vented, with prosoma and opisthosoma intimately fused and with inapparent segmentation. The mouth part consists of a pair of chelicerae and pedipalps (Franz-Guess 2019).

The most recent classification was given by Walter and Proctor (1999). It subdivides the mites into four groups: Prostigmata, Astigmata, Gribatida, and Mesostigmata. The systematic identification of the species collected was carried out using the dichotomous keys of Smith et al. (2001). Hydracarids also exhibit effective biological control against Culicidae through their voracious predation on the larvae of these insects. When the water mites attack the mosquito larvae with two needles in their mouths, called the Chelicer, they inject a poison that numbs them. When the larvae stop moving, the water mites suck their guts and kill them (Vasquez et al. 2020).

Sampling biological material

Adult mosquitoes were collected in a residential area located in eastern Algeria in the state of Annaba. Using a test tube closed on one side, they were then placed in cubic cages (25x25 cm) with a wooden frame covered with a wire mesh lid on both sides. The rearing cages contain dates suspended by a thread as food for the adult mosquito, as well as a container with tap water for it to lay its eggs at its level, in the form of boats floating on the surface of the water while providing adequate warmth conditions. After about 24 hours, the adult mosquito lays its eggs in a bowl of water inside the cage to give larvae to use in biological and chemical studies. Mosquito larvae reproduction was carried out under laboratory conditions with the appropriate temperature, humidity, and photoperiod, taking into account the addition of nutrients, such as fish feed every 2-3 days, as the most important conditions for larval feeding (Gacem 2015).

Figure 2. The front and back of a *Culex pipiens* larva (Alomar 2021)

Figure 3. The general morphology of an adult water carapace (Gr. x150) (Gacem 2015)

Predatory mite stock colony and experimental units

The samples were collected by using a container attached to a rope. We took a quantity of water from Lake Tonga, that contains a number of swimming organelles. The contents of the bowl were placed into containers or plastic containers. Before taking samples, the water in Lake Tonga must be examined for the sake of identifying the organisms that are swimming in it. It is better to take the sample from an area that contains plants and rocks because that is where they breathe, and their food is rich in aquatic plant remains. In addition, we filter the water from Lake Tonga to obtain the mites. In the first study, hydracarids were incorporated into the biological control of the Culicidae in order to determine the predatory potential of adults of the most abundant species, *Piona uncata*. The predatory capacity of individual adult mites was tested by placing them in plastic food storage boxes with 20 individual *C. pipiens* larvae for each test stage, with 250 mL of lake water, where these mites live, and the number of mites could be calculated beforehand. The tests were repeated 3 times, plus one control test (without *P. uncata* and containing only the previous larval stages). Finally, determining the predatory activity of the individuals was done by recording the mortality of the larvae. In the last one, we calculated the mortality rate of the mosquito larvae after one day, two days, three days, and seven days.

Among the many pollutants affecting continental aquatic ecosystems, "Rustile" is an insecticide of the Acetamiprid chemical family. It acts as a neonicotinoid insecticide, an environmental pollutant, and a xenobiotic. The chemical used in this study is Rustile with specific toxicity used to kill various insects. It is very effective. The chemical used in this study is Rustile with specific toxicity used to kill various insects. It is a very effective insecticide against crawling insects, especially cockroaches (Féat 2019; Narayanasamy 2020). According to DEKACHIM (The only private formulator in the field of agrochemistry in Algeria, ensures you a high-quality product, tailored), which has several product lines in the agriculture and public hygiene, it is used for general hygiene and for all kinds of insects with a dose of 1 liter of Rustile insecticide in 200 liters of water.

The active ingredient in the pesticide is acetamiprid, which accounts for 20% of the pesticide (Pagano et al. 2020). The common name is Rustile and the trade name is Rustile Decision No. 465 of 07/2014, which includes a SAM manufacturing permit. The chemical formula of the active ingredient is $C_{10}H_{11}CIN_4$ and the molecular weight of the active ingredient is 222.67 g/mol. Its color is blue, net weight of 10 g, The shelf life is 3 years. These are harmful particles that are highly toxic to the aquatic oceans and can have serious long-term effects on the aquatic environment (Sánchez-Bayo et al. 2016). A set of warnings can be seen on the product: Do not eat, drink, or smoke after using it unless you have washed your hands; Avoid contact with eyes, skin, and clothing; Keep out of reach of children; In case of contact with eyes, rinse immediately with water and seek professional advice. For the second chemical study in this work, a Rustile solution has been prepared using a spoon. A quantity of Rustil pesticide weighing 0.33 g was prepared using an electronic balance. Then, it was placed in a plastic bottle and mixed with 0.5 liters of tap water. Next, toxicity tests were performed by taking the ready-to-use Rustil solution in different volumes of 0.5, 2.5, and 4.5 mL/L with the following volumes of tap water 199.5, 197.5, and 195.5 mL, respectively. To ensure that the larvae were fed every second day, the treatment was carried out in three replicates for all larval stages (L1, L2, L3, L4) of *C. pipiens* mosquitoes, in 500 mL plastic boxes, each box containing 25 larvae. Dead larvae were counted after 24, 48, 72 hours, and seven days of existence at these different concentrations.

Statistical analyses

Results are presented as mean ± standard error (SD) and percent dead. Significance between the different series was tested using the Kruskall-Wallis test (Predation of the four larval stages by mites) and the ANOVA 2 test for the presence or absence of potential differences between the coefficients of the factors studied using the Fisher test (Comparison of each dose of Rustile). Statistical analyses were performed using Minitab 16 software. Statistically, differences were identified.

RESULTS AND DISCUSSION

Mite predation of the four larval stages of *Culex pipiens*, using Kruskall-Wallis

The results of comparing the potentials of *P. uncata* after 24h, 48h, 72h and 7 days regarding the four larval stages of *Culex pipiens* (Table 1) and the mean values of each larval stage of *C. pipiens* by Kruskall Wallis are summarized in Table 2. Examination of the results in Table 2 shows that there is not a significant difference between the four larval stages (L1, L2, L3 and L4). Therefore, it can be said that mites are good predators of all four larval stages of mosquitoes (*C. pipiens*).

Table 1. Mean and standard deviation of *Culex pipiens* larval superiority over 7 days

Stages time	L_1	L_2	L_3	L_4
24 h	0.33±0.57	1±0	1.33±1.52	2±1
48 h	0.33±0.57	0.33±0.57	0±0	0.33±0.57
72 h	2±1	1±1	1.33±0.57	1±0
7 days	0±0	0±0	0±0	0.33±0.57

Table 2. Comparison of the potentials of *Piona uncata*, after a certain time (24h, 48h, 72h) in relation to the different larval stages of *Culex pipiens* using the Kruskall Wallis test

Stages time	SV	df	Fobs	P
L_1	Temps	3	6.93	0.07 ns
L_2	Temps	3	7.56	0.05 ns
L_3	Temps	3	5.53	0.13 ns
L_4	Temps	3	7.30	0.06 ns

Note: SV: Sources of Variation; df: degrees of freedom; Fobs: observed value of Fisher's F variable; P: probability of finding significant differences; $P>\alpha = 0.05$: (ns) non-significant differences

Table 3. Comparison of rust toxicity for each of the three doses (0.5 mL/L, 2.5 mL/L and 4.5 mL/L) against the four larval stages of *Culex pipiens*, when using an anova with two scores fixed to the criterion model (ANOVA 2)

Time	SV	ddl	SCE	CM	Fobs	P	Observation
24 h	Doses	2	522.89	261.14	105.75	<0.001	***
	Larval stages	3	434.33	144.78	58.56	<0.001	***
48 h	Doses	2	208.39	104.19	14.26	<0.001	***
	Larval stages	3	141.41	47.13	6.45	0.002	**
72 h	Doses	2	9.05	4.52	5.26	0.013	*
	Larval stages	3	49.00	16.33	18.97	<0.001	***

Table 5. Search for homogeneous time slices by dose and species: Results of the TUKEY test

Larval stages	Dose	Averages and homogeneous time groups					Number of groups
24h	Doses	D1		D2		D3	2
		8.3		16.3		16.5	
	Larval stages	L_3	L_4		L_2	L_1	3
		10.6	10.8		14.4	19.1	
48h	Doses	D1		D2		D3	2
		15.3		19.9		20.8	
	Larval stages	L_3	L_4		L_2	L_1	2
		16.2	17.6		19.6	21.4	
72h	Doses	D1		D2		D3	2
		22.6		23.5		23.8	
	Larval stages	L_4	L_3		L_2	L_1	2
		22.1	22.2		23.9	24.9	

Comparison of each dose of Rustile to the mean values of the four larval stages of *Culex pipiens*: result of the analysis of variance test (ANOVA 2)

The comparison results between three times the toxicity of Rustile for the 3 doses (0.5 mL/L, 2.5 mL/L, and 4.5 mL/L) in relation to the 4 larval stages of *C. pipiens*; the mean values for each larval stage of *Culex* are summarized by the ANOVA test in Table 4. The table shows that at each stage, there were differences with very high statistical significance. After 72 hours, the results show that there is a significant difference between the disrupted doses and the presence of a very large difference for the larval stages. Therefore, rust is considered one of the toxic insecticides that affect insects in general and aquatic insects in particular, negatively affecting the environment.

Search for homogeneous time groups by species: results of the Tukey test

The statistical results for the search for homogeneous time groups for each of the three doses using the TUKEY test are illustrated in (Table 5). These results are generally presented as underlined means, and the underlining corresponds to means or combinations of means that are not significantly different from each other. After rejecting the hypothesis of equivalence of means by the analysis of variance, the TUKEY test was yielded for 24 hours; there were two homogeneous time slices for the doses and three homogeneous time slices for larval stages. But after 48 and 72 hours, there were two homogeneous time slices for doses and larval stages.

Discussion

Mosquitos have attracted the attention of scientists and researchers for many centuries due to their medical and veterinary importance, as they are responsible for the transmission of several pathogens causing human and animal diseases, including malaria, which affected more than half of the world's population (Tandina et al. 2018). Chemical control, mainly with synthetic chemical pesticides, continues to be the major means of vector control (Nicolopoulou-Stamati et al. 2016). However, the side effects of conventional insecticides or environmental imperatives have encouraged the search for alternative methods, such as biological control (Gill and Garg 2014; Lamichhane et al. 2016; Brzozowski and Mazourek 2018). Invertebrate and vertebrate organisms, as well as entomopathogens, have been used in the biological control of mosquitoes. In the biological control of mosquitoes, measures must be integrated to protect humans from mosquitoes while also conserving biodiversity and avoiding toxicological effects and ecotoxicological risks (Benelli and Mehlhorn 2016; Brüehl et al. 2020). Therefore, the regulatory power of the ecosystem is maintained by protecting the existing community of mosquito predators and its natural enemies, such as *Gambusia affinis*, *Pseudophoxinus callensis* and *Pseudophoxinus guichenoti*, from culiciphagous freshwater fish (Karami and kamkari 2019).

Among mosquito entomopathogens, the delta endotoxin, secreted by *Bacillus thuringiensis israelensis* serotype H14, has been the subject of several studies (Ahmed 2017). *B. thuringiensis* has been widely used because of the peculiarities of Culicidae. The results showed that after the treatment with biocides, the results showed a toxic effect of *B. thuringiensis* on *C. pipiens* larvae in the fourth L stage. Thus, laboratory and field studies show that *B. thuringiensis* has a toxic effect on nematoceran Culicidae species. In other studies, a decrease in the number of mosquito larvae was observed after treatment with *B. thuringiensis*. The latter acts specifically on Culicidae; the toxin binds to receptors in the cell walls to form pores in the cell, resulting in larval death (El-kersh et al. 2016; Allgeier 2019). Thus, its specificity reduces the possibility of bacteria remaining outside the aquatic environment. Studies on the growth of Bti outside the appropriate insect environment indicate that the reproduction is reduced and the effect of *B. thuringiensis* on *Piona uncata* mites is low, confirming the safety of using *B. thuringiensis* in the presence of non-target species. Plants have a complex composition and have a particular biological activity, and as a result, many plant products have been used in mosquito control (Moltini-Conclois et al. 2018). Showed the toxicity of Menthapulegium against larvae of the family Culicidae. The effect of aqueous extracts of three economically important plants was also tested. All three aqueous extracts showed insecticidal activity against fourth instar larvae of *C. pipiens*, where myrtle showed greater toxicity (Niroumand et al. 2016).

In another study conducted by the EPA in 2002, it was found that acetamiprid's toxicity is selective to insects, but we do not deny that some of its uses may pose a threat to some non-target aquatic invertebrates (Goulson 2013; Sánchez-Bayo et al. 2016). By exposing fourth instar *Culex* mosquito larvae to different doses for 24 hours, high mortality was observed with abnormalities in the remaining larvae. This ampligo affects the muscles, stimulating them to continuous contraction by activating ryanodine receptors. As a result, calcium in the muscle fibers is consumed and depleted, causing paralysis, including tale, and many other studies have proven the effectiveness of Amblego against many insect pests, and many researchers have studied the effects of many substances used to control mosquito larvae. One of these, and perhaps the most famous of them, is the growth modifier Novaloron, which has become evident its toxicity by interfering with the excretion process by inhibiting chitin; hence the inability to form the skin of the cuticle, including death. In another method of mosquito control, the effectiveness of juniper was studied by applying increasing doses to the adult mosquito. It has been speculated that its toxicity may be due to the increased accumulation of the active substance within its body and, thus, the increased effect on the body. The effectiveness of juniper can be attributed to the fact that it contains many effective compounds, such as alkaloids, phenols, and flavonoids. Each compound functions differently from the others (Raina et al. 2019; Tahghighi et al.2019). Water mites are also involved in the regulation of mosquito populations. Indeed, adults are predators of Culicidae larvae, while their larvae are ectoparasites of adults (Kirkhoff et al. 2013; Karami et al. 2019). The Early work on Hydracarans in Algeria revealed the presence of Hydracarans larvae in different parts of the body of aquatic larval insects, concerning the works, carried out at our laboratory (Gacem 2015).

Therefore, regardless of the diversity of the control methods, the goal is always to eliminate insect pests without causing side effects on non-target organisms, and this can only be done by controlling the rational use of pesticides and using the best available methods as alternatives. The use of medicinal plants because they are effective in biological control and do not affect the ecosystem at large or cause any damage to its components in general or to non-target organisms in particular, which can benefit them as well as humans. According to the results we obtained by studying the effect of the pesticide Rustile on the four larval stages of *C. pipiens* mosquitoes, we used three different concentrations: 0.5mL/L, 2.5 mL/L, and 4.5 mL/L in order to reach the most effective and efficient concentration. Through the clear differences in the proportions and mortality rate, it was found that the use of 2.5 mL of Rustile had a greater effect compared to the doses of 0.5 mL and 4.5 mL, and this was clearly evident in the first and second phases, where a very high mortality rate was recorded from the first day until it reached its maximum (100% kill) on the third day. It also showed that the use of a 4.5 mL/L dose of the pesticide was more effective in the third and fourth stages compared to the two doses of 0.5 mL/L and 2.5 mL/L of the same pesticide. However, the use of this concentration is not recommended for several reasons, including being ineffective in the early larval stages (first and second) and allowing them to develop and reach the later stages (third and fourth), which require a higher concentration. In addition, the dose of 4.5 mL/L might be relatively high, which may lead to some undesirable consequences that may affect some other non-target beneficial aquatic organisms to the point of being poisoned. Finally, the use of this high dose can lead to numerous pollution problems, including water pollution and, consequently, sedimentation and impact on the balance of the aquatic environment where it is used. The author's results do not differ from the other results, which prove that biological control is better than chemical control and that it can be trusted. In addition, the identification of unknown factors is very important in this research and may lead to further sequential searches. Through the shown data, we concluded that the mortality rate of chemically treated mosquito larvae is more than that of biologically treated using water moths, and this is due to the toxic particles present in the insecticide that have a toxic and lethal effect on the larvae. Although the chemical method, that is, the use of insecticides, has a great ability to poison and kill mosquito larvae, it affects the environment, even if it is in a small amount or a small dose, because it thus affects non-target organisms when exposed, to them. By ingestion or contact, it damages the food chain and the ecosystem because pesticides do not decompose but remain in nature.

In conclusion, chemical and biological control approaches, including Rustile pesticides and aquatic tick pesticides, were used to control *C. pipiens* mosquito larvae. According to our results, the chemical treatment was more effective as the results were excellent with the doses used.

But the indiscriminate use of chemical pesticides causes harm to the environment, while the biological treatment using water mites is effective only for the target organisms and does not have a harmful effect on other organisms or on the environment.

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