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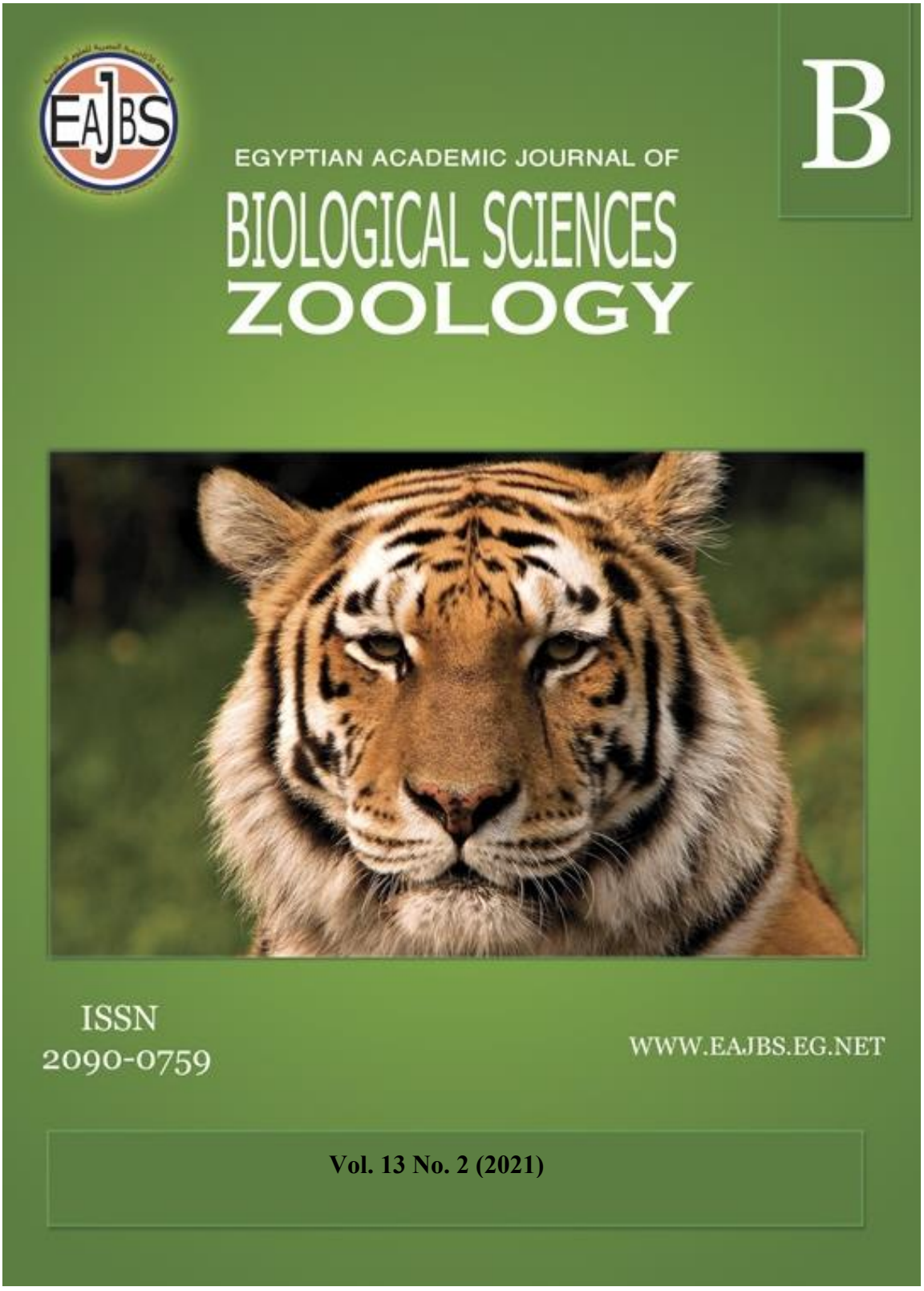

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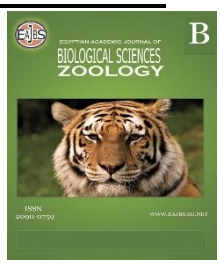

The Toxic Effect of Indoxacarb Exposure on Some Hematological and Hormonal Indices and Evaluating the Potential Alleviative Effects of Vitamin C and Zinc in Male Albino Rats

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ABSTRACT

The world is facing very severe disasters, most notably the toxic effects of pesticides on living organisms' health and the environment, whether directly or indirectly and in the short or long term. Some developing countries suffer from severe shortcomings regarding the necessary precautions to reduce the potential toxicity risks from handling or exposure to pesticides. This work achieved to study the toxic effect of sub-lethal dose of indoxacarb (100 mg/kg) exposure and evaluate the protective effects of vitamin C (200 mg/kg) and zinc (Zn) (100 mg/kg) (separately or together) in male albino rats. The experimental rats were randomly divided into five groups (n=6): control group, indoxacarb-treated group, indoxacarb+vitamin C- treated group, indoxacarb+Zn- treated group, and indoxacarb+vitamin C+Zn- treated group. All groups received orally the tested doses every 48 h for 21 days. The results indicated that indoxacarb induced significant changes of some hematological parameters (red blood cells (RBC) counts, white blood cells (WBC) counts, hemoglobin (Hb) content, hematocrit (Hct) value, mean corpuscular volume (MCV) and platelets counts) besides substantial alterations in the thyroid hormones (tri-iodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH)) and the sex hormones (total and free testosterone, progesterone, and estradiol). Furthermore, the administration of vitamin C and zinc together alleviated the alteration of later hematological and hormonal parameters in indoxacarb-treated rats.

Conclusion: a mixture of vitamin C and zinc may show ameliorating effects against indoxacarb-toxicity through improving the examined biochemical parameters about the use of both alone.

INTRODUCTION

Pesticide use, in general, has become an issue of public concern in many countries in recent decades. This resulted from an increased awareness of the effects and risks that may result from it on human health and the components of the environment. This coincided with the beginning of interest in the environment and its purity after the technological progress of man, especially in the second half of the last century, which led to many pollution problems in water, land, air, and outer space (Nicolopoulou-Stamati *et al.*, 2016). Indoxacarb is a member of the new oxadiazine pesticide class. its name is methyl (4*aS*)-7-chloro-2- [methoxycarbonyl- [4-(trifluoromethoxy) phenyl] carbamoyl]-

3,5- dihydroindeno [1,2-e] [1,3,4] oxadiazine-4*a*- carboxylate. Indoxacarb is a commonly used pesticide in agriculture and horticulture. It is effective against lepidopteron pests of tree fruits, vegetables, cotton, soybean, peanut, and other crops. Indoxacarb's biological activity is not restricted to insects; its widespread use causes major health risks to cattle, aquatic organisms, and humans. The active metabolite of indoxacarb works in a unique way by inhibiting sodium channels in nerve cells, causing paralysis and death in the target pest species (Bhojane *et al*., 2018). A recent study demonstrated that sub-lethal doses of indoxacarb can have a negative impact on some blood biochemical markers and tissue health. Also, it has been shown that exposure to indoxacarb can reduce aquatic animals' tolerance to cope with environmental stress (Ghelichpour *et al*., 2019).

Vitamin C (VC) is a hydrophilic free-radical scavenger that traps radicals in the aqueous phase and protects bio-membranes from peroxidative damage in extracellular fluids. It reduces the generation of free radicals in many cellular compartments and tissues caused by oxidative damage to lipids and lipoproteins. In a range of in *vivo* and in *vitro* systems exposed to pesticides and radiation, the anticarcinogenic, anticlastogenic, and even antimutagenic properties of VC have been investigated (Eroglu *et al*., 2013).

Zinc (Zn) is one of the most significant and vital trace elements that is required by all living organisms for a variety of physiologic processes, with three key biological roles: catalytic, structural, and regulatory. It's an antioxidant with anti-inflammatory characteristics that also control innate and adaptive immunological responses, making it essential for infection resistance. Previous studies revealed the role of zinc in alleviating oxidative stress exerted by low doses of many pesticides such as methomyl and abamectin in male albino rats (Escobedo-Monge *et al*., 2019).

Some research has sought to assess the function of VC and Zn in reducing the biochemical changes caused by pesticides like chlorpyrifos (Uchendu *et al*., 2012). As a result, the major goal of our study is to determine the level of risk posed by a sub-lethal dose of indoxacarb on some hematological and hormonal parameters in male albino rats. In addition, the current research assesses the efficacy of VC and Zn together or both alone in reducing the harm caused by the investigated pesticide.

MATERIALS AND METHODS

Animal Ethics:

All experiments, transportation, and care of the animals used in this study were done in accordance with the Faculty of Science, Minia University's policy on animal use and ethics. During the experimental activity for this investigation, all mandatory laboratory health and safety protocols were followed.

Experimental Animals:

At the age of 6-8 weeks, thirty adult male Sprague-Dawley rats weighing 150-200 g were taken from the study laboratory's animal house in Egypt. The rats were housed in clean plastic cages in a well-ventilated room at 25±3°C for 3 weeks prior to the start of the experiment as an acclimatization period. Animals have unlimited access to ordinary food and water *ad libitum.*

Chemicals:

The pesticide indoxacarb is an oxadiazine. Methyl (4*aS*)-7-chloro-2-[methoxycarbonyl- [4-(trifluoromethoxy) phenyl] carbamoyl]-3,5- dihydroindeno[1,2-e][1,3,4] oxadiazine-4*a*- carboxylate is the IUPAC (International Union of Pure and Applied Chemistry) name for it. The Agrimatco Business provided the indoxacarb (Minia, Egypt). Indoxacarb was given orally every 48 h for 21 days at a sublethal dose (100 mg/kg

body weight in 1.0 ml corn oil). A local pharmacy provided vitamin C (200 mg/kg) and zinc (100 mg/kg).

Experimental Design:

The rats were divided into five groups of six (n=6):

Control group was given 1.0 mL of corn oil, indoxacarb-treated group was given indoxacarb (100 mg/kg body weight in 1.0 ml corn oil), indoxacarb + VC- treated group received a mixture of indoxacarb (100 mg/kg body weight in 1.0 ml corn oil) + VC (200 mg/kg), indoxacarb + Zn- treated group received a mixture of indoxacarb (100 mg/kg body weight in 1.0 ml corn oil)+ Zn (100 mg/kg), indoxacarb + VC + Zn- treated group received a mixture of indoxacarb (100 mg/kg body weight in 1.0 ml corn oil) + VC (200 mg/kg) + Zn (100 mg/kg). All doses were administered orally every 48 hours for 21 days using a stainless-steel stomach tube. Every day, the animals were observed for any signs of poisoning.

Recording of Body Weights:

Rats were weighed at the beginning of the experiment and before being dissected to measure body weight changes.

Blood Sampling:

The rats in each group were starved overnight and sacrificed by cervical decapitation at the end of the trial period (21 days). Hematological analysis was performed on whole blood samples taken promptly with the anti-coagulant EDTA. Blood samples were centrifuged at 3000 rpm for 15 minutes to separate plasma and serum samples. For the hormonal assay, plasma and serum samples were maintained at a temperature of 80° C.

Evaluation of Hematological Parameters:

The auto hematology analyzer (Celltac, NEK-6510k) was used to examine hematological parameters such as red blood cell (RBC) counts, hemoglobin (Hb) content, hematocrit (Hct) value, mean corpuscular volume (MCV), white blood cell (WBC) counts, and platelet counts. Each sample was tested twice.

Evaluation of the Hormonal Assay:

Assays of both plasma and serum biochemicals were analyzed using a competitive chemiluminescent enzyme immunoassay kit. The level of plasma thyroxine (T4), triiodothyronine (T3), and thyroid-stimulating hormone (TSH) were measured according to the method of Witherspoon and Shuler (1984), Felig *et al*. (1987), and Hay and Klee (1993), respectively. Determination of serum total and free testosterone hormone levels were assayed according to the method of Ismail *et al*. (1986) and McCann and Kirkish (1985), respectively. Serum progesterone and estradiol hormone levels were determined using a method described by Burtis and Ashwood (1994).

Statistical Analysis:

The current study's findings were assessed using the statistical package of social sciences (SPSS) statistics program for Windows, Version 22. (IBM crop., Armonk, NY, USA). The significance of the differences between groups was determined using a one-way analysis of variance (ANOVA) and Tukey's multiple comparison test. The results were reported as mean standard error, with $P<0.05$ denoting statistical significance. Excel MS Office version 2016 was used to create the graphs.

RESULTS AND DISCUSSION

Evaluation of Hematological Parameters:

As shown in table (1) and figure (1), There was a significant increase in RBC counts, Hb content, Hct value, MCV, WBC counts, and platelet counts after indoxacarb administration in comparison to the control group ($P<0.05$). In spite of administration of

VC and Zn reverted all changes in the hematological parameters in indoxacarb-treated rats to near the control values, except for WBC counts, which were still significantly higher in an indoxacarb+VC-treated group and an indoxacarb+Zn-treated group in comparison with the control group (P<0.05). On the other hand, the mixture of VC + Zn decreased significantly all changes in hematological parameters in indoxacarb-treated rats and returned approximately the values to the control values, except for platelet counts, which were still significantly higher in comparison with the control group (P<0.05).

Table 1: Hematological parameters (Red blood cells (RBCs), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), white blood cells (WBCs), and platelets) in control and experimental rats.

Groups / Parameters	Control group	Indoxacarb-treated group	Indoxacarb +VC treated group	Indoxacarb+Zn treared group	Indoxacarb +VC+Zn treated group
RBCs (10^6 /mm^3)	6.25±0.51	9.35±0.20^a	6.96±0.07^b	7.08±0.61^b	6.93±0.24^b
Hb (g/dl)	13.08±0.01	15.9±0.14^a	13.65±0.54^b	13.90±0.67^b	12.87±0.6^b
Hct (%)	37.52±0.21	46.68±0.8^a	39.85±1.8^b	40.75±1.8^b	37.93±1.3^b
MCV (fL)	50.75±0.45	61.83±3.03^a	57.9±3.03^a	57.58±1.8^a	51.05±0.6^b
WBC (10^3 /mm^3)	8.04±0.09	15.52±1.1^a	12.17±1.5^{a,b}	12.13±1.1^{a,b}	9.57±0.92^b
Platelets (10^3/mm^3)	421.86±23.6	867±97^a	737.50±22.7^a	740.17±78.9^a	685.33±50.2^{a,b}

Values are means ± standard error (n=6). At P < 0.05, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups.

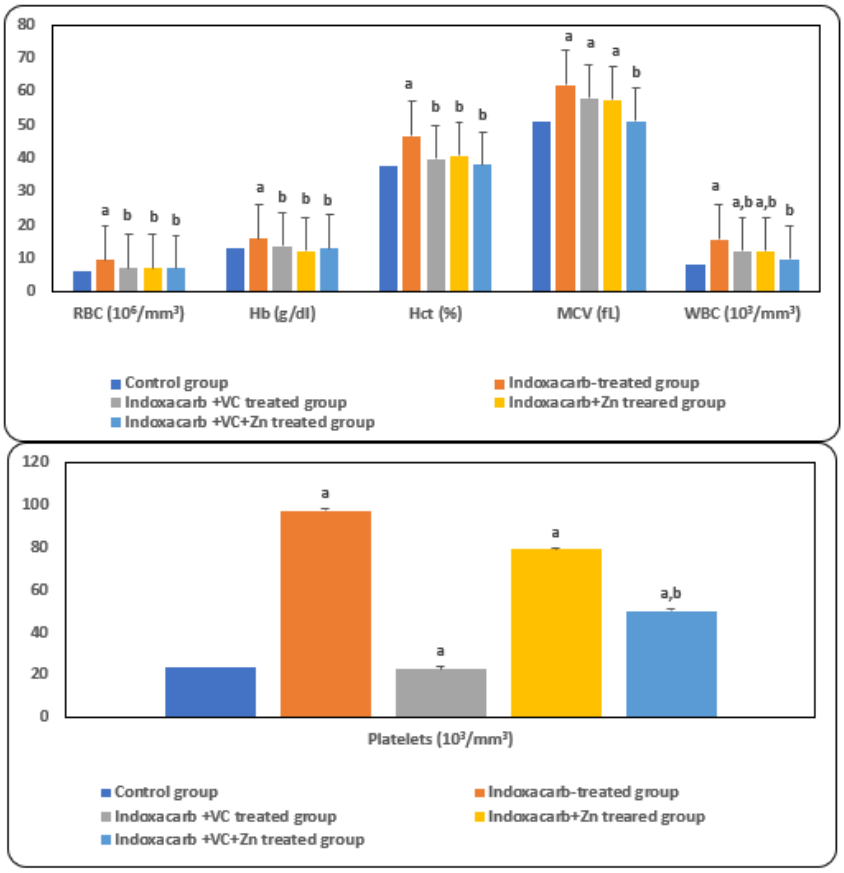

Fig. 1: Hematological parameters in control and experimental rats. Values are means ± standard error (n=6). At P < 0.05, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups.

Evaluation of Hormonal Parameters:

As indicated in table (2) and figure (2), plasma thyroid hormone levels as T3 and T4 were decreased but not significantly following treatment with indoxacarb, but TSH hormone level was increased significantly in the indoxacarb-treated rats compared to the control group (P<0.05). At the same time for rats treated with indoxacarb + VC and indoxacarb + Zn, there was a slight increase in T3 and T4 hormone levels and a significant decrease in TSH hormone level when compared to the indoxacarb-treated group. However, the administration of VC + Zn in combination with indoxacarb amended most of these latter hormones (P<0.05).

Table 2: Plasma tri-iodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone levels (TSH) in control and experimental rats.

Groups / Parameters	Control group	Indoxacarb-treated group	Indoxacarb+VC treated group	Indoxacarb+Zn treared group	Indoxacarb+VC+Zn treated group
Tri-iodothyronine (ng/ml)	56.59± 5.2	48.95± 3.9	49.34± 1.1	51.96± 1.5	55.26±3.6
Thyroxine (ng/ml)	4.03±0.23	3.42±0.19	3.47±0.22	3.77±0.29	3.83±0.27
TSH (ng/ml)	0.50±0.02	4.18±0.03[a]	3.18±0.03[a, b]	1.58±0.03[a, b]	1.48±0.03[a, b]

Values are means ± standard error (n=6). At P < 0.05, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups.

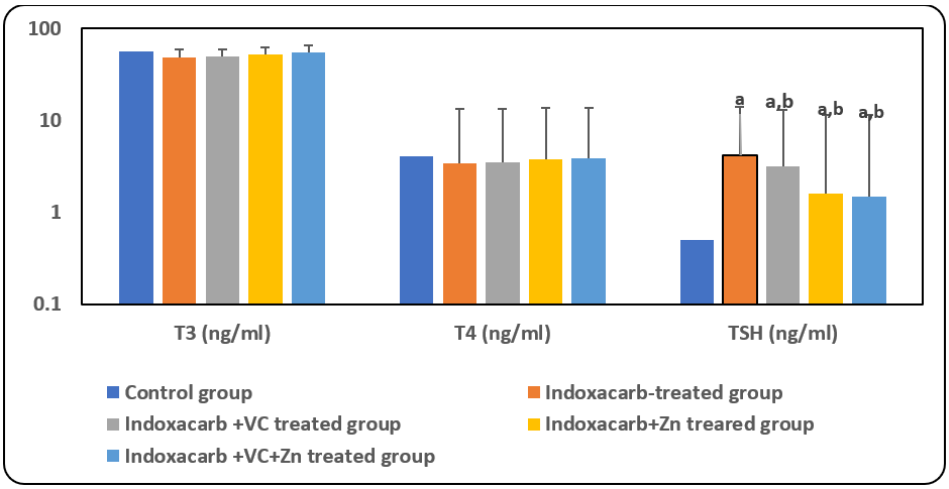

Fig. 2: Plasma tri-iodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone levels (TSH) in control and experimental rats. Values are means ± standard error (n=6). At P < 0.05, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups.

From the results in table (3) and figure (3), serum total and free testosterone hormone levels were significantly decreased in the indoxacarb-treated group versus the control group (P<0.05). Nevertheless, there was a significant increase in serum progesterone hormone level but an insignificant increase in serum estradiol hormone level after indoxacarb exposure compared to the control group (P<0.05). While the administration of VC and Zn separately significantly modulated all changes in serum sex hormone levels in the indoxacarb-treated rats, they were still significantly different from those in the control values (P<0.05). We found that the mixture of VC + Zn has greatly improved all disturbances in sex hormone levels in indoxacarb-treated rats, except for total testosterone hormone, which was still significantly lower in the indoxacarb-treated group in comparison with the control group (P<0.05).

Table 3: Serum total testosterone, free testosterone, progesterone, and estradiol hormone levels in control and experimental rats

Groups / Parameters	Control group	Indoxacarb-treated group	Indoxacarb +VC treated group	Indoxacarb+Zn treared group	Indoxacarb +VC+Zn treated group
Total testosterone (ng/mL)	4.47±0.35	0.98±0.33[a]	2.13±0.29[a, b]	1.12±0.14[a]	2.70±0.5[a, b]
Free testosterone (ng/mL)	7.34±0.5	1.14±0.3 [a]	3.23±0.4[a]	2.24±0.6[a]	5.47±1.6 [b]
Progesterone (ng/mL)	0.73±0.05	2.77±0.11[a]	2.22±0.67[a]	1.74±0.13[a, b]	1.03±0.11[b]
Estradiol (pg/mL)	29.6±5.88	45.72±8.60	34.00±9.21	29.84±4.56	29.70±6.21

Values are means ± standard error (n=6). At $P < 0.05$, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups.

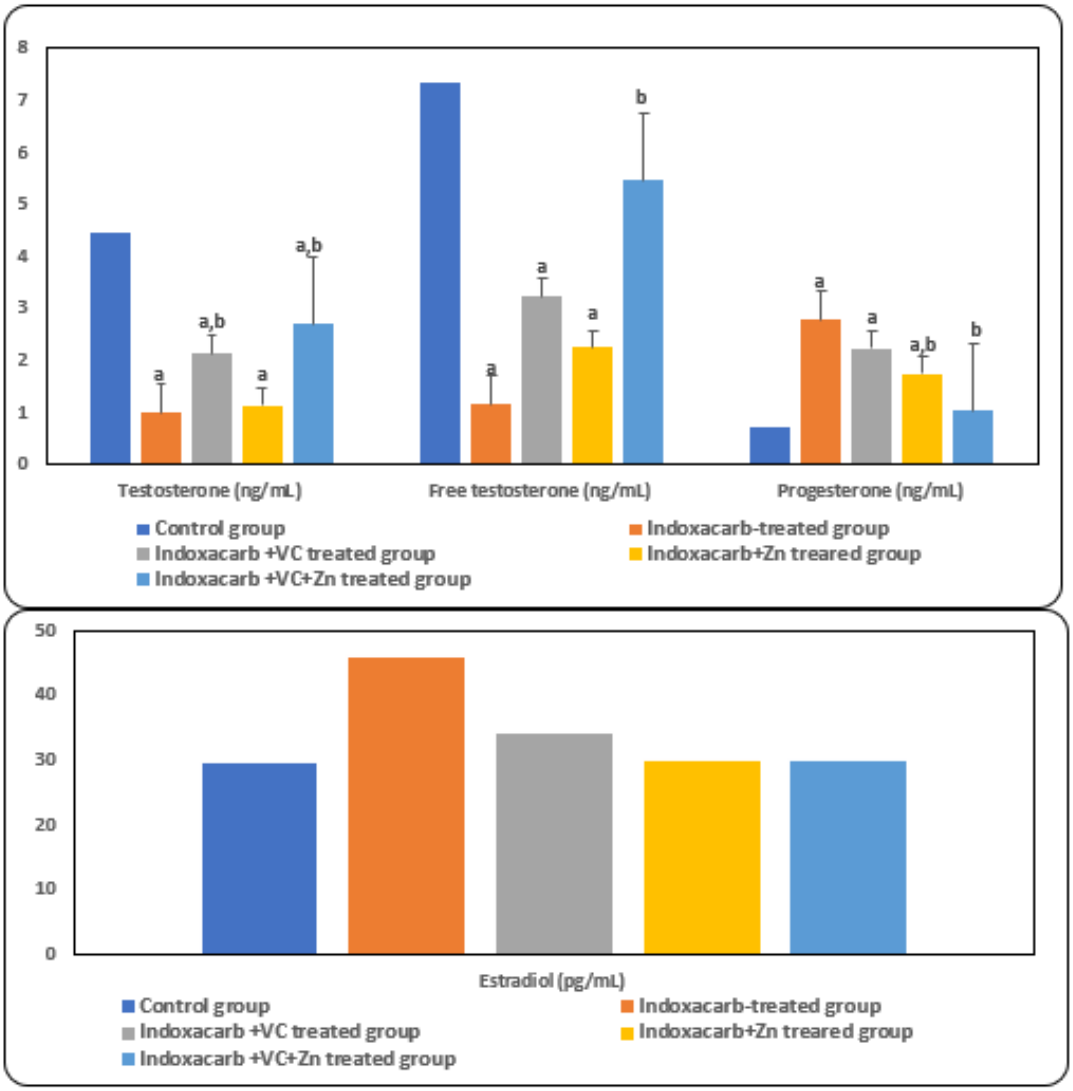

Fig. 3: Serum total testosterone, free testosterone, progesterone, and estradiol hormone levels in control and experimental rats. Values are means ± standard error (n=6). At $P < 0.05$, the difference is significant. [a] Comparison of the control and other groups. [b] Comparison of the indoxacarb-treated group and the indoxacarb+VC+Zn -treated groups

According to the present study, indoxacarb was given at a sublethal dose of (100 mg/kg body weight) where no death was observed during the experiment. But, after indoxacarb treatment, the rats' body weight decreased. This drop could be attributed to the

rats' loss of appetite, causing them to eat less. During the experiment, The rats displayed poisoning symptoms such as nose and eye hemorrhage with closed eyelids, skin sensitization, head tilt, muscle spasms in arms and legs, bluish tongue, salivation, increased heart rate and respiration, restlessness, and general body weakness.

In the present study, an increase in RBC counts, Hb content, Hct value, MCV, WBC counts, and platelet counts were recorded after indoxacarb treatment (Fig. 1). In contrast with our results, Abdelrasoul (2018) documented that indoxacarb significantly decreased the RBC counts, Hb content, and Hct value but significantly increased the WBC counts. Also, Lee *et al*. (2015) proposed that the reduction in erythrocyte counts and,therefore, the hemoglobin concentration might be attributed to methemoglobinemia. On the other hand, the increased RBC count, Hb content, Hct value, MCV, WBC counts, and platelet counts in our study might be obtained as the result of polycythemia. Secondary polycythemia is a chronic myeloproliferative disorder characterized by excessive amounts of all three types of peripheral blood cells: red blood cells, white blood cells, and platelets, resulting in hyperviscosity and a higher risk of thrombosis. It most often develops as a response to chronic hypoxemia, which triggers the increased production of erythropoietin by the kidneys. The most common causes of secondary polycythemia include hypoventilation syndrome, renal disease, and chronic obstructive pulmonary disease (Stuart and Viera, 2004). In addition, leukocytosis and thrombocytosis were described (Koller *et al*., 1979), which is consistent with our findings. Our present study revealed that indoxacarb treatment resulted in a rise in WBC counts (Fig. 1), indicating that the animal's defensive mechanism and immune system were activated. It's also possible that the pesticide caused tissue damage and necrosis. MCV has been shown to provide information on the size and status of erythrocytes (Nussey *et al*., 1995). In the present study, a significant increase of MCV (Fig. 1) was observed in an indoxacarb-treated group when compared with the control group. The significant increase in MCV, WBC counts and platelets counts along with the RBC counts might be an indicator of completely depressed bone marrow (Meligi and Hassan, 2017).

Hormones are needed for the normal growth, development and metabolism of cells. Hormones are generated in the blood by a variety of glands, including the thyroid gland, which is the biggest gland in humans and produces three main hormones: T3, T4, and TSH. These hormones are bio-indicators of hypothalamus and pituitary gland activity, and they play a vital role in the body, particularly in metabolic stimulation. T3 and T4 aid in the acquisition of iodine and convert it into the form that is biologically available (Nassar, 2016). Many pesticides cause disturbance in the levels of the thyroid hormones in rats through affecting the thyroid gland, otherwise through an elevation of peripheral elimination of thyroid hormones (Hassan *et al*., 2021). In the current study, indoxacarb-exposed rats had lower plasma T3 and T4 levels and a significantly higher plasma TSH level when compared to the control group (Fig. 2). Previous studies suggested that the insecticide-induced disturbance in the thyroid hormones level may be the result of increased hepatic enzyme activity (Al-Amoudi, 2018) or the consequence of oxidative stress in the central nervous system and its related glands, including the hypothalamic-pituitary axis, which may be one of the most important factors in the general ageing process. The ageing of the hypothalamic-pituitary axis leads to progressive functional loss and gradually develops into endocrine deficiency (El-sheikh and Ibrahim, 2017).

Insecticides have a direct effect on the male reproductive system, damaging reproductive organs and germ cells, as well as disrupting the hormonal balance in the secondary endocrine system. In men, neuroendocrine systems including the hypothalamic, pituitary, and gonadal hormones control sexual and reproductive function (Hamed, 2021). Testosterone is the primary steroid sex hormone in male rats. It is secreted by testicular

Leydig cells which are controlled by complex neuroendocrine interactions. Previous researches have shown that organochlorine and organophosphorus insecticides, as well as abamectin, cause a decrease in this hormone level in male rats (Mansour *et al*., 2017). The present findings showed a significant decrease in total and free testosterone levels (Fig. 3) following the exposure of male rats to indoxacarb. These later hormone levels may have decreased as a result of direct damage caused by indoxacarb to Leydig cells in the interstitial tissues, which are the primary sites of testicular androgen biosynthesis. Some pesticides have the ability to activate or block steroid hormone receptors, as well as sex hormone levels, potentially altering the development of the female and male reproductive systems. This highlights the importance of testing pesticides for a variety of hormone-mimicking effects. These pesticides have some estrogenic characteristics, which could alter the steroid feedback mechanism in the hypothalamus and the pituitary gland. Exogenous estrogens (natural or synthetic) generate all of the pharmacologic reactions that endogenous estrogens produce (Sein and Kumar, 2019). Our current investigation showed a significantly high level of the progesterone hormone level and an increase, but not significant, in the estradiol hormone level in an indoxacarb-treated group compared to the control group (Fig. 3). According to previous studies, pesticides like dicofol (El-Kashoury *et al*., 2010) and abamectin enhanced progesterone and estradiol levels in male rats due to adrenal cortex hypertrophy, which increased steroidogenic activity. Furthermore, additional studies have revealed that dicofol mimics the estrogenic action, which could have an effect on the testes directly (Hassan and Meligi, 2017).

Generally, according to the current study, the improvement in the hematological and hormonal parameters generated by the combination of VC and Zn against indoxacarb toxicity was more than that recorded for each of them alone, and sometimes VC appears to be more effective than Zn by a minor amount. As shown in our results, the mixture of VC and Zn caused a significant decrease in RBC counts, Hb content, Hct value, MCV, WBC counts, and platelet counts compared to the indoxacarb-treated group (Fig. 1). In addition, an increase in T3, T4 (Fig. 2), free, and total testosterone (Fig. 3) hormone levels and a decrease in TSH (Fig. 2), progesterone, and estradiol (Fig. 3) hormone levels were observed in an indoxacarb +VC+Zn treated group compared to the indoxacarb-treated group.

Eroglu *et al.* (2013) have shown that VC is a powerful antioxidant, protecting human erythrocytes in *vitro* from oxidative stress induced by dichlorvos. VC is a significant water-soluble antioxidant in plasma that reacts with free radicals in extracellular body fluids or scavenges the free radicals formed as a byproduct of metabolic reactions. McRae (2008) reported that VC provides antioxidant protection against coronary heart disease because it regulates cholesterol and triglyceride concentrations, controls blood pressure, inhibits blood platelet aggregation (Owu *et al*., 2016) and improves wound healing. Recently, pre-clinical studies (Morelli *et al*., 2020) investigated whether VC potentiates nitric oxide synthesis in cultured human endothelial cells, a mechanism that can preserve vessels from vasoconstriction, atherosclerosis, and coagulation abnormalities. Various clinical studies have investigated the role of VC in protecting the risk of cardiovascular disease, heart failure, hypertension, and other major adverse cardiac events. Vitamin C is known to improve endothelial function and reduce vascular permeability during infectious disorders. Thus, it is possible that VC could be useful in treating infectious diseases. For example, because COVID–19 causes endotheliopathy, lipid VC may be effective for COVID–19 and other infectious diseases (Morelli *et al*., 2020). On the other hand, Sharaf *et al*. (2017) indicated that pre-administration of vitamin C before treatment with lead and cadmium ameliorated its adverse effect on hematological parameters in male albino rats. They reported that VC

reduced a significant increase in WBC and platelet counts in rats exposed to lead acetate and cadmium chloride. Vitamin C is an effective antioxidant in the reproductive (Uboh *et al*., 2010) and endocrine systems. It protected the thyroid acinar from oxidative damage and may have helped in restoring thyroid hormones' synthetic function. Some other non-antioxidant activities of VC may have complemented the restoration of thyroidal function. For example, it has been shown to aid the synthesis of paraoxonase, an important esterase that aids in the detoxification of insecticides (Ambali *et al*., 2011).

Zinc is a trace element essential for human metabolism. It plays an important role in the activation of more than 300 enzymes, regulatory protein synthesis and influencing cell division and differentiation (Amara *et al*., 2008). It is an important component in the activation of the antioxidant system and functions at many levels. Also, it is an inhibitor of the NADPH oxidase enzyme which catalyzes the production of O_2^- from oxygen by using NADPH as the electron donor (Abbassy *et al*., 2014). In addition to iron, vitamin B_{12}, and folate, zinc is considered an essential factor for erythropoiesis. Currently, recombinant human erythropoietin is used to treat patients with chronic kidney disease in which zinc supplementation affects erythrocyte and hemoglobin production and Hct value. Also, rat bone marrow cells were cultured in suspension with $ZnCl_2$ supplementation present, zinc stimulates RBC formation in rats in *vivo* and in *vitro*. Zinc-transferrin complex in the blood to be carried to the bone marrow, where erythropoiesis occurs (Chen *et al*., 2018). Zinc is known to play an important role in immune regulation, gene transcription, and other fundamental physiological processes. It stimulates the hypothalamus-pituitary-adrenal axis, leading to increased changes in white blood cells and therefore altered responses of other physiological defense systems, such as the autonomic nervous system and the endocrine system. Previous research indicated that zinc deficiency disrupted the maturation of bone marrow hematopoietic stem cell-derived precursor T lymphocytes from the thymus gland (Someya *et al*., 2009). Zinc induced high activity of endocrine glands such as the thyroid gland through the activation of the pituitary gland and reversed the thyroid hormone levels to their normal value. It also improved male sex hormone alterations, testicular tissue disorders, spermatogenesis, and steroidogenesis against pesticide-induced toxicity in male albino rats (Mansour *et al*., 2017).

Conclusion

According to the findings, rats exposed to a sub-lethal dose of indoxacarb (100 mg/kg body weight) changed some hematological indices and hormonal profiles. Following that, a mixture of vitamin C and zinc, as well as utilizing both alone, induced marked alleviative effects against indoxacarb toxicity.

Compliance with Ethical Standards

The Faculty of Science, Minia University's policy on animal use and ethics was followed during all experiments, transportation, and care of the animals used in this work. While carrying out the experimental work for this study, all mandatory laboratory health and safety protocols were followed.

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ARABIC SUMMARY

التأثير السام للتعرض للإندوكساكارب على بعض مؤشرات الدم والهرمونات وتقييم التأثيرات المخففة المحتملة لفيتامين C والزنك في ذكور الجرذان البيضاء

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يواجه العالم كوارث شديدة الخطورة ، أبرزها الآثار السامة لمبيدات الآفات على صحة الكائنات الحية والبيئة ، سواء بشكل مباشر أو غير مباشر وعلى المدى القصير أو الطويل. تعاني بعض البلدان النامية من أوجه قصور شديدة فيما يتعلق بالاحتياطات اللازمة لتقليل مخاطر السمية المحتملة من تداول المبيدات أو التعرض لها. تم إنجاز هذا العمل لدراسة التأثير السام للجرعة تحت المميتة من التعرض لإندوكساكارب (100 مجم / كجم) وتقييم التأثيرات الوقائية لفيتامين C (200 مجم / كجم) والزنك (Zn) (100 مجم / كجم) (بشكل منفصل أو معًا) في ذكور الجرذان البيضاء. قسمت الفئران التجريبية عشوائياً إلى خمس مجاميع (ن = 6): المجموعة الضابطة، المجموعة المعالجة بالإندوكساكارب، المجموعة المعالجة بالإندوكساكارب + فيتامين سي ، المجموعة المعالجة بالإندوكساكارب + الزنك ، المجموعة المعالجة بالإندوكساكارب + فيتامين سي + الزنك. تلقت جميع المجموعات الجرعات المختبرة عن طريق الفم كل 48 ساعة لمدة 21 يومًا. أشارت النتائج إلى أن إندوكساكارب تسبب في تغيرات معنوية في بعض المتغيرات الدموية (عدد خلايا الدم الحمراء (RBC) ، عدد خلايا الدم البيضاء (WBC) ، محتوى الهيموجلوبين (Hb) ، قيمة الهيماتوكريت (Hct) ، متوسط حجم خلايا الدم الحمراء (MCV) وعدد الصفائح الدموية) بالإضافة إلى ذلك. تغيرات كبيرة في هرمونات الغدة الدرقية (ثلاثي يودوثيرونين (T3) ، هرمون الغدة الدرقية (T4) ، وهرمون تحفيز الغدة الدرقية (TSH)) والهرمونات الجنسية (التستوستيرون الكلي والحر، البروجسترون ، والإستراديول). علاوة على ذلك ، فإن تناول فيتامين C والزنك معًا قد خفف من تغيير المعلمات الدموية والهرمونية اللاحقة في الفئران المعالجة بالإندوكساكارب. الخلاصة: قد يُظهر مزيج من فيتامين ج والزنك تأثيرات محسّنة ضد سمية إندوكسكارب من خلال تحسين المعلمات البيوكيميائية التي تم فحصها حول استخدام كلاهما بمفرده.