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Impact of Lead Acetate on Quantitative Consumption and Utilization of the Cotton Leaf Worm, Spodoptera littoralis (Boisduval, 1833) (Lepidoptera: Noctuidae)

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Abstract. The 3rd, 4th, 5th, and 6th instars of the cotton leaf worm *Spodoptera littoralis* (Boisduval, 1833) were treated with lead acetate, 100 mg lead [Pb $(C_2H_3O_2)_4$]/kg, using the leaf-dip method, to evaluate the effect of Pb on nutritional indices. The consumption index was significantly increased at the 3rd and 6th instars. The growth rate significantly increased in 4th instars. The reverse was true in 6th instars. The absorptive capacity, in terms of approximate digestibility, was insignificantly changed in the entire instars. The food utilization efficiencies, in terms of the conversion of ingested (ECI) and digested food (ECD) to biomass, were significantly increased in 4th instars. However, the ECD was significantly decreased in the 5th and 6th instars. In conclusion, treatment with lead may adversely affect the population biomass of *S. littoralis* due to the gross reduction in the final weight gain of larvae approaching to pupation. This might lead to reduced level of population size.

Key words: *Spodoptera littoralis*, lead, food consumption, food utilization, heavy metals.

Introduction

The cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833) (Lepidoptera: Noctuidae) is a polyphagous insect, and it is one of the major cotton pests. Accordingly, it causes a considerable damage to many important vegetables and crops in the Mediterranean and Middle East countries (SHONOUDA & OSMAN, 2000; MAGD EL-DIN & EL-GENGAIHI, 2000; KHAWAS & ABD EL-GAWAD, 2002; ADHAM *et al.*, 2005a; TIESSEN, 2012). Lead (Pb) is widely used in industries, and it is considered as a significant environmental pollutant that contaminates food, water, urban soil, and air (BOGDANOV, 2005; HAQ *et al.*, 2012). It is listed at number two on the Comprehensive Environmental Response, Compensation, and Liability Act Priorities List of Hazardous substances (US EPA, 2011).

Several studies have been carried out on the biological effects of Pb, however, its toxic potential against insects remains unestablished. Due to the possible hazardous effects of this metal, its presence in the environment is, therefore, a matter of urgent concern. The poor accumulation of Pb in the organisms could be one cause to its less toxicity. Nevertheless, Pb is considered to be an important toxic waste. Consequently, insects could be influenced by such metal. Few studies have been carried out to demonstrate the biological effects of lead and its toxic potential against insects (MARGIM, 2005).

The present investigation aims to determine the effect of lead on the growth and food utilization of 3rd, 4th, 5th and 6th instar larvae of the cotton leaf worm, *S. littoralis*.

Materials and Methods

Insect rearing. The stock colony of *S. littoralis* was started as egg masses obtained from a standard laboratory colony maintained at the Department of Entomology, Faculty of Science, Cairo University, Giza, Egypt at 25 ± 2°C, 65 ± 5% R. H. and 12:12 hours (D:L) photoperiod (ABU ELELA & ELSAYED, 2015a; b). The larvae were fed fresh castor-bean leaves, *Ricinus communis* (Linnaeus, 1753), whilst the adults were fed on 15% sugar solution.

Bioassay protocol. Twenty newly moulted 3rd, 4th, 5th and 6th instar larvae were treated by Pb acetate using the leaf dipping method technique (BAGHBAN *et al.*, 2014; ABU ELELA & ELSAYED, 2015a; b). Fresh castor bean leaves, *Ricinus communis* (Linnaeus, 1753), were dipped in Pb acetate solution [100 mg $Pb(C_2H_3O_2)_4$/kg] for 20 seconds and then left to dry in room air for 10 minutes (MOADELI *et al.*, 2014). The dried leaves were placed singly in clear and clean plastic boxes (18 w x 10 h x 25 l cm). Newly moulted 3rd, 4th, 5th and 6th instar larvae were allowed to feed randomly on Pb-treated leaves. Three replicates of each instar group with 20 larvae each were setup. A parallel control of non-treated instars was also conducted.

Nutritional indices. Nutritional indices were calculated using standard gravimetric procedures described by WALDBAUER (1968) as follows:

1) Consumption index (CI) measures the amount of food eaten per unit time relative to mean weight of larvae during the feeding period, CI=C/ [(T) (A)].

Where C - fresh weight of leaf consumed, T - duration of feeding period and A - mean fresh weight of the larvae during the feeding period.

2) Growth rate (GR) measures the amount of weight gained per unit time relative to the mean weight of the larvae during the feeding period; GR= G/[(T)(A)].

Where G - fresh weight gain of the larvae.

3) Efficiency of conversion of ingested food to body tissue (ECI) is an overall measure of the larvae's ability to utilize ingested food for growth, ECI= (G/C) x (100%).

4) Efficiency of conversion of digested food to body tissue (ECD) is an overall measure of the larvae's ability to utilize digested food for growth, ECD= [G/(C-F)] x (100%). Where F - faeces weight during the feeding period.

5) Approximate digestibility (AD) measures the larvae's ability to digest the introduced food, AD= [(C-F)/C] x (100%).

Statistical analysis. Data were given as mean ± SE, and they were analyzed with one way analysis of variance (ANOVA). All statistical computations were carried out by PAST ver. 2.17 software (HAMMER *et al.*, 2001).

Results and Discussion

Figure 1 shows that treatment with Pb significantly enhanced ($p<0.05$) the CI in 3rd and 6th instars. However, 4th and 5th instars did not elicit any appreciable change ($p>0.05$) in CI due to such treatment. It appears that CI decreased gradually with advancing instars in both non-treated and Pb-treated instars. The CI was steadily decreased through the studied instars. HARE (1992) reported that Cd, Pb, and Hg, even at low concentrations, are toxic for the test organisms.

GR of Pb-treated larvae significantly increased in 4th instars. In contrast, exposure of 6th instar to Pb significantly ($p<0.05$) decreased the GR (Fig. 2). In the present study, the enhanced GR could be due to the increased efficiency of food eaten (ECI and ECD), as evident in this study (Fig. 4 and 5). This result is in agreement with that of BAGHBAN *et al.* (2014) who reported that treatment of the cotton boll worm, *Helicoverpa armigera* with Cd, Cu, and Zn enhanced the GR.

The pattern of the change in GR, due to exposure to Pb, was similar to that of the CI, i.e. GR decreased gradually with advancing instars. The present results indicates that Pb does not necessarily have a negative impact on the organism, where treatment with this heavy metal increased the GR in 3rd and 4th instars (Fig. 2). This finding is confirmed by WOODRING *et al.* (1978) who indicated that the amount of growth reduction was proportional in general to reduced food consumption.

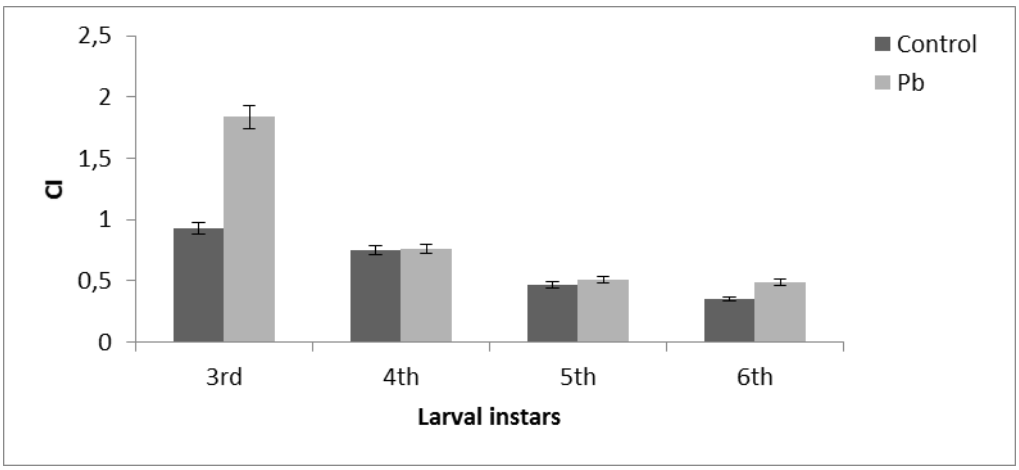

Fig. 1. Consumption index (CI) of the cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833), fed on Pb-treated castor leaves. Bar on the top of column represents SE.

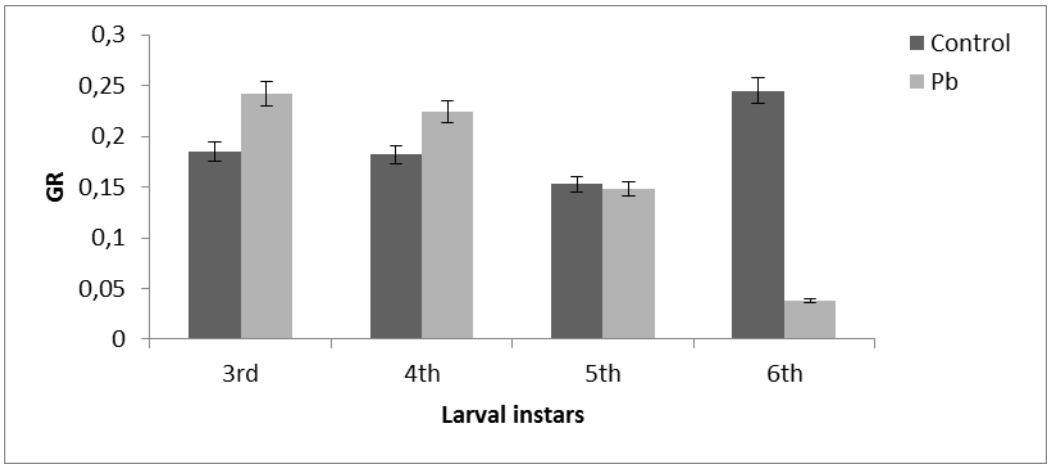

Fig. 2. Growth Rate (GR) of the cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833), fed on Pb-treated castor leaves. Bar on the top of column represents SE.

The absorptive capacity of larvae, expressed as AD, did not significantly change ($p>0.05$) due to treatment with Pb compared to the control (Fig. 3). AD constantly declined with advancing instars. The same pattern was true for CI and GR (Fig. 1 and 2). The AD is inversely proportional to ECD and ECI, as stated by WALDBAUER (1968). This statement agrees with our results (Fig. 4 and 5).

ECD showed significant ($p<0.05$) increase due to treatment with Pb compared to the control in the 4th instar larvae (Fig. 4). It appears that the 4th instar larvae were more selective feeders and choose more digestive foliage from the inter-vein regions of the leaf. Also, their metabolic rate was higher than older ones and hence more of the digested food is available for conversion to body substance (ECD) (ABU ELELA & ELSAYED, 2015a).

Treatment with Pb significantly declined the ECI in 5th and 6th instars. In contrast, significant increase was achieved for 4th instars (Fig. 5). EMRE *et al.* (2013) and BAGHBAN *et al.* (2014) attributed the increase in ECI under the stress of heavy metal treatment to the fact that insect requires a lot of energy to deal with the metal toxicity. This explanation may extend to our results.

Conclusions

In conclusion, the Pb treatment may adversely affect the population biomass of *S. littoralis* due to the gross reduction in the final weight gain of larvae approaching to pupation. This might also lead to reduced level of population size.

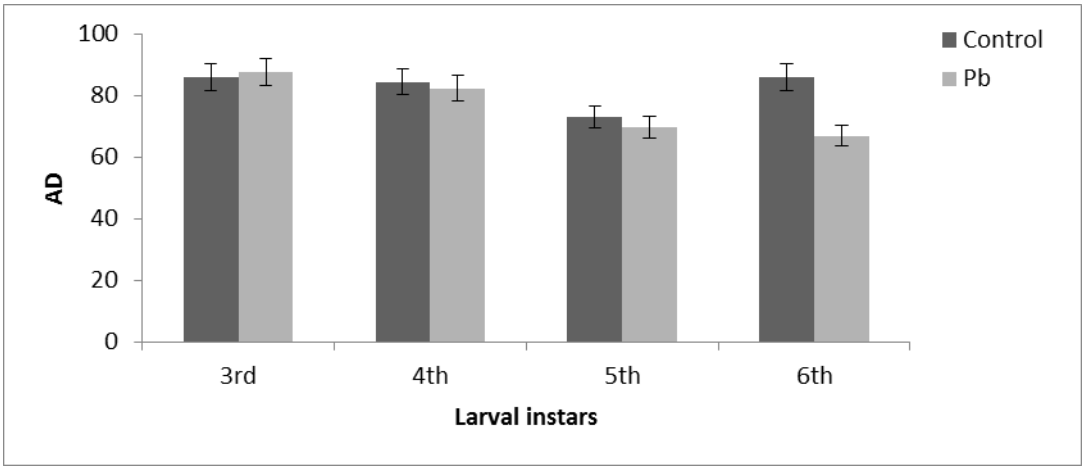

Fig. 3. Approximate Digestibility (AD) of the cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833), fed on Pb-treated castor leaves. Bar on the top of column represents SE.

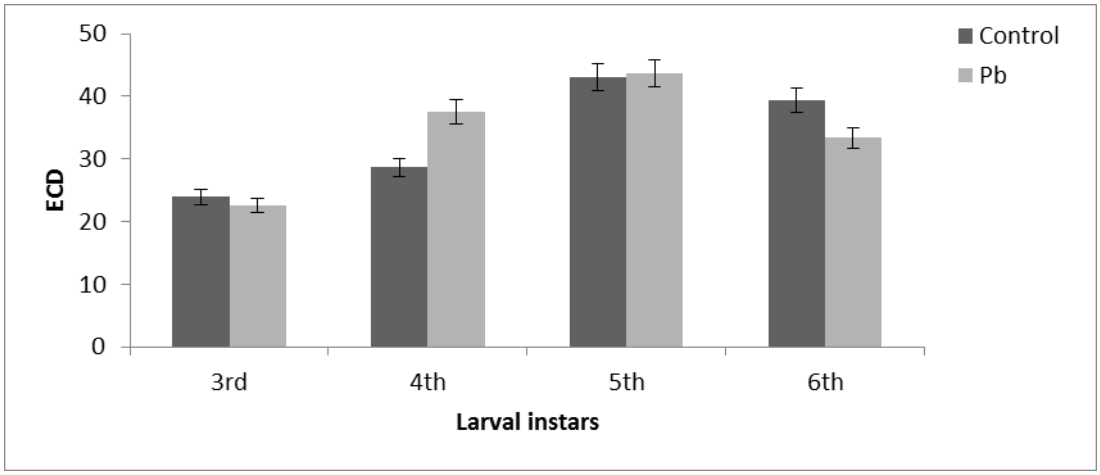

Fig. 4. Efficiency Conversion of Digested food (ECD) of the cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833), fed on Pb-treated castor leaves. Bar on the top of column represents SE.

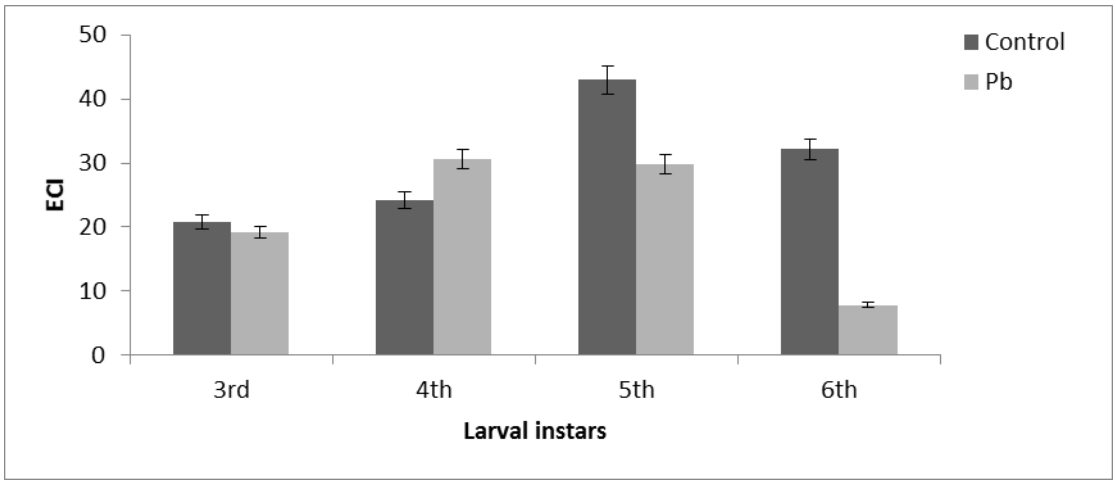

Fig. 5. Efficiency Conversion of ingested food (ECI) of the cotton leaf worm, *Spodoptera littoralis* (Boisduval, 1833), fed on Pb-treated castor leaves. Bar on the top of column represents SE.

References

ABU ELELA S. A., W. M. ELSAYED. 2015a. The Influence of Cadmium on the Food Consumption and Utilization of the Cotton Leaf Worm *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). - *Ecologia Balkanica*, 7(1): 81-85.

ABU ELELA S. A., W. M. ELSAYED. 2015b. Heavy metals stress on the growth parameters of the cotton leaf worm, *Spodoptera littoralis* (Boisd.), (Lepidoptera: Noctuidae). - *Journal of Biodiversity and Environmental Sciences*, 6(4): 297-302.

ADHAM F. K., R. M. GABRE, S. A. ABU EL-ELA, M. M. HASSAN. 2005a. Growth and feeding efficiency of cotton leaf worm *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) on cotton plant *Gossypium barbadens* (Malvaceae) grown in enriched CO_2 atmosphere. - *Bulletin of Entomological Society of Egypt*, 82: 187-196.

ADHAM F. K., R. M. GABRE, S. A. ABU EL-ELA. 2005b. The performance parameters of *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) fed on cotton leaves grown in enriched CO_2 atmosphere. - *Bulletin of Entomological Society of Egypt*, 82: 197-205.

BAGHBAN A., J. SENDI, A. ZIBAEE, R. KHOSRAVI. 2014. Effect of heavy metals (Cd, Cu, and Zn) on feeding indices and energy reserves of the cotton boll worm *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae). - *Journal of Plant Protection Research*, 54(4): 367-373.

BOGDANOV S. 2005. Contaminants of bee products. - *Apidologie*, 37: 1–18.

EMRE I., T. KAYIS, M. COSKUN, O. DURSUN, H. COGUN. 2013. Changes in antioxidative enzyme activity, glycogen, lipid, protein, and malondialdehyde content in cadmium-treated *Galleria mellonella* larvae. - *Annals of the Entomological Society of America*, 106(3): 371–377 [DOI].

HAMMER T., D.A.T. HARPER, P.D. RYAN. 2001. PAST: Paleontological statistics software package for education and data analysis. - *Palaeontologia Electronica*, 4(1): 9 pp. Available at: [palaeo-electronica.org]

HAQ R., M.F. KHAN, E. HAQ. 2012. Heavy Weight Protein Affected by Lead Acetate in *Bactrocera dorsalis*. - *Journal of Basic and Applied Sciences*, 8: 411-415.

HARE L. 1992. Aquatic insects and trace metals: Bioavailability, bioaccumulation, and toxicity. - *Critical Reviews in Toxicology*, 22: 327-369 [DOI].

KHAWAS M.A.M., H.A.S. ABD EL-GAWAD. 2002. The efficiency of two plant extracts (Fenugreek and Lupine) and commercial biofungicide (Biofly) on the cotton leaf worm, *Spodoptera littoralis* (Lepidoptera: Noctuidae) larvae as a new approach of control. - *Journal of the Egyptian German Society of Zoology*, 37: 39-57.

MAGD EL-DIN M., S.E. EL-GENGAIHI. 2000. Join action of some botanical extracts against the Egyptian cotton leafworm, *Spodoptera* (Lepidoptera: Noctuidae). - *Egyptian Journal of Biological Pest Control*, 10: 51-56.

MARGIM A. 2005. Chromosome affected in experimental lead poisoning. – *Toxicology*, 41: 6–14.

MOADELI T., M. J. HEJAZI, G. H. GOLMOHAMMADI. 2014. Lethal effects of pyriproxyfen, spinosad, and indoxacarb and sublethal effects of pyriproxyfen on the 1st instars larvae of beet armyworm, *Spodoptera exigua* Hübner (Lepidoptera: Noctuidae) in the Laboratory. - *Journal of Agricultural Science and Technology*, 16: 1217-1227.

SHONOUDA M.L., S.L. OSMAN. 2000. New botanical derivatives, used in medicinal reparations, showing bioactive action on insect pests. 1- Toxicological effect on the development of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae). - *Journal of the Egyptian German Society of Zoology*, 31: 227-234.

TIESSEN S. 2012. Egyptian cotton leaf worm, *Spodoptera littoralis* (Boisduval). – In: *Indiana's most unwanted invasive plant pests*, Indiana Cooperative Agricultural Pest Surveys Program (CAPS). Available at: [extension.entm.purdue.edu].

US EPA 2011. *CERCLA Priorities List of Hazardous Substances*. [atsdr.cdc.gov].

WALDBAUER G. P. 1968. The consumption and utilization of food by insects. - *Advanced Insect Physiology*, 5: 229- 288.

WOODRING J. P., C. W. CLIFFORD, R. M. ROE, B. R. BECKMAN. 1978. Effects of CO_2 and anoxia on feeding, growth, metabolism, water balance, and blood composition in larval house crickets, *Acheta domesticus*. - *Journal of Insect Physiology*, 24: 499- 509.

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