

**COMPARATIVE TOXICITY AND BIOCHEMICAL
STUDIES OF THREE ORGANOMETALLIC
PESTICIDES AND THEIR METAL SALTS
AGAINST THE GASTROPOD SLUG
Limax flavus (MÜLLER).**

By

Mohamed A. Radwan

Department of Pesticide Chemistry, Faculty of Agriculture (El-Shatby) ,
University of Alexandria, Alexandria, Egypt.

ABSTRACT

Three organo-metal containing compounds (Copper 8-oxine, Berstan, and Ferbam) and their simple metal salts (Copper sulphate, Stannous chloride and Ferrous sulphate) were tested for their molluscicidal activity against *Limax flavus* slugs, by crawling slugs on treated Petri-dishes under laboratory conditions. The impact of these poisons (1/10 of its LC_{50}) on slug weight, on three biochemical constituents (total proteins, total lipids, and glycogen content) and on activities of three enzymes (GOT, GPT, and ATPase) of the slug tissue were also investigated three days after exposure for one hour. The results showed that the three simple metal salts, were all toxic to slugs, while the three organo-metal containing compounds were partially less toxic to slugs than that with metal salts. LC_{50} values of Berstan, Copper 8-oxine, Ferbam, Copper sulphate, Ferrous sulphate, and Stannous chloride were 13.1, 19.3, 86.2, 8.1, 9.7 and 16.27 $\mu\text{g metal cm}^{-2}$, respectively. The loss of water from slug body was correlated with the molluscicidal potency. Significant reduction in total proteins, total lipids, and glycogen content, expressed as mg/animal was recorded, among slugs exposed to the three tested metal salts in addition to Berstan treatment when compared with the untreated slugs. The highest reduction was noticed in Copper sulphate treated slugs, while Berstan treatment exhibited the lowest one. All of the tested chemical

treatments resulted in significant elevation of GOT and GPT activities. Both copper and tin derivatives significantly reduced the activity of ATPase. The pronounced reduction was higher among slugs exposed to copper compounds than that to tin compounds.

INTRODUCTION

The terrestrial pulmonate gastropods (slugs and snails) have been generally distributed in northern coastal areas of Egypt (Kassab and Daoud, 1964 and El-Okda, 1983) where the conditions necessary for their rapid reproduction are most suitable. The land mollusca cause serious damage to a wide variety of plants including vegetables, forage crops, fruit trees, shrubs, flowers, and lawn grasses.

Terrestrial slugs and snails are known to accumulate several heavy metals from contaminated areas and are used as bioindicators of environmental pollution levels (Coughtrey and Martin 1977; and Ireland, 1980).

The organometallic compounds are currently used in agriculture practices as contact fungicides e.g. compounds containing Copper (Copper 8-oxine), Tin (Berstan) and Iron (Ferbam). Large amounts of pesticides containing metals (both inorganic and organic forms), sewage sludge, solid wastes and foliar fertilizers which have been introduced into the fields either to control plant pests and diseases or to improve plant productivity may affect the population of land gastropods by contact poisoning.

The molluscicidal poison baits are still used as the most effective control measure for controlling terrestrial gastropods. Unfortunately, the inherent weakness of a toxic bait itself can be due to either feeding to the sublethal dose of toxic bait which may exhibit resistance especially in slugs such as *Limax maximus* (Runham and Hunter, 1970) or to prevent them from feeding completely (Godan, 1983).

Nowadays, much progress has been made to the use of contact metal - based molluscicides and more efficient than bait delivery system (Henderson *et al.*, 1989; Henderson and Martin, 1990; Bullock *et al.*, 1992; and Clark *et al.*, 1995). Biochemical studies of mollusca are very important to see whether their pathways and enzymes system are peculiar

to mollusca which may suggest a selective control program (Duncan, 1983). The effect of different pesticides on some biochemical targets in terrestrial snails was studied by Radwan *et al.* (1991), El-Wakil and Radwan (1991); Radwan *et al.* (1992); and Radwan *et al.* (1993). Only one article is available which deals with the interaction of pesticides with slug cholinesterase as a biochemical target (Pessah and Sokolove, 1983).

So, the present experiments have therefore been performed to study the toxicity of three simple metal salts in comparison with their organo-metal derivative in a pesticide form. Besides the impact of sublethal concentration of these chemicals on some biochemical targets e.g. total proteins, total lipids, glycogen content, as well as the activities of glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT) and adenosine triphosphatase (ATPase) were assessed to gather more information about the biochemical mode of action of these chemicals in the twany *Limax flavus* (Müller) slugs (Pulmonate : Limacidae).

MATERIALS AND METHODS

Test animals :

Specimens of the herbivorous slug, *Limax flavus* (Müller) [Pulmonate : Limacidae] were collected from the nursery greenhouses and garden in Alexandria governorate. Animals with similar average weight of 2.11 ± 0.09 gm were kept at 10°C in cooled incubator under laboratory conditions for at least one week and fed on carrot discs. The slug was classified according to Runham and Hunter, 1970 and Godan, 1983.

Test Chemicals :

Three simple metal salts were chosen for testing :

- Tin chloride ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$), Merck, Darmstadt.
 - Copper II sulphate 5-hydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), Merck, Darmstadt.
 - Ferrous sulphate 7-hydrate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$), BDH chemicals Ltd, England.
- And another three formulated metal containing pesticides were also chosen for testing:

- Berstan® "triphenyl tin acetate" 45% W.P, was produced by Hoechst AG, Germany;

- Quinolate "Copper 8-Oxine" 40% S.C, was supplied by Hokko Co., Ltd. Tokyo, Japan;
- Ferbam 76% W.P [Tris (dimethyldithiocarbamate)iron.], was provided by Du pont de Nemours comany, USA.

All the other chemicals were of the highest purity grade available from Sigma, BDH and/or Aldrich chemical companies.

Experimental methods :

Since the susceptibility of slug to molluscicides depends on their weight rather than on their age (Henderson, 1968) and also their highly susceptible to desiccation and tend to loss water to an atmosphere of 45% relative humidity at 3-5% initial body weight per hour (Dainton, 1954), therefore enough specimens of the herbivorous slugs *Limax flavus* (Müller) with an average weight of 2.11 ± 0.09 gm/slug were collected from the field, maintained and tested at 10°C in cooled incubator to overcome these problems.

Experimental slugs were divided into two groups; the first group was used to assess the contact-action toxicity of the tested chemicals and the second one was used to study the impact of sublethal concentration (1/10 of its LC_{50}) of these chemicals on some biochemical constituents in the whole body of terrestrial *Limax flavus* slugs.

Contact-action toxicity : Eight concentrations from each chemical ranged between 500-5000 ug/ml were prepared using distilled water as a solvent and were administered to the animal from residual deposits. Each concentration (1 ml) was applied to the bottom of a glass Petri-dish (15 cm in diameter) with a pipette and spread uniformly by rotating the dish. The dishes were air dried at room temperature before introducing slugs. Six Petri dishes were used for each concentration and an equal number was used for the control. Five animals were introduced in each dish. Control dishes were treated with water only. Slugs were exposed to deposits of metal salts or pesticide containing metal in Petri-dish for one hour at 10°C. Following exposure, animals were then wiped with tissue paper to remove mucus and adhering chemical residues, transferred to wet filter paper in another 15 cm Petri-dishes containing carrot discs for food, and held at 10°C for three days for assessment of mortality. After three days, the

dishes were checked and the number of dead slugs were recorded. LC_{50} values with fiducial limits and slope for each chemical were calculated by probit-analysis method of Finney (1971).

Biochemical : Animals were exposed to $1/10 LC_{50}$ form the tested chemicals in Petri-dishes by the same procedure as described before. Two slugs were withdrawn from each replicate (2 x 6 slugs), three days later, for the estimation of weight of slug to know the % loss of water and some biochemical targets e.g. total proteins, total lipids and glycogen content as well as the activities of the three enzymes; GOT, GPT and ATPase.

The animals from each chemical treatment were homogenized in 10 volumes (w/v) of 0.1M phosphate buffer pH 7.4 using a polytron homogenizer for one minute. The homogenate was divided into two parts; the first part was taken to determine the biochemical constituents (total proteins, total lipids and glycogen content), while the second part was Centrifuged at 6000 xg for 20 minutes using a cooling centrifuge at 4°C. The supernatant was used as the enzyme source for GOT, GPT and ATPase. Total proteins were measured by the method of Lowery *et al.* (1951), glycogen content was measured according to Van (1965), and total lipids were measured by the method of Knight *et al.* (1972) with slight modifications (El-Wakil and Radwan, 1991). All the previous constituents were expressed in milligrams per gm tissue and in milligrams per slug.

Glutamic-oxaloacetic transaminase (GOT) and glutamic Pyruvic transaminase (GPT) activities were assayed by the method of Reitman and Frankel (1957) using "Boehringer Mannheim GmbH Diagnostica Kit"; and the activity of ATPase was measured according to Kock (1969) using adenosine triphosphate as a substrate.

All the data presented as mean $\pm$ SD were subjected to analysis of variance and means were compared for significance by L.S.D method at the probability of 0.05 (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Toxicity studies :

The toxicity parameters expressed as LC_{50} values ($\mu\text{g metal ion. cm}^{-2}$) with its fiducial limits and slope for the tested three metal containing pesticides and their simple metal salts were computed after *Limax flavus* slugs exposed to their surface residue in Petri-dish at one hour and presented in Table (1).

The use of a surface residue and dermal contact toxicity of molluscicides would be a useful step forward to slug control (Young and Wilkins, 1989) and the work of Ryder and Bowen (1977) has shown that it is possible to enhance the uptake of chemicals by the slug foot during its foraging.

Table (1) : Toxicity parameters of three organometallic pesticides and their simple metal salts to the *Limax flavus* slug exposed to their residue in Petri dish.

Treatment	LC_{50}^* ($\mu\text{g metal. cm}^{-2}$)	95% Fiducial limits of LC_{50}		Slope & Variance
		Lower	Upper	
Copper-8 oxine	19.30	17.68	20.61	5.18 ± 0.31
Copper sulphate	8.10	7.36	8.89	3.32 ± 0.19
Berstan	13.10	11.42	14.85	3.94 ± 0.11
Stannous chloride	16.27	15.21	17.41	3.52 ± 0.21
Ferbam	86.20	83.13	89.68	2.56 ± 0.17
Ferrous sulphate	9.70	8.85	10.63	3.78 ± 0.13

* LC_{50} values calculated as median lethal surface loading of metal ion in petri-dish after one hour exposure.

The data presented in Table (1) showed that the inorganic metal salts; Copper sulphate, Ferrous sulphate and Stannous chloride were all toxic to slugs crawling on coated Petri-dishes. Copper sulphate was the most toxic against slug while Stannous chloride had the least toxic among the tested metal salts. LC_{50} values of the tested metal salts were 8.1, 9.7, and $16.27 \mu\text{g metal. cm}^{-2}$ for Copper sulphate, Ferrous sulphate and Stannous chloride, respectively.

The high (> 90%) mortality levels of *Deroceras reticulatum* slugs resulted in the greatest uptake of Copper metal ion (Bullock *et al.*, 1992). A 0.5% water solution of Copper sulphate ensured 100% mortality of *Helicella vestalis* after seven days from treatment (Kassab and Daoud, 1964). Henderson *et al.* (1989) showed that the sulphate of Cu, Fe, Zn, and Al were very toxic to *D. reticulatum* slugs at 200 ug.cm⁻² (tested on glass surface) for 50 min. exposure.

Also, data in Table (1) clearly show that the organic compounds containing metal were partially less toxic than that with simple metal salts. The toxicity of these compounds could be arranged ascendingly according to LC₅₀ (in ug metal ion cm⁻²) values as follows : Berstan (13.1), Copper 8-oxine (19.3), and Ferbam (86.2). Rodriguez and Lorenzana (1991) mentioned that Berstan (triphenyl tin acetate) which was initially developed as fungicide, also gave good control measure against Golden *Pomacea canaliculata* snails in rice field. Copper 8-oxine caused 88.46, 96.30 and 100% mortality of slugs when used at the dose of 0.5, 5, and 10 gm/m² surface soil cultivated with cabbage (Sato and Uchama, 1992). Also, the new patented Copper complex compound formulated as spray, caused significant mortality of *D. reticulatum* slugs and proved to be highly effective in reducing the number of *Helix aspersa* snails in a Vineyard orchard (Davis *et al.*, 1996). On contrary, Copper containing compounds; the mixture of Copper sulphate: Lime at 65 kg/ha and Copper hydroxide at 0.55 kg/ha did not significantly reduce adult slug *Deroceras laeve* densities on strawberries field when applied as broadcasting and spraying, respectively (Prystupa *et al.*, 1987).

The first requirement for the toxicity of tested poisons in the present study is due to their ability to penetrate to site of activity and mobility within the slug tissue depends on their physical properties e.g. solubility. So, the high water solubility of the metal salts giving rapid uptake into slug body then reflected high mortality than metal in an organic form.

Biochemical studies :

Table (2) shows the effect of 1/10 LC₅₀ of the tested poisons on the total fresh weight of the tested slug, also the *in vivo* effect of these poisons used at low concentration (1/10 LC₅₀) on some biochemical constituents (Total proteins, total lipids, and glycogen content) as well as the

activity of three indicator enzymes; GOT, GPT, and ATPase of terrestrial *Limax flavus* slugs were investigated and illustrated in Table (3) and (4).

Effect on slug weight : Table (2) shows the effect of pesticide containing metal and their metal as salts on the total fresh weight of *Limax flavus* slugs. An average weighed 2.11 ± 0.09 gm, which after treatment with Copper sulphate, Ferrous sulphate, and Stannous chloride decreased 27.49, 17.53, and 13.74%, respectively. As for the pesticide containing metal, the corresponding decreased values were 15.64, 7.58, and 4.74% for Berstan, Copper 8-oxine, and Ferbam, respectively. This decrease in weight is probably due to desiccation induced by all treatments. The maximum reduction in weight was noticed with all tested metal salts, whereas the lower one was observed in the case of pesticide containing metal.

Comparing the data presented in Table (2) with the toxicity parameters in Table (1), showed that the loss of water from the slug body was correlated with the molluscicidal potency.

The inorganic fertilizer presumably kill slugs by salt effects, causing them to emit copious amounts of slime which leads to dehydration of the animals (Gödan, 1983), also the molluscicidal activity of metal salts in simple or chelated form being quicker in action and independent of the slugs water relations (Henderson *et al.*, 1989).

Table (2) : Effect of $1/10$ LC_{50} of three organometallic pesticides and their simple metal salts on the weight of *Limax flavus* slug.

Treatment	Average weight gm / slug*	% reduction with reference to control
Control	2.11 ± 0.09^a	---
Copper-8 oxine	1.95 ± 0.08^b	7.58
Copper sulphate	1.53 ± 0.06^d	27.49
Berstan	1.78 ± 0.05^c	15.64
Stannous chloride	1.82 ± 0.04^c	13.74
Ferbam	2.01 ± 0.1^a	4.74
Ferrous sulphate	1.74 ± 0.05^c	17.53

* The average weight / slug based on 12 slugs involved in each treatment, one hour exposure.

Each value presented as mean $\pm$ S.D.

Value followed by the same letters are not significantly at $P \leq 0.05$.

Effect on some biochemical constituents : The effect of the tested metal salts and metal containing pesticides on some biochemical constituents of *Limax flavus* slugs is shown as mg/gm tissue is also means mg/unit weight of animal, and mg/animal (Table3).

On the basis of biochemical constituent/unit weight of animal, there was a significant reduction in total proteins among slugs treated with Copper sulphate, Stannous chloride, and Ferrous sulphate, while an apparent decrease was noticed with Copper 8-oxine, Berstan, and Ferbam when compared with the untreated slugs. The maximum decrease (to 23.44% of the control value) was observed in slugs exposed to Copper sulphate followed by Stannous chloride (18.85%), and Ferrous sulphate (12.26%).

Table (3) :Changes in biochemical constituents of *Limax flavus* slugs exposed to 1/10 LC₅₀ of three organometallic pesticides and their simple metal salts.

Treatment	Biochemical constituents					
	Total protein		Total lipids		Glycogen content	
	mg / g tissue*	mg / slug	mg / g tissue	mg / slug	mg / g tissue	mg / slug
Control	119.9 ± 0.30 ^a	252.99 ± 9.15 ^a	64.4 ± 0.88 ^a	135.88 ± 4.96 ^a	68.6 ± 0.15 ^a	144.75 ± 5.20 ^a
Copper-8 oxine	113.9 ± 0.20 ^{ab}	207.30 ± 4.3 ^{bc}	58.9 ± 0.37 ^{ab}	107.2 ± 6.2 ^{abc}	66.0 ± 0.12 ^b	120.12 ±3.62 ^{ab}
Copper sulphate	91.8 ± 0.18 ^{cd}	140.45 ± 3.96 ^d	36.5 ± 0.72 ^d	55.84 ± 2.81 ^d	52.5 ± 0.05 ^d	80.32 ± 2.90 ^c
Berstan	110.8 ± 0.11 ^{ab}	197.22 ± 6.20 ^c	52.5 ± 0.91 ^b	93.45 ± 1.47 ^{bc}	59.1 ± 0.36 ^c	105.20 ±2.00 ^{bc}
Stannous chloride	97.3 ± 0.09 ^{bd}	189.73 ± 5.70 ^c	45.0 ± 0.59 ^c	87.75 ± 9.50 ^c	53.8 ± 0.00 ^d	104.91± 4.05 ^{bc}
Ferbam	114.3 ± 0.70 ^{ab}	229.74 ±10.1 ^{ab}	60.2 ± 1.02 ^c	121.0 ± 7.16 ^{ab}	69.8 ± 0.16 ^a	140.30 ± 7.50 ^a
Ferrous sulphate	105.2 ± 0.65 ^b	183.05 ± 8.51 ^c	47.2 ± 1.05 ^c	82.13 ± 3.20 ^c	56.7 ± 0.05 ^c	98.66 ± 6.35 ^{bc}

* Tissues from 12 slugs were pooled and homogenized for each treatment; each treatment replicated three times.

Values within each column followed by the same letters are not significantly different at P ≤ 0.05.

The level of total lipids in slug tissue were significantly decreased by the treatment with all simple metal salts in addition to Berstan treatment. The same sequence was noticed here like that in total proteins. The percent significant decrease in total lipids as a reference to control value could be arranged ascendingly as follows : Copper sulphate (43.32%), Stannous chloride (30.12%); Ferrous sulphate (26.71%); and Berstan (18.48%). On the other hand, apparently decrease were observed in case of slug exposed to Copper 8-oxine and Ferbam.

Significant decreases were shown in glycogen content among slugs treated with all of the tested poisons except Ferbam treatment as compared with the untreated slugs. Copper sulphate has a pronounced effect on glycogen content than the other tested treatments.

From these findings, it can be suggested that the decrease in glycogen content of the treated slugs with the test poisons may result either from increased rate of glycogen breakdown (glycogenolysis) or due to a decreased rate of glycogenesis. Moreover, the decrease in glycogen content may have an indirect affect on the protein and lipids reserved in slug tissue. These biochemical results and suggestions are supported with those reported by Sharaf *et al.* (1975) they mentioned that, exposure of *Biomphalaria alexandrina* and *Bulinus truncatus* snails to triphenyl tin hydroxide (Du-Ter), affected glucose utilization, glycoglysis, glycogen content and gluconeogenesis in snail tissue. The compound at its LC_{50} inhibited glyconeogenesis, stimulated glycolysis and markedly reduced the glycogen content and glucose utilization in both snails. Copper sulphate at (1/10 of its LC_{50}) cause a significant decrease in total proteins, carbohydrates, and lipids from the 3rd day of exposure of *B. alexandrina* snails (Mohamed *et al.*, 1981). Also, Copper sulphate decreased the lipid content of the whole body of gastropod *Thiara tuberculata* (Mule and Lomte, 1993).

Considering, the decrease in slug weight after exposed to lethal concentration of the tested poisons, the content of three biochemical constituents were calculated on per slug basis (Table 3) to account for desiccation as a result of exposure either to metal salts or to pesticides containing metal. Total proteins in slug tissue was affected, by all of the tested chemicals except Ferbam treatment. While lipids content and glycogen content were not affected by both Copper 8-oxine and Ferbam treatments.

From Table (3) it could be concluded that Copper sulphate proved superior to the other tested chemicals in reducing total proteins, total lipids and glycogen contents per unit weight or slug basis. The percent reduction values were 23.44%, 43.32%, and 23.47% or 44.48%, 58.90%, and 44.51% for total protein, total lipids, and glycogen content, respectively. Regarding to the metal containing pesticides, Berstan has highly affected treatment on the three biochemical contents among the tested chemicals.

The control slug, therefore largely contain water the balance of the 80% weight. After chemical treatments, the slug lose, respectively 7.58, 27.49, 15.64, 13.74, 4.74, and 17.53% of their weight (Table 2). This desiccation particularly account for Copper 8-oxine and Berstan which did not significantly decrease in total proteins (per unit weight), but when total proteins was calculated with reference to their desiccated weights, total proteins was significantly decreased. Also, Copper 8-oxine resulted a significant reduction in glycogen content (per unit weight), but no effect on this respect was noticed (per animal). On the other hand, no differences in lipids content was observed between the data calculated per unit weight or per animal (Table 3).

Changes in the activity of Transaminases (GOT & GPT) and ATPase enzymes among both control and treated slugs with 1/10 LC₅₀ of three organometallic compounds and their metal salts were recorded in Table (4).

Results listed in Table (4) show that the two transaminases were distinctly affected. There were significant increases in GOT and GPT activity among slugs exposed to either metal salts or compounds containing metal as compared with untreated slugs. The highest elevation was noticed in Copper sulphate treated slugs, while the lowest one was Ferbarm.

The possible mechanisms involved in the elevation of GOT and GPT activities observed in the present study may be based on tissue damage, increased synthesis or decreased catabolism of both enzymes (Tordior and Van Heemstra-Lequin, 1980).

The ATPase activity behaved differently, Iron Chemicals (Ferrous sulphate or Ferbam) did not bring about any appreciable change, while Copper chemicals (Copper sulphate or Copper 8-oxine) and Tin chemicals (Stannous chloride or Berstan) exhibited significant decrease of ATPase

activity as compared with the control slugs. The pronounced decrease was significantly higher among slugs exposed to copper treatments than that to tin treatments.

The inhibition of ATPase activity which is responsible for ATP synthesis after slugs being exposed to chemical treatments leads to the inhibition of oxidative phosphorylation in target tissues. These observations are in agreement with other studies; showing that ATPase preparation from house flies was inhibited by μM concentrations of triphenyl tin chloride (Pieper and Casida, 1965). Also, $\text{Na}^+\text{-K}^+$ ATPase activity was inhibited by 33% with 24 hours of Copper exposure to rainbow trout (Lauren and McDonald, 1987). ATPase inhibition can be fatal to the organism by depletion of the required energy for biological processes.

Table (4) : Activities of three indicator enzymes (GOT, GPT, and ATPase) of *Limax flavus* slugs exposed to 1/10 LC_{50} of organometallic pesticides and their simple metal salts.

Treatment	Enzymes [@]		
	GOT*	GPT*	ATPase**
Control	19.75 $\pm$ 0.70 ^f	8.56 $\pm$ 0.13 ^f	6.53 $\pm$ 0.08 ^a
Copper-8 oxine	23.44 $\pm$ 0.21 ^c	10.75 $\pm$ 0.55 ^b	4.33 $\pm$ 0.50 ^b
Copper sulphate	30.20 $\pm$ 0.00 ^a	13.15 $\pm$ 0.32 ^a	3.05 $\pm$ 0.13 ^b
Berstan	26.90 $\pm$ 0.35 ^b	10.75 $\pm$ 0.10 ^b	2.18 $\pm$ 0.09 ^c
Stannous chloride	22.30 $\pm$ 0.14 ^d	9.80 $\pm$ 0.97 ^d	2.79 $\pm$ 0.39 ^{bc}
Ferbam	20.90 $\pm$ 1.62 ^e	8.72 $\pm$ 0.44 ^e	6.42 $\pm$ 1.10 ^a
Ferrous sulphate	21.80 $\pm$ 0.97 ^{de}	10.00 $\pm$ 0.98 ^c	6.00 $\pm$ 0.04 ^a

[@] Abbreviation used : GOT, glutamic oxaloacetic transaminase ; GPT, glutamic pyruvic transaminase and ATPase, adenosine triphosphatase.

* Measured specific activity x 1000 (units / mg protein).

** ATPase is expressed as μ moles of Pi/mg protein/min.

It is also reasonable to conclude that the decrease of water fluid in slug body exposed to the tested chemicals was correlated to its toxic action and leads to deleterious alteration in the level of its biochemical parameters.

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الملخص العربى

دراسات مقارنة على التأثيرات السامة والبيوكيميائية لثلاثة من المركبات المعدنية العضوية وأملاحها المعدنية ضد البزاق ليمكس فلافس *Limax flavus*

د. محمد على رضوان

قسم كيمياء مبيدات الآفات - كلية الزراعة (الشاطبي) - جامعة الأسكندرية

تم دراسة للفعل السام لثلاثة من المركبات المعدنية العضوية (لوكسين للنحاس، البرستان، الفريام* وأملاحها المعدنية البسيطة كبريتات النحاس، كلوريد القصديروز، كبريتات الحديدوز* ضد البزاق فى أطباق بترى تحت الظروف المعملية بالإضافة إلى دراسة للتأثير لعشر التركيز القاتل لـ ٥٠٪ من البزاقات المعاملة ($1/10 LC_{50}$) للمركبات الثلاثة المختبرة وأملاحها المعدنية على وزن البزاق، ثلاثة من المحتويات البيوكيميائية وهى البروتين الكلى، الدهون الكلية ومحتوى الجليكوجين وكذلك على نشاط ثلاثة من الإنزيمات وهى الجلوتاميك-أوكسالوأسيتيك ترانس أمينيز، الجلوتاميك-بيروفيك ترانس أمينيز والأدينوسين تران فوسفاتيز وذلك بعد ثلاثة أيام من التعرض لمدة ساعة.

وقد أظهرت النتائج أن المركبات المعدنية العضوية المختبرة كانت أقل سمية ضد البزاق عن أملاحها المعدنية وأوضح ذلك من خلال قيم " LC_{50} " كالتى: ١٩,٣، ١٣,١، ٨٦,٢، ٨,١، ٩,٧، ١٦,٢٧ ميكروجرام معدن/سم^٢ لكل من البرستان، أوكسين النحاس، الفريام، كبريتات النحاس، كبريتات الحديدوز، كلوريد القصديروز على الترتيب. وأوضح أيضا أن نتائج فقد الماء من جسم البزاق أثر التعرض تتوافق مع نتائج السمية المتحصل عليها. وقد سجلت أملاح المعادن المختبرة بالإضافة إلى البرستان إنخفاضاً معنوياً فى البروتين الكلى، الدهون الكلية ومحتوى جسم البزاق ككل من الجليكوجين مقارنة بالبراقات الغير معاملة وكان أعلى إنخفاض عند التعرض لكبريتات النحاس وأقلها عند التعرض للبرستان. وقد أدت كل المركبات المختبرة إلى زيادة معنوية فى نشاط كل من الجلوتاميك-أوكسالوأسيتيك ترانس أمينيز والجلوتاميك-بيروفيك ترانس أمينيز وقد إتضح أن مركبات النحاس والقصدير أحدثا إنخفاضاً معنوياً فى نشاط أنزيم الأدينوسين تران فوسفاتيز وقد سجل أعلى إنخفاض فى حالة البزاقات المعرضة لمركبات النحاس عنه لمركبات القصدير.