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Lethal efficacy of the chitin synthesis inhibitors flufenoxuron (cas-101463) and lufenuron (cga-184699) on *Schistocerca gregaria* (orthoptera: acrididae)

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ABSTRACT

The present work was carried out aiming to assess the lethal activity of the chitin synthesis inhibitors (CSIs): Flufenoxuron (CAS-101463) and Lufenuron (CGA-184699) on the desert locust *Schistocerca gregaria*. Five concentration levels of each CSI: 1000, 500, 250, 125 and 62.5 ppm, were given through fresh clover leaves as a food to the newly moulted (4 th or 5th) instar nymphs or the late-aged 5th instar nymphs. All observations and results were recorded after 24 hours of feeding.

During few days after feeding of the newly moulted penultimate instar nymphs on Flufenoxuron treated food, the mortality increased (40%) at the highest concentration level but decreased (10%) at the lowest concentration level. The lethal action of Flufenoxuron appeared also along the later days of penultimate instar at the lower concentration levels . With few exceptions, the mortality of the last instar nymphs increased proportionally to the ascending concentration level. At the highest concentration level, the lethal action was lately exhibited in the adult stage at the lower concentration levels. Lufenuron exerted its mortal activity on the penultimate instar nymphs proportionally to the concentration level. No certain trend of the mortality of last instar nymphs could be appreciated by Lufenuron. Also, some deaths were observed among adults varying between 40% (at 250 ppm) and 14.2% (at 62.5 ppm).

After treatment of the newly moulted last instar nymphs, the available results show no certain trend of mortality, whether nymphal instar or adult stage. After treatment with the highest concentration level, the lethal effect was easily detected which spread along the nymphal instar. With regard to the adult stage, the greatest mortality was observed at 250 ppm. Among the newly moulted last instar nymphs, the mortality ascended as the conc. level of Lufenuron was increased but estimated in 49% at both 250 and 500 ppm. Several adult mortalities were recorded but in no certain trend.

After treatment of the late-aged last instar nymphs, the lethal activity of Flufenoxuron, to some extent, increased consecutively to the ascending concentration level in both nymphs and adults. The highest lethal effect of Lufenuron on late-aged last instar nymphs (30%) was observed at the higher two conc. levels. However, the lethal effect of Lufenuron on nymphs was lately recorded. Also, increasing adult mortality paralleled to the ascending concentration level with an exception.

Kew words: desert locust, *Schistocerca gregaria*, chitin synthesis inhibitors, Flufenoxuron, Lufenuron, mortality, survival potential

INTRODUCTION

Few decades ago, the so called "Third generation insecticides" was suggested including juvenile hormone analogues (JHAs). Many efforts have been made to synthesize and utilize a wide variety of JH-based insecticides against several insect species, originally advanced by Williams in 1976. All these compounds are called, also, insect growth regulators (IGRs) which are generally considered to be environmentally acceptable because they only affect systems unique to insects and certain other arthropods (Ghoneim *et al*., 2003).

The benzoylphenyl ureas (BPUs) constitute a class of the IGRs that interfere with insect growth and development by inhibiting chitin synthesis in insects (Post and Vincent, 1973). Many institutions have engaged for searching about different derivatives of the optimum molecule of BPUs "diflubenzuron", which are considerably more potent than it on various serious pests (Ishaaya *et al*., 1984, 1987; Ascher and Nemny, 1984).

Among the chitin synthesis inhibitors, BPUs (or acylureas) are gaining importance in insect pest control because their effects can easily be monitored with chemical analyses and anti-tumour activity in animal tests (Mayer *et al*., 1984). Moreover, they are relatively harmless to natural enemies (Furlong *et al*., 1994). The purpose of the present paper was to assess the lethal activity of two CSIs: Flufenoxuron (CAS-101463) and Lufenuron (CGA-184699) against the dangerous agricultural pest, desert locust *Schistocerca gregaria*.

MATERIALS AND METHODS

Experimental Insect:

A gregarious stock culture of *Schistocerca gregaria* (Forsk.) was raised by a sample from the established culture of Locust and Grasshopper Res. Division, Agric. Res. Center, Giza, Egypt. The insects were reared under crowded breeding conditions outlined by Hunter-Jones (1961) and Hassanein (1965). Newly hatched hoppers were kept in wooden cages with wire-gauze sides (40x40x60 cm) and small door in the upperside to allow the daily feeding and cleaning routine. The bottom was covered with 20 cm layer of sterilized sand. Each cages was equipped internally with 60 W electric bulb for lightening (17:7 LD) and warming (32±2 C.). The relative humidity varied from 70-80% following the introduction of fresh food plant to 60-70% several hours later. Successive generations were raised before obtaining the nymphs for the present experimental work. Fresh food plant was clover *Medicago sativa* along the period of study except few weeks every year because of the absence of this plant species. During these weeks, insects were fed on *Sesbania eagyptiaca*. All experiments were conducted with *M. sativa* only.

Nymphal Treatments with Chitin Biosynthesis Inhibitors:

Five concentration levels of the chitin biosynthesis inhibitors: Flufenoxuron and Lufenuron were prepared using the distilled water: 1000, 500, 250, 125 and 62.5 ppm. A technical concentrate 10% of Flufenoxuron (Cascade, CAS-101463-101463) was used. Its chemical name is N-{{{4-{2-chloro-4-(trifluoromethyl) phenoxy}-2-fluorophenyl} amino} carbonyl}-2,6-difluorobenzamide. A similar concentrate of Lufenuron (Match, CGA-184699) was used. Its chemical formula is: N-{{{2,5-dichloro-4-(1,1,2,3,3-hexafluoro-propoxyl)-phenyl} amino}-2,6-difluorobenzamide (CA)}}}.The concentration range was chosen depending on some preliminary trials

carried out on the present insect species. Feeding technique was applied using fresh clean clover leaves (*M. sativ*a) after dipping for 3 minutes in each concentration level. Feeding on treated food plant was allowed for 24 h for the newly moulted penultimate (4^{th}) instar, newly moulted last (5^{th}) instar or late-aged (5-day old) last instar nymphs. Control insects had been allowed to feed on untreated food plant and kept under the same laboratory conditions. Three replicates (10 nymphs/rep.) were carried out for each treatment. Each individual nymph was kept in a suitable glass vial whose bottom covered with a thin layer of sterilized sand. All vials were carefully located in a cage provided with a suitable electric bulb for lightening and warming.

Determination of the Mortal Activity:

All observations of mortal activity of each compound were recorded 24 h after feeding. The lethal effect was calculated in mortality% along the nymphal and adult days considering the initial number of treated or control nymphs.

RESULTS

A) Lethal Activity of Flufenoxuron

1) Treatments of the newly moulted penultimate instar:

The newly moulted penultimate (4^{th}) instar gregarious nymphs of *S. gregaria* were treated with five concentrations of the chitin biosynthesis inhibitor Flufenoxuron through the fresh clover leaves : 1000, 500, 250, 125 and 62.5 ppm. After a day of treatment, all possible observations were recorded. To explore the lethal activity of Flufenoxuron and consequently the survival potential of *S. gregaria*, mortality % s were assorted in Table (1). The mortality %s among the penultimate instar nymphs decreased at the lowest conc. level (10%) but increased at the highest one (40%). Through the first three days, the mortalities were recorded at the higher three concentration levels. On the other hand, a late lethal effect of Flufenoxuron during the later days was observed at the lowest concentration level. In respect of the last (5^{th}) instar nymphs, data of the same table show an increasing mortality %, with few exceptions, where no mortality % was deduced at the lowest conc. level, and the highest one (37.3%) was recorded at 500 ppm, but regressed (33.3%) at the highest conc. level !! The gradually ascending mortality % was seen through the adult stage, because the lowest % (11.11%) was calculated at the lowest conc. level but the highest one (50%) at the highest conc. level.

Table (1): Lethal effects (%) of Flufenoxuron after treatment of the newly moulted penultimate instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fourth Nymphal instar (Age in days)								Fifth Nymphal instar (Age in days)						Adult stage (Age in days)					
	1st	2nd	3rd	4th	5th	6th	7th	Total	1st	2nd	3rd	4th	5th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	100	00	00	00	00	00	00	40	50	50	00	00	00	33.3	50	50	00	00	00	50.00
500.0	50	50	00	00	00	00	00	20	33.3	00	66.6	00	00	37.3	00	50	00	50	00	40.00
250.0	50	00	00	50	00	00	00	20	00	00	50	00	50	25.0	00	00	00	100	00	16.66
125.0	00	00	50	00	00	00	50	20	00	00	00	00	100	12.5	00	00	00	00	100	14.28
62.5	00	00	00	00	100	00	00	10	00	00	00	00	00	00.0	00	00	00	00	100	11.11
Control	00	00	00	00	00	00	00	00	00	00	00	00	100	10.0	00	00	00	00	00	00.00

Conc. (ppm): Concentration (part per million).

In addition, the mortal potency was detected through the early days of both last nymphal instar and adult stage, at the higher conc. levels of Flufenoxuron. Then, this potency was lately exhibited at the lower conc. levels.

2) Treatments of the newly moulted last instar nymphs:

Dealing with the lethal effect of Flufenoxuron after treatment of the newly moulted last instar nymphs, data of Table (2) show no certain trend of the mortality % s, whatever the nymphal instar or the adult stage since the two lower conc. levels caused only 10% (vs 10% of control congeners), while the two higher concentration levels caused 40% mortality.

It was clearly noticed that the lethal effect of Flufenoxuron in the nymphal instar was exhibited immediately in the next day after treatment with the highest concentration level and then extended along all days. After treatment with the other concentration levels , the lethal action was exerted through only the later days of the nymphs.

Moving to the adult stage, data of the same table evidently show that the median conc. level yielded the highest mortality (37.5%). However, the lethal effect was observed through some days post-eclosion. After treatment with other conc. levels, such effect was lately detected through the later days of the adults.

Table (2): Lethal effects (%) of Flufenoxyron after treatment of the newly moulted last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fifth Nymphal instar (Age in days)								Adult stage (Age in days)					
	1st	2nd	3rd	4th	5th	6th	7th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	00	25	25	25	25	00	00	40	50	50	00	00	00	33.30
500.0	00	00	25	25	00	25	25	40	00	00	50	50	60	33.30
250.0	00	00	00	00	50	00	50	20	33.3	00	33.3	00	33.3	37.50
125.0	00	00	00	00	00	100	00	10	00	00	50	50	00	22.22
062.0	00	00	00	00	00	00	100	10	00	00	00	100	00	11.11
Control	00	00	00	00	00	00	100	10	00	00	00	00	00	00.00

Conc. (ppm): see footnote of Table (1).

3) Treatment of the late-aged last instar nymph:

To assess the lethal action of Flufenoxuron after treatment of the late nymphal instar, data of Table (3) reveal an increasing activity parallely- to some extent- to the ascending concentration level, whatever the nymphs or adults. The highest mortality was recorded at the highest conc. level (40% mortality of nymphs and 33.3% mortality of adults). As clearly seen in the same table, Flufenoxuron exhibited a lethal action along some days after the 1st day in both nymphal instar and adult stage.

B) Lethal Activity of Lufenuron

1) Treatments of the newly moulted penultimate instar nymphs:

Lufenuron exhibited a lethal activity on the nymphs and adults as evidently shown in Table (4). The penultimate instar nymphs suffered the mortal potency of Lufenuron as observed in different %s of mortality. These mortality %s gradually increased as the conc. level was increased (e.g., 70, 50 & 40% at 1000, 500 & 250 ppm, respectively). After treatment with the higher three conc. levels, mortalities were recorded along the first four days post-treatment. Similar result could not be obtained by the other concentration levels because the lethal effect appeared lately in the 4th nymphal instar.

In respect to the last instar nymphs, an unexpected observation was recorded since the highest mortality was caused by the lowest concentration level of Lufenuron . Moreover, a certain trend could not be attained among these mortality percentages. Also, some deaths were observed among adults. The highest mortality (40%) was found at 250 ppm and the lowest mortality (14.2%) was recorded at the lowest concentration level.

Table (3): Lethal effects (%) of Flufenoxuron after treatment of the late-aged* last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fifth Nymphal instar (Age in days)								Adult stage (Age in days)					
	1st	2nd	3rd	4th	5th	6th	7th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	25	25	00	25	00	00	25	40	50	00	50	00	00	33.3
500.0	00	00	33.3	00	66.6	00	00	30	00	50	50	00	00	28.5
250.0	00	00	00	00	00	50	50	20	00	00	100	00	00	12.5
125.0	00	00	00	00	00	100	00	20	00	00	00	00	100	12.5
62.0	00	00	00	00	00	100	00	10	00	00	00	100	00	11.11
Control	00	00	00	00	00	00	00	00	00	00	00	00	00	00.00

Conc. (ppm): see footnote of Table (1). * The 5-day old nymphs of last instar were treated with Flufenoxuron.

Table (4): Lethal effects (%) of Lufenuron after treatment of the newly moulted penultimate instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fourth Nymphal instar (Age in days)								Fifth Nymphal instar (Age in days)							Adult stage (Age in days)					
	1st	2nd	3rd	4th	5th	6th	7th	Total	1st	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	28.5	28.5	42.8	00	00	00	00	70	00	00	00	00	00	00	00	00	00	00	00	00	33.3
500.0	20.0	20.0	00.0	60	00	16.6	00	50	00	100	00	00	00	00	20	00	00	00	100	00	25.0
250.0	25.0	25.0	25.0	00	00	00	25	40	00	00	100	00	00	00	16.66	00	00	00	00	00	40.0
125.0	00.0	00.0	00.0	50	00	00	50	20	00	00	00	00	00	100	12.5	00	00	00	100	00	28.5
62.5	00.0	00.0	00.0	00	00	00	100	10	00	00	00	50	50	00	22.2	00	00	00	00	100	14.2
Control	00.0	00.0	00.0	00	00	00	00	00	00	00	00	100	00	00	10	00	00	00	00	00	00.0

Conc. (ppm): see footnote of Table (1).

2) Treatments of the newly moulted last instar nymphs:

Table (5) contains the results of lethal activity of Lufenuron after treatment of newly moulted last (5^{th}) instar nymphs with different concentration levels . The nymphal mortalities were found in a proportional relationship to the concentration level except a constant % (40%) at both 500 and 250 ppm. The mortality varied between 60% (as a maximum at 1000 ppm) and 10% (as a minimum at 62.5 ppm).

No certain trend was detected for the mortality in the adult stage but ranged from 16.6% (at 250 ppm) to 50% (at 500 & 1000 ppm). However, the lethal effect early appeared during the first two days post-eclosion (at the higher two concentration levels) but lately exhibited at 125 ppm.

Table (5): Lethal effects (%) of Lufenuron after treatment of the newly moulted last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fifth Nymphal instar (Age in days)							Adult stage (Age in days)					
	1st/	2nd	3rd	4th	5th	6th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	50	16.6	16.6	16.6	00.0	000.0	60	50.0	50.0	00	000	00	50.00
500.0	25	25	00.0	25.0	25.0	000.0	40	66.6	33.3	00	000	00	50.00
250.0	00	00	25.0	25.0	00.0	050.0	40	00.0	00.0	00	100	00	16.60
125.0	00	00	00.0	33.3	33.3	033.3	30	00.0	00.0	00	050	50	28.57
062.5	00	00	00.0	00.0	00.0	100.0	10	00.0	00.0	00	100	00	22.20
Control	00	00	00.0	00.0	00.0	000.0	00	00.0	00.0	00	000	00	00.00

Conc. (ppm): see footnote of Table (1).

3) Treatments of the late-aged last instar nymphs:

As distributed in Table (6), the nymphal mortalities almostly run consecutively to the concentration level of Lufenuron with few exceptions. Regardless of the highest concentration level, Lufenuron exhibited its mortal potency lately in the nymphal instar. With regard to the adult survival potential, data of the same table show increasingly affected potential with increasing concentration level, with few exceptions. All adult mortalities were observed during the first or the second day post-eclosion, except at the highest concentration level.

Table (6): Lethal effects (%) of Leufenuron after treatment of the late-aged* last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Fifth Nymphal instar (Age in days)									Adult stage (Age in days)					
	1st	2nd	3rd	4th	5th	6th	7th	8th	Total	1st	2nd	3rd	4th	5th	Total
1000.0	00	33.3	33.3	33.3	00.0	00.0	00.0	00	30	50	00	25.0	25.0	00.0	57.14
500.0	00	00.0	00.0	33.3	33.3	00.0	33.3	00	30	00	50	50.0	00.0	00.0	28.50
250.0	00	00.0	00.0	00.0	00.0	00.0	50.0	50	20	00	00	33.3	33.3	33.3	37.50
125.0	00	00.0	00.0.	00.0	100	00.0	00.0	00	10	00	00	50.0	50.0	00.0	22.20
062.5	00	00.0	00.0	00.0	00.0	100	00.0	00	10	00	00	00.0	50.0	50.0	22.20
Control	00	00.0	00.0	00.0	00.0	00.0	00.0	00	00	00	00	100	00.0	00.0	10.00

Conc. (ppm): see footnote of Table (1). * : see footnote of Table (3).

DISCUSSION

The chitin synthesis inhibitor "Flufenoxuron" (Cascade, CAS-101463) was assessed against several serious insect species, such as oriental migratory locust, *Locusta migratoria manilensis* (Long *et al*., 1999; Zhongren *et al*., 2002); European vine moth *Lobesia botrana* (Charmillot *et al.*, 1994; Boselli *et al*., 2000; Bressan *et al*., 2002).

Also, Lufenuron (Fluphenacurn, Match, CGA-184699) is a chitin synthsis inhibitor (CSI) (or insect growth regulator IGR, in general) which was assessed against various harmful insect species, such as fruit tortix, *Adoxophyes orana*

(Charmillot *et al*., 1991; Ioriatti *et al*., 1993); cat flea, *Ctenocephalides felis* (Hink *et al*., 1991; Jacobs *et al*., 2001); the hemipteran *Triatoma infestans* (Diotaiuti *et al*., 1996); the red palm-weevil, *Rhynchophorus ferrugenius* (Tanani, 2001); the dipteran *Drosophila melanogaster* (Bogwitz *et al*., 2005); the homopteran *Bemisia tabaci* and lepidopteran *Helicoverpa armigra* (Gogi *et al*., 2006); bumble bee, *Bombus terrestris* (Mommaerts *et al*., 2006), etc……

These and other promising results fostered to assess these two CSIs, Flufenoxuron and Lufenuron on the desert locust *Schistocerca gregaria* in the present study. Five concentration levels were given through the fresh food to the newly moulted penultimate instar, newly moulted or late-aged last instar nymphs: 1000, 500, 250, 125 and 62.5 ppm.

After treatment of the newly moulted penultimate instar nymphs of *S. gregaria*, Flufenoxuron exhibited a lethal activity along the treated instar. The mortality of the next instar nymphs was early observed and was dose-dependent. Also, Lufenuron exerted a mortal action on the treated penultimate instar nymphs proportionally to the conc. level which could not be observed in the next nymphal instar. However, some adult deaths were caused by both CSIs. Among other CSIs, the mortal potency depends on the compound itself or on other factors such as the application method, the instar or stage under test, the timing of treatment (or the physiological age), etc… By using some CSIs, Ishaaya *et al*. (1984) found that triflumuron (Bay Sir-8514) was 4.3 times more in favor of chlorfluazuron (IKI-7899). Ghoneim *et al*. (1992) recorded a dose-dependent initial larval mortality of *Muscina stabulans* by the action of Bay Sir-8514. Whereas the dimiloid DU-19111 acted only on the immature stages but not on the adult (Van Daalen *et al*., 1972), Ghoneim et al. (2004) recorded pupal and adult mortalities of *Musca domestica* but no larval mortality by Lufenuron (CGA-184699) of Diofenolan (CGA-59205). Dissimilarly, the second instar larvae of *Spodoptera littoralis* were the most susceptible and the last instar larvae were the least susceptible to benzoylphenyl ureas (BPUs) (Betana, 2000) which confirmed other similar findings (Aikins and Wright, 1985).

After treatment of the newly moulted last (5^{th}) instar nymphs of *S. gregaria* with Flufenoxuron (CAS-101463) in the present study, no certain trend of the lethal action of Flufenoxuron could be detected for either the nymphal instar or adult stage. On the other hand, Lufenuron exhibited a dose-dependent mortal activity against nymphs but not adults. Furthermore, the lethal effect of Flufenoxuron was nearly dose-dependent in both nymphs and adults after treatment of the late-aged last instar nymphs. Also, Lufenuron caused late mortality among nymphs and adult deaths were almostly parallel to the concentration level.

More or less, the present results agree with those findings by several CSIs against the same acridid species, *S. gregaria*, such as diflubenzuron (DFB) which interfered with the chitin synthesis during the nymphal ecdysis to the last instar causing some mortalities (Taha and El-Gammal, 1985) and chlorfluazuron which affected the survival potential in a dose-dependent manner (Tiwari, 2000). Diflubenzuron caused various mortality %s after 14 days of the treatment of the second instar nymphs (Azam and Al-Seegh, 1993). The CSI, IKI-7899 caused increasing mortality during the 4^{th} and 5^{th} instars (Abdel-Magid, 1993). Triflumuron (Alsystin, Bay Sir-8514) caused different mortalities after the 5 to 15 days of the barrier application in Mauritania (Wilps and Diop, 1997). The compounds DFB, hexaflumuron (XRD-473) and teflubenzuron (CME-13406) exhibited different LC50s during a comparative laboratory evaluation conducted by Coppen and Jepson (1996)

who recorded the narrowest response to DFB and the widest range of response to CME-13406. Imidazole (KK-42) caused 80% mortality after treatment with 100 µg/insect (Kumari *et al*., 2001). Flufenoxuron showed high toxicity with an average LD50 of 26.5 mg/kg and LT50 of 4.94 days (Zhongren *et al*., 2002). The CSI, IKI-7899 exhibited LC50 of 28.4 mg/kg and LT50 of 5.22 days (Zhongren *et al*., 2002).

In addition, several species of grasshoppers had been affected by the lethal activity of different CSIs (Ahmad and Khan, 1992; Jec *et al*., 1993; Krokene, 1993; Mathure and Saxena, 1997; Mohamed, 1998; Smith and Lockwood, 2003).

The present study showed various degrees of the mortal power of two CSIs: Flufenoxuron and Lufenuron, depending on the developmental nymphal instar under treatment or its physiological age. Whatever, the lethal action of each CSI was dose-dependent or no, such nymphal and adult mortalities may be ascribed to a direct inhibition of chitin synthesis within the integument rather than to any indirect extra-cuticular effects on hormone levels (Sowa and Marks, 1975; Hajjar and Casida, 1978). Also, the actual cause of insect death by CSIs may be attributed to either rupture of the newly formed cuticle or an interference with feeding (Salama *et al*., 1976; Abid *et al.,* 1978; Fytizus and Mourikis, 1979). These suggestions can be appreciated for the later death as recorded in the present study on *S. gregaria* in which initial killing power of Flufenoxuron or Lufenuron could not be recorded since no mortality was observed immediately after the treatment.

On the other hand, the adult mortality by the nymphal treatments with Flufenoxuron or Lufenuron , in the present study, can be explained by the high retention and distribution of CSIs (or IGRs, in general) in the insect body as a result of rapid transport from the gut into the nymphal tissues, the direct and rapid transport through the haemolymph to the nymphal tissues, and/or of lower detoxification, in addition to slow and gradual elimination for such compounds from the insect body (Granett *et al.*, 1980; Osman, 1984; Guyer and Neuman, 1988). However, the larvicidal action of CSIs results primarily from the ingestion of these compounds and their penetration through the larval body (Ishaaya, 1990).

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ARABIC SUMMERY

الكفاءة المميتة لكل من فلوفينوكسرون ولوفينورون في الجراد الصحراوي *شيستوسركا جريجاريا*
(مستقيمات الأجنحة: الجراديات).

رضا فضيل بكر[1]، كارم السيد غنيم[2]، علاء جودة الدالي[2]، محمد علي طناني[2]، أحمد صابر بريم[2]
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استهدف البحث الحالي الكشف عن نشاط اثنين من مثبطات تخليق الكيتين، هما: فلوفينوكسرون، لوفينورون ، في موت الجراد الصحراوي *شيستوسركا جريجاريا* . ومن أجل هذا ، عوملت حوريات الدور الرابع (حديثة الإنسلاخ) ، وحوريات الدور الخامس حديثة الإنسلاخ أو المتقدمة في العمر) بخمسة تركيزات من المركب ، هى : 1000 ، 500 ، 250 ، 125 ، 62.5 ج ف م ، وذلك من خلال الغذاء الطازج الذي تناولته الحوريات ليوم واحد فقط ، وبعده تم تسجيل النتائج . خلال الأيام القليلة بعد معاملة حوريات الدور الرابع (ما قبل الأخير) بمركب فلوفينوكسرون ، تزايدت النسب المئوية (40%) عند أعلى تركيز ، لكنها تناقصت (10%) عند

أقل تركيز. كما ظهر التأثير المميت للمركب بامتداد عمر الدور الرابع عند التركيزات المنخفضة . وتزايدت نسب الوفيات في الدور الحوري الأخير تزايداً موازياً لارتفاع التركيز ، مع وجود استثناءات قليلة . وبعد استعمال أعلى تركيز، ظهر التأثير المميت للمركب في الأيام الأولى من فترة حياة اليافعات ، لكنه ظهرا متأخرا بعد استعمال التركيزات المنخفضة . بذل مركب لوفينورون نشاطا قاتلاً على حوريات الدور الرابع ، وتزايد هذا النشاط مع ارتفاع مستوى التركيز . ولم يلاحظ وجود اتجاه محدد للوفيات في الدور الحوري الخامس (الأخير)، ولكن هناك بعض الوفيات تم تسجيلها في اليافعات ، تراوحت نسبها بين 40% (عند تركيز 250 ج ف م) و 14،2% (عند تركيز 62.5 ج ف م) .

أدت المعاملات التي أجريت لحوريات الدور الأخير حديثة الإنسلاخ بمركب فلوفينوكسرون إلى وقوع وفيات ، دون وضوح اتجاه محدد لنسبها المئوية . وبالنسبة لوفيات اليافعات ، فلقد أدى استعمال تركيز 250 ج ف م إلى حدوث أعلى نسبة وفيات. تزايدت نسب الوفيات فيما بين حوريات الدور الأخير بتزايد مستوى تركيز مركب لوفينورون ، ولكنها ثبتت عند 49% بعد استعمال كل من 500 ، 250 ج ف م .

أما معاملة حوريات الدور الأخير المتقدمة في العمر ، بتركيزات من مركب فلوفينوكسرون ، فقد أدت إلى تصاعد نسب الوفيات مع تصاعد مستوى التركيز ، إلى حد ما ، سواء كان هذا في الحوريات أم في اليافعات. وأما مركب لوفينورون ، فقد ظهر أعلى تأثير إماتي له (30%) بعد استعمال أعلى تركيزين منه ضد هذه الحوريات المتقدمة في العمر. وظهر التأثير الإماتي له ، عموماً ، في الأيام المتأخرة من حياة الحوريات . وكذلك ظهر تأثير المركب في وقوع وفيات اليافعات متزايداً بتزايد مستوى التركيز، مع استثناء وحيد هو ثبات النسبة 22،2% عند أقل تركيزين .