Int. J. Indust. Entomol. Vol. 5, No. 2, 2002, pp. 75~79

International Journal of *Industrial Entomology*

Effect of Zinc Chloride on Commercial Traits of the Bivoltine Silkworm, *Bombyx mori* L.

I. I. Hugar and B. B. Kaliwal*

Post-graduate Department of Studies in Zoology, Karnataka University, Dharwad-580003, India.

(Received 6 July 2002; Accepted 4 March 2003)

Oral supplementation of zinc chloride to silkworm larvae in different concentrations (30, 60 and 90 µg/ml) to the fourth and fifth instar resulted in a significant increase in commercial traits, like larval weight, silk gland weight, cocooning percentage in lower concentrartion (30 µg) treated group. The female cocoon weight, shell weight and its ratio were significantly increased in 30 and 60 µg treated groups, male cocoon weight, and shell weight in 30 µg treated group and its ratio in 60 and 90 µg treated groups, filament length, weight and moth emergence percentage in all the treated groups and egg productivity in 90 µg treated group were increased significantly. The remaining groups did not show any significant changes compared with that of carrier control.

Key words: Zinc chloride, Commercial traits, *Bombyx mori*.

Introduction

Mulberry silkworm, *Bombyx mori* (Lepidiptera: Bombycidae) in particular is a very sensitive and choosy for its food habit (Sengupta, 1990). Silkworms requires certain essential sugars, proteins, amino acids, fatty acids, vitamins and micro nutrients for its normal growth, survival and for growth of silkgland and higher production of good quality silk. Silkworm nutrition is considered as the major area of research from the scientific point of view. It has been suggested that the supplementation with minerals play a vital role in the larval development and cocoon characters (Horie *et al.*, 1967; Ito and Niminura 1966; Loknath *et al.*, 1986; Vishwanath and Krishnamuthy 1982). House (1974) reported that magnesium, calcium, Phosphorous, potassium, iron, manganese and zinc were essential salt elements required by *B. mori*.

Oral supplementation with copper sulphate, nickel chloride and potassium iodide in different concentrations to polyvoltine pure Mysore breed of the Silkworm, *B. mori* (Magadum, 1987), cupric chloride, zinc chloride, mangnese and copper sulphates to eri silkworm *Philosomia ricini* (Padaki, 1991) increased the economic parameters and larval weight respectively.

Feeding with calcium, magnesium, manganese sulphate, iron, potassium iodide and iodized salt, zinc, nickel, manganese and ferrous sulphate to silkworm have shown to increase the commercial characters and decrease the larval duration (Bajpayi *et al.*, 1991; Qudar *et al.*,1993; Islam and Khan, 1993; Chamundeshwari and Radhakrishniah, 1994; Sarkar *et al.*, 1995).

Oral supplementation of zinc chloride to bivoltine NB_4D_2 and potassium, magnesium and ferrous sulphates to silkworm showed significant increase in the larval, cocoon and post-cocoon traits (Balamani *et al.*, 1995, Nirwani, 1995). It is well known that zinc is an essential element and it has a key role in the growth process. Hence, an attempt has been made to study the effect of zinc chloride on the commercial traits of the bivoltine (NB_{18}) silkworm, *B. mori*.

Materials and Methods

The disease free layings (DFLS) of the bivoltine race NB_{18} of the silkworm larvae were obtained from Sericulture Grainage, Rayapur, Dharwad district, Karnataka and reared in the laboratory according to the improved method of rearing techniques (Krishnaswami, 1978). The fourth instar larvae were randomly grouped into five experimental groups. Each group consisted of five replications each of 20 silkworms.

*To whom correspondence should be addressed.
Post- graduate Department of Studies in Zoology, Karnatak University, Dharwad-580 003, India. Tel: +91-0836-747121 (Extn. 230); Fax: +91-0836-747884; E-mail: b_kaliwal@yahoo.com

The chemical zinc chloride procured from E-merck (India) limited, Worli, Bombay, was individually dissolved in distilled water and diluted in three concentrations (30, 60 and 90 µg/ml). The zinc chloride was uniformly sprayed on fresh mulberry leaves with each concentration and then the leaves were dried and fed to the silkworm alternately with untreated mulberry leaves out of four feedings per day (two feedings treated leaves + two feeding untreated leaves). The controls were fed with the leaves, sprayed with distilled water and normal leaves.

The larval, cocoon and post-cocoon parameters were recorded separately. The larval parameters such as larval and silkgland weights were recorded before commencement of the spinning activity. The larval duration was recorded from the day of hatching to till the completion of the spinning activity. The cocoon parameters such as female and male cocoon weights and their shell weights were recorded on the 5th day after the completion of spinning activity. Filament length was recorded with epprovette by reeling single cocoon. The reeled silk was dried in hot air oven and weight was taken in an electrical balance. The cocoon shell ratio, and denier of the filament was calculated. The egg productivity was recorded in the adult after mating. The cocooning, moth evergence and hatching percentage were also calculated by the formulas shown bellow. Each mean value, a record of 10 observations is shown in Tables 1, 2 and 3. The experiments were conducted twice to conclude the results.

$$\text{Survival percentage} = \frac{\text{Number of cocoon formed}}{\text{Total number of larva kept}} \times 100$$

$$\text{Coocon shell ratio} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

$$\text{Denier} = \frac{\text{Single cocoon filament weight (gm)}}{\text{Single cocoon filament length (mt)}} \times 9000$$

$$\text{Moth emergence percentage} = \frac{\text{Number of moth emerged}}{\text{Number of cocoon kept}} \times 100$$

$$\text{Hatching percentage} = \frac{\text{Total number of eggs hatched}}{\text{Total number of eggs laid}} \times 100$$

The data collected were subjected to analysis of variance test to find out the significance between the parameters of the untreated and treated groups (Snedecor and

Table 1. Effect of zine chloride ontraits of the silkworm, *B. mori*

Treatment	Dose (ug/ml)	Larval weight (g)	Silkgland weight (g)	Larval Duration (hrs)	Survival percentage (%)
		4.52*	1.39*	618	98.1
Zine chloride	30				82.1**
		(107)	(112)	(99)	(103)
		4.49	1.36	620	96.3
Zine chloride	60				78.8**
		(106)	(109)	(99)	(101)
		4.32	1.31	618	95.8
Zine chloride	90				78.0**
		(102)	(106)	(99)	(101)
	Distilled	4.21	1.4	621	94.4
Carrier control	water				76.3*
		(100)	(100)	(100)	(100)
		4.11	1.08	628	93.4
Normal	–				75.1*
		(97)	(87)	(101)	(98)
		(NS)	(S)	(NS)	(S)
S. E. M. ±		0.157	0.074	10.879	1.617
C. D. at 5%		0.306	0.144	20.091	2.986

*: Significant increase/decrease at 5%
**: Angular transformed values
S: Significant
NS: Non significant
S. E. M. ±: Standard error mean
C. D.: Critical difference
Percent increase/decrease over that of carrier control in parenthesis.

Table 2. Effect of zinc chloride on cocoon traits of the silkworm, *B. mori*

Treatment	Dose (ug/ml)	Female cocoon weight (g)	Female cocoon shell (cg)	Female cocoon shell (%)	Male cocoon weight (g)	Male cocoon shell (cg)	Male cocoon shell (%)
Zine chloride	30	1.76 (109)	33.9 (108)	19.3 (100)	1.39* (105)	26.1* (112)	18.8 23.81** (107)
Zine chloride	60	1.76* (109)	34.2 (109)	19.4 24.95** (100)	1.36 (102)	25.0 (108)	18.4* 24.95** (105)
Zine chloride	90	1.68 (104)	30.8 (98)	18.3 24.80** (94)	1.34 (101)	24.5 (106)	18.3 25.48** (105)
Carrier control	Distilled water	1.61 (100)	31.3 (100)	19.4 23.97** (100)	1.32 (100)	23.1 (100)	17.5 23.19** (100)
Normal	–	1.59 (99)	28.3 (90)	17.8 24.04** (92)	1.27 (96)	18.1 (78)	14.3 21.13** (82)
		(S)	(S)	(S)	(S)	(S)	(S)
S. E. M. ±		0.076	0.012	0.839	0.036	0.013	0.665
C. D. at 5%		0.148	0.024	1.629	0.070	0.025	1.291

*: Significant increase/decrease at 5 %
**: Angular transformed values
S: Significant
NS: Non significant
S. E. M. ±: Standard error mean
C. D.: Critical difference
Percent increase/decrease over that of carrier controls in parenthesis.

Table 3. Effect of zinc chloride on the cocoon and post cocoon traits of the silkworm, *B. mori*

Treatment	Dose (ug/ml)	Filament length (m)	Filament weight (cg)	Deneir (d)	Moth emergence (%)	Egg producivity (No. s)	Hatching percentage (%)
Zine chloride	30	1.139* (170)	38.2* (184)	3.02 (107)	91 72.64** (102)	562 (102)	97 80.02** (101)
Zine chloride	60	1.092* (163)	31.3 (150)	2.58 (92)	95 77.21** (107)	573 (104)	97 80.54** (101)
Zine chloride	90	962 (144)	30.6* (147)	2.86* (02)	(95) 77.21** (107)	651 (118)	(96) 78.46** (100)
Carrier control	Distilled water	667 (100)	20.8 (100)	2.81 (100)	89 70.27** (100)	550 (100)	96 78.46** (100)
Normal	–	656 (98)	20.8 (100)	2.85 (101)	87 60.61** (97)	517 (94)	96 70.75** (98)
		(S)	(S)	(S)	(S)	(S)	(S)
S. E. M. ±		45.70	0.007	0.836	0.882	39.241	1.139
C. D. at 5%		84.39	0.014	0.160	1.629	72.422	2.104

*: Significant increase/decrease at 5%
**: Angular transformed values
S: Significant
NS: Non significant
S. E. M. ±: Standard error mean
C. D.: Critical difference
Percent increase/decrease over that of carrier controls in parenthesis.

Cochron, 1967). The percent values for cocooning, female and male cocoon shell ratio and hatching percentage were transformed into sine angular values for statistical analysis. The percent index was calculated for each parameter of the experimental groups over that of the corresponding parameters of the control.

Results and Discussion

The data on the effect of zinc chloride on the commercial traits of the bivoltine (NB_{18}) silkworm are presented in Tables 1, 2 and 3.

Larval weight

Larval weight did not show any significant changes in three concentrations except in 30 µg/ml treated group where the larval weight is significantly increased when compared with that of the carrier control. Similar increase in larval weight with low concentration of zinc was reported in *B. mori* (Chamundeshwari and Radhakrishnaih, 1994; Balamani *et al.*, 1995).

Silkgland weight

There was no significant change in the wet weight of the silkgland in all the three concentrations except in 30 µg/ml treated group where the silkgland weight is significant increase when compared with that of the carrier control. Similar results of increased silkgland weight obtained with cobalt chloride in nistari race (Bhattacharyya and Medda, 1978), potassium iodide, copper sulphate and nickel chloride in pure Mysore breed of *B. mori* (Magadum, 1987), with rain water containing dissolved calcium, magnesium, iron, chloride and calcium carbonate in trace amount (Thangavelu and Bania, 1990), potassium nitrate in nistari race (Dasmahapatra *et al.*, 1989). The increased silkgland weight with lower concentration of zinc chloride might possibly be due to the stimulatory effect on protein synthetic activity of the silkgland as in case of larval growth.

Larval duration

There was a slight decrease in the larval duration but the decrease was not significant. However, decrease in the larval duration has been reported after supplementation with potassium iodide in nistari race of *B. mori* (Chakraborthi and Medda, 1978; Majumdar, 1982), potassium and ferrous sulphates in bivoltine NB_4D_2 race of *B. mori* (Nirwani and Kaliwal, 1995).

Survival percentage

There was no significant change in survival percentage in all the concentrations of zinc chloride treated groups except for low dose (30 µg) in which the survival percentage is significantly increased. It has been reported that the survival percentage of the larvae was higher after supplementation with copper sulphate, nickel chloride and potassium iodide in pure Mysore breed of silkworm, *B. mori* (Magadum, 1987). Nirwani (1995) has reported that the supplementation with potassium and magnesium sulphates significantly increased the survival percentage. In the present study, at low concentration of zinc chloride (30 µg) showed significant increase in the survival percentage there by suggesting the increased survival rate of the larvae, whereas no significant change in the remaining groups suggesting that there is no side effect of this chemical on the larvae.

Cocoon weight, shell weight and shell ratio

Oral supplementation with 30 and 60 µg zinc chloride significantly increased the female cocoon weight when compared with that of carrier control. In males, the cocoon weight and its shell weight significantly increased with 30 µg zinc chloride treated group. Male cocoon shell ratio was also increased with in 60 and 90 µg treated groups.

The treatment with low concentration of zinc chloride is reported to increase the cocoon weight and shell weight in $PM \times NB_4D_2$ race of *B. mori* (Chamundeshwari and Radhakrishnaiah, 1994; Balamani *et al.*, 1995). Supplementation with 30 µg zinc chloride in female and 60 and 90 µg in male significantly increased the shell ratio. It is suggested that low dose zinc chloride is more effective in increasing the cocoon traits. The results also seem to suggest that female and male respond differently with this chemical in their diet. However, mulberry leaves were not chemically analysed for the concentration of this chemical in them.

Length and weight of silk filament and its denier

There was significant increase in the filament length and weight in all the concentrations of zinc chloride treated groups when compared with those of the corresponding parameters of the carrier control. The longest filament length with heavier weight was obtained with 30 µg zinc chloride treated group. Similar increase in length of the filament is reported after supplementing the feed with low concentration of zinc and nickel chlorides in $PM \times NB_4D_2$ race (Chamundeshwari and Radhakrishnaiah, 1994), zinc in $NB_4 D_2$ race (Balamani *et al.*, 1995).

The denier values increased in all zinc chloride treated groups except for the group treated with 60 µg zinc chloride. The increased denier values may suggest the increased fineness of the silk filament.

Moth emergence percentage

There was a significant increase in the moth emergence percentage in all the treated groups. Similar results were reported after feeding mulberry leaves soaked in potassium sulphate to the bivoltine race of *B. mori* (Nirwani, 1995). It is suggested that the survival rate of the pupae was significantly increased and it is might be due to non-toxic effect of this chemical in the pupal stage.

Egg productivity

There was no significant change in the egg productivity except for the group treated with 90 µg zinc chlorode where the egg productivity is significantly increased. Similar increase in egg productivity is reported after supplementing the feed with potassium iodide in nistari race (Majumdar, 1982), a pure Mysore breed (Magadum, 1987), with rain water and minerals in *B. mori* (Thangavelu and Bania, 1990; Subburathinam and Chetty, 1991), and potassium and magnesium sulphates in bivoltine NB_4D_2 race of the silkworm, *B.mori* (Nirwani, 1995).

Hatching percentage

There was no significant change in the hatching percentage in all the zinc chloride treated groups when compared with carrier control. This indicates that the used concentrations had no advers effect on the egg hatching percentages.

Acknowlegement

The authors express their sincere thanks to Karnatak University, Dharwad for providing financial assistance and Prof. V. L. Kallapur, Former Chairman, P. G. Department of studies in Zoology, Karnatak University, Dharwad for providing necessary facilities.

Reference

Battacharyya, A. and A. K. Medda (1981) Effect of cyanocobalamine and cobalt chloride on lipid content of silkgland of *Bombyx mori* L. race nistari. *Sci. and Cult.* **47**, 140-141.

Balamani, R. S. P. M., W. Prince and V. Subburam (1995) Effect of zinc on the mutritional Indices, economic characters of cocoon and quality of silk of *Bombyx mori* L. *Indian J. Seric.* **34**, 69-71.

Bajapeyi, C. M., R. N. Singh and K. Thangavelu (1991) Supplementary nutrients to increase silk production. *Indian silk* **30**, 41-47.

Chakraborti, M. K. and A. K. Medda (1978) Effect of potassium iodide on silkworm *Bombyx mori* L. Nistari race. *Sci. Cult.* **44**, 231-223.

Chamundeshwari, P. and K. Radhadrishniaish (1994) Effect of zinc and nickel on the larval and cocoon characters of the silkworm, *Bombyx mori* (L). *Sericologia* **34**, 327-330.

Dasmahapatra, A. K., M. K. Chakraborthi and A. K. Medda (1989) Effect of potassium iodide, cobalt chloride, calcium chloride and potassium nitrate on protein, RNA and DNA conten of silkgland of silkworm (*Bombyx mori* L.) Nistari race. *Sericologia* **29**, 335-359.

Horie, Y., Watanabe K. and T. Ito (1967). Nutrition of the silkworm *B. mori* XVIII. Quantitative requirements for potassium, phosporus, magnesium and zinc. *Bull. Sericul. Expt. Sta.* **22**, 181-193.

House, H. L. (1974) The Physiology of Insecta. Academic Press, New York.

Ito, T. and M. Niminura (1966) Nutrition of the silkworm *B. mori* its specific requirements and its nutrition in relation to the mineral nutrition of its host plant mulberry *Morus indica* L. *Indian J. Exptl. BLC* **4**, 31-36.

Islam, Z. and A. R. Khan (1993). Growth and development of mulberry silkworm *Bombyx mori*. L. (Lepidoptera: Bombycidae) on field supplemented with manganese sulphate. *J. Biol. Sci.* **1**, 21-30.

Krishnaswami, S. (1978) New technology of silkworm rearing. *Bulletin CSRI* **2**, 1-24.

Loknath, R., K. Shivshankar and K. Kasivishwanathan (1986) Effect of foliar application of magnesium and micronutrients to mulberry on the quality and production of cocoons. *Indian J. Seric.* **25**, 40-41.

Magadum, S. B. (1987) Studies on the effect of some chemicals and hormones on the gonad and the life cycle of the silkworm, *Bombyx mori* L. Ph. D. Thesis, Karnatak University, Dharwad, India.

Majumdar, A. C. (1982) Note on the physiological effect on the growth and reproduction of silkworm fed on mulberry leaves soaked in potassium iodide. *J. Agric. Sci.* **52**, 50-52.

Nirwani, R. B. (1995). Studies on the effect of minerals, vitamins, solvents and vertebrates hormones on the economic parameters and reproduction of the silkworm, *Bombyx mori* L. Ph. D. Thesis, Karnatak University, Dharwad, India.

Padaki, P. R. (1991) Some aspects of physiology of the eri silkworm, Philosamia ricine Ph. D. Thesis, Karnatak University, Dharwad, India.

Qader, M. A., A. A. Sarker, M. A. Rab and N. Absar (1995) Effects of feeding mulberry (*Morus* sp.) leaves supplemented with different nutrients to silkworm, *Bombyx mori* (L.) *Curr. Sci.* **69**, 185-188.

Sengupta, K. (1990) Artificial diet for silkworm, Are we nearer the goal? *Indian Silk* **29**, 16-18.

Snedecoder, G. W. and W. G. Cochran (1967) Statistical Methods. Oxford and IBH Publishing Co., New Delhi.

Subbu Rathinam, K. M. and J. Sculochaba Chetty (1991). Effect of fortification mulberry leaves with minerals to silkworm, *Bombyx mori* L. *Seric.* **30**, 121-123.

Thangavely, K. and H. R. Bania (1990) preliminary investigation on the effects of minerals in the vain water on the growth and reproduction of Silkworm, *Bombyx mori* L. *Indian J. Seric.* **29**, 37-43.