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Assessment of the Impact of Deltamethrin on the Different Life Stages of *Culex pipiens* (Diptera: Culicidae)

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***Abstract*:**

The present study aimed to evaluate the effect of the insecticide Deltamethrin on various life stages of the mosquito *Culex pipiens.* The research was conducted on *Culex pipiens* in Salah al-Din Governorate, Tikrit District, from early October to the end of November 2023, and again from March to the end of May 2024. Statistical analysis revealed a significant effect of Deltamethrin concentration and exposure duration on egg incubation periods. The 2.00% concentration yielded the highest incubation period after 72 hours (4.00 days), which was not significantly different from the 1.50% concentration. The shortest incubation period (3.02 days) was recorded at 0.50% concentration after 24 hours. A significant impact was also observed on egg hatching rate, with 0.50% concentration achieving the highest hatchability (51.57%), while 2.00% resulted in the lowest (16.39%). The third-instar larval mortality rate showed significant variation based on insecticide concentration and exposure time. The highest mortality (98.97%) was recorded at 2.00% after 72 hours, whereas the lowest (37.04%) was noted at 0.50% after 24 hours. Similarly, fourth-instar larval mortality was significantly affected, with the highest value (93.92%) observed at 2.00% after 72 hours and the lowest (33.19%) at 0.50% after 24 hours.

***Keywords*: Culex pipiens, Deltamethrin, incubation periods, egg.**

1. Introduction

The mosquito *Culex pipiens* is among the most widespread species in Iraq, commonly found in both urban and rural settings, as well as in water channels, caves, and cellars (Sarwar, 2016). Mosquitoes pose a major global health threat as vectors of numerous human diseases, including malaria, filariasis, yellow fever, dengue, and encephalitis. In addition to transmitting pathogens, they also provoke allergic reactions ranging from localized skin responses to systemic effects such as angioedema and urticaria. According to the World Health Organization (WHO, 2019), malaria alone accounted for approximately 228 million cases and 405,000 deaths globally in 2018.

Since the introduction of synthetic pesticides, they have become a primary strategy in vector control due to their rapid action and ease of application, despite growing concerns regarding toxicity and environmental persistence. A wide range of chemical classes has been employed to combat different mosquito stages. For instance, inorganic compounds such as Paris green have been used against larvae, while organic agents, such as petroleum oils, have also been applied (Al-Adil and Abdul, 1979).

Deltamethrin, formerly known as Decamethrin before 1980, is a synthetic pyrethroid insecticide characterized by its white, odorless crystalline form, decomposing above 300°C and melting between 101–102°C. It is marketed under various trade names including Butox, Butoflin, Cislin, Crackdown, Decis, and K-Othrine. The technical-grade Deltamethrin has a purity of over 98% (WHO, 1990), and WHO specifications (1985) require at least 98% purity for formulations used in public health. It is available in multiple formulations including emulsifiable concentrates, flowable powders, wettable powders, ultra-low volume concentrates, granules, and aerosols. Several analytical methods, such as thin-layer chromatography, gas chromatography, and high-performance liquid chromatography, have been developed for detecting Deltamethrin residues.

Deltamethrin exhibits high efficacy against a wide spectrum of insect orders including Lepidoptera, Hemiptera, Diptera, and Coleoptera (Lu *et al*., 2019). While it is considered one of the most effective control agents due to its fast-acting properties, its excessive and indiscriminate use has led to the emergence of insecticide resistance, environmental contamination, and elevated toxicity to humans and animals. Moreover, these pesticides persist in soil and biological tissues and are costly (Richards *et al*., 2020).

2. Methodology

2.1 Insect Collection

Immature stages of *Culex pipiens* (larvae and pupae) were collected from swampy areas in the Aweinath region of Tikrit District during two study periods: from October to November 2023 and March to May 2024. These aquatic habitats are rich in organic matter and essential nutrients conducive to mosquito development. Larvae were collected using locally made larval dippers consisting of a 1-meter wooden handle ending in a 10 mm diameter metal mesh scoop. The collected specimens were transferred to the rearing room using glass containers.

2.2 Mosquito Rearing

Immature stages were placed in 500 mL disposable plastic containers filled with 400 mL of distilled water (Sivagnaname & Kalyanasundaram, 2004). These containers were kept in wooden rearing cages measuring 50×50×50 cm, with metallic mesh sides and one side covered with fabric. The cages were maintained in a controlled room at 27±2°C with a 10:14 light-dark cycle. Larvae were fed 1.5 g of powdered rodent feed comprising 21.5% corn, 20.8% barley, 12.2% soybean meal, 3% meat extract, and 6% fishmeal (Al-Faisal & Zayia, 1986).

Water was replaced every 3–4 days and molted exoskeletons were removed with a pipette. Fermented residues were also discarded to prevent water contamination (Al-Sharook *et al*., 1991). Pupae were isolated into 500 mL containers with 400 mL of distilled water to obtain adult mosquitoes. Emerged males and females were fed a 10% sugar solution using a cotton ball placed on a plastic plate to provide energy for flight (Service, 1993).

To facilitate egg production, females were blood-fed by placing a featherless pigeon (with wings and legs tied) atop the cage overnight. After 2–3 days, egg rafts were collected in 500 mL containers with distilled water to promote hatching while avoiding disturbance to prevent egg fragmentation (Mohsen & Mehdi, 1989).

2.3 Preparation of Deltamethrin Concentrations

Four concentrations of Deltamethrin (0.5, 1.0, 1.5, and 2.0 mL/L of water) were prepared along with a control treatment (distilled water only). Fifty milliliters of each concentration were placed in 100 mL disposable plastic containers, with three replicates per concentration. Five third-instar larvae were added to each replicate, and 1 g of powdered rodent feed was supplied. The same procedure was repeated for fourth-instar larvae. Larval mortality rates were recorded at 24, 48, and 72 hours post-treatment.

3. Result Discussion

3.1 Efficacy of Deltamethrin Concentration, Exposure Duration, and Their Interaction on the Incubation Period of *Culex pipiens* Eggs (in days)

The statistical analysis presented in Table (1) revealed a significant effect of Deltamethrin concentration and exposure duration on the egg incubation period. The 2.00% concentration after 72 hours resulted in the longest incubation period (4.00 days), which was not significantly different from the 1.50% concentration. In contrast, the shortest incubation period was observed at 0.50% after 24 hours (3.02 days).

The average incubation period varied with insecticide concentration, where 1.00% recorded the longest average period (3.45 days), and 0.50% resulted in the shortest (2.32 days). Regarding exposure time, the longest average incubation period was observed after 72 hours (3.88 days), while the shortest was after 24 hours (3.28 days). These results indicate that the incubation period increased with both higher concentrations and longer exposure durations.

Table 1: Effect of Deltamethrin concentration and exposure duration on the egg incubation period (days) of *Culex pipiens*

Deltamethrin Concentration (%)	**Exposure Duration (hrs)**	**Mean per Concentration**
	24	**48**
0.50	3.02 f	3.30 e
1.00	3.15 f	3.33 e
1.50	3.35 e	3.59 d
2.00	3.60 d	3.80 b
Mean per Exposure Duration	3.28 C	3.51 B

L.S.D. ($p \leq 0.05$): Interaction = 0.1461, Concentration = 0.0843, Exposure Time = 0.073
Identical letters in rows or columns indicate no significant differences at $p < 0.05$.

3.2 Efficacy of Deltamethrin and Exposure Duration on the Hatching Rate (%) of *Culex pipiens* Eggs

Table (2) shows significant differences in egg hatching percentage based on Deltamethrin concentration and exposure duration. The highest hatchability (68.96%) was recorded at 0.50% concentration after 24 hours, whereas the lowest was at 2.00% after 72 hours (1.03%).

The average hatchability percentage was highest at 0.50% (51.57%) and lowest at 2.00% (16.39%). Regarding exposure duration, the highest hatch rate occurred after 24 hours (49.15%) and the lowest after 72 hours (18.29%). This demonstrates that both higher concentration and prolonged exposure significantly reduced egg hatchability.

Table 2: Effect of Deltamethrin and exposure time on the egg hatching percentage of *Culex pipiens*

Deltamethrin Concentration (%)	**Exposure Duration (hrs)**	**Mean per Concentration**
	24	**48**
0.50	68.96 a	49.88 c
1.00	55.81 b	39.00 d
1.50	40.43 d	23.26 g
2.00	31.38 f	16.76 h
Mean per Exposure Duration	49.15 A	32.23 B

L.S.D. ($p \leq 0.05$): Interaction = 3.3477, Concentration = 1.1802, Exposure Time = 1.0221
Identical letters in rows or columns indicate no significant differences at $p < 0.05$.

3.3 Efficacy of Deltamethrin on the Mortality Rate of Third Instar *Culex pipiens* Larvae (%)

According to Table (3), Deltamethrin significantly affected third instar larval mortality, depending on both concentration and exposure time. The highest mortality rate (98.97%) was observed at 2.00% concentration after 72 hours, while the lowest (37.04%) occurred at 0.50% after 24 hours.

Concentration had a significant effect, with 2.00% achieving the highest mean mortality (83.61%) and 0.50% the lowest (52.09%). Similarly, exposure time significantly influenced mortality: the highest mortality rate was after 72 hours (81.71%) and the lowest after 24 hours (52.36%). These results are consistent with Jasim (2009), who reported that larval mortality increased with higher insecticide concentrations.

Table 3: Effect of Deltamethrin concentration and exposure time on the mortality of third instar larvae of *Culex pipiens*

Deltamethrin Concentration (%)	Exposure Duration (hrs)	Mean per Concentration
	24	**48**
0.50	37.04 j	55.12 h
1.00	44.19 i	61.00 g
1.50	59.57 g	76.74 d
2.00	68.62 e	83.24 c
Mean per Exposure Duration	52.36 C	69.03 B

L.S.D. ($p \leq 0.05$): Interaction = 1.4995, Concentration = 0.8657, Exposure Time = 0.7497
Identical letters in rows or columns indicate no significant differences at $p < 0.05$.

4. Efficacy of Deltamethrin on the Mortality Rate of Fourth Instar *Culex pipiens* Larvae (%)

Table (4) shows a significant effect of both concentration and exposure time on fourth instar larval mortality. The highest mortality (93.92%) was observed at 2.00% after 72 hours, while the lowest (33.19%) occurred at 0.50% after 24 hours.

Mortality rates increased significantly with concentration: 2.00% yielded 79.76%, while 0.50% gave only 48.21%. Exposure time also played a key role: 77.93% after 72 hours versus 49.75% after 24 hours. These findings align with Aweed and Fadhel (2015), who observed similar trends in *Cx. molestus* when treated with Abate insecticide, as well as with the study of Al-Awsi (2017).

Table 4: Effect of Deltamethrin concentration and exposure time on the mortality of fourth instar larvae of *Culex pipiens*

Deltamethrin Concentration (%)	Exposure Duration (hrs)	Mean per Concentration
	24	**48**
0.50	33.19 j	49.31 h
1.00	43.14 i	56.54 g
1.50	56.91 g	71.89 d
2.00	65.76 e	79.60 c
Mean per Exposure Duration	49.75 C	64.34 B

L.S.D. ($p \leq 0.05$): Interaction = 3.0963, Concentration = 1.7877, Exposure Time = 1.5482
Identical letters in rows or columns indicate no significant differences at $p < 0.05$.

4. Conclusion

The present study demonstrated that chemical control using Deltamethrin significantly affected the mortality rates across the studied life stages of *Culex pipiens*. It was also evident that the longer the exposure duration, the higher the mortality rate, indicating a direct relationship between exposure time and larvicidal effectiveness.

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