Pesticides effect on growth performance and induced clastogenic effect in Nile tilapia (*Oreochromis niloticus*) fingerlings.

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ABSTRACT

Nile tilapia is the main cultured species in Egypt; the Egyptian fish farms are irrigated with agricultural drainage which contains pesticides residues or their metabolites which may affect fish. The present study was carried out in order to explore the capability of chlorpyrifos [LC_{10} (0.053 mg/L) and LC_{20} (0.073 mg/L)] and Lambda- cyhalothrin [LC_{10} (0.020 mg/L) and LC_{20} (0.023 mg/L)] in including chromosomal aberrations as well as these effects on growth performance in Nile tilapia fingerlings with mean weight 7.57± 0.11g/fish. The period of exposure to both insecticides was 4 weeks, followed with further 4 weeks without exposure as a recovery period. The effect of both insecticides on fish chromosomes was, also, investigated and the obtained results revealed different types of aberrations i.e. stickiness, chromatid deletions and fragment. Total aberrant metaphases ranged from 3(negative control) to 92 % for LC_{10} of Lambda- cyhalothrin, giving a strong evidence that both insecticides were proven to be highly positive as clastogen. Fish weights were negatively affected by tested concentrations of both insecticides. Growth performance and survival rates were reduced as result of treatment with selected concentrations.

ADDITIONAL INDEX WORDS: Clastogenic, growth performance, chromosomal aberration, Nile tilapia, pesticides.

INTRODUCTION

Pesticides are well recognized as an economic approach to control pests, at the same time such chemicals are highly toxic to other species in the environment. Now there is growing concern worldwide over the indiscriminate use of such chemicals, which result in environmental pollution and toxicity risk to nontarget organisms. However, Most of pesticides find their way into rivers, lakes and ponds, and have been found to be highly toxic not only to fish but also to the organisms which contribute to the food chain of fish (Gaafar *et al.*, 2010).Introduced commercially less than 20 years, synthetic pyrethroids now account for more than 30% of insecticide used worldwide in agricultural, domestic, veterinary applications (Eisler, 1992). These halogenated and lipophilic compounds are generally recognized as potent neurotoxicants, characterized by high insecticidal properties and low mammalian toxicity (Velmurugan *et al.*, 2006). Lambda-cyhalothrin is a pyrethroid insecticide used for controlling pest insects in agriculture, public health, and in construction and households.

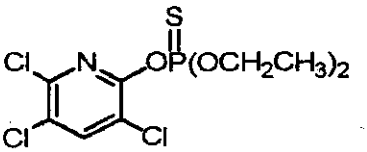
Organophosphate (OP) pesticides are widely used in tropical agriculture. These pesticides are likely to enter water bodies in several ways, including spray drift, leaching from soil and water, and run off from agriculture (Chandrasekara and Pathiratne, 2007).Chlorpyrifos is a broad-spectrum organophosphate used heavily throughout the world for agriculture and domestic purposes.Fish are considered as an excellent material for the study of the mutagenic and/or carcinogenic potential of contaminants present in the water samples since they can metabolize, concentrate and store water borne pollutants (Al-Sabti, 1991). Nile tilapia (*Oreochromis niloticus*) is very important in aquaculture today and is currently used in varied areas of study as an 'experimental model'. *Oreochromis niloticus* has been characterized using classical and cytogenetic techniques, with special attention paid to heterochromatin structure and the identification of sex chromosomes (Guilherme *et al.* 2009).Likewise, cytogenetic changes measured by observing the frequency of chromosomal aberration in the gill cells of the treated *Oreochromis niloticus* by pesticides (Mohamed *et al.*, 2008). Mahrous and Abdou (2001) detected that the environmental water pollution (agricultural and industrial waste water) have significant effects on *Oreochromis niloticus*, which appeared via chromosomal aberration breaks, deletion, and centromeric attenuation in somatic cells. Micronuclei are cytoplasmic chromatin-containing bodies formed when acentric chromosome fragments or chromosomes lag during anaphase fail to become incorporated into daughter cell nuclei during cell division. Because genetic damage that results in chromosome breaks or spindle abnormalities leads to micronucleus formation, the incidence of micronuclei serves as an index of these types of damage. Whereas counting of micronuclei is much faster and less technically demanding than scoring of chromosomal aberrations, the micronucleus assay has now been widely used to screen for chemicals that cause these types of damage (Fagr *et al*, 2008).The present work aims at investigating the effect of two selected insecticides, which are environmental contaminants, namely chlorpyrifos and lambda-cyhalothrin on Nile tilapia fingerlings growth performance, survival (%), the capability of both insecticides to induce genetic damage and causing clastogenic effect.

MATERIALS AND METHODS

This experiment was carried out at the laboratory of fish experiments, Department of Animal and Fish Production, the Faculty of Agriculture (Saba-Basha), Alexandria University at the season of summer 2012.

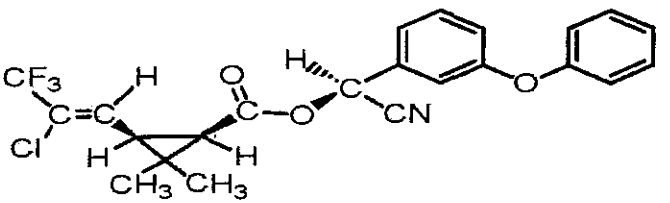
Chemical structures of both insecticides

1. Chlorpyrifos



2. Lambda-Cyhalothrin

(*S*) (*Z*)-(1*R*)-*cis*-



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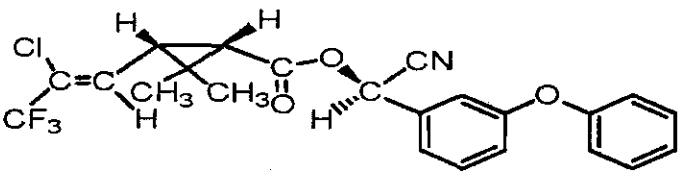

(*R*) (*Z*)-(1*S*)-*cis*-

Fish and treatments

Nile tilapia (*Oreochromis niloticus*) fingerlings were obtained from a private fish farm near by Edku Lake. Fish were transported to the laboratory in plastic bags filled with 30 l of water. Fishes were kept for two weeks as an acclimatization period in circular fiberglass tanks measured one cubic meter in volume filled with 730 l and fed on a diet contained 32.38% crude protein. Nile tilapia (*O. niloticus*) fingerlings, with an average body weight of 7.57± 0.11g/fish, were treated by LC_{10} and LC_{20} concentrations of both insecticides for 4 weeks in addition to the untreated group (control treatment). However, 5 replicates were used for control and other treated groups (15 fingerlings per each).

Five experimental groups of water were designed as the following:

1) Control (without exposure to tested insecticides).
2) Exposure to LC_{10} of chlorpyrifos (CA) (0.053 mg/L).
3) Exposure to LC_{20} of chlorpyrifos (CB) (0.073 mg/L).
4) Exposure to LC_{10} of lambda-cyhalothrin (LA) (0.020 mg/L).
5) Exposure to LC_{20} of lambda-cyhalothrin (LB) (0.023 mg/L).

After the exposure treatment (4 weeks), the fish of each group were transferred to clean water (without exposure to tested insecticides) for additional 4 weeks to see if a repair will happen or not. All ingredients of experimental diet were brought from the local market. Diet was completed with vitamins and minerals mixture according to NRC (1993). Oil was added drop by drop during mixing. Experimental fish fed two times a day (9.00-14.00 hrs.) at the rate of 3% of the actual live fish body weight (6 days weekly) as shown in Table (1).

Table (1).Feed ingredients (%) of the experimental diet

Ingredient	%
Fish Meal	24
Soybean	33
Yellow Corn	27
Rice	6
Wheat Bran	6
Corn Oil	2
Vitamins & minerals mixture*	2

* Vitamin & minerals mixture (P-Fizzer, Cairo, Egypt)Contains(/kg) Vitamin A, 4.8 MIU ;Vitamin D, 0.8 MIU ;Vitamin E, 4.0 g; Vitamin K , 0.8 g ;Vitamin B1, 0.4 g; Vitamin B2 1.6 g; Vitamin B6 0.6 g; Vitamin B7, 20.0 mg; Vitamin B12 , 40.0 g; Folic acid , 0.4 g; Nicotinic acid , 8.0 g; Pantothenic acid , 4.0 g; Colin chloride , 200 G; Zinc, 22 g; Copper , 4.0 g; Iodine , 0.4 g; Iron ,12.0 g ;Manganese, 22.0 g; Selenium, 0.04 g.

Evaluation methods

1. Growth performance

Control and treated fish were weighted at the beginning of the treatment (initial weight [T_i]) and after 4 weeks of treatment (final weight [T_f]) the beginning of the repair (initial weight [R_i]) and after 4 weeks of repair (final weight [R_f]). Body weight gain (BWG), average daily gain (ADG) and specific growth rate (SGR) were calculated according to the following equations (Ricker, 1975; Castell and Tiewes, 1980). Statistical analysis was performed using the F-test analysis.

Total weight gain (g/fish):

Total weight gain= $W_t - W_0$

Where:

W_0 :initial mean weight of fish in grams

W_t :final mean weight of fish in grams

Average daily gain (ADG) (mg/fish/day):

ADG= $(W_t - W_0)/n$

Where:

n: duration period

Specific growth rate (SGR) (%/day):

SGR= $100 \times (\ln W_t - \ln W_0)/$no. of days

Where:

ln: natural logarithm

2. Analysis of chromosomal aberrations of fish

Each fish had received 0.25 mg colchicine per gram fish. After seven hours, the fish was killed and gills were removed. Preparations of chromosome complement were carried out according to the method described by Seehy (2012).

2.1.The staining process

Cells in fixative were dropped onto very clean glass slides and air dried. Spreads were stained according to Seehy(2012).

3. Micronucleus test

The peripheral blood smears were obtained through the gills blood by means of a medial-kidney imprint following dissection. The slides were air-dried for 12 h and then fixed in methanol for 10 min, followed by 5% Giemsa (v/v) staining. From each fish 1000 erythrocytes were counted. The slides were analyzed using a 1000X oil-immersion lens. This method was carried out following procedure that was described by (Grisolia and Starling, 2001).

RESULTS AND DISCUSSION

Results presented in Tables (2 and 3) summarize the effects of chlorpyrifos and lambda-cyhalothrin on growth performance and survival rate (%) of *O. niloticus* fingerlings. The results showed that treated fish after 4 weeks of exposure with both insecticides had significantly ($p< 0.05$) lower final body weight (FBW, g/fish), weight gain (WG, g/fish), average daily gain (ADG, g/fish/day) and specific growth rate (SGR, %/day) compared to untreated fish (control). The recovery period of 4 weeks did not lead to decrease the damage but not reached to the control. Growth rates had reduced significantly when exposed to lambda-cyhalothrin more than chlorpyrifos. These results are parallel to the findings of Huynh and Nugegoda (2012) on Australian catfish (*Tandanus tandanus*); they showed that fish exposed to a short term pulse of chlorpyrifos (2 or 10 µg L^{-1}) revealed significant reduction in final weight (8.54±0.19 and 8.77±0.44g) respectively compared to the control fish (10.5±0.72g).

Table (2). Effects of Chlorpyrifos and Lambda-cyhalothrin on final body weight (FBW), body weight gain (BWG), average daily gain (ADG), specific growth rate (SGR) and survival (%) of *O.niloticus* after 4 weeks treatment.

Groups	Initial body weight	FBW (g/fish)	BWG (g/fish)	ADG (g/fish/day)	SGR (%/day)	Survival (%)
Control	7.6±0.31	10.9±0.17^{a}	3.3±0.23^{a}	0.118±0.02^{a}	1.288±0.01^{a}	100.00±0.00
CA	7.6±0.22	9.4±0.31^{b}	1.8±0.52^{b}	0.064±0.03^{b}	0.759±0.03^{b}	90.67±8.15
CB	7.53±0.35	9.13±0.24^{a}	1.6±0.37^{a}	0.057±0.02^{a}	0.688±0.05^{a}	82.67±10.52
LA	7.55±0.19	9.05±0.37^{a}	1.5±0.47^{b}	0.053±0.04^{b}	0.647±0.06^{b}	90.67±6.92
LB	7.59±0.25	8.99±0.15^{b}	1.4±0.45^{b}	0.050±0.02^{a}	0.604±0.04^{b}	78.67±13.55

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.073 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.023 mg/L).

Table (3). Effect of Chlorpyrifos and Lambda-cyhalothrin on final body weight (FBW),body weight gain(BWG).average daily gain(ADG) ,specific growth rate (SGR) and survival (%) of *O. niloticus* after 4 weeks recovery

Groups	Initial body weight	FBW (g/fish)	BWG (g/fish)	ADG (g/fish/day)	SGR (%/day)	Survival (%)
Control	10.9±0.17	14.4±0.25^{a}	3.5±0.39^{a}	0.125±0.02^{a}	0.994±0.01^{a}	100.00±0.0
CA	9.4±0.31	11.8±0.41^{b}	2.4±0.45^{b}	0.086±0.04^{b}	0.812±0.02^{b}	95.83±2.8
CB	9.13±0.24	11.03±0.34^{b}	1.9±0.65^{b}	0.068±0.03^{b}	0.675±0.03^{c}	100.00±0.0
LA	9.05±0.37	11.15±0.31^{b}	2.1±0.44^{b}	0.075±0.01^{b}	0.745±0.02^{b}	100.00±0.0
LB	8.99±0.15	10.93±0.27^{b}	1.94±0.37^{b}	0.069±0.05^{b}	0.698±0.04^{c}	97.44±3.15

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.073 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.023 mg/L).

Analysis of chromosomal abnormalities showed that different types of aberrations (stickiness, deletion, and fragment) were observed as shown in Table (4). Total aberrant metaphases ranged from 3% (control) to 92% for LC_{20} of lambda-cyhalothrin, giving a strong evidence that both chemicals chlorpyrifos and lambda-cyhalothrin were proven to be highly positive as clastogen. However ,lambda-cyhalothrin was found to be higher than that of

chlorpyrifos. Notably, total aberrant metaphases were found to be decreased.

Table (4). Chromosomal abnormalities in gills of fish after treated with the tested pesticides for 4 weeks (T) and after a recovery period of 4 weeks (R)

Groups	Stickiness		Deletion		Fragments		Total aberrant metaphase	
	T	R	T	R	T	R	T	R
Control	2	2	-	-	1	1	3	3
CA	12	8	6	2	2	1	20	10
CB	20	8	11	6	6	4	37	18
LA	28	16	17	9	12	4	47	29
LB	44	20	32	11	16	4	92	35

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.073 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.023 mg/L).

Results outlined in table (5) illustrate the effect of the two tested insecticides upon the induction of micronucleated erythrocytes after treatment for 4 weeks and recovery period for 4 weeks as well. These results, however indicate gave a positive indicator that both tested insecticides have clastogenic activity. However, lambda-cyhalothrin presented an evidence that it was found higher level than that of chlorpyrifos. Respectively the effect of chlorpyrifos and lambda-cyhalothrin on cell division via analysis the induction of binucleate cells is given in Table (6).

Table (5). Micronucleated erythrocytes in gills of fish after treatment with the tested pesticides for 4 weeks (T) and after a recovery period of 4 weeks (R)

Groups	No. red cells counted	Micronucleated cells		% of Micronucleated	
		T	R	T	R
Control	1000	12	10	0.12	0.1
CA	1000	102	60	10.2	6
CB	1000	210	98	21	9.8
LA	1000	320	112	32	11.2
LB	1000	640	230	64	23

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.073 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.023 mg/L).

Table (6). Binucleate cells in gills of fish after treatment with the tested pesticides for 4 weeks (T) and after a recovery period of 4 weeks (R)

Groups	No. red cells counted	Binucleate cells		% of Binucleate cells	
		T	R	T	R
Control	1000	8	6	0.8	0.6
CA	1000	62	41	6.2	4.1
CB	1000	120	62	12	6.2
LA	1000	160	98	16	9.8
LB	1000	310	116	31	11.6

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.073 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.023 mg/L).

These results, however, gave an evidence that both tested insecticides are capable in interfering with cell division raising to significant percentages of binucleate cells that ranged from 0.8% to 31% and from 6% to 9.8% after recovery period for 4 weeks. Also, data of Table (7) illustrates the genotoxic effect of the two pesticides upon the induction of fragmented apoptotic cells. Such a result gave a strong evidence that the tested insecticides having a clastogenic effect, whereas a percentage of this type of aberration ranged from 1.4% (for the control) to 21.4% for the higher concentration of lambda-cyhalothrin.

Table (7). Fragmented apoptotic cells in gills of fish after treatment with the tested pesticides for 4 weeks (T) and after a recovery period of 4 weeks (R).

Groups	No. red cells counted	Fragmented apoptotic cells		% of Fragmented apoptotic cells	
		T	R	T	R
Control	1000	14	12	1.4	1.2
CA	1000	42	38	4.2	3.8
CB	1000	88	46	8.8	4.6
LA	1000	116	90	11.6	9.0
LB	1000	214	117	21.4	11.7

CA= (L.C $_{10}$ of Chlorpyrifos = 0.053 mg/L), CB= (L.C $_{20}$ of Chlorpyrifos = 0.0730 mg/L), LA= (L.C $_{10}$ of Lambda-cyhalothrin = 0.020 mg/L), LB= (L.C $_{20}$ of Lambda- cyhalothrin =0.02300mg/L).

Histologically, Photos (1-4) show the effect of the two tested insecticides upon fish genome. For instance, comparing the effect of chlorpyrifos with that of lambda-cyhalothrin, could led to conclude that although the two insecticides are positive clastogens, lambda-cyhalothrin was proven to be higher than that of chlorpyrifos.

Photo (1). Photomicrograph showing chromosome complement of *Oreochromis niloticus* (Control)

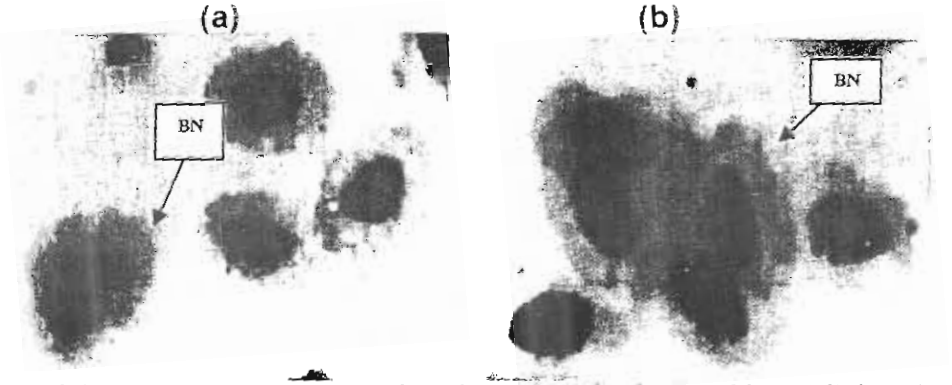

Photo (2). Photomicrograph showing binucleate in gills of fish after treatment with (a) chlorpyrifos and (b) lambda-cyhalothrin

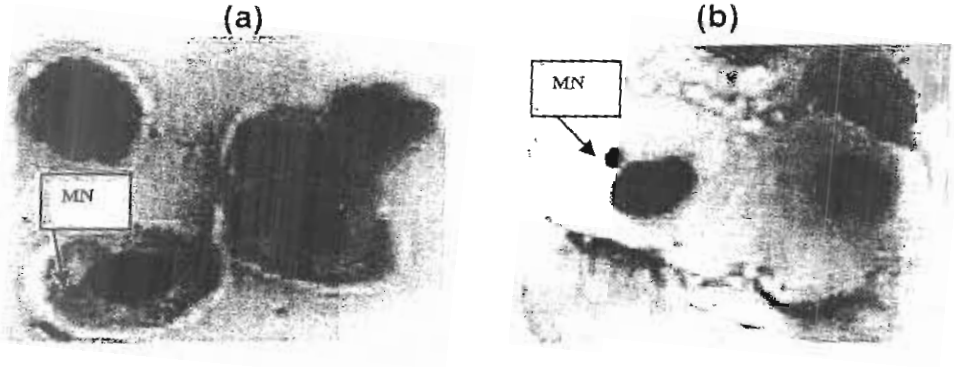

Photo (3). Photomicrograph showing micronucleated erythrocyte (MN) in gills of fish after treatment with (a) chlorpyrifos and (b) lambda-cyhalothrin

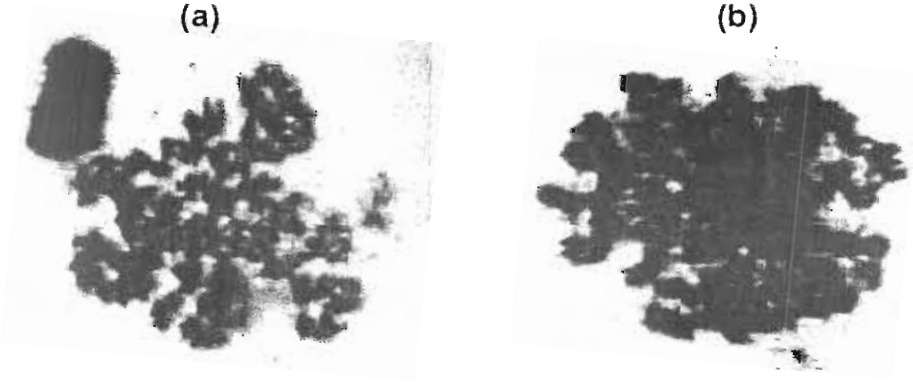

Photo (4). Photomicrograph showing stickiness in gills of fish aft treatment with (a) chlorpyrifos and (b) lambda-cyhalothrin

The production of either chromatid and/or chromosome aberrations by such agent depends on the nature of the clastogen (chromosome-breaking agent) and the cell cycle stage at the time of exposure (Brusick, 1984).The continuously increasing population and the need to increase agricultural productivity have encouraged extensive use of agricultural chemicals in Egypt during the last few decades. Successive large scale aerial and ground applications of insecticides to control insect pests mainly on cotton, maize, and rice crops during the hot summer in Egypt are repeatedly associated with many poisoning to humans, livestock, beside non-target organisms, and phytotoxicity to host plants.It is believed that numerous undocumented cases of acute poisoning to humans, farm animals, honey bees, and fish either due to direct dermal contact or ingestion of contaminated food, water, or feed occur frequently in Egypt (El-

Sebae, 1990). The concentration of insecticides and heavy metals in the Domietta branch of the Nile has been found to exceed the "Critical Limit" set by Egyptian official regulations (Fathi *et al.,* 1990).Furthermore, it is well known that disposal of pollutants into aqueous ecosystems might lead to their accumulation both in sediments and the upper food chain (including fish). Interest in the action of chemical mutagens in inducing chromosomal damage stems not only from the possibility that the presence of chemical mutagens in the environment could result in increased incidence of cancer, but also from the fact that exposure to these agents may result in increased incidence of transmitted genetic disease.Because of low public and governmental interest in environmental mutagenesis and carcinogenesis, it is believed that wild and cultured fish are already exposed to relatively high levels of these uncontrolled carcinogenic mutagenic chemicals as industrial waste products which affect human health. The short- term test used for fish carcinogenicity also provides an approximate measure of human carcinogenicity. Because of the universality of the DNA molecule as an agent which is genotoxic for one group of living organisms is typically genotoxic for other groups (Landolt and Kocan, 1983).Similar results, more or less, were recorded by Mohamed *et al.* (2008) on *O. niloticus* fish exposed to different heavy metals. They observed that chromatid deletion, stickness and fragments were more frequent than other chromosomal aberrations. Also, Yadav and Trivedi (2009) found that the exposure of *Channa punctata* (2n=32) to mercuric chloride, arsenic trioxide and copper sulphate pentahydrate for a week, the kidney cells revealed chromatid and chromosome breaks, chromatid and chromosome gaps, along with ring and di-centric chromosomes. These results are in agreement with that mentioned by Velmurugan *et al.* (2006) who found enhancement in the frequency of chromatid breaks, acentric fragments, centromeric fusions, aneuploidy, condensation, sticky plates and ring, of *Mystus glulio* fish exposed to a Lambda-cyhalothrin compared with those in the tap water control. Chromosomal aberrations frequency increased regard to the increase of concentrations of herbicide, whip super (Farag *et al.*, 2009).

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الملخص العربى

تأثير المبيدات على أداء النمو والأثر التكسيرى لكروموسومات إصبعيات البلطى النيلى

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أجريت هذه الدراسة بقسم الإنتاج الحيوانى والسمكى، كلية الزراعة (سابا باشا)، جامعة الأسكندرية، بهدف دراسة تأثير مبيدى الكلوربيريفوث (التابع لمجموعة مبيدات الفوسفات العضوية) ومبيد لامدا- سيهالوثرين (التابع لمجموعة البيريثرويدات المصنعة) على أداء النمو وكذلك القدرة التكسيرية لكروموسومات اصبعيات البلطى النيلى (2n = ٤٤ كروموسوم منها زوج طويل والباقى كروموسومات قصيرة وهى تعتبر من النوع ذو السنترومير تحت الطرفى) .تم صيد اصبعيات البلطى النيلى من مزرعة خاصة بالقرب من بحيرة ادكو وتمت أقلمتها بالمعمل لمدة اسبوعين. وتم تعريض الأسماك بمتوسط وزن

٧.٥٧ ±٠.١١ جم/ سمكة لمدة ٤ أسابيع للتركيز المكافئ لـ ١٠%من التركيز المميت و للتركيز المكافئ لـ ٢٠%من التركيز المميت ([٠.٠٥٣ مجم/لتر و٠.٠٧٣ مجم/لتر على الترتيب من مبيد الكلوربيريفوث] و[٠.٠٢٠ مجم/لتر و٠.٠٢٣ مجم/لتر على الترتيب من مبيد لامدا-سيهالوثرين]. وتم تغذية الأسماك مرتين فى اليوم بعليقة بها بروتين خام بنسبة ٣٢.٣٨% وتم تقدير نسبة البقاء وتسجيل الأوزان كل ١٥ يوم. وتم الحصول على الدم لدراسة النواة الصغيرة وخلايا الخياشيم لدراسة الشذوذ الكروموسومى ثم تم نقل الأسماك المعاملة لأحواض بدون معاملة بالمبيدات لمدة ٤ أسابيع أخرى لدراسة القدرة على الاصلاح هذا وقد أظهرت النتائج ما يلى:

أولاً : بالنسبة لأداء النمو :

أظهرت النتائج أن هناك فرقاً معنوياً بين جميع المعاملات مقارنة بمجموعه الكنترول عند المعاملة بالمبيدين لمدة ٤ أسابيع أما بالنسبة لنسبة البقاء ، كان هناك فرق معنوي بين المعاملات والكنترول أيضاً لكن تساوت نتائج المبيدين عند التركيز المميت لـ١٠%معاً وكذلك عند التركيز المميت لـ٢٠% للمبيدين. كما كان هناك فرق معنوي بين المبيدات والكنترول على مستوى فترة ٤ أسابيع بدون المعاملة بالمبيدين ولم يكن التحسن معنوياً مما يدل على أنه عند تعريض الأسماك للتلوث بالمبيدات فانه يؤثر على أداء النمو حتى بعد إزالة هذا التأثير فإن التحسن لم يكن تحسناً معنوياً ليصل لمستوى المجموعة الضابطة(الكنترول)

ثانياً : بالنسبة للشذوذ الكروموسومى:

أظهرت النتائج أن قدرة هذين المبيدين على إحداث شذوذ كروموسومى تراوحت بين الشظايا واللزوجة والفجوات بنسب موجبة معنوية مقارنة بالمجموعة الضابطة (الكنترول) . ودلت هذه النتائج على أن كلا المبيدين مكسرين موجبين للمادة الوراثية فى سمك البلطى النيلى. هذا وبمقارنة تأثير مبيد لامدا-سيهالوثرين بالكلوربيريفوث رغم أن كلاهما موجب إلا ان قدرة لامدا-سيهالوثرين أعلى بكثير.

ثالثاً : بالنسبة لانتاج أنوية صغيرة:

اظهرت النتائج المتحصل عليها قدرة هذين المبيدين على انتاج أنوية صغيرة مما يدل على أنهما يقدمان دليلاً موجباً لقدرتهما التكسيرية للمادة الوراثية.

رابعاً : بالنسبة الخلايا ذات النواتين:

اظهرت النتائج المتحصل عليها قدرة هذين المبيدين فى انتاج خلايا ذات نواتين بصورة معنوية موجبة وقد زادت قدرة لامدا-سيهالوثرين على الكلوربيريفوث فى انتاج هذا النوع من الشذوذ. وتدل هذه النتائج على أن كلا المبيدين رغم أن لهما قدرة على التداخل مع انقسام الخلية الا أن قدرة لامدا-سيهالوثرين أعلى.

وفى النهاية يمكن القول أن كلا المبيدين ذو تأثير موجب فى انتاج ضرر للمادة الوراثية إلا أن لامدا-سيهالوثرين قد أعطى نتائج إيجابية أعلى من الكلوربيريفوث.