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Original Article

Effects of Pirimicarb carbamate insecticide alone and in combination with lead (Pb) on biochemical parameters of soft tissues in freshwater snail, *Galba truncatula*

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Abstract: In this study, potential effects of Pirimicarb and lead (Pb) were investigated on biochemical parameters in tissues of freshwater snails, *Galba truncatula*. During an 8-day experiment, snails were exposed to sub-lethal concentrations of Pirimicarb (0.5 and 1 mg/L) and/or lead acetate (0.1 and 0.2 mg/L). Biochemical analyses of tissues to Photometric method in snails indicate that snails treated with Pirimicarb, Pb, or both Pirimicarb and Pb increased malondialdehyde (MDA) and catalase (CAT) and decreased gamma-glutamyl transferase (GGT) levels, compared to the control group. Alanine transferase (ALT), lactate dehydrogenase (LDH), and alkaline phosphatase (ALP) activity were increased in combined treatments of Pirimicarb and Pb. Total antioxidant (TAO) level increased in snails exposed to both Pirimicarb and Pb, while it decreased in snails treated with either Pb or Pirimicarb. Cholesterol level increased in most experimental groups. Aspartate aminotransferase (AST) was showed no significant changes in groups treated with 0.1 and 0.2 mg/L of Pb compared to the control; however, AST enhanced in other treatments. In groups exposed to 0.5 and 1 mg/L of Pirimicarb, the inhibition of acetylcholinesterase (AChE) was not significant, although a significant reduction was found in AChE level in other treatments. The results indicated that cytotoxicity of Pirimicarb alone and in combination with Pb depended on their concentrations. Higher concentrations of Pb induced significant changes in some biochemical parameters. Moreover, increased Pb level in water intensifies toxic effects of Pirimicarb in snails. Pirimicarb or/and Pb, in sub-lethal concentrations, induced oxidative damages in soft tissue of snails. Finally, these data support the hypothesis that changes in biochemical parameters were induced by exposure to Pirimicarb or/and Pb.

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Introduction

Carbamate pesticides are among the most common pesticides used worldwide to control pests in grains, fruit trees and ornamental plants (CASAFE, 2009). Pirimicarb is a carbamate and selective pesticide with chemical formula 2-dimethylamino-5,6-dimethylpyrimidin-4-yl-N-dimethylcarbamate that acts by preventing the activity of acetylcholinesterase (AchE). Lipid peroxidation and oxidative stress are among other mechanisms causing Pirimicarb toxicity (Vera-Candioti et al., 2010). This insecticide is toxic for different species of aquatic organisms, and especially for aquatic invertebrates (Walker et al., 2007; Vera-Candioti et al., 2010). An increase in production and widespread application of agrochemicals, such as chemical pesticides can cause varied environmental and health problems for humans and other organisms (Bravo et al., 2011).

Some environmental pollutants have increasing, synergistic or antagonistic effects on bioavailability and toxicity of each other (Nematdoost Haghi and Banaee, 2017; Hamidipoor et al., 2015). Therefore, it is expected that pesticides influence the bioavailability and toxicity of other environmental pollutants, including heavy metals (Banaee et al., 2015a; Banaee et al., 2015b). These compounds and their interactions can affect the physiological response and detoxification system of organisms and turn into a serious threat for organisms inhabiting near agricultural farms or industrial areas.

Heavy metals are hazardous due to their bio-accumulation capacity (Adedeji and Okocha, 2011).

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These elements are really sustainable in aquatic environments, bio-concentrate in tissues and bones of organisms due to lack of biological disposal, and thus their concentration increases in food chains. This increase is more remarkable on top of the food pyramid and causes toxic effects and diseases for organisms consuming the top of the food pyramid, including human beings (Abbas Zadeh, 1995). Lead (Pb) is one the heavy metals that pollutes the environment more than any other elements. Human activities are the main source of introducing Pb into the environment. Pb gradually accumulates in the body and may replace calcium in bones as divalent lead (Jarup, 2003).

The production of agricultural products and expansion of different industries is of a significant importance in Iran; therefore, a wide range of pesticides and other environmental pollutants, including heavy metals enter surface and underground waters through wastewater of farm lands and industrial sites. In fact, the entrance of these pollutants to surface and heavy metals can have a significant effect on water pollution and health of aquatic organisms. In order to determine the combined effect of contaminants and their source and concentration in aquatic ecosystems, the environment should be evaluated and monitored. The pollutants are troublesome when they are absorbed by living organisms (Wright and Welbourn, 2002). Therefore, the rate of pollutants being biologically available should be evaluated (Ruelas-Inzuna and Paez-Osuna, 2000). That is why evaluating the combined effect of sub-lethal concentrations of Pirimicarb and Pb on biochemical parameters of aquatic organisms seems essential.

In the Marun River (Khuzestan Province, Iran), different species are found, including gastropods. Because of their lifestyle and nutrition, gastropods are used as a bio-indicator to evaluate the pollution of aquatic systems (Macías-Mayorga et al., 2015). Alterations in physiological indices, growth (Coeurdassier et al., 2001), behavioral changes in *Bellamya aeruginosa* (Zheng et al., 2012), oxidative stress, damage to tissues and alterations in biochemical parameters in freshwater snail, *Pila globosa* (Bhattacharya et al., 2016), in Asiatic hard clam, *Meretrix meretrix* (Wan et al., 2015), grooved carpet shell, *Ruditapes decussatus* (Kamel et al., 2012), *Lanistes carinatus* (Khalil, 2015), green garden snail, *Cantareus apertus* (Leomanni et al., 2015), *Biomphalaria alexandrina* (Ibrahim et al., 2018; Barky et al., 2012), *Lymnaea luteola* (Ali et al., 2012), *Helix aspersa* (Abdel-Halim et al., 2013), *Theba pisana* (Radwan et al., 2010), and genetic damages in *P. aeruginosa* (Zheng et al., 2012) are reported following exposure to environmental pollutants, such as pesticides and heavy metals. Also, accumulation of Cd, Zn, Pb and Cu in snails, *T. pisana* (Radwan et al., 2010) and *H. aspersa* (Abdel-Halim et al., 2013) are studied. Snails are highly prone to accumulate heavy metals in their tissues (Silva et al., 2017).

Lymnaea, a genus of snails, are found in abundance in freshwater ecosystems, including the Marun River. Moreover, they are found among plants grown along the edge of rivers and dams. *Galba truncatula* is a sedentary species of this genus that inhabits freshwater ecosystems. It can be easily collected, identified, and kept under laboratory conditions without much challenge. Therefore, the present study uses *G. truncatula* as a lab model to study the synergistic and antagonistic Effects of sub-lethal concentrations of Pirimicarb and lead (Pb) on biochemical parameters of freshwater snail, *G. truncatula*. The results of this study can be useful in environmental monitoring of aquatic ecosystems and a better evaluation of type and rate of pesticides in agricultural lands.

Materials and Methods

Chemical materials: Pirimicarb (2-dimethylamino-5,6-dimethylpyrimidin-4-yl-N- dimethylcarbamate) (produced by Golsam Chemicals Company, with 50% active material) was bought from Shiraz, Iran, and lead acetate was provided by Merck company (Germany, 99% pure). Biochemical kits were bought from Pars Azmoon Co. and other chemical materials were bought from Merck, Germany.

Snail: The freshwater snails, *G. truncatula*,

considering the national ethical framework for animal research in Iran (Mobasher et al., 2008) were randomly collected from 30-40 cm depth of the vegetation by the Marun River near the city of Behbahan, Khuzestan Province, Iran. Snails were immediately sent to the Laboratory of Reproduction and Cultivation of Ornamental Species at Faculty of Natural Resources at Behbahan Khatam Alanbia University of Technology for an adaptation period prior to the beginning of the experiment. Before the experiment, snails were kept in plastic buckets under certain conditions (22±2°C, pH: 7.4±0.2, 16/8 light/dark) to adapt to laboratory conditions. In order to do the experiment, snails were kept in tanks containing 2 liters of distilled water and fed with lettuce extract.

Sub-acute toxicity test: The snails were divided into nine treatment groups and each group was triplicate. Each aquarium contained thirty freshwater snail *G. truncatula* initially. Group 1 was the control group, while groups 2 and 3 were respectively exposed to 0.1 and 0.2 mg/L of lead acetate. Groups 4 and 5 were respectively treated with Pirimicarb 0.5 and 1 mg/L. In group 6, snails were exposed to Pirimicarb (0.5 mg/L) and lead acetate (0.1 mg/L). Group 7 was treated with 1 and 0.1 mg/L of lead acetate. Finally, groups 8 and 9 were respectively exposed to Pirimicarb 0.5 mg/L plus lead acetate 0.2 mg/L and Pirimicarb 1 mg/L plus lead acetate 0.2 mg/L. Each treatment had three replications with a totally randomized design. Pirimicarb pesticide (Laznik et al., 2010) and lead (Grosell et al., 2006) are chosen according to their subacute concentrations for mollusks. During the experiment, 50% of the water was exchanged daily to reduce excessive metabolites. Moreover, the pesticide and lead (Pb) was added to keep concentrations of Pirimicarb and Pb constant.

Sampling and analysis of biochemical parameters of tissue: To evaluate enzymes, soft tissue of snails was removed from the hard part by cold physiologic saline in a porcelain mortar. Then, tissue samples were homogenized by a mechanical glass homogenizer with a mixture of phosphate-buffered saline (pH 5.6) for 2 minutes and then centrifuged for 8 minutes in a refrigerated centrifuge at 12000 rpm at 4°C so that it turned into a complete solution. Finally, the supernatant was extracted with a sampler from the centrifuged soft tissue. It was kept in a freezer at -20°C till analyses of biochemical parameters.

Biochemical parameters were measured by a UV-Vis spectrophotometer (Biochrom Libra S22). The activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) was measured according to NADPH consumption and its conversion to NAD^+ at the wavelength of 340 nm (Moss and Henderson, 1999). The activity of lactate dehydrogenase (LDH) was evaluated based on pyruvate reaction with NADH and hydrogen in presence of LDH and the production of lactate and NAD^+ at 340 nm (Moss and Henderson, 1999). The activity of alkaline phosphatase (ALP) in plasma was measured according to the conversion of nitrophenyl phosphate to nitrophenol and phosphate at 405 nm (Moss and Henderson, 1999). The activity of glucose-6-phosphate dehydrogenase (G6PDH) was measured based on the reaction rate of glucose-6-phosphate to 6-phosphogluconate and restoration of NADP to NADPH in presence of G6PD at 340 nm (Burtis and Ashwood, 1999). Gamma-glutamyl transferase (GGT) level was estimated based on glutamic acid transfer to glycylglycine and 5-amino-2-nitrobenzoate release at 405 nm (Moss and Henderson, 1999). The Activity of acetylcholinesterase (AChE) was measured according to butyrylthiocholine hydrolysis at 405 nm (Knedel and Boetteger, 1967). Cholesterol level was measured based on CHOD-PAP enzymatic colorimetric analysis at 510 nm (Rifai et al., 1999). The activity of catalase (CAT) was measured based on degradation of hydrogen peroxide and formation of a stable complex with ammonium molybdate at 405 nm (Goth, 1991).

Malondialdehyde (MDA) level was measured by thiobarbituric acid at 532 nm. In this experiment, tetra-ethoxy propanol and absolute ethanol were used as the standard MDA (Placer et al., 1966). Total antioxidant capacity (TAO) of the cell was measured by the reducing ability of ferric iron to ferrous, i.e. FRAP method, and with TPTZ or 2,4,6-Tripyridyl-S-triazine

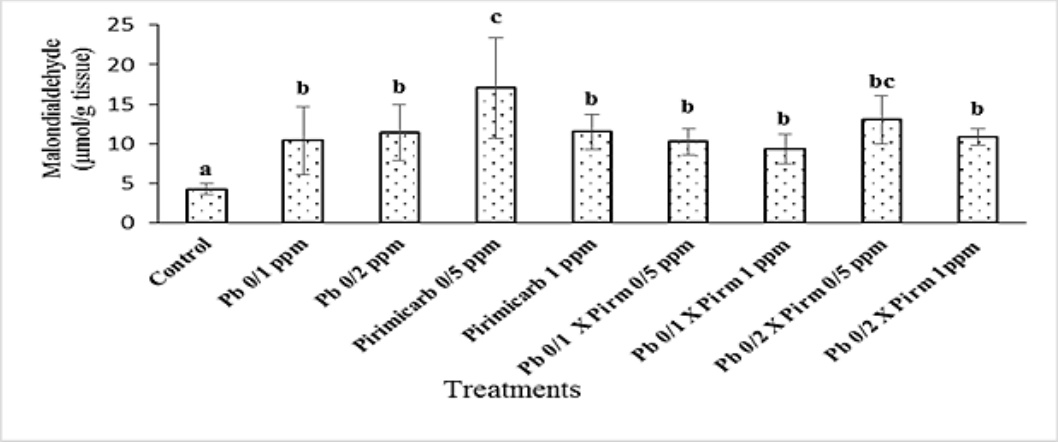

Figure 1. Alterations of MDA level in different treatments. Identical letters express the absence of a significant difference.

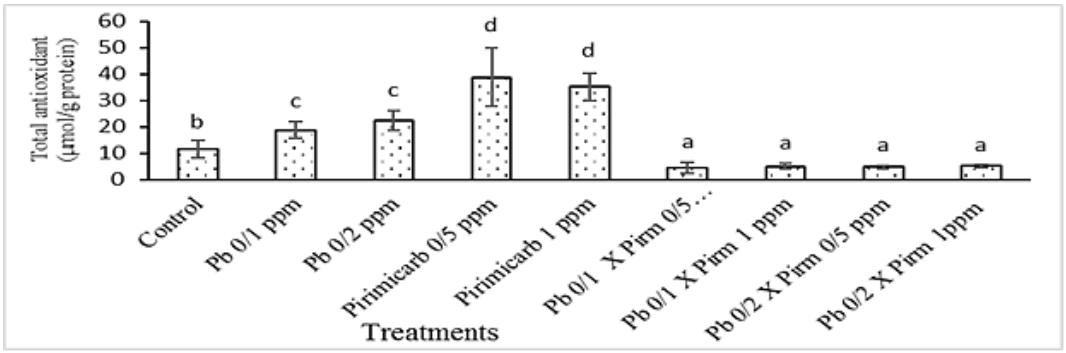

Figure 2. Alterations of antioxidant level in different treatments. Identical letters express the absence of a significant difference.

as the substrate at 593 nm. To plot a standard curve, ferrous sulfate heptahydrate solution at 100-1000 µmol/L was used (Benzie and strain, 1996).

Statistical analysis: IBM SPSS software (version 19) was used for statistical analysis with $P<0.01$ Normality of data was assessed with Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) was used to compare treatments and when data were significant, Duncan method at 99% confidence interval was used. The results are shown in a diagram in Excel and presented as mean ± standard deviation (SD).

Results

During the experiment, no mortality was found in snails. Alterations in biochemical parameters in snail tissues exposed to sublethal concentrations of Pirimicarb and/or lead acetate (separately or in combination) and compared to control are depicted in diagrams.

Malondialdehyde: There was a significant increase in MDA level in all experimental treatments compared to the control group. The highest increase was in snails treated with 0.5 mg/L of Pirimicarb (Fig. 1).

Total antioxidant: Levels of total antioxidant (TAO) concentration in snails treated with Pb 0.1 mg/L + Pirimicarb 0.5 mg/L, Pb 0.1 mg/L + Pirimicarb 1 mg/L, Pb 0.2 mg/L + Pirimicarb 0.5 mg/L, and Pb 0.2 mg/L + Pirimicarb 1 mg/L were significantly lower than TAO concentration levels in the control group. However, antioxidant level in snails exposed to 0.1 and 0.2 mg/L of Pb, and 0.5 and 1 mg/L of Pirimicarb was significantly higher than its level in the control group (Fig. 2).

Catalase: According to the results, catalase (CAT) level was significantly increased in all experimental treatments compared to its level in the control group (Fig. 3).

Glucose-6-phosphate dehydrogenase: The rate of glucose-6-phosphate dehydrogenase (G6PDH) in snails treated with 0.5 mg/L of Pirimicarb was significantly reduced. However, no significant

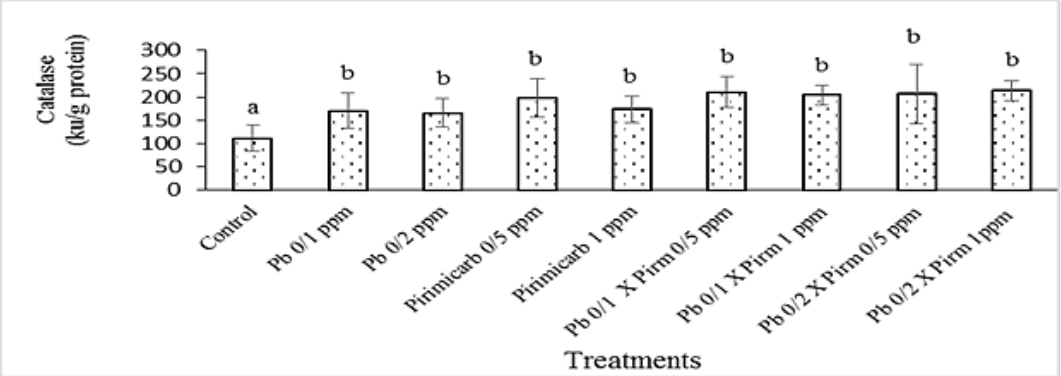

Figure 3. Alterations of CAT level in different treatments. Identical letters express the absence of a significant difference.

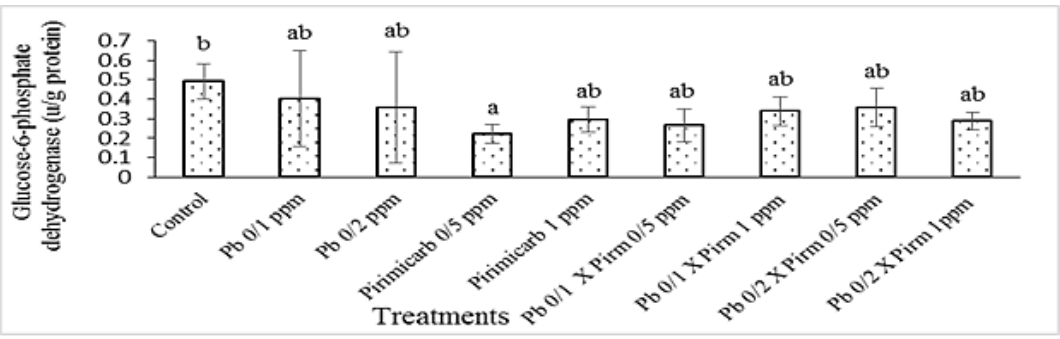

Figure 4. Alterations of G6PDH in different treatments. Identical letters express the absence of a significant difference.

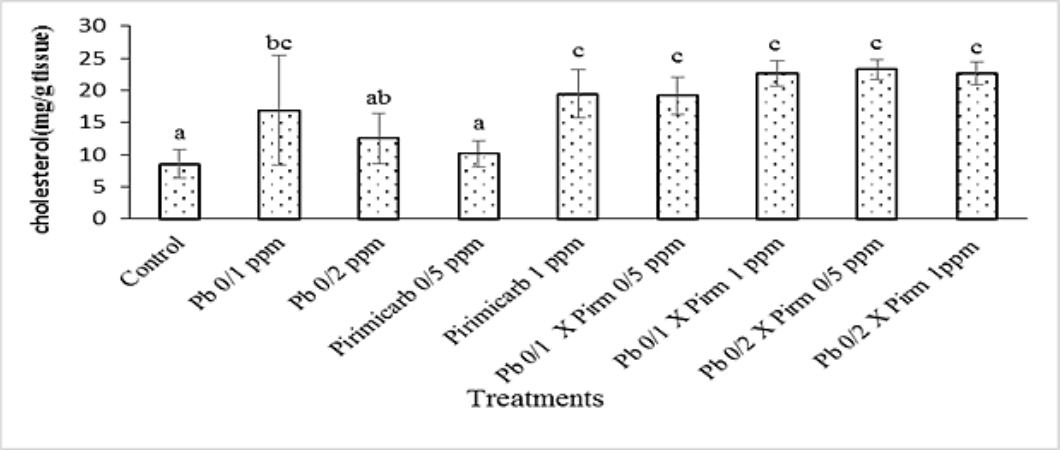

Figure 5. Alterations of cholesterol level in different treatments. Identical letters express the absence of a significant difference.

difference was found in the activity level of G6PDH in other treatments when compared to the control group (Fig. 4).

Cholesterol: No significant difference was found in cholesterol level in groups treated with Pb 0.2 mg/L and Pirimicarb 0.5 mg/L. However, other treatments indicated a significant difference in cholesterol level compared to the control group (Fig. 5).

Lactate dehydrogenase: Levels of lactate dehydrogenase (LDH) in snails treated with the combined treatments of Pb 0.1 mg/L + Pirimicarb 1 mg/L, Pb 0.2 mg/L + Pirimicarb 0.5 mg/L, and Pb 0.2 mg/L + Pirimicarb 1 mg/L were significantly increased. No significant increase was found in LDH activity in other treatments compared to the control group (Fig. 6).

Acetylcholinesterase: No significant difference was found in acetylcholinesterase (AChE) level in the groups treated with 0.5 and 1 mg/L of Pirimicarb, compared to the control. However, a significant difference was recorded in AChE activity of other experimental groups, compared to the control group.

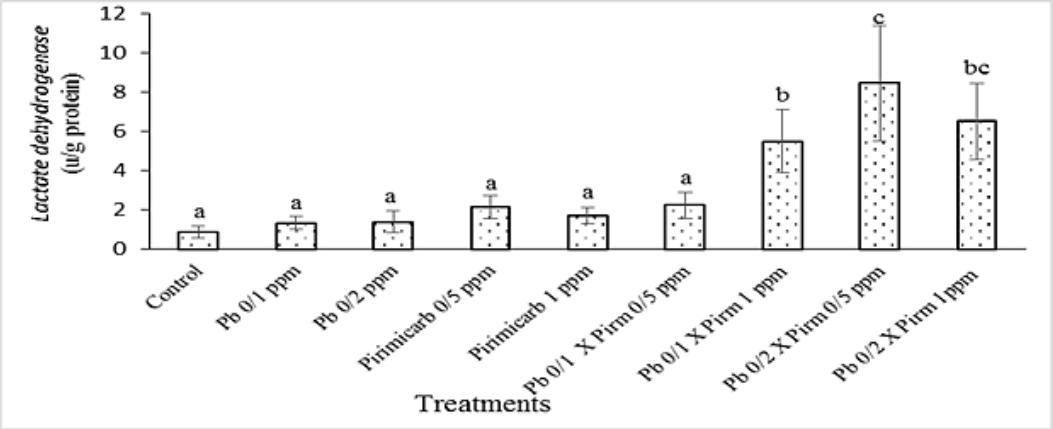

Figure 6. Alterations of LDH level in different treatments. Identical letters express the absence of a significant difference.

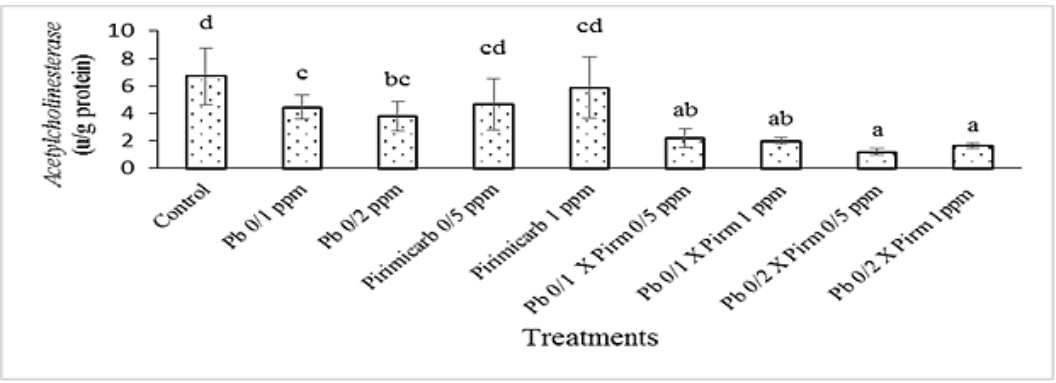

Figure 7. Alterations of AChE activity in different treatments. Identical letters express the absence of a significant difference.

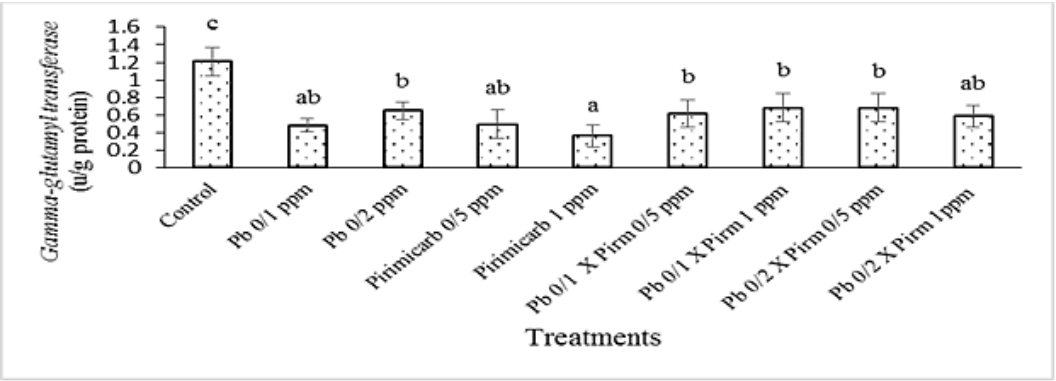

Figure 8. Alterations of GGT in different treatments. Identical letters express the absence of a significant difference.

The biggest reduction in AChE activity was observed in the combined treatments of Pb 0.1 mg/L + Pirimicarb 0.5 mg/L, Pb 0.1 + Pirimicarb 1 mg/L, Pb 0.2 mg/L + Pirimicarb 0.5 mg/L, and Pb 0.2 mg/L + Pirimicarb 1 mg/L (Fig. 7).

Gamma-glutamyl transferase: The activity level of gamma-glutamyl transferase (GGT) was significantly reduced in all experimental treatments and the biggest increase was found in snails treated with Pirimicarb 1 mg/L (Fig. 8).

Alkaline phosphatase: The activity of alkaline phosphatase (ALP) in snails inhabiting water containing both Pb and Pirimicarb (0.1 mg/L + 1 mg/L; 0.2 mg/L + 0.5 mg/L; and 0.2 mg/L + 1 mg/L, respectively) was significantly increased. However, no significant difference was observed in ALP activity of other groups when compared to the control (Fig. 9).

Aspartate aminotransferase: No significant difference was found in aspartate aminotransferase (AST) levels in groups treated with 0.1 and 0.2 mg/L of Pb,

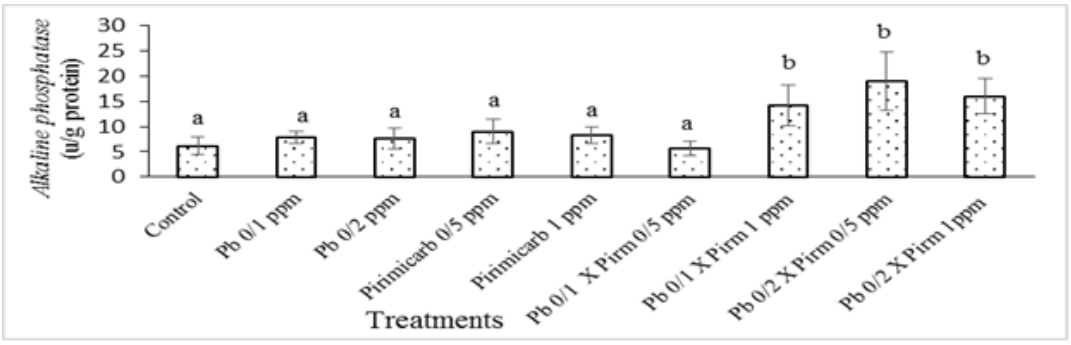

Figure 9. Alterations of ALP level in different treatments. Identical letters express the absence of a significant difference.

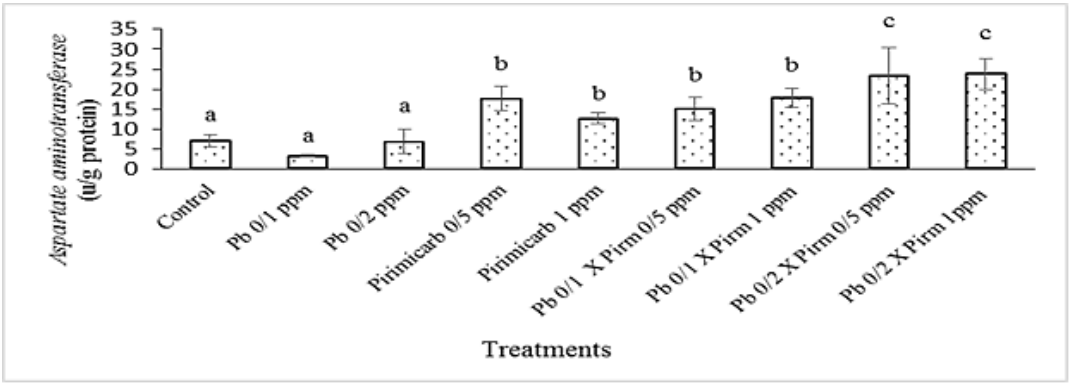

Figure 10. Alterations of AST level in different treatments. Identical letters express the absence of a significant difference.

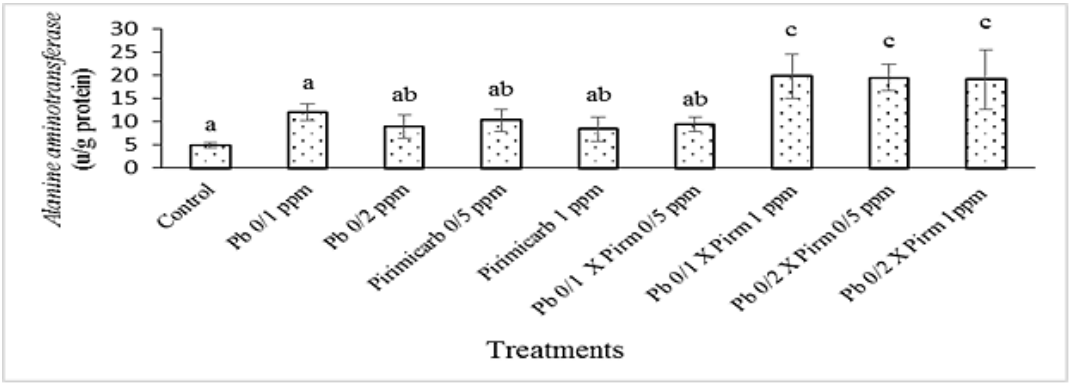

Figure 11. Alterations of ALP level in different treatments. Identical letters express the absence of a significant difference.

compared to the control group. However, a significant difference was observed in AST level in snails of other treatments compared to the control group (Fig. 10).

Alanine aminotransferase: Levels of alanine aminotransferase (ALT) significantly increased in snails treated with Pb 0.1 mg/L + Pirimicarb 1 mg/L, Pb 0.2 mg/L + Pirimicarb 0.5 mg/L, and Pb 0.2 mg/L + Pirimicarb 1 mg/L. In other groups, no significant difference was found in ALT activity compared to the control group (Fig. 11).

Discussion

The objective of the present study was to evaluate biochemical parameters in soft tissue of *G. truncatula* treated with sublethal concentrations of lead acetate and Pirimicarb. An increase in MDA level, as the final metabolite of lipid peroxidation, in tissues of snails in all groups treated with Pb and/or Pirimicarb can be attributed to an increase in reactive oxygen species (ROS) and enhancement of lipid peroxidation rate. Moreover, an increase in MDA indicates an imbalance

between ROS level and the cellular antioxidant defense system in snails treated with Pb and Pirimicarb. An increase in MDA level is reported in snails, *T. pisana* and *H. aspersa*, exposed to lead, zinc, copper and cadmium (Radwan, 2010; Atailia et al., 2016). Similar results are reported in fish treated with Pb (Nourian et al., 2015), and in snails (*L. carinatus*) treated with chlorpyrifos (M.Khalil, 2014). The MDA produced during peroxidation of fatty acids can make a covalent bond due to having a double bond with other elements of cell membrane, and therefore affect the physiologic activity of the cell membrane.

The cellular antioxidant defense system, including antioxidant enzymes and non-enzymatic antioxidants has an important role in removing free radicals. In the present study, a significant increase in total antioxidant (TAO) level in snails treated with Pb and Pirimicarb demonstrates a cellular response to an increase in the production rate of ROS. However, a significant reduction in TAO in snails treated with a combination of Pb and Pirimicarb can indicate oxidative stress and an imbalance between the antioxidant defense system and production level of free radicals. Therefore, snails' exposure to Pb and Pirimicarb can reduce the activity of antioxidant enzymes, decrease non-enzymatic antioxidant levels, and diminish the organism's ability in restoring the antioxidant defense system in cells.

Catalase (CAT) is one of the major antioxidant enzymes that is responsible in degrading hydrogen peroxide in cells under normal conditions. Therefore, a significant increase in CAT activity in tissues of snails treated with different concentrations of Pirimicarb and/or Pb can be a physiologic response to increased levels of hydrogen peroxide in cells. Our results are in accordance with those of El-Shenawy (2012) on snails, *Eobania vermiculata*, treated with lead, cadmium, iron, and copper, and Khalil's research (2015) on snails, *L. carinatus*, exposed to chlorpyrifos. In addition, Basopo and Ngabaza's work (2015) on snails (*L. carinatus*) treated with Pb and Chlorpyrifos, and Mleiki's research (2015) on snails, *C. apertus*, exposed to Pb and Cd announced similar results.

G6PDH is an important cytoplasmic enzyme in glucose metabolism in the pentose phosphate pathway. This is an important source of producing Nicotinamide adenine dinucleotide phosphate (NADPH), essential for DNA and RNA bond, carbon or phosphate sugars (Kletzien et al., 1994). NADPH is used for restoration of glutathione and so important in regulating the intracellular redox state (Leopold and Loscalzo, 2000). Therefore, G6PDH activity is highly important to maintain the cytosolic reserve and cellular redox balance. That is why G6PDH is known as an index of oxidative stress (Mehrpak et al., 2016). A reduction or disturbance in the activity of G6PDH can increase the chance of oxidative stress-induced cell death (Lin et al., 2013). A decrease in G6PDH in snail tissue treated with Pirimicarb (0.5 mg/L) may reduce the cellular NADPH level and disturb the balance between oxidant and antioxidant level in cells.

AST, ALT, LDH, GGT, ALP are found in different tissues such as liver, heart, the nervous system, skeletal muscles, kidney, pancreas, spleen, blood cells, intestine and gills of aquatic organisms (Banaee, 2013; Azubuike, 2012).

A significant increase in ALT and AST levels in snails treated with Pirimicarb and/or lead can indicate a severe damage to the cell membranes, and especially hepatocytes. Due to the effective role of aminotransferase enzymes in cellular nitrogen metabolism, oxidation of amino acids, or glucogenesis (Banaee, 2013; Rao, 2006), it can be used as an appropriate clinical marker to diagnose liver damages. An increase in AST and ALT is reported in blood plasma of fish exposed to Pb (Nourian et al., 2015), quails treated with Deltamethrin and Pb (Hamidipour, 2015), and snails, *L. carinatus,* treated with methylmalonat (Khalil, 2015).

ALP is a cell membrane enzyme that catalyzes the dephosphorylation of many molecules, including nucleotides, proteins, and alkaloids in an alkaline pH. A significant increase in ALP in snails treated with a combination of Pirimicarb and Pb can be the result of degeneration and necrosis of hepatocytes, and damage to cell membranes. An increase in ALP activity is found in blood plasma of fish exposed to Pb (Nourian et al., 2015), in snails (*L. carinatus*) treated with

methymalonat (Khalil, 2015) and in fish exposed to paraquat (Banaee et al., 2016).

LDH is an anaerobic enzyme that catalyzes lactate to pyruvate. An increase in LDH in snails treated with a combination of Pirimicarb and lead acetate might be due to hepatocytes necrosis, heart diseases, kidney failure, kidney cells necrosis, muscular dystrophy and anemia (Banaee et al., 2016). Enhanced levels of LDH in fish exposed to paraquat and microplastics is reported by Banaee et al. (2016).

A significant decrease in GGT activity in snails exposed to Pirimicarb and Pb in all experimental treatments compared to the control can be due to the direct effect of Pirimicarb and Pb on GGT and preventing its biosynthesis in damaged hepatocytes. GGT has a key role in glutamyl cycle and glutathione homeostasis. Therefore, a reduction in GGT activity in tissues of snails exposed to Pirimicarb and Pb of all treatments may suggest a disturbance in glutathione homeostasis or an imbalance between oxidants and antioxidants. A reduction in GGT activity is reported in plasma of fish exposed to Pb (Ziyadlou et al., 2011) and in plasma of common carp that were treated with paraquat (Sharifinasab et al., 2016; Banaee et al., 2016).

Cholesterol is a precursor of steroid hormones and under stressful conditions its available concentration increases to provide cortisol precursor (Hoseini and Ghelichpour, 2011). Moreover, changes in cholesterol concentration, as the main marker of animals' health status, indicate liver metabolism (Seyit et al., 2000). An increase in cholesterol level in tissues of snails that were treated with Pirimicarb and/or Pb might be due to a change in snails' metabolism and a damage to kidney (Zhou et al., 2009; Gul et al., 2011). An increase in cholesterol activity is reported in quails treated with both deltamethrin and Pb (Hamidipour, 2015).

AChE plays an important role in breakdown of acetylcholine and is known as a behavioral marker in organisms exposed to environmental pollutants (Banaee, 2013). In the present study, a significant decrease in AChE activity in snails treated with only 0.1 or 0.2 mg/L of Pb and in groups treated with both Pirimicarb and Pb can negatively affect the snails' behavior. Pb and Pirimicarb influence cysteine in the active site of acetylcholinesterase and thus irreversibly inhibit AChE activity. Therefore, the enzyme cannot sit on substrate, nor hydrolyze acetylcholine. The inhibition of AChE is reported in snails, *C. apertus*, exposed to Pb and Cd (Mleiki et al., 2015).

Conclusion

The imbalance between the reactive oxygen species and the antioxidant capacity in the snail exposed to the Pirimicarb Pesticide and lead metal alone and in combination is one of the important reasons that cause undesirable changes in the biochemical parameters of the tissue. Consequently in this study exposure to sublethal concentrations of Pirimicarb and/or Pb (alone or combined) in snails causes remarkable biochemical changes that these changes were greater in snails treated with both Pirimicarb and Pb (Pb 0.1 mg/l + Pirimicarb 0.5 mg/l, Pb 0.1 mg/L + Pirimicarb 1 mg/L, Pb 0.2 mg/L + Pirimicarb 0.5 mg/L, and Pb 0.2 mg/L + Pirimicarb 1 mg/L), because an increase in Pb concentration in aquatic ecosystems can Due to The imbalance between the reactive oxygen species and the antioxidant capacity intensify the toxicity and bioavailability of pesticides. Furthermore, biochemical parameters' response in the soft tissue of snails (*G. truncatula*) that were exposed to different concentrations of Pirimicarb and Pb indicate that this species can be used as a suitable bioindicator to assess and monitor aquatic ecosystems that are contaminated with heavy metals and pesticides.

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چکیده فارسی

اثرات غلظت‌های تحت‌کشنده آفت‌کش پریمیکارب به تنهایی و در ترکیب با فلز سرب بر پارامترهای بیوشیمیایی بافت حلزون آب شیرین (*Galba truncatula*)

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چکیده:

در این مطالعه تأثیرات احتمالی پریمیکارب و فلز سرب بر روی پارامترهای بیوشیمیایی بافت حلزون آب شیرین (*Galba truncatula*) بررسی شد و حلزون‌ها به مدت ۸ روز در معرض غلظت‌های تحت کشنده پریمیکارب (۰/۵ و ۱ میلی‌گرم بر لیتر) و استات سرب (۰/۱ و ۰/۲ میلی‌گرم بر لیتر) به تنهایی و به‌صورت توأم قرار داده شدند. آنالیز بیوشیمیایی بافت به روش فتومتریک نشان داد که حلزون‌های در معرض غلظت‌های پریمیکارب و سرب به تنهایی و به‌صورت توأم باعث افزایش سطح آنزیم‌های MDA و CAT و کاهش سطح آنزیم GGT در مقایسه با گروه کنترل شدند. سطح آنزیم‌های ALT، LDH و ALP در تیمارهای ترکیبی پریمیکارب و سرب افزایش یافت. سطح آنزیم TAO در حلزون‌های تحت تیمار ترکیبی سرب و پریمیکارب کاهش و در حلزون‌های تحت تیمار سرب و پریمیکارب به‌تنهایی افزایش یافت. سطح کلسترول در اکثر تیمارهای در معرض پریمیکاب و سرب افزایش یافت. سطح آنزیم AST در حلزون‌های تحت تیمار غلظت‌های ۰/۱ و ۰/۲ میلی گرم بر لیتر سرب تغییر معنی‌داری را نسبت به گروه کنترل نشان نداد اما AST در سایر تیمارها افزایش یافت. مهار معنی‌داری در سطح آنزیم AchE در حلزون‌های در معرض غلظت‌های تحت کشنده پریمیکارب ۰/۵ و ۱ میلی‌گرم بر لیتر در مقایسه با گروه کنترل مشاهده نشد اما کاهش معنی‌داری در سطح AchE در سایر تیمارها مشاهده شد. نتایج نشان می‌دهد که سمیت سلولی پریمیکارب به تنهایی و یا توام با سرب بستگی به غلظت آن‌ها دارد. غلظت‌های بالاتر سرب سبب ایجاد تغییرات معنی‌داری در برخی از پارامترهای بیوشیمیایی شده است. علاوه براین، افزایش سطح سرب در آب اثرات سمی پریمیکارب در حلزون‌ها را تشدید می‌کند. پریمیکارب و سرب به تنهایی و یا به‌صورت توام در غلظت‌های زیرکشنده سبب ایجاد آسیب‌های استرس اکسیداتیو در بافت‌های نرم حلزون شده است. در نهایت، این داده‌ها فرضیه مطرح شده مبنی بر ایجاد تغییرات در پارامترهای بیوشیمیایی ناشی از قرار گرفتن در معرض پریمیکارب و سرب را اثبات می‌کند.

کلمات کلیدی: حشره‌کش پریمیکارب، سرب، پارامترهای بیوشیمیایی، حلزون آب شیرین.