Egypt. Acad. J. biolog. Sci., 1 (1) 41- 57 (2008) ISSN: 1687 – 8809
E. mail. egyptianacademic@yahoo.com
Received: 24/12/2007

Efficiency of the chitin synthesis inhibitor lufenuron (cga-184699) on growth, development and morphogenesis of *Schistocerca gregaria* (orthoptera: acrididae).

Bakr, R.F.[1]; Ghoneim, K.S. [2]; Al-Dali, A.G. [2]; Tanani, M.A. [2] and Bream, A.S. [2]
1- Department of Entomology, Faculty of Science, Ain Shams University
2-Department of Zoology, Faculty of Science, Al-Azhar University, Cairo, Egypt
For Corresponding: kar_ghoneim@yahoo.com

ABSTRACT

This paper deals with the objective of investigating the effects of Lufenuron (CGA-184699) on the growth, development and morphogenesis of the desert locust *Schistocerca gregaria*. Five concentration levels (1000, 500, 250, 125 and 62.5 ppm) were given through the fresh plant food to the newly moulted (4^{th} or 5^{th}) instar or late-aged 5^{th} instar nymphs. All results were obtained 24 h after feeding.

The growth of Lufenuron-treated nymphs was profoundly inhibited because their weight gain was drastically reduced. Such reducing action of Lufenuron was dose-dependent after treatment of 4^{th} instar nymphs but at the higher two concentration levels after treatment of newly moulted 5^{th} instar nymphs and at the higher three concentration levels after treatment of late-aged 5^{th} instar nymphs. After treatment of the last instar nymphs, early or late-aged, the developmental rate detrimentally regressed as a response to the prohibiting action of Lufenuron on the development. In contrast, such rate was promoted during significantly shortened duration after treatment of 4^{th} instar nymphs, may be to accelerate the development for avoiding additional adverse effects of Lufenuron.

Lufenuron exhibited an inhibitory effect on the adult emergence after treatment of last instar nymphs, regardless of the timing of treatment. On the other hand, Lufenuron exerted no effect on this vital process after treatment of 4^{th} instar nymphs. Moreover, the present compound, at certain concentration levels, induced the adults to emerge in a rate more than that on control congeners. However, the emerged adults suffered a morphogenic action of Lufenuron because different deformed females were produced in increasing % as, at least, the higher three concentration levels were increased. In addition, the adult females spent only shortened longevity and then died. The shortening effect was dose-dependent after treatment of 4^{th} instar nymphs.

Kew Words: *Schistocerca gregaria*, Lufenuron, growth, development, emergence, morphogenesis, longevity.

INTRODUCTION

Because the use of insecticides for controlling insect pests has several disadvantages to various environmental aspects, including human health and economics, numerous institutions have extensively searched alternatives such as insect growth regulators (IGRs) including juvenile hormone analogues (JHAs), chitin synthesis inhibitors (CSIs) and ecdysteroids (for reviews, see: Post and Vincent, 1973; Slama, 1974; Staal, 1975; El-Ibrashy, 1984; Hoffman and Lorenz, 1998; Tunaz and Uygun, 2004). Retnakaran *et al.* (1985) identified benzoylphenyl ureas (BPUs), JHAs (or juvenoids), antijuvenoids and miscellaneous IGRs as 4 distinct classes of growth

regulators. The BPUs have been subjected to intensive investigations because of their commercial importance and their interference with the moulting and other physiological processes (Soltani *et al.*, 1993; Casida and Quistad, 1998; Ghoneim *et al.*, 2006). The present investigation deals with various growth and developmental impacts of the CSI, Lufenuron (CGA-184699) on the 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.

Lufenuron Preparation and Administration:

Five concentration levels of the chitin biosynthesis inhibitor Lufenuron were prepared using the distilled water: 1000, 500, 250, 125 and 62.5 ppm. A technical concentrate 10% 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 provided with a thin layer of sterilized sand. The vials were carefully located in a cage supported with a suitable electric bulb for lightening and warming.

Criteria Studied and Calculations:

Growth, development, metamorphosis and morphogenesis were determined as detailed herein. The fresh body weight was recorded every day using an electric digital balance. The weight gain was calculated as follows: initial weight (before the beginning of experiment) – final weight (at the end of experiment). The growth inhibition was calculated as follows: {a- A/A}x 100, where: a: maximal weight of treated nymphs, A: maximal weight of control nymphs. The developmental duration of nymphal instars, treated or control, was estimated using Dempster' equation (1957). The developmental rate was calculated according to the equation: Developmental rate = 100/mean duration (in days). The adult emergence was estimated in %

whatever the morphogenesis was perfect or defected. All morphogenic aberrations were counted, calculated in % and recorded in photographic plates. The adult longevity comprised all adult physiological phases: maturation period, reproductive lifetime and post-oviposition period. It was calculated in mean days ±SD.

Statistical Analysis :

Data obtained were analyzed using the Student *t*-distribution and were refined by Bessel's correction (Moroney, 1969) for testing the significance of difference between means.

RESULTS

Treatments of the newly moulted penultimate instar nymphs:

a) Growth and Developmental Effects of Lufenuron:

Assorted data in Table (1) obviously show the enormous action of Lufenuron on growth and development of *S. gregaria*. The nymphal growth was prohibited since the weight gain pronouncedly decreased as the concentration level (concentration level) was increased. For some details, while nymphs gained 0.281±0.113 g (not significant) at the lowest concentration level, the reduction of their weight gain increased until 0.120±0.01 g ($p< 0.001$) at the highest concentration level . Another parameter may be informative, because the somatic growth change% of control nymphs was recorded as 83.80±9.68% vs 76.70±12.15 and 25.14±12.14% at 62.5 and 1000 ppm, respectively. In addition, the highest growth inhibition% (35.82%) was calculated after treatment with the highest concentration level of Lufenuron.

The developmental rate, on the other hand, was undergone to the action of Lufenuron , but in a reverse correlation. As for example, it was 11.76 at 62.5 ppm and 14.49 at 1000 ppm (vs 10.52 of control congeners). Depending on these data, Lufenuron promoted the nymphal rate of development through shortened time intervals (e.g., 6.90±1.03 days at 1000 ppm, vs 9.50±1.15 days of control congeners).

Table (1): Growth and developmental effects of Lufenuron on *Schistocerca gregaria* after treatment of the newly moulted penultimate instar nymphs.

Conc. (ppm)	Mean weight (g ± S.D.)	Weight gain (g ± S.D.)	Change (%)	Growth inhibition (%)	Duration (days ± S.D.)	Develop. Rate
1000.0	0.430 ± 0.091 d	0.120 ± 0.010 d	25.14 ± 12.14 d	35.82	6.90 ± 1.03 d	14.49
500.0	0.437 ± 0.089 d	0.183 ± 0.034 d	38.94 ± 18.16 d	34.77	7.00 ± 1.41 d	14.85
250.0	0.457 ± 0.173 c	0.216 ± 0.075 b	46.59 ± 24.30 c	26.11	7.00 ± 2.05 b	14.85
125.0	0.495 ± 0.183 b	0.258 ± 0.112 a	57.05 ± 25.06 b	21.34	8.10 ± 2.76 a	12.34
062.5	0.606 ± 0.127 a	0.281 ± 0.113 a	76.70 ± 12.15 a	09.55	8.50 ± 2.17 a	11.76
Control	0.670 ± 0.053	0.375 ± 0.105	83.80 ± 9.68	00.00	9.50 ± 1.15	10.52

Conc. (ppm): concentration (part per million), Mean ± S. D. followed with same letter (a) are not significantly ($p>0.05$), (b): significantly different ($p<0.05$), (c): highly significantly different ($p<0.01$), (d): very highly significantly ($p<0.001$). Develop. Rate: Developmental rate.

b) Metamorphosing and Morphogenic Effects of Lufenuron:

Just a look at the data of Table (2), the eclosion of treated adults had astonishingly exceeded that of control congeners. This metamorphosing event was unexpectedly promoted by Lufenuron and increased by increasing concentration level . Whatever, several grades of affected morphogenesis were recorded. The %s of

malformed adults increased as the conc. level was ascended, especially the higher three ones (14.2, 28.5 & 40.0% at 250, 500 % 1000 ppm, respectively). Various symptoms or shapes of deformation are shown in Plate (1), such as: incomplete eclosion with twisted legs and curled wings. It is easy to say all these adult derangements might be due to the morphogenic action of Lufenuron (for more details, see Table 2).

Table (2): Adult performance as affected by Lufenuron after treatment of the newly moulted penultimate instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Deform.	Emerg.	Longevity*
1000.0	33.3	100.0	23.00 ± 6.67 d
500.0	25.0	080.0	39.00 ± 3.70 d
250.0	40.0	083.3	39.50 ± 4.20 d
125.0	28.5	087.5	47.75 ± 3.86 a
062.5	14.2	077.7	49.75 ± 3.75 a
Control	00.0	090.0	54.35 ± 4.34

Conc. (ppm), a and d: see footnote of Table (1). Emerg.: Emergence (%), Deform.: Deformation (%). *: Mean days ± SD

Not only the adult morphogenesis and metamorphosis but also the adult longevity was pronouncedly affected by Lufenuron Those successfully emerged adults lasted short longevity and then died. Generally. longevity was found in a reverse correlation with the concentration level of Lufenuron .

Treatments of the newly moulted last instar nymphs:

a) Growth and Developmental Effects of Lufenuron:

By the careful examination of the data given in Table (3), it can be concluded that Lufenuron considerably affected the nymphal growth and development. The nymphal weight gain was reversely correlated to the conc. level. It was deduced as 0.515±0.263 and 0.497±0.138 g at the two lower concentration levels, while as 0.362±0.131 and 0.128±0.102 g at the two higher concentration levels .

The change% supported the previously mentioned finding (78.86±18.7 and 38.56±15.36 % at 62.5 and 1000 ppm, respectively, vs 85.71±16.46 % of control congeners). In addition, the highest growth inhibition was found as 23.39 % at the highest concentration level of Lufenuron.

Table (3): Growth and developmental effects of Lufenuron on *Schistocerca gregaria* after treatment of the newly moulted last instar nymphs.

Conc. (ppm)	Mean weight (g ± S.D.)	Weight gain (g ± S.D.)	Change (%)	Growth inhibition (%)	Duration (days ± S.D.)	Develop. Rate
1000.0	0.881 ± 0.203 b	0.128 ± 0.102 d	38.56 ± 15.36 d	23.39	07.8 ± 1.95 d	12.82
500.0	0.885 ± 0.216 a	0.362 ± 0.131 c	56.41 ± 11.14 d	23.04	08.5 ± 1.95 c	11.76
250.0	0.896 ± 0.325 a	0.488 ± 0.116 a	68.15 ± 23.25 a	22.08	08.9 ± 2.46 a	11.23
125.0	0.943 ± 0.322 a	0.497 ± 0.138 a	75.71 ± 23.01 a	18.12	09.3 ± 2.58 a	10.75
062.5	0.968 ± 0.337 a	0.515 ± 0.263 a	78.86 ± 18.76 a	15.82	10.1 ± 1.10 a	09.90
Control	1.151 ± 0.244	0.536 ± 0.168	85.71 ± 16.46	00.00	10.9 ± 0.98	09.17

Conc. (ppm), a, b,. c, d, Develop. Rate : see footnote of Table (1).

Data of the same table clearly provide a dissimilar action of Lufenuron on the nymphal developmental rate, since increased by increasing concentration level (9.90 and 12.82 at 62.5 and 1000 ppm, respectively , vs 9.17 of control congeners). That is to say, Lufenuron hastened the nymphal development through shortened durations (10.1±1.10 and 7.8±1.95 days at the same mentioned concentration levels, respectively , vs 10.9±0.98 days of control congeners).

b) Metamorphosing and Morphogenic Effects of Lufenuron:

Data assorted in Table (4) demonstrate the possible effects of Lufenuron on the adult performance of *S. gregaria* after treatment of the newly moulted last instar nymphs. Firstly, the adult emergence was partially blocked. This blockage was seen parallely to the concentration level reaching 40% (at 1000 ppm) in comparison to 100% of control adults.

Aside with the metamorphic action of Lufenuron, it remarkably affected the adult morphogenesis. The highest % of adult deformity was recorded at the higher two concentration levels . Also, various symptoms of such deformation can be easily observed in Plate (1).

Moreover, the emerged adults survived only a shortened longevity which could be attributed to the death- accelerating action of Lufenuron . The shorter longevities were 37.00±3.96 and 37.50±4.60 days at 1000 and 500 ppm, respectively (compared to 48.30±2.55 days of control adults).

Table (4): Adult performance as affected by Lufenuron after treatment of the newly moulted last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Deform.	Emerg.	Longevity*
1000.0	50.00	040	37.00 ± 3.96 d
500.0	50.00	060	37.50 ± 4.60 c
250.0	16.66	060	40.50 ± 4.27 b
125.0	28.57	070	43.50 ± 3.51 a
062.5	22.20	090	47.75 ± 4.11 a
Control	00.00	100	48.30 ± 2.55

Conc. (ppm), a, b, c, d: see footnote of Table (1). Emerg., Deform., *: see footnote of Table (2).

Treatments of the late-aged last instar nymphs:

a) Growth and Developmental Effects of Lufenuron:

After treatment of the late-aged last instar nymphs, the obtained results were arranged in Table (5). An inhibitory action of Lufenuron can be easily detected because the treated nymphs were prevented to gain normal somatic increments, especially at the higher three concentration levels (0.468±0.137, 0.340±0.131 & 0.316±0.116 g at 250, 500 & 1000 ppm, respectively , vs 0.598±0.233 g of their control correspondings). Moreover, the growth inhibition % expressed and confirmed the previously denoted data since it increased by the increasing concentration level (as for example, 9.90 and 42.23 % at 62.5 and 1000 ppm, respectively). Also, Lufenuron

prohibited the nymphal development because their life duration was prolonged consecutively to the ascending concentration level and *vice versa* (Table 5).

Table (5): Growth and developmental effects of Lufenuron on *Schistocerca gregaria* after treatment of the late-aged** last instar nymphs.

Conc. ppm	Mean weight (g ± S.D.)	Weight gain (g ± S.D.)	Change (%)	Growth inhibition (%)	Duration (days ± S.D.)	Develop. Rate
1000.0	0.930 ± 0.285 d	0.316 ± 0.116 c	41.39 ± 10.16 d	42.23	10.20 ± 2.78 c	09. 80
500.0	1.112 ± 0.375 c	0.340 ± 0.131 b	64.61 ± 11.27 a	31.05	09.80 ± 3.40 b	10.20
250.0	1.271 ± 0.398 b	0.468 ± 0.137 b	65.46 ± 11.07 a	21.11	09.50 ± 2.34 b	10.52
125.0	1.296 ± 0.483 a	0.490 ± 0.225 a	67.85 ± 15.66 a	19.87	08.01 ± 2.12 a	12.34
062.5	1.450 ± 0.222 a	0.518 ± 0.281 a	70.19 ± 5.66 a	09.90	07.80 ± 2.20 a	12.82
Control	1.610 ± 0.223	0.598 ± 0.233	70.64 ± 10.88	00.00	06.80 ± 1.85	14.70

Conc. (ppm), a, b,. c, d, Develop. Rate and No. of insect used for each replicates of treatment and control: see footnote of Table (1). ** the 5-day old nymphs of last instar were treated with Lufenuron.

b) Metamorphosing and Morphogenic Effects of Lufenuron:

Data given in Table (6) evidently reveal the affected adult performance, by Lufenuron treatments against the last instar nymphs .

The adult emergence was blocked in different degrees depending on the conc. levels of Lufenuron. These successfully eclosed adults suffered a morphogenic action of Lufenuron because the highest deformity (57.14%) had been recorded at the highest concentration level. However, the adult deformity increased by increasing conc. level. Several malformed adults have been shown in Plate (1). Only short longevity, but statistically insignificant, was lasted by the treated adult females ending in death.

Table (6): Adult performance as affected by Lufenuron after treatment of the late-agde** last instar nymphs of *Schistocerca gregaria*.

Conc. (ppm)	Deform.	Emerg.	Longevity*
1000.0	57.14	070	41.75 ± 3.24 a
500.0	28.50	070	43.30 ± 4.02 a
250.0	37.50	080	43.25 ± 3.81 a
125.0	22.20	090	43.33 ± 3.88 a
62.5	22.20	090	42.25 ± 2.06 a
Control	00.00	100	44.79 ± 3.85

Conc. (ppm), a and b: see footnote of Table (1). Emerg., Deform., * : see footnote of Table (2). **: see footnote of Table (5).

DISCUSSION

Growth of *S. gregaria* as influenced by Lufenuron.

Studies on different insects have shown that chitin synthesis inhibitors (CSIs) can affect the production of the peritrophic matrix of the locust *Locusta migratoria* (Clarke *et al*., 1977) and the blowfly *Calliphora erythrocephala* (Becker, 1978).

These chemicals also affect hardening of the cuticle of the boll weevil *Anthonomus grandis grandis* (Haynes and Smith, 1994) and development of the pupal integument of the yellow mealwom *Tenebrio molitor* (Soltani *el al*., 1987).

The diflubenzuron (DFB), pioneer of the Bezoylphenyl ureas (BPUs), affects the growth and development, among other important criteria, of several insect species (Osman, 1984; Soltani-Mazouni, 1994; Khebbeb *et al*., 1997; Basiouny, 2000). Reduction of the body weights, weight gain, or the growth in general, was reported for several species by different CSIs, such as*: Musca domestica* (Bakr *et al*., 1991), *Spodoptera littoralis* (Ghoneim *et al*., 1998), *Spodoptera exempta, Spodoptera exigua, Mamestra brassicae* and *Galleria mellonella* (Smagghe and Degheele, 1994).

In the present study, five concentration levels of each of the CSI (Lufenuron, CGG-184699) were given to the newly moulted penultimate, newly moulted last, or late-aged last instar nymphs of *S. gregaria* through the fresh food. Lufenuron obviously deteriorated the growth of nymphs because their weight gain drastically decreased as the concentration level was increased after treatment of the newly moulted 4^{th} instar nymphs but at the higher two concentration levels after treatment of the last instar (early or late-aged) nymphs.

The present results resemble, to a great extent, those results of other BPUs against different insect species (Mitsui *et al*., 1980; Estal *et al*., 1994; Mondall and Port, 1995; Parween, 1996a). Also, decreased body weight gain and inhibited growth were caused by cyromazine on the house fly *M. domestica* (El-Oshar *et al*., 1985), IKI-7899 on the grey flesh fly *Parasarcophaga argyrostoma* (Ghoneim and Ismail, 1995c), chlorfluazuron on *S. gregaria* (Tiwari, 2000) and by Lufenuron and Diofenolan (CGA-59205) on *M. domestica* (Ghoneim *et al*., 2004).

Lufenuron Effects on the Development of *S. gregaria*

Prolongation of the immature stages of different insect species had been recorded for several BPUs (and CSIs, in general), such as IKI-7899 against *S. littoralis* (Morsi, 1985), DFB against *Trogoderma granarium* (Vir, 1988), hexaflumuron (XRD-473) and Bay Sir-8514 against *Tribolium castaneum* (Estal *et al*., 1994; Parween, 1996a), DFB and furyltriazine against *T. granarium* (Saxena and Kumar, 1991), Bay Sir-8514 or IKI-7899 against *S. gregaria* (Abdel-Magid, 1993), IKI-7899 and XRD-473 against *Eupripocnemis plorans* (Mohamed, 1998), DFB, XRD-473 and CME-13406 against *S. gregaria* (Coppen and Jepson (1996a), Bay Sir-8514 against *M. stabulans* (Ghoneim *et al*., 1992), IKI-7899 against *P. argyrostoma* (Ghoneim and Ismail, 1995 c), DFB against *S. littoralis* (Radwan *et al*., 1978), Bay Sir-8514 against *Tribolium confusum* (El-Sayed *et al*., 1984), IKI-7899 against *Culex pipiens* (Bakr *et al*., 1989), XRD- 473 and Bay Sir-8514 against *Aedes aegypti* (Mohapatra *et al*., 1996).

On the contrary, CGA-184699 and CGA-59205 failed to affect the developmental duration or rate of the immature stages of *M. domestica* (Ghoneim *et al*., 2004). Moreover, some CSIs induced the developmental rate along shortened duration, as seen in the present study on *S. gregaria* after treatment with Lufenuron at certain physiological ages of nymphs. So, many similar findings can be obtained by the literature, as for example, Tanani (2001) recorded shortened developmental duration of *Rhynchophorus ferrugineus* by CGA-184699 and CGA-59205 and El-Sheikh (2002) observed shortened larval duration of *Agrotis ipsilon* by Flufenoxuron. Also, Flufenoxuron exhibited a shortening effect on the developmental duration of *S. gregaria* at certain concentration levels and insignificant lengthening effect at other concentration levels (communication with Tanani, 2007)

A variation in the developmental action was clearly observed by the action of Lufenuron, in the present study. Whereas Lufenuron promoted the developmental rate along significantly shortened duration after treatment of the newly moulted nymphs (of 4^{th} or 5^{th} instar), it retarded such rate along pronouncedly prolonged duration after treatment of the late-aged last instar nymphs. Anyhow, the considerably shortened nymphal duration usually indicates a fostered developmental rate may be for avoiding a further serious action of Lufenuron during the normal duration.

The presence of great variation in effects of BPUs (or CSIs, in general) on the insect development may be largely due to the large species-variations in respect to relative potency of various BPUs on different insect species. This variation may also be resulted from the different mechanisms of ecdysteroid metabolism existing in different insects (Whisenten *et al*., 1989). However, the inhibitory action of CSIs on the development (as expressed in prolonged developmental duration) in various insect species may be explained by causing an imbalance in the hormone titers at critical times of moulting because the proper balance in the hormone titers is necessary for normal growth and transformation into the pupal stage (Retnakaran *et al*., 1985; Sehnal and Bryant, 1993).

Adult Performance of *S. gregaria* as affected Lufenuron.

In regard to the ***Adult emergence*** of *S. gregaria*, in the present study, no inhibitory effect could be detected after treatment of the newly moulted penultimate instar nymphs with Lufenuron. On the contrary, a considerable inhibitory action was exerted on the adult emergence after treatment of the late-aged last instar nymphs.

However, partial or complete blocking of the adult emergence, of other than the orthopterans, have been documented for several CSIs such as: IKI-7899 against *S. littoralis* (Morsi, 1985), CME-13406, XRD-473, DFB, IKI-7899 & Bay Sir-8514 against *Culex pipiens* and *C*ulex *quinquefasciatus* (Mulla and Darwazeh, 1988), CME-13406 and IKI-7899 against *M. domestica* (El-Kordy *et al*., 1989; Ghoneim *et al*., 2004), XRD-473 against some mosquito species (Vasuki and Rajavel, 1992), DFB against *S. littoralis* (Gamal *et al*., 1994), IKI-7899 against *P. argyrostoma* (Ghoneim and Ismail, 1995 c), DFB against the stone fly *Pelloperta arcuata* (Griffth *et al*., 1996), DFB and some of its analogues against *Muscina stabulans* (Basiouny, 2000), IKI-7899 against *S. littoralis* (Mesbah *et al*., 1996; Bakr *et al*., 2005), IKI-7899 against *Pectinophora gossypiella* (El-Nemaky, 2000), IKI-7899 against *Earias insulana* (El-Nemaky and Azab, 2004), Lufenuron (CGA-184699) against *Lobesia botrana* (Saenz-de-Cabezon *et al*., 2006), etc… In contrast, CME-13406 exhibited no influence on the adult emergence of the grasshopper *Aiolopus thalassinus* (Schmidt *et al*., 1993).

Whatever these contradictory results, a number of suggestions have been introduced to shed some light on the mode of action of CSIs since Mulder and Gijswijt (1973) supposed that the ingestion of these compounds by insect larvae disturbs the endocuticular deposition during moulting process because they block the chitin synthesis. The blockage of chitin synthesis occurs due to disruption of the function of connecting N-acetylglucose amine moieties to the chitin chain in spite of that the coupling of uridine diphosphat-N-acetyl-glucose amine (UDPAG), the ultimate chitin precursor, to the chitin synthetase still proceeds (Post *et al*., 1974). However, the exact mode of action of these CSIs on the adult transformation and eclosion is still puzzling (Merzendorfer and Zimoch, 2003).

Adult differentiation and morphogenesis of various insect species had been impaired by the action of different CSIs, such as: DFB against *S. littoralis* (Radwan *et al*., 1978), *Glossina morsitans* (Jordan *et al*., 1979), *Simulium vittatum* (Lacy and Mulla,

1979), *S. gregaria* (Rao and Mehrotra, 1986), *T. molitor* (Soltani *et al*., 1987), *C. pipiens* (Bakr *et al*., 1989), *Blatella germanica* (Ross and Cochran, 1990), *Mamestra brassicae* (Butaye and Degheele, 1995), *M. stabulans* (Basiouny, 2000); Bay Sir-8514 against *Tribolium confusum* (El-Sayed *et al*., 1984), *M. domestica* (Miller and Schmidtman, 1985), *C. pipiens* (Bakr *et al*., 1989), *M. stabulans* (Ghoneim *et al*., 1992), *Synthesiomyia nudiseta* (Khalaf, 1993); IKI-7899 against *S. gregaria* (Aboel-Ela *et al*., 1993; El-Gammal *et al*., 1993), *P. argyrostoma* (Ghoneim and Ismail, 1995 c), *M. stabulans* (Basiouny, 2000); XRD-473 against some mosquito species (Vasuki and Rajavel, 1992); Diofenolan against *Cydia pomonella* and *Cydia molesta* (Streibert *et al*., 1994); XRD-473 and IKI-7899 against *Eupripocnemis plorans* (Mohamed, 1998), *M. stabulans* (Basiouny, 2000) and *Rh. ferrugineus* (Tanani, 2001), chlorfluazuron against *S. gregaria* (Tiwari, 2000). On the contrary, neither CGA-184699 nor CGA-59205 caused adult deformities in *M. domestica*, irrespective of the dose or time of treatment (Ghoneim *et al*., 2004). Also, Flufenoxuron could not cause nymphal deformations but only adult morphogenic defects of *S. gregaria* (communication with Tanani, 2007)

In the present study on *S. gregaria*, the adult morphogenesis was significantly subjected to a deteriorating action of Lufenuron because various deformed adults were observed. Such morphogenic action of Lufenuron increased proportionally to the increasing higher three concentration levels against the newly moulted penultimate instar nymphs.

However, no nymphal deformities, permanent nymphs, nymphal-adult intermediates, supernumerary nymphal instar, extramoult or adultoids of *S. gregaria* were observed in the present study, but only adult malformations which appeared as twisted legs, coiled antennae, curled wings as well as adult failure to get rid the last nymphal exuvia. Generally, these defected features may provide relevant evidence to a morphogenic action of Lufenuron. Each of them seriously interferes, directly or indirectly, with the programme of adult morphogenesis…

In addition, several hypotheses have been introduced to explain the mode of action of CSIs on the morphogenesis including: direct inhibition and/or interference with chitin synthase (Deul *et al*., 1978), effect on the chitinase levels comprising that chitin is being digested faster than deposited (Soltani *et al.*, 1993), interference with juvenile hormone and ecdysteroid metabolism causing a disruption in the chitin metabolic system (Yu and Terriere, 1975), inhibition of chitin synthase by metabolites of CSIs (Cohen and Casida, 1980), inhibition of protease (s) that activate the chitin synthase zymogen (Leighton *et al*., 1981), inhibition of DNA synthesis (Mitlin *et al*., 1977), inhibition of glycosyl transferases that are involved with synthesis of lipid-linked oligosaccharides in cell membranes which possibly provide primer molecules for chitin synthase (Mayer *et al*., 1980), and/or inhibition of facilitated diffusion and active transport across cell membranes of nucleosides and amino acids (Mayer *et al*., 1988).

Adult longevity of *S. gregaria* was significantly shortened after the nymphal treatments with Lufenuron, in the present study, but in no certain trend. These results agree with shortening effects of DFB on *T. molitor* (Soltani *et al*., 1983), of IKI-7899 and Flufenoxuron on *Agrotis ipsilon* (Shaurub *et al*., 1999; El-Skeikh, 2002) , of CGA-184699 and CGA-59205 on *M. domestica* (Ghoneim *et al*., 2004) and of Flufenoxuron on *S. gregaria* (personal observation). Adult longevity depends on healthy immature stages. Digestive disorders such as starvation, disturbance in metabolism, degeneration of peritrophic membrane and accumulation of faecal materials at the hind gut may be the cause of untimely adult mortality as a result of

CSIs exposure (Soltani, 1984; Parween, 1997a). Generally, the shortened adult longevity can be explicated by the accumulation of toxic xenobiotics in the insect body which upsets a complicated balance of factors such as absorption, excretion and detoxification (Abdel-Al, 1996; Mustafa, 2002).

REFERENCES

Abdel-Al, A.E. (1996): Biological, histological and physiological effects of some insect growth regulators on the greasy cutworm, *Agrotis ipsilon* (Hufn) (Lepidoptera : Noctuidae). Unpublished M.Sc. Thesis, Cairo Univ., Egypt.

Abdel-Magid, A.D. (1993): Effects of some insect growth regulators on the developmental stages of *Schistocerca gregaria*. Unpublished M.Sc. Thesis, Zagazig Univ., Fac. Sic. (Benha).

Abuoel-Ela, R.G.A.; Allam, S.M.; Ibrahim, A.A. and Abdel-Magid, A.D. (1993): Morphogenetic and morphometric aberrations induced by the IGR`s chlorfluazuron (IKI) and two formulations of triflumuron on *Schistocerca gregaria* (Forsk.). Bull. Ent. Soc. Egypt (Econ. Series), 20 : 217-227.

Bakr, R.F.A.; Abo-Gabil, N.M. and Hussein, M.A. (1989): Insect growth regulators. I: Biological activity of some IGRs against the susceptible and resistant strains of *Culex pipeins* larvae. J. Egypt. Soc. Parasitol., 19(2):589-597.

Bakr, R.F.A.; Abdel-Razik, N.A.; Hamed, M.S. and Guneidy, A.M. (1991): Physiological effect of some insect growth regulators on the respirometric measurements, total protein and free amino acids of the house fly *Musca domestica*. Ain Shams Sci. Bull., 23(B):169-183.

Bakr, R.F.A.; Guneidy, N.A.M. and El-Bermawy, S.M. (2005): Toxicological and biological activities of three IGR`s against fourth larval instar of the cotton leaf worm, *Spodoptera littoralis* (Boisd) J. Egypt. Acad. Soc. Environ. Develop., 6(4):103-132.

Basiouny, A.L. (2000): Some physiological effects of certain insect growth regulators (IGRs) on the false stable fly, *Muscina stabulans* (Fallen). (Diptera: Muscidae). Unpublished Ph.D. Thesis, Fac. Sci., Al-Azhar Univ. (Cairo).

Becker, B. (1978): Effects of 20-hydroxyecdysone, juvenile hormone, dimilin and captan on *in vitro* synthesis of peritophic membranes in *Calliphora erythrocephala*. J. Econ. Entomol., 24:699-705.

Butaye, L. and Degheele, D. (1995): Benzoylphenyl ureas effect on growth and development of *Eulophus pennicornis* (Hymenoptera : Eulophidae), a larval ectoparasite of cabbage moth (Lepidoptera : Noctuidae). J. Econ. Entomol, 88(3) : 600-605.

Casida, J.P. and Quistad, G.B. (1998): Golden age of insecticide research: past, present and future. Annu.Rev.Entomol., 43:1-16.

Clark, L.; Tempale, G.H.R. and Vincent, J.F.V. (1977): The effects of chitin inhibitor – Dimilin on the production of peritrophic membrane in locust, *Locusta migratoria.* J. Insect Physiol., 23 : 241-246.

Cohen, E. and Casida, J.E. (1980): Inhibition of *Tribolium* gut synthetase. Pestic. Biochem. Physiol., 13:129.

Coppen, G.D.A. and Jepson, P.C. (1996): Comparative laboratory evaluation of the acute and chronic toxicology of diflubenzuron, hexaflumuron and teflubenzuron against II instar desert locust *Schistocerca gregaria* (Orthoptera : Acrididae). Pestic. Science, 46:183-190.

Dempster, C. (1957): The population dynamic of moroccan locust *Dociostarus murcocamus* in Cyprus. Anti. Locust Bull., 27.

Deul, D.J.; de Jong, B.J. and Kortenback, J.A.M. (1978): Inhibition of chitin synthesis by two 1-(2,6-disubstituted benzoyl)-3-phenylurea insecticides. Pest. Biochem. Physiol., 8 : 98-105.

El-Gammal, A.M.; Osman, M.A.; Shaban, O.A. and Badawy, N.S. (1993): The role of the antichitin synthesis, chlorofluazuron (IKI) on the main metabolites during metamorphosis of *Schistocerca gregaria* (Forsk.) Egyptian J. Agric. Res., 71:891-899, 15 ref.

El-Ibrashy, M.T. (1970): Insect hormones and analogues : chemistry, biology and insecticidal potencies. Z. Angew. Ent., 66:113-114.

El-Kordy, M.W.; Metwally, M.M.; El-Khouly, A.S. and Hamdy, A.M. (1989): Biological activity of the insect growth regulators, chlorofluazuron and teflubenzuron on *Musca domestica* L. Proc. 1st Int. Conf. Econ. Entomol., 1:349-357.

El-Nemaky, I.H.I. (2000): Studies of the effect of integrated pest management elements on physiology of bollworm. Unpublished Ph.D. Thesis, Fac.Agric., Al-Azhar Univ., Cairo, Egypt.

El-Nemaky, I.H. and Azab, A.M.H. (2004): Effectiveness of some benzoylphenylureas on the larvae of the spiny boll worm *Earias insulana* (Boisd.). Egypt J. Agric. Res., 82(2) : 573-582.

El-Oshar, M.A.; Motoyama, N.; Hughes, P.B. and Dauterman, W.C. (1985): Studies on cyromazine in the house fly *Musca domestica* (Diptera : Muscidae). J. Econ. Entomol., 78:1203-1207.

El-Sayed, M.A.; Abdel-Razik, F. and Kandil, M.A. (1984): Biological activity of insect growth regulator triflumuron against *Tribolium confusum*. Bull. Ent. Soc. Egypt, 14:171-175.

El-Sheikh, T.A.A. (2002): Effects of application of selected insect growth regulators and plant extracts on some physiological aspects of the black cutworm, *Agrotis ipsilon* (HUF). Unpublished Ph.D. Thesis, Fac. Sci., Ain Shams Univ., Egypt.

Estal, P.D.; Vinuela, E.; Adan, A. and Budia, F. (1994): Effects of the insect growth regulator XRD-473 (Hexaflumuron) on *Tribolium castaneum* (Herbst) (Coleoptera : Tenebrionidae). Boletin de Sanidad Vegetal Plates, B., 16(1) : 339-345.

Gamal, E.S.; Abo El-Gar, G.E.; Radwan, S.A.; El-Bermawy, Z.A. and Zidan, L.T.M. (1994): Biological activity of Avermectin B_1, β-Exotoxin of *Bacillus thuringiensis* and diflubenzuron against cotton leaf worm (Lepidoptera : Noctuidae). Bull. Ent. Soc., Egypt, 21:11-23.

Ghoneim, K.S.; Essa, N.; Abul-Ela, R.G.; Al-Morsy, A.A. and Nassar, M.I. (1992): Efficacy of Triflumuron (Bay Sir-8514) for remedial control of the false stable fly *Muscina stabulans* (Fallen) (Diptera : Muscidae). Al-Azhar Bull. Sci. 3(2):687-693.

Ghoneim, K.S. and Ismail, I.E. (1995): Survival, developmental and morphogenic deficiencies of *Parasarcophaga argyrostoma* (Diptera : Sarcophagidae) induced by the chitin biosynthesis inhibitor, chlorofluazuron (IKI). J. Egypt Soc. Parasitol., 25(2):561-581.

Ghoneim, K.S.; Bream, A.S. and Mohamed, H.A. (1998): Bioactivity of the ecdysteroid against Tebufenozide (RH-5992) on the Egyptian cotton

leafworm, *Spodoptera littoralis* (Boisd) (Lepidoptera : Noctuidae). Al-Azhar Bull., Sci., 9(2):947-963.

Ghoneim, K.S.; Amer, M.S.; Bream, A.S.; Al-Dali, A.G. and Hamadah, Kh.Sh. (2004): Developmental and morphogenic responses of the house fly *Musca domestica* to the CSIs : Lufenuron and Diofenolan. Al-Azhar Bull. Sci., (2):25-42.

Ghoneim, K.S.; Abdel-Ghaffar, A.A.; Amer, M.S.; Bream, A.S.; Al-Dali, A.G. and Hamadah, Kh.Sh. (2006): Effects of certain insect growth regulators and plant extracts on carbohydrate metabolism in the house fly *Musca domestica* (Diptera: Muscidae). Egypt. J. Biomed.Sci., 21:206-220.

Griffith, B.; Michael, B.M. and Perry, A.S. (1996): Effects of aerial application of diflubenzuron on emergence and flight of adult aquatic insects. J. Econ. Entomol., 89(2):442-446.

Hassanein, M.S. (1965): Laboratory and outdoor cultures and breeding of locusts and grasshoppers. FAO Publ., 5/31901, 10 pp.

Haynes, J.W. and Smith, W. (1994): Diflubenzuron plus cottonseed oil : effects on boll weevil (Coleoptera : Curculionidae) cuticle hardness, mating, and flight. J. Econ. Entomol., 87:339-344.

Hoffman, K.H. and Lorenz, M.W. (1998): Recent advances in hormones in insect pest control. Phytoparasitica, 26(4):xx-xxx.

Hunter-Jones, P. (1961): Rearing and breeding locusts in laboratory. Bull. Anti-locust Res. Cent. Lond., 12 pp.

Jordan, A.M.; Trewern, M.A.; Borkcovec, A.B. and De Milo, A.B. (1979): Laboratory studies on the potential of three insect growth regulators for control of tsetse fly *Glossina morsitans* Westwood (Diptera : Glossinidae). Bull. Entomol. Res., 69:55-64.

Khalaf, A.A.A. (1993): Effect of some insect growth regulators on certain biological, histological and physiological aspects of the fly *Synthesiomyia nudiseta* Wulp (Diptera : Muscidae). Unpublished Ph.D. Thesis, Fac. Sci., Zagazig Univ. Egypt.

Khebbeb, M.E.H.; Delachamber, J. and Soltani, N. (1997): Ingested diflubenzuron disturbed the lipidic metabolism during the sexual maturation of meal worm. Pestic. Biochem. Physiol., 58:209-217.

Lacy, L.A. and Mulla, M.S. (1979): Field evaluation of diflubenzuron against *Simulium* larvae. Mosq. News, 39:86-90.

Leighton, T.E.; Marks, E. and Leighton, F. (1981): Pesticides : Insecticides and fungicides are chitin synthesis inhibitors. Science, 213:905-907.

Mayer, R.T.; Chen, A.C. and De Loach, J.R. (1980): Characterization of chitin synthesis from the stable fly *Stomoxys calcitrans*. Insect Biochem., 10:549-556.

Mayer, R.T.; Witt, W.; Kitschka, G.E. and Chen, A.C. (1988): Evidence that chitin synthesis inhibitors affect cell membrane transport. In "Endocrinological Frontiers in Physiological Insect Ecology". (Sehnal, F.; Zabza, A.; Denlinger, D.L., eds.). Wroclow Tech. Univ. Press Wroclaw.

Merzendorfer, H. and Zimoch, L. (2003): Chitin metabolism in insects : Structure, function and regulation of chitin synthases and chitinases. J. Exp. Biol., 206:4393-4412.

Mesbah, H.A.; El-Deeb, A.S.; Saad, A.S. and Nagah, S. (1996): Effect of lower doses of insect growth inhibitors and insect growth regulators: insecticide

formulations on cotton leafworm, *Spodoptera littoralis*. Egypt.Ger.Soc.Zool., 21(E): 371-390.

Miller, R.W. and Schmidtman, E.T. (1985): Feeding cyromazin (Lerodex) to dairy calves for the control of house flies. J. Agric. Entomol., 2:31-36.

Mitlin, N.; Wiygul, G. and Haynes, J.W. (1977): Inhibition of DNA synthesis in boll weevil *Anthonomus grandis* (Boheman) sterilized by Dimilin. Pestic. Biochem. Physiol., 7:559-563.

Mitsui, T.; Nobusawa, C.; Fokami, T.I.; Collins, I. and Riddiford, L.M. (1980): Inhibition of chitin synthesis by diflubenzuron in *Manduca* larvae. J. Pest. Sci., 5:335-341.

Mohamed, A.A. (1998): Morphogenic, embryonic and physiological effects induced by some insect growth regulators (IGRs) in berseem hopper; *Euprepocnemis polrans* Charp (Orthoptera : Acrididae). Unpublished Ph.D. Thesis, Fac. Sci. Al-Azhar Univ., Cairo, Egypt.

Mohapatra, A.R.E.; Ranjit, M.R. and Dash, A.R. (1996): The effect of chitin synthesis inhibitor on the development of *Brugia malayia* in *Aedes aegypti*. J. Helminth., 70:269-270.

Mondal, K.A.M.S.H. and Post, G.R. (1995): Effects of cyromazine on larval growth and adult population of susceptible and malathion – resistant strains of *Tribolium castanium* (Herbst.). J. Bio. Sci. Rajshahi Univ., 3:1-10.

Moroney, M.J. (1959): Facts from figures (3rd ed.). Penguim books Ltd., Harmondsworth. Middle Sex.

Morsi, M.A. (1985): Studies on the integrated control on certain cotton pests. Unpublished M.Sc. Thesis, Fac. Agric., Al-Azhar Univ., Egypt.

Moustafa, R.A. (2002): Biochemical studies on the effects of some chitin synthesis inhibitors on the black cutworm *Agrotis ipsilon* (Lepidoptera : Noctuidae). Unpublished M.Sc. Thesis, Fac. Sci. Ain Shams, Egypt.

Mulder, R. and Gijswijt, M.J. (1973): The laboratory evaluation of two promising new insecticides which interfere with cuticle deposition. Pest. Sci., 4:737-745.

Mulla, M.S. and Darwazeh, H.A. (1988): Efficacy of new insect growth regulator against mosquito larvae in diary waste water lagoons. J. Am. Mosq. Control Assoc., 4(3):322-325.

Osman, S.E. (1984): Effect of anti-moulting agent "Dimilin" on the blood picture and cuticle formation in *Spodoptera littoralis* (Boisd.) larvae. Bull. Ent. Soc. Egypt (Econ. Ser.), 14:37-46.

Parween, S. (1996): The effects of Triflumuron on malathion – susceptible (Fss II) and malathion – resistant (CTC 12) strains of *Tribolium castaneum* Herbst. Ph.D. Thesis, Univ. New Castle Tyne; U.K.

Parween, S. (1997): Effect of triflumuron on the adult mid gut of *Tribolium castaneum* (Herbst.) (Coleoptera : Tenebrioidae). Univ. J. Zool. Rajshahi Univ., 16:11-18.

Post, L.C. and Vincent, W.R. (1973): A new insecticide inhibits chitin synthesis. Nature Wissenschaften, 60:431-432.

Post, L.C.; De Jong, B.J. and Vincent, W.R. (1974): 1-(2,6-disubstituted benzoyl) 3-phenylurea insecticides : inhibitors of chitin synthesis. Pest Biochem. Physiol., 4:473-483.

Radwan, H.S.; Abou El-Ghar, M.P. and Ammar, I.M. (1978): Reproductive performance of *Spodoptera littoralis* (Boisd) treated topically with sublethal doses of an antimoulting IGR "Dimilin". J. Appl. Entomol., 86:414-419.

Rao, P.A. and Mehrotra, K.N. (1986): Toxicity of diflubenzuron to *Schistocerca gregaria* (Forsk.). Indian J. Entomol., 48:474-477.

Retnakaran, A.; Granett, J. and Ennis, T. (1985): Insect growth regulators. In "Comprehensive Insect Physiology Biochemistry and Pharmacology" (Kertut G.A. and Gilbert, L.I., eds), Vol. 12, pp:529-601. Oxford : Pergaman Press.

Ross, M.H. and Cochran, D.G. (1990): Response of late-instar *Blattella germanica* (Dictyoptera : Blattellidae) to dietary insect regulator. J. Econ. Entomol., 83(6):2295-2395.

Saenz-de-Cabezon, F.J.; Perez-Moreno, I.; Zalom, F.G. and Marco, V. (2006): Effects of lufenuron on *Lobesia botrana* (Lepidoptera : Torticidae) egg, larval, and adult stages. J. Econ. Entomol., 99(2):427-431.

Schmidt, G.H.; Ascher, K.R.S. and Schultz, W. (1993): Effect of Teflubenzuron [Nomalt(R)] on the reproductive capacity of the grass hoppers *Aiolopus thalassinus* (Fabr.) and *Euprepocnemis polrans* (Charp) (Orthoptera : Acrididae). J. Plant Disc. Prot. 100(3):225-238.

Sehnal, F. and Bryant, P. (1993): Delayed pupariation in *Drosophila imaginal* (disc.) over growth mutants is associated with reduced ecdysteroid titer. J. Insect Physiol., 39(12):1051-1059.

Shaurub, E.H.; Emara, S.A.; Zohy, N.Z. and Abdel-Aal, A.F. (1999): Effect of four insect growth regulators on the black cutworm *Agrotis ipsilon* (Hufn.). (Lepidoptera : Noctuidae). The 2nd Int. Conf. Pest Control, Mansoura, Egypt, Sep. 1999:733.

Slama, K. (1974): Physiological effects of ecdysteroids. In "Insect Hormones and Bioanalogues" (Slama, K.; Romanak, M. and Sorm, P., eds.), pp:339-368, Springer, Vienna.

Smagghe, G. and Degheele, D. (1994): Action of the nonsteroidal ecdysteroid mimic RH-5849 on larval development and adult reproduction of insects of different orders. Invert. Res. Develop., 25(3):227-236.

Soltani – Mazouni, N. (1994): Effects of ingested diflubenzuron on ovarian development during the sexual maturation of meal worm. Tis. Cell, 26(3):439-445.

Soltani N.; Besson, M.T. and Delachambre, J. (1983): Penetration and insecticidal activity of diflubenzuron in *Tenebrio molitor* pupae. Pestic. Sci., 14:625-632.

Soltani N.; Quennedey, A.; Delbecque, J.P. and Delachambre, J. (1987): Diflubenzuron induced alterations during *in vitro* development of *Tenebrio molitor* pupae integument. Arch. Insect. Biochem. Physiol., 5:201-209.

Soltani N.; Chebira, S.; Delbecque, J.P. and Delachambre, J. (1993): Biological activity of flucycloxuron, a noval benzoylphenylurea derivative, on *Tenebrio molitor* comparison with diflubenzuron and triflumuron. Experientia. 49(12):1088-1091.

Staal, G.B. (1975): Insect growth regulators with juvenile hormone activity. Annu. Rev. Entomol., 20:417-460.

Streibert, H.P.; Frischknecht, M.L. and Karrer, F. (1994): Diofenolan – a new insect growth regulator for the control of scale insects and important lepidopterous pests in deciducaus fruits and citrus. Proc. Brighton Crop Prot. Conf., Pests and Dis., 1:23-30.

Tanani, M.M.A. (2001): Study on the effects of certain IGRs and plant extracts on some physiological aspects of the red palm weevile *Rhyncophorus*

ferrugineus (Curculionidae : Coleoptera). Unpublished M.Sc. Thesis, Fac. Sci., Al-Azhar Univ., Cairo, Egypt.

Tiwari, L.D. (2000): Toxicity of chlorfluazuron to fifth instar hoppers of *Schistocerca gregaria*. Indian J.Entomol., 62(2):211-213.

Tunaz, H. and Uygun, N. (2004): Insect growth regulators for insect pest control. J.Agric.Turk., 28:337-387.

Vasuki, V. and Rajavel, A.R. (1992): Influence of short-time exposure to an insect growth regulator, hexaflumuron, on mortality and adult emergence of vector mosquito. Mm. Inst. Oswaldo Cruz., Riode Janeiro, 87(2):275-283.

Vir, S. (1988): Effect of diflubenzuron – a chitin synthesis inhibitor on Khapra beetle, *Trogoderma granarium* Everts. (Coleoptera : Tenebrionidae). Bull. Grain Technol., 26(2):126-129.

Whisenton, L.R.; Warren, J.T.; Manning, M.K. and Bollembacher, W.E. (1989): Ecdysteroid titers during pupal – adult development of *Aedes aegypti* : basis for a sexual dimorphosim in the rate of development. J. Insect Physiol., 35(1):67-73.

Yu, S.J. and Terriere, L.G. (1975): Activities of hormone metabolizing enzymes in house flies treated with some substituted urea growth regulators. Life Sci., 17:619-628.

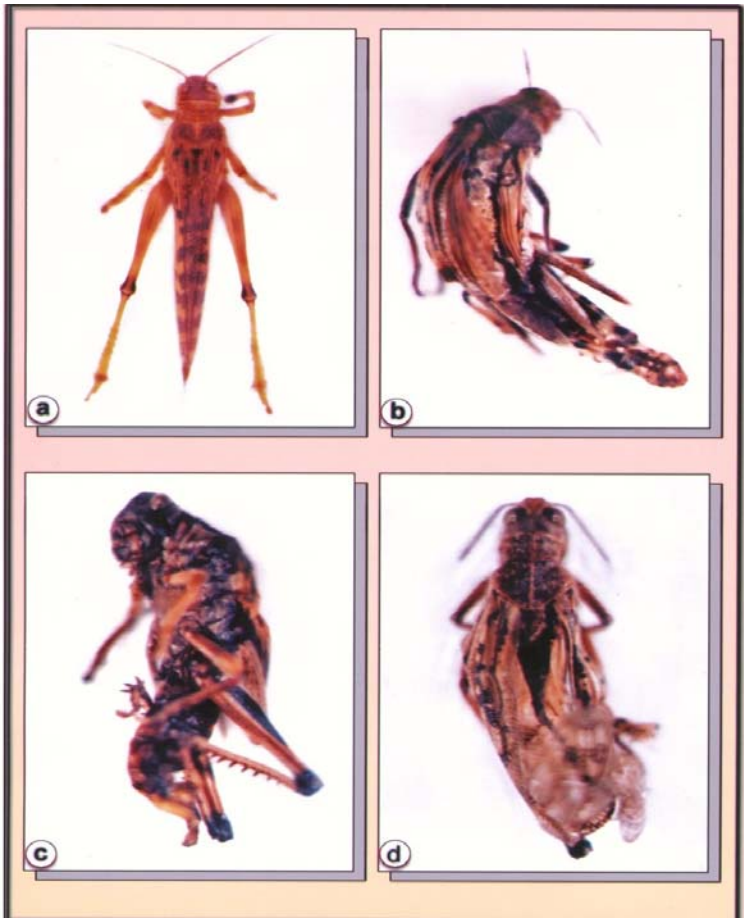

Plate (1): *Various shapes of the adult deformation of Schistocerca gregaria were recorded after nymphal treatment with the chitin biosynthesis inhibitor, Lufenuron. Several aberrations can be seen in comparison to the normal adult (**a**), such as: deformed legs and shortened antennae (**b**), retained nymphal exuvium (**c**), abnormally developed wings and legs (**d**).*

ARABIC SUMMERY

كفاءة مثبط تخليق الكيتين لوفينورون في التأثير على النمو والإنماء والتشكل للجراد 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]
1- قسم علم الحشرات بكلية العلوم جامعة عين شمس.
2- قسم علم الحيوان بكلية العلوم جامعة الأزهر

استهدفت هذه الورقة بحث تأثيرات مركب لوفينورون في نمو وإنماء وتشكل الجراد الصحراوي *شيستوسركا جريجاريا* . ومن أجل هذا ، تمت معاملة حوريات الدور الرابع (حديثة الإنسلاخ) ، وحوريات الدور الخامس (حديثة الإنسلاخ والمتقدمة في العمر) بخمسة تركيزات من المركب ، هى : 1000، 500، 250 ، 125 ، 62.5 ج ف م ، من خلال الغذاء الطازج الذي تناولته الحوريات ليوم واحد فقط ، وبعده تم تدوين جميع الملاحظات .

تعرض نمو الحوريات المعاملة لتثبيط كبير، إذ تنازلت أوزانها المكتسبة تنازلا بالغا على التوازي مع تصاعد مستوى التركيز المستعمل. هذا بعد معاملة حوريات الدور الرابع ، أما بعد معاملة حوريات الدور الخامس حديثة الإنسلاخ ، فقد تزايد التثبيط بعد استعمال أعلى تركيزين. كما تصاعد التثبيط تدريجيا بعد معاملة حوريات الدور الخامس المتقدمة في العمر بأعلى ثلاثة تركيزات .

وبخصوص معدل الإنماء ، فقد سجلت النتائج انحدارا شديدا له بعد معاملة حوريات الدور الأخير ، حديثة الإنسلاخ أو المتقدمة في العمر ، وذلك استجابة لفعل مركب لوفينورون في الإنماء. وعلى العكس ، فقد حفز هذا المركب الإنماء في الحوريات التي تمت معاملها في بداية الدور الرابع ، مما حضها على قضاء فترة قصيرة جدا، ربما لتفادي المزيد من التأثير التثبيطي للمركب .

أبدى مركب لوفينورون ، أيضا ، فعلا كابحا لبزوغ اليافعات بعد معاملة الحوريات بتركيزات منه ، بصرف النظر عن توقيت العاملة . ومن جهة أخرى ، فإن المركب لم يبد تأثيرا ملحوظا في هذه العملية التحولية بعد معاملة حوريات الدور الرابع . وأكثر من هذا ، فقد شجع لوفينورون ، باستعمال تركيزات معينة منه ، على بزوغ اليافعات حتى فاق معدله معدل بزوغ اليافعات الضابطة !! .

وعلى أية حال ، فإن اليافعات التي نجحت في البزوغ عانت من الفعل التشكلي لمركب لوفينورون وقد ظهر هذا جليا في الأشكال المشوهة التي بدت على أعداد من هذه اليافعات ، وقد تصاعدت نسبها المئوية ، على الأقل بعد استعمال أعلى ثلاثة تركيزات . وإضافة إلى هذا ، قضت اليافعات فترة حياة قصيرة ثم ماتت ، وقد اشتد القصر في فترة حياتها مع تصاعد مستوى التركيز بعد معاملة حوريات الدور الرابع .