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Effect of Deltamethrin on Biochemical and Hematological Parameters in Male Rats

Lamia Berkane[1*], Maitre assistant A. Ghania Ahmed[2], Azzeddine Choughrem[3], Nadjah Bedida[4], PhD (c) Dalal Doudi[5], Medicl (c) Mohammed Sadok Derki[6], Dr. Mohammed Nadjib Derki[7], Dr. Soundes Akriche[8], Dr. Chikha Maria[9]

[*1:] Department of Molecular and cellular biology, faculty of biology, university of El Oued, Algeria, lamia-berkane@univ-eloued.dz. ORCHID ID: https://orcid.org/0009-0001-9986-6685

[2:] Department of Molecular and cellular biology, faculty of biology, university of El Oued, Algeria, ghania-ahmed@univ-eloued.dz

[3:] Department of Molecular and cellular biology, faculty of biology, university of El Oued, Algeria, choughrem-azzeddine@univ-eloued.dz

[4:] Department of Molecular and cellular biology, faculty of biology, university of El Oued, Algeria, Nadjahbe29@gmail.com

[5:] Department of Molecular and cellular biology, faculty of biology, university of El Oued, Algeria, Doudidalal1989@gmail.com

[6:]Faculty of Medicine, Heinrich-Heine university Düsseldorf, Germany, derkimohammedsadok@gmail.com

[7:] General Surgical Service, El Rimal Private Clinic, Algeria, derkinadjib@gmail.com

[8:] National Research Mordovia State University named after N.P. Ogarev, Saransk, Russi, soundes.akriche@univ-soukahras.dz

[9:] Institute of Agricultural and Veterinary Sciences, Laboratory of Science and Techniques for Living, Mohamed Cherif Messaadia University - Souk Ahras. m.chikha@univ-soukahras.dz

***Corresponding Author**
ORCHID ID: https://orcid.org/0009-0001-9986-6685
Email: lamia-berkane@univ-eloued.dz

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Abstract:

Deltamethrin has been shown to cause significant toxic effects in various mammalian and non-mammalian organs. For this study, we divided the rats into two groups. The control group consisted of three rats that were not injected with deltamethrin, while the treated group consisted of six rats injected with deltamethrin. Hematological and biochemical analyses were conducted. We observed a highly significant difference between the control and treated groups in white blood cells (WBC) ($p=0.001$) and a significant difference in red cell distribution width (RDW-SD) ($p=0.026$). However, no significant differences were found in hemoglobin (Hb), red blood cells (RBCs), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width by coefficient of variation (RDW-CV), platelets (Plt), mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT). Moreover, there was a highly significant difference in Gamma Glutamyl Transferase (GGT) ($p=0.001$) and AST ($p=0.003$) and significant differences in urea ($p=0.024$) and uric acid (UA) ($p=0.037$). Conversely, no significant differences were found in total bilirubin, direct bilirubin, indirect bilirubin, alkaline phosphatase (ALP), ALT, and creatinine (CREA) ($p>0.05$). Our findings indicate that deltamethrin exerts toxic effects on certain hematological and biochemical parameters.

Keywords:biochemical, Deltamethrin, hematology, metabolites, toxicity.

Introduction

Deltamethrin (DLM), a Type II synthetic pyrethroid, [(1R,3S) [α-cyano (3-phenoxyphenyl) methyl]-3-(2,2-dibromo-ethenyl)-2,2-dimethyl-cyclopropanecarboxylate], is extensively utilized worldwide as an insecticide and acaricide. Renowned for its effectiveness in managing pests in agriculture, aquaculture, and even disease vectors like mosquitoes, it also plays a vital role in safeguarding food supplies (Sharma et al., 2014; Qironge et al., 2018). Although deltamethrin is considered to have low toxicity to birds and mammals, recent research has revealed that it can cause significant toxic effects in various organs of both mammals and non-mammals. These effects encompass hepatic toxicity, neurotoxicity, cardiotoxicity, reproductive toxicity, nephrotoxicity, and immunotoxicity (Qironge et al., 2018). In Wistar rats, deltamethrin-induced systemic toxicity is mainly linked to its metabolism in the brain and liver (Qironge et al., 2018). It has been found to negatively affect the reproductive system (Oda SS, El Maddawy, 2012; Issam et al., 2009). Moreover, Arora et al. (2016) reported that DLM induces degenerative changes, including fibrosis, in the liver of Wistar rats.

This study aims to investigate the impact of deltamethrin on male rats by evaluating changes in biochemical parameters in the blood, such as enzyme levels and metabolic markers, as well as

alterations in hematological parameters, including red and white blood cell counts and hemoglobin levels. By analyzing these factors, the study seeks to elucidate the potential toxic effects of deltamethrin on the health and function of the liver and reproductive system in male rats.

Materials and methods

Animals

The male rats used in this study were sourced from the animal laboratory within the Faculty of Life and Nature Sciences. At the time of acquisition, the rats weighed between 130 to 160 grams and were in overall good health, with no detectable diseases or disorders. Each rat was individually identified and assigned a unique identification number for precise tracking throughout the study. The rats were housed in dedicated animal facilities that maintained controlled environmental conditions. These conditions included regulated temperature and humidity, along with a standard 12-hour light-dark cycle. The rats were provided with ad libitum access to water and a standard laboratory diet. Before commencing the experimental procedures, the rats underwent a one-and-a-half-month acclimatization period to adapt to their new environment. During this period, they were closely monitored for any signs of stress or abnormal behavior. Following this adaptation period, the rats continued to grow, and after two and a half months, their weights ranged from 220 to 260 grams.

Animal treatment

We divided the rats into two groups for the study. The first group consisted of three rats that were not injected with deltamethrin, serving as the control group. The second group consisted of six rats that were injected with deltamethrin. The treated group received an initial injection of 1 ml of deltamethrin. Subsequently, they were administered 0.3 ml of deltamethrin every two days for a period of ten days. Following the treatment regimen, the rats were sacrificed, and blood samples were collected for further analysis

Measurement of biochemical and Hematological Parameters

Hematological parameters were determined using the Autoanalyzer Mindray BC-2800. These parameters included Hemoglobin (Hb), Red Blood Cells (RBCs), Hematocrit (Hct), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Cell Distribution Width by Coefficient of Variation (RDW-CV), Red Cell Distribution Width by Standard Deviation (RDW-SD), White Blood Cells (WBCs), Platelets (Plt), Mean Platelet Volume (MPV), Platelet Distribution Width (PDW), and Plateletcrit (PCT).

For biochemical analysis, the Autoanalyzer Mindray BS-360 E was used to measure the following parameters: Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALAT), Total Bilirubin, Direct Bilirubin (Bilirubin D), Indirect Bilirubin, Gamma-Glutamyl Transferase (GGT), Alkaline Phosphatase (ALP), Uric Acid, Creatinine, and Urea.

Statistical study

The haematological and biochemical parameters data were analysed using IBM SPSS Statistics, version 28.0, based in Armonk, NY, USA. The findings were expressed as mean values ± standard deviation (SD). To see the effect of deltamethrin a one-way ANOVA test was applied. The significance level was established at $p < 0.05$.

Results and discussion

Table 1 present the effect of deltamethrin on haematological parameters. There is a highly significant difference between the control group and the treated group in white blood cells (WBC), with a p-value of 0.001. Additionally, there is a significant difference between the control group and the treated group in red cell distribution width (RDW-SD), with a p-value of 0.026. However, there is no significant difference between the control group and the treated group in hemoglobin (Hb), red blood cells (RBCs), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width by coefficient of variation (RDW-CV), platelets (Plt), mean platelet volume (MPV), platelet distribution width (PDW), and plateletcrit (PCT).

Similar to our results, Luty et al. (2001) found that administering a dose of 1/10 of deltamethrin for 28 days to male mice had a significant effect on increasing erythrocyte and hematocrit levels. However, contrary to our findings, they reported a significant rise in hemoglobin levels. Luty et al. (2001) explained that the increase in leukocytes was due to the stimulation of lymphopoiesis and, to a lesser degree, myelopoiesis. Furthermore, they observed that administering a dose of 1/2 of deltamethrin to male mice resulted in a significant increase in leukocyte levels over a 28-day period.

As showed in the figures, there is a highly significant difference in Gamma Glutamyl Transferase ($p=0.001$) and AST ($p=0.003$). Significant differences were observed in UREA ($p=0.024$) and UA ($p=0.037$). However, there is no significant difference between the control group and the treated group in total bilirubin ($p=0.34$), direct bilirubin ($p=0.2$), and indirect bilirubin ($p=0.6$). And, no significant differences were found in Alkaline Phosphatase ($p=0.27$), ALT ($p=0.96$), and CREA ($p=0.035$).

In contrast to our results, Ncir et al. (2016) found a significant increase in Alkaline Phosphatase levels. Our findings are consistent with previous studies on DM, where this pyrethroid, administered orally at 15 mg/kg for 30 days to both sexes of rats, caused significant increases in transaminases, Alkaline Phosphatase, lactate dehydrogenase, and serum glucose levels (Manna et al., 2005). Ncir et al. (2016) also reported a significant rise in AST levels, consistent with our findings of increased plasma AST concentrations in DM-treated groups, especially after administering the highest dose of DM (0.3 mg/kg bw/d) (Chargui et al., 2012). Additionally, Chargui et al. (2012) observed significant increases in plasma ALT concentrations, particularly after 45 and 60 days of DM administration. Our results indicate that elevated transaminase levels, primarily found in the cytosol of hepatocytes, signal liver dysfunction in treated rats. Notably, some increase in ALT and AST was observed in control rats, potentially due to the 70% ethanol used as a solvent in our study. These findings align with research on fenvalerate (Manna et al., 2004) and other studies reporting significant liver enzyme increases following 30 days of oral DM exposure in male rats (Youcef et al., 2006). DM administration resulted in no significant change in plasma creatinine concentrations throughout the experimental period (Chargui et al., 2012). Similarly, plasma creatinine measurements in treated rats showed no significant change compared to controls, mirroring the results for plasma urea concentrations (Chargui et al., 2012).

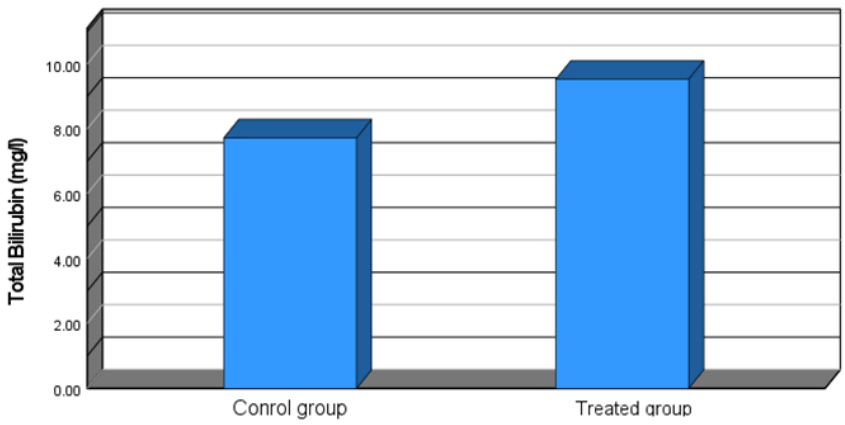

Figure 1: effect of deltamethrin on total bilirubin (mg/l)

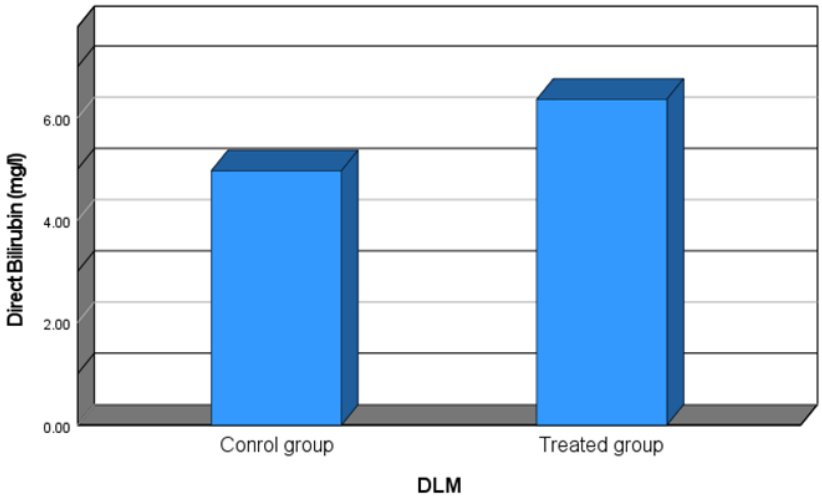

Figure 2: effect of deltamethrin on direct bilirubin (mg/l)

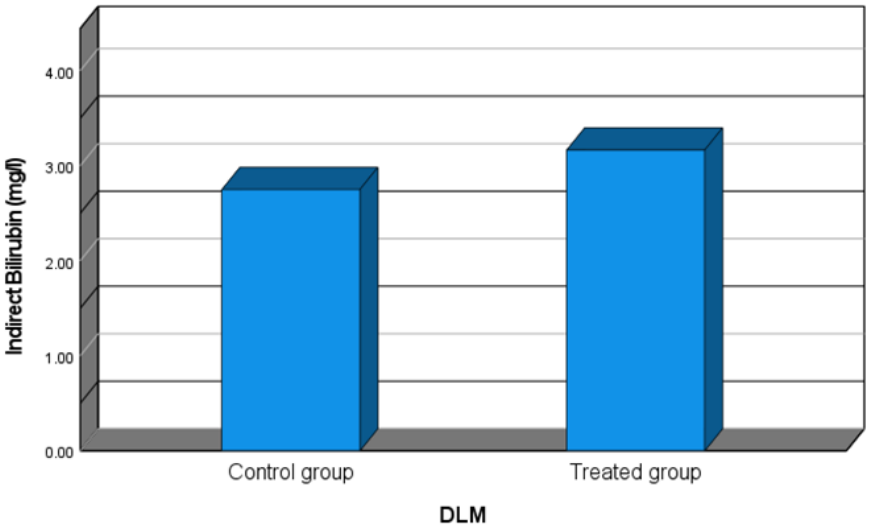

Figure3: effect of deltamethrin on indirect bilirubin (mg/l)

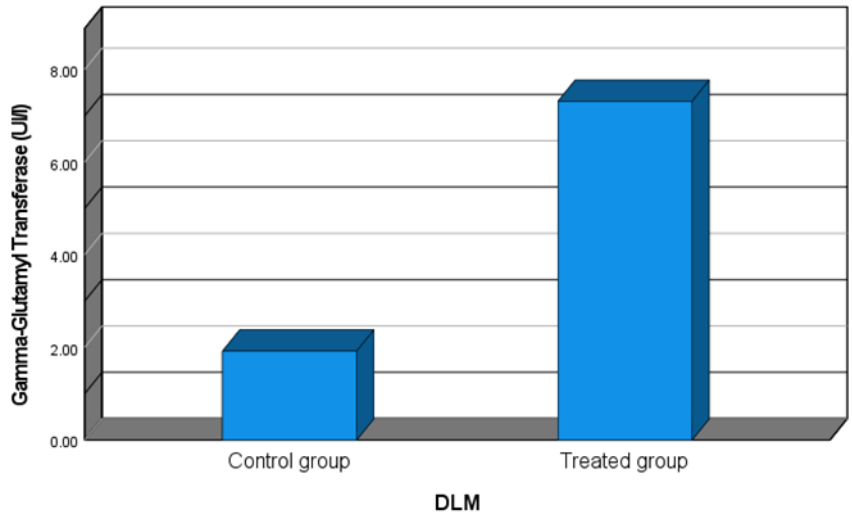

Figure4: effect of deltamethrin on Gamma-Glutamyl Transferase

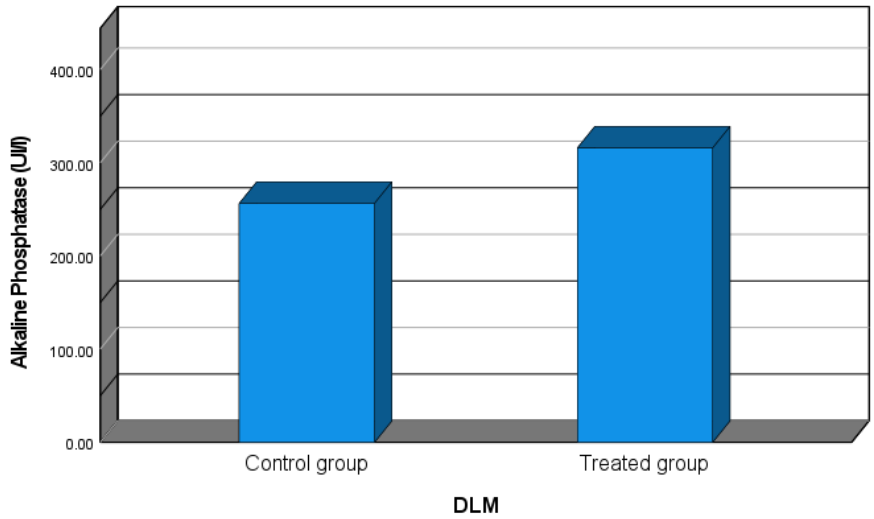

Figure5: effect of deltamethrin Alkaline Phosphatase

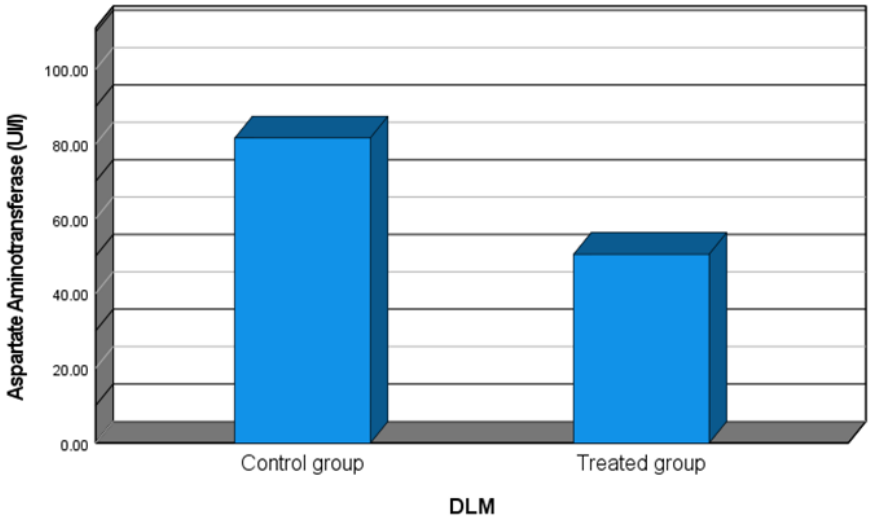

Figure6: effect of deltamethrin Aspartate Aminotransferase

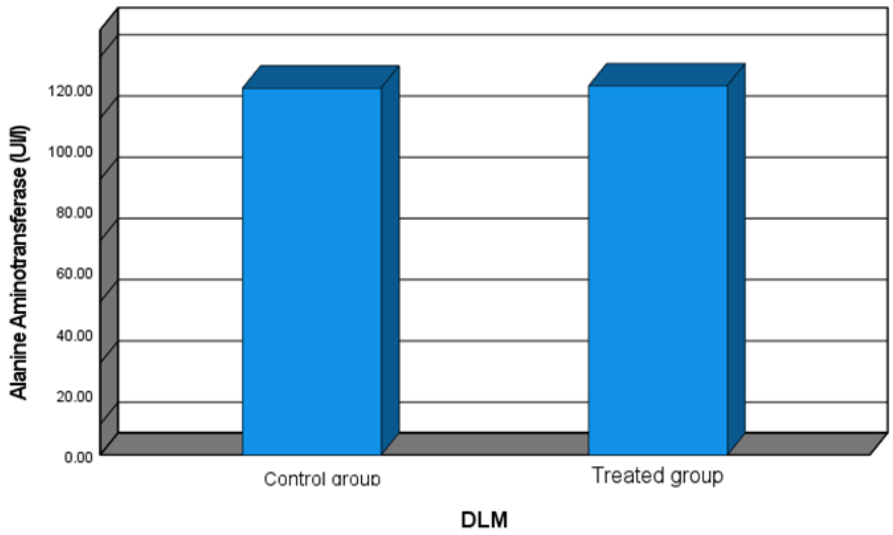

Figure7: effect of deltamethrin Alanine Aminotransferase

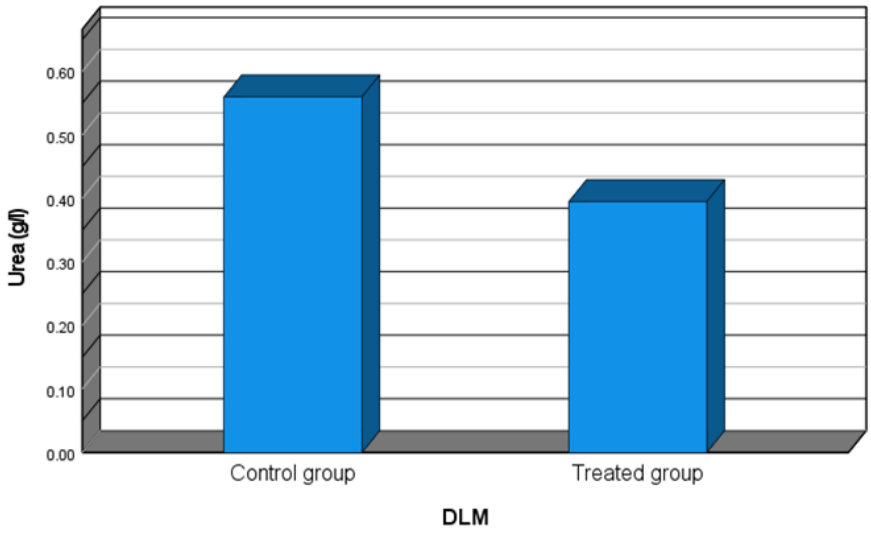

Figure8: effect of deltamethrin on urea

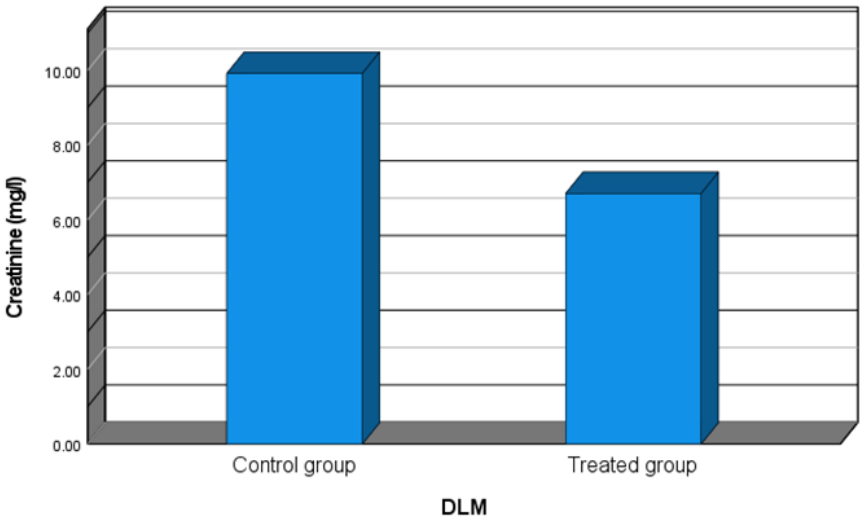

Figure9: effect of deltamethrin on creatinine

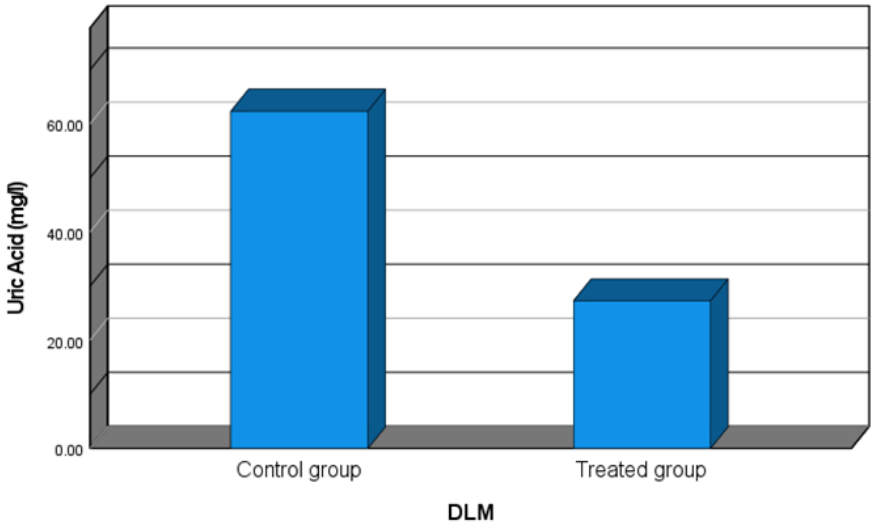

Figure10: effect of deltamethrin on uric acid

Table: effect of deltamethrin on hematological parameters

Parameters	Control Group	Treated Group	P value
White blood cell (WBC)× 10^9/L	7.4±0.14	12.05±0.77	0.001
Hemoglobin (Hb) g/dl	14.50±3.14	13.63±1.12	0.54
Red Blood Cells (RBCs) ×10^{12}/L	7.24±0.59	7.81±0.55	0.19
Hematocrit (Hct) %	36.40±5.72	44.53±5.62	0.081
Mean Corpuscular Volume (MCV) fL	50.13±4.13	47.86±1.27	0.23
Mean Corpuscular Hemoglobin (MCH) pg	19.83±2.83	17.90±0.49	0.12
Mean Corpuscular Hemoglobin Concentration (MCHC) g/dL	39.56±2.29	38.31±0.77	0.244
Red Cell Distribution Width by Coefficient of Variation (RDW-CV) %	18.90±1.50	14.96±3.81	0.13
Red Cell Distribution Width by Standard Deviation (RDW-SD) fL	31.73±5.26	20.26±5.96	0.026
Platelets (Plt) × 10^9/L	796.33±718.99	180.46±25468	0.089
Mean Platelet Volume (MPV) fL	12.26±6.44	2.36±0.33	0.15
Platelet Distribution Width (PDW)	14.56±0.48	14.63±0.48	0.88
Plateletcrit (PCT) %	0.21±0.18	0.37±0.11	0.15

Conclusion

This study demonstrates that deltamethrin exposure results in significant alterations in specific hematological and biochemical parameters including white blood cells, hemoglobin (Hb), Gamma GlutamylTransferase, Aspartate Aminotransferase, urea and uric acid, highlighting its potential toxic impact on health. These findings underscore the need for cautious use and further investigation into the long-term effects of deltamethrin exposure.

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