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Impact of cadmium mediated artificial diet on growth and nutritional indices of *Spodoptera litura* F (Lepidoptera: Noctuidae)

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ABSTRACT

The studies were conducted in the Department of Environmental Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2012-2013 on tobacco caterpillar (*Spodoptera litura* F). The artificial diet mixed with various concentrations of cadmium was offered continuously to the larvae of the insect for three generations. Maximum growth rate was attained at lower doses (1 to 5 mg/kg) and minimum at higher doses (30 to 40 mg/kg). The consumption index of all the larval instars at higher doses (30 mg and 40 mg/kg) was less than control. Maximum approximate digestibility (71.62%) of second instar larva was recorded with 1 mg Cd/kg which decreased in successive instars and digested approximately to 27.74 per cent in sixth instar. Maximum efficiency of conversion of ingested food (36.32%) of second instar larva was in the same treatment which decreased in successive instars and efficiency of conversion of ingested food was 17.59 per cent in sixth instar. Maximum efficiency of conversion of digested food (51.66%) of second instar larva was also with 1 mg Cd/kg which increased in successive instars (68.29% in sixth instar). Hence it can be concluded that growth rate and various nutritional indices (consumption index, approximate digestibility, efficiency of conservation of ingested food and efficiency of conservation of digested food) were lower at higher doses in three successive generations as compared to control and lower doses under study.

Keywords: Cadmium; artificial diet; *Spodoptera litura*; larva; instar

INTRODUCTION

There is growing concern on presence of heavy metals in the environment. Toxic heavy metals in air, soil and water are global threats to the environment. Insects living in polluted areas accumulate heavy metals particularily Ni and Cu (Heliovaara et al 1987). Waste water from industries when used for irrigation of vegetable crops contaminates growing crops. Though heavy metals are not essential for the plant growth yet they are taken up by the roots and translocated to the leaves in many plant species (Marschner 1983). Vegetable crops are attacked by sundry of insect pests which are directly or indirectly influenced by heavy metals particularly Ni (Heliovaara et al 1987). Environment plays an important role in the course of biological evolution as a selective force which acts on the species and influences the genetic capacity of the species to respond (Harrington et al 2001). Himachal Pradesh is well known for off-season commercial vegetable crop production. Since last two decades this state has emerged as an industrial hub resulting in various environmental problems. Insects feed on vegetable crops and consume large amount of food and are themselves eaten by other animals and the heavy metals may move on to other organisms and through biomagnification enter the food chain. Because insect behaviour is key contributor to the ecology of insect interactions with other plant and animal species as well as with their abiotic environments these behaviours are critical to the stability and diversity of ecosystems (Fisher 1998). The consumption of heavy metal contaminated vegetables may also result in human exposure risk. Despite the importance of insects in most ecosystems and the worldwide pollution of systems by heavy metals little information is available on the effects of metal and metalloid pollution on the behaviour of insects. Among various insect pests attacking vegetable crops *Spodoptera litura* Fabricius is a cosmopolitan and polyphagous pest affecting several crops like cotton, pulses, oilseeds, vegetables etc all over the world and is causing loss to agricultural production. Therefore the present investigation was carried out to know the impact of heavy metal-contaminated artificial diet on consumption index of *S litura*.

MATERIAL and METHODS

Rearing of pure culture of *S litura*

The pure culture of tobacco caterpillar (*S litura*) was maintained under laboratory conditions on castor leaves in rearing cages (36 × 34 × 26 cm). The adults were collected from the field manually and with the help of light trap in the month of April 2012. Cotton swab soaked in 25 per cent sugar solution was served as food to the adults. For experimental studies adults were paired and 5 pairs were released into the oviposition chambers. The studies were carried out at room temperature during which the maximum and minimum temperatures were 32 .05 and 17.2^{o}C respectively. The eggs laid by the freshly emerged adults were taken as starting point for first generation.

Rearing of *S litura* on artificial diet

Freshly hatched larvae were reared on chickpea artificial diet which was prepared as per method of Anonymous (1988). Different doses of cadmium and nickel were added to the diet separately in each case. The artificial diet was impregnated separately with cadmium in the

Table 1. Effect of cadimum (Cd) mediated artificial diet on the growth rate and consumption index of *Spodoptera litura* (mean of three generations)

Treatment	Growth rate of instar						Consumption index of instar				
	1	2	3	4	5	6	2	3	4	5	6
T_1	0.103	0.183	0.302	0.431	0.560	0.796	0.383	0.578	0.888	1.588	1.969
T_2	0.105	0.199	0.315	0.434	0.560	0.814	0.396	0.587	0.887	1.493	2.055
T_3	0.104	0.182	0.301	0.431	0.547	0.793	0.329	0.520	0.795	1.227	1.837
T_4	0.098	0.154	0.270	0.407	0.534	0.776	0.295	0.486	0.767	1.129	1.739
T_5	0.097	0.149	0.264	0.389	0.525	0.762	0.271	0.480	0.732	1.044	1.566
T_6	0.095	0.143	0.256	0.377	0.517	0.747	0.239	0.457	0.709	0.969	1.439
T_7	0.094	0.136	0.249	0.372	0.502	0.739	0.224	0.423	0.669	0.923	1.334
T_8	0.092	0.130	0.234	0.360	0.489	0.714	0.204	0.397	0.636	0.849	1.179
Mean	0.098	0.160	0.274	0.400	0.529	0.768	0.293	0.491	0.761	1.153	1.640
$CD_{0.05}$	0.009	0.011	0.015	0.029	0.030	0.028	0.06	0.007	0.008	0.077	0.076

T_1- 0, T_2- 1, T_3- 5, T_4- 10, T_5- 15, T_6- 20, T_7- 30 and T_8- 40 mg Cd/kg

form of $CdCl_2$. The cadmium chloride and nickel chloride were procured from Central Drug House Pvt Ltd, New Delhi which were of analytical and laboratory reagent grade respectively. The eggs laid by the first generation adults of each treatment were used as the starting point for the second generation and second generation eggs were used as starting point for the third generation with the same treatment. There were eight treatments (T_1- 0, T_2- 1, T_3- 5, T_4- 10, T_5- 15, T_6- 20, T_7- 30 and T_8- 40 mg/kg) of each heavy metal including control. Each treatment was replicated thrice and in each replication ten larvae of *S litura* were released and each larva was kept in individual vial of 6 × 4 cm size containing weighed quantity of artificial diet. The various nutritional indices were calculated according to the method of Waldbauer (1968).

RESULTS and DISCUSSION

Data presented in Table 1 reveal that maximum growth rate (0.105) of first instar larva was recorded when fed on artificial diet impregnated with 1 mg Cd/kg which increased in successive instars and attained a maximum growth rate of 0.814 in sixth instar larva while minimum growth rate (0.092) of second instar larva was recorded with 40 mg Cd/kg which increased in successive instars and attained a growth rate of 0.714 in sixth instar with same dose. Maximum growth rate was attained at lower doses (1 to 5 mg/kg) and minimum with higher doses (30 to 40 mg/kg). The larva grew better in control than heavy metal mediated artificial diet. The larval growth rate differed between metal mediated and control suggesting that there is additive genetic variance in larval growth rate. The larvae with poor growth rate were compensated by extending their larval period. According to van Ooik et al (2007) metal contamination had negative effects on larval growth rate and pupal weight. Warrington (1987) reported that generally at low concentration pollutants have positive effects on insects but when concentration increases contaminants tend to have harmful effects on their growth rate. It is evident from Table 1 that maximum consumption index (0.396) of second instar larva was recorded when it was fed on artificial diet impregnated with 1 mg Cd/kg which increased in successive instars and attained a consumption index of 2.055 in sixth instar larva while minimum consumption index (0.204) of second instar larva was recorded with 40 mg Cd/kg which increased in successive instars with a consumption index of 1.179 in sixth instar. Irrespective of larval instars the consumption index decreased with the increase in doses of heavy metals. The consumption index of all the larval instars at higher doses (30 mg and 40 mg/kg) was less than control and it decreased with increase in dose of the cadmium. These findings are in confirmation with the finding of HongXia et al (2007) who reported that sixth instar larvae fed on 40 mg Ni/kg during the second generation displayed a significant lower relative consumption rate than control. White (1984) reported that low levels of pollution usually enhance the nutritional quality of plants and insects often perform well on those plants which are exposed to low levels of pollution. Gendy et al (2011) reported that artificial diet containing different doses of heavy metals decreased food consumption rate up to 50 per cent and after 5 weeks reduction in consumption rate was increased.

Data contained in Table 2 indicate that maximum approximate digestibility (71.62%) of second instar larva was recorded when larvae were fed on artificial diet impregnated with 1 mg Cd/kg which decreased in successive instars and digested approximately 27.74 per cent in sixth instar. Approximate digestibility of second instar larva was minimum (65.75%) with 40 mg Cd/kg which decreased in successive instars and digested approximately (24.50%). Since food eaten during the later instars contained a greater portion of roughage or fiber, the digestible components in the food were bound to be in lower proportion than that ingested by the earlier instars and hence a decrease in digestibility was observed. According to studies on birch trees cadmium affected food consumption and digestibility indicating that polluted birch leaves had low digestibility and larvae could not process them as efficiently as in control leaves. As a result, larvae on polluted trees grew less and produced more frass than larvae on control trees (Migula and Binkowska 1993, Fountain and Hopkin 2001, vanan Oik et al 2007, van Ooik et al 2007). Maximum efficiency of conversion of ingested food (36.32%) of second instar larva was

Table 2. Effect of cadimum (Cd) mediated artificial diet on approximate digestibility, efficiency of conversion of ingested food and efficiency of conversion of digested food of *S litura* (mean of three generations)

Treatment	Approximate digestibility (%) of instar					Efficiency of conversion of ingested food (%) of instar					Eefficiency of conversion of digested food (%) of instar				
	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
T	71.72	50.15	37.04	33.66	27.19	36.15	29.11	21.52	19.40	17.10	50.23	54.01	58.15	63.27	67.73
T^0	71.62	50.32	37.40	34.40	27.74	36.32	29.46	21.89	19.93	17.59	51.66	54.70	58.27	63.80	68.29
T^1	71.05	49.69	37.59	32.37	26.35	35.50	27.91	21.29	19.53	16.73	50.05	53.83	56.53	63.29	66.63
T^2	70.18	48.66	37.08	31.37	25.93	34.96	26.77	20.42	18.52	16.20	49.14	52.17	55.25	60.42	63.84
T^3	69.23	48.12	35.61	30.56	25.67	34.63	26.55	19.86	17.77	15.69	48.42	51.28	53.75	58.16	62.13
T^4	68.49	46.92	35.40	29.96	25.33	34.18	26.21	19.47	17.45	15.35	47.97	49.96	53.41	55.26	60.05
T^5	67.43	45.89	34.43	28.88	25.02	33.58	25.73	19.02	16.76	14.75	47.44	49.43	52.47	53.92	58.08
T^6	65.75	44.46	32.82	27.85	24.50	32.98	24.78	18.41	16.15	13.74	46.15	48.19	50.70	52.60	55.65
^{7}Mean	69.44	48.03	35.92	31.13	25.96	34.79	27.07	20.23	18.19	15.89	48.88	51.70	54.82	58.84	62.80
$CD_{0.05}$	1.54	1.47	0.70	1.67	1.53	0.46	1.03	1.16	0.69	0.45	1.06	1.08	3.47	3.58	1.40

T_1- 0, T_2- 1, T_3- 5, T_4- 10, T_5- 15, T_6- 20, T_7- 30 and T_8- 40 mg Cd/kg

recorded with 1 mg Cd/kg which decreased in successive instars and efficiency of conversion of ingested food was17.59 per cent in sixth instar. Minimum efficiency of conversion of ingested food of second instar larva was recorded with 40 mg Cd/kg (32.98%) which decreased in successive instars (13.74%) in sixth instars(Table 2). Waldbauer (1968) pointed out that the efficiency of conversion of ingested food usually decreases with age and the decrease may partly be due to the concomitant decline in digestibility of food. The lower utilization efficiency of larvae fed on metal mediated artificial diet in comparison to those fed on the control artificial diet could be due to the reason that more food was being metabolized for energy and less was being converted to body mass. Cadmium affects food digestibility as polluted birch leaves had low digestibility and larvae could not process them as efficiently as in control leaves (Migula and Binkowska 1993, Fountain and Hopkin 2001, van Ooik et al 2007).

It is evident from Table 2 that maximum efficiency of conversion of digested food (51.66%) of second instar larva was recorded with 1 mg Cd/kg which increased in successive instars (68.29% in sixth instar). Minimum efficiency of conversion of digested food of second instar larva was recorded with 40 mg Cd/kg (46.15%) which increased in successive instars (55.65% in sixth instar). Efficiency of conversion of digested food increased with age of instar which implies that the insect utilized more of digested food during its later instar. Mukerji and Guppy (1970) reported that in later instar of *P unipuncta* growth took place at higher rate but digestibility was lower resulting in a high rate of utilization of digested food.

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