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Effects of Selenium on the Physiology of Heart Beat, Oxygen Consumption and Growth in Silkworm *Bombyx mori* L.

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Abstract: Selenium is known to be an essential nutrient and is required for the prevention of a number of selenium deficiency diseases in various animals. Hence an approximate dose of selenium in the silkworm rearing can be predicted based on the behavioral responses of the inhabiting silkworms. Physiological parameters such as oxygen consumption, rate of heart beat and growth studies are carried out in Vth instar silkworm *Bombyx mori* L. on exposure to the lethal and sub lethal doses of selenium. At lethal dose of selenium decreased trends of oxygen consumption associated with low rate of heart beat has been observed. From this study, it is possible to establish limits and levels of susceptibility of silkworms to selenium in rearing.

Keywords: Selenium · *Bombyx mori* L. · Heart beat · Oxygen Consumption and growth

INTRODUCTION

Although there are several commercial species of silkworms, *Bombyx mori* is the most widely used and intensively studied insect. This insect is the sole living species in its family, Bombycidae and has been domesticated for a long time that it probably no longer survives in the wild. The ideal food for silkworm, *Bombyx mori* L. is mulberry from which it ingests various nutrients to support physiological activities. Many studies are carried out to improve the quality and quantity of cocoon crop by supplementing nutrients such as sugars, proteins, lipids, vitamins and trace elements [1-3]. Earlier reports [4] discussed about the nutritional role and metabolic functions of important nutrients such as aminoacids, lipids, carbohydrates and requirements of vitamins, minerals and trace elements.

Among the trace elements, understanding the biological functions of selenium has evolved from its highly toxic properties to the essential nutrient for humans and animals. However selenium can be hazardous and toxic in higher doses.Selenium is increasingly recognized as an essential nutrient [5] and exerts their biological effects either directly or by being incorporated into enzymes and other bioactive proteins. Dietary selenium supplement was reported to be an essential nutrient in the diets of mature poultry [6]. Metabolic disorders resulting from selenium deficiency have been recognized practically in all the major livestock producing countries of the world, Reports [7] exhibited the association of Keshan disease with selenium deficiency and also responsible for an enlarged and poor hearing function. Studies on selenium deficiency proved that the active supplies of thyroid hormone was associated with the selenium and its deficiency leads to abnormality of thyroid functioning [8]. It is evident that the involvement of selenium in maintaining structure and functional efficacy of mitochondria [9]. Selenium supplements were investigated in terms of the selenium effect on live weight, wool production in sheep and it had increased the wool length and fiber diameter [10].

The known function of selenium is that it is an important part of anti-oxidant enzymes that protect cells against the effects of free radicals that are produced during normal oxygen metabolism which would otherwise can damage cells and contribute to the development of some chronic diseases [11]. Bansal and Parminder Kour [12] showed that the absence of selenoprotein of low molecular weight which can be compared to cytochrome caused muscular dystrophy in selenium deficient sheep. Although much information is available on the effects of selenium on mammals, a little information has been reported in insects. Deka *et al.* [13] demonstrated that selenium could increase the economic traits of Eri silk

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cocoon. Supplementation of the diet with selenium enhances the life span of Drosophila by a process that may involve the newly identified proteins [14]. However the presence of selenium in high concentration than normal may alter the metabolic functions. Although selenium toxicity has been studied in several animal species [15-18], only a few studies on insects have been reported [19-21]. It is an established fact that the toxicity can produce lethal effects that reduce animal performance of crucial activity for survival in physically controlled habitats. The effect of lethal and sub-lethal dose of selenium on the physiology of oxygen consumption, heart beat and growth of silkworm, *Bombyx mori* L..is presented in this study.

MATERIALS AND METHODS

The silkworms *Bombyx mori* L. of V instar with parentage PM x NB_4D_2 race were used for the present investigation. All are maintained at a temperature of 23°C±1°C and humidity 75% and the photoperiod included 16 hrs day light and 8 hrs of darkness. These conditions were maintained during the experiment. A batch of 50 silkworms was fed with mulberry leaves (untreated) served as control. Then successive batches by 50 silkworms each treated with lethal and sub-lethal doses of seleniumThe rate of oxygen consumption of the silkworm larvae of V instar was measured by a method as advocated by Welsh and Smith [23]. The rate of heart beat was noted by dissecting the silkworm exposed to lethal and sub-lethal dose of selenium [24]. The growth of the silkworm was estimated using the method adopted by Venkata Reddy *et al.* [25].

RESULTS AND DISCUSSIONS

The results were showed in tables 1 to 3 and figures 1-3. Sodium selenite is known for its toxicity and tested against Spodoptera exigua with an LC_{50} of 9.14 in μmg^{-1} body weight. Many reports reveal that insects are highly sensitive to selenium [26]. This susceptibility to selenium might be due to their higher metabolic rate at high concentration of selenium exposure. This coincides with the opinion of [28] those toxicants rapidly incorporative into the tissues due to higher metabolic rate.

Smitha [29] found the 24 hr LD50 obtained to V instar silkworm B.mori.L is as 32.39 mg /kg b.wt. In the present study the dose of 32.39 mg/kg.b.wt,. is taken as lethal dose and 1/5 of the lethal dose as sub-lethal dose (6.47 mg./kg.bw.). At lethal exposure significant disruption in the normal behavior such as hyper excitation, abnormal sluggish movements, body undergoing convolutions etc. in silkworms was observed. Silkworms also exhibited profuse vomiting and equilibrium is totally disrupted leading to death of the worms. This might be due to the decreased oxygen consumption at lethal exposure to selenium. Because of the rate of metabolic activity is estimated in terms of the rate of oxygen consumption. It can be postulated that inhibition of motor nerves due to selenium might be resulted in low locomotor activity. According toWyatt and Kalf [30]

Table 1: The rate of oxygen (O_2/hr/gm wet wt) in V instar of PM x NB_4D_2 race of silkworm, *Bombyx mori* exposed to selenium at different doses

S.No	Dose	ml of O_2/hr/gm Wet wt.
1.	Control	0.819^{b}
2.	Lethal	0.773^{a} (-5.6)
3.	Sub-lethal	0.823^{b} (+0.48)

** Each value is a mean of eight estimations*

*** Percent decrease over control is given in parenthesis.*

**** Means within a column followed by the same letter are not significantly different (P > 0.5) from each other according to Duncans Multiple Range Test.*

Table 2: The rate of heart beat in V instar of PM x NB_4D_2 race of silkworm, *Bombyx mori* exposed to selenium at different doses

S.No.	Dose	ml of O_2/hr/gm Wet wt.
1.	Control	46^{b}
2.	Lethal	31^{a} (-32.60)
3.	Sub-lethal	47^{b} (+2.17)

** Each value is a mean of eight estimations*

*** Percent decrease over control is given in parenthesis.*

**** Means within a column followed by the same letter are not significantly different (P > 0.5) from each other according to Duncans Multiple Range Test.*

Table 3: Growth in PMXNB_4D_2 races of silkworm *Bombyx mori* prior to spinning on exposure to selenium

S.No.	Dose	Prior to spinning
1.	Control	387.5^{b}
2.	Lethal	277.4^{a} (-28.41)
3.	Sublethal	552.96^{c} (+42.69)

** Each value is a mean of eight estimations*

*** Percent decrease over control is given in parenthesis.*

**** Means within a column followed by the same letter are not significantly different (P > 0.5) from each other according to Duncans Multiple Range Test.*

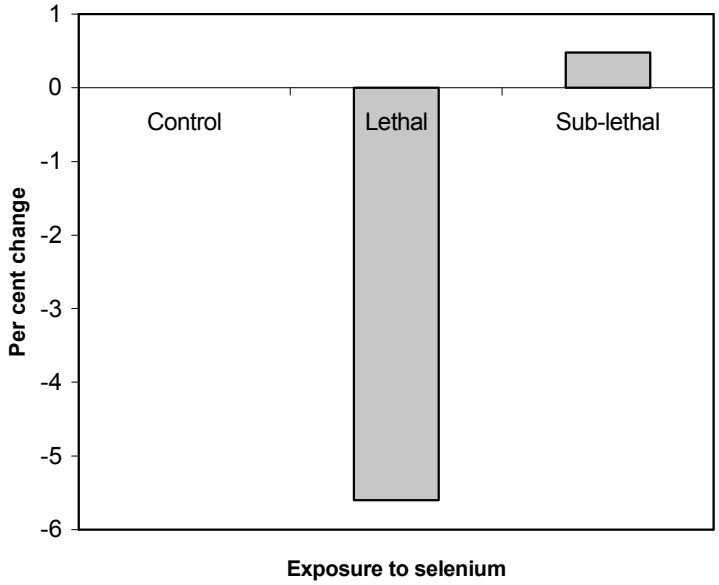

Fig. 1: Percent change over control in the rate of oxygen in V instar of PM x NB_4D_2 race of silkworm, *Bombyx mori* exposed to selenium at different doses

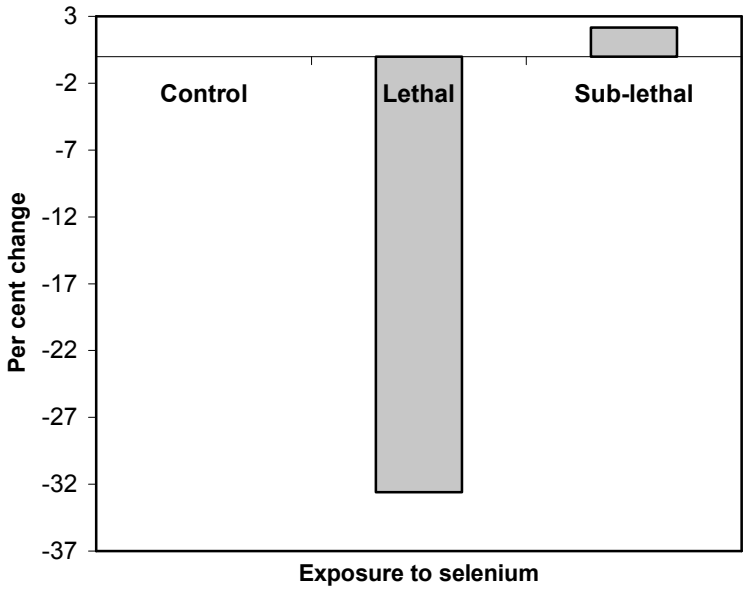

Fig. 2: Percent change over control in the rate of heart beat in V instar of PM x NB_4D_2 race of silkworm, *Bombyx mori* exposed to selenium at different doses.

the neurohormonal organ has been identified as a probable site for the action of toxicant in mediating the metabolic reserves. From this study is clear that selenium might have caused an indiscriminate release of neurohormones which ultimately lead to the metabolic imbalance in lethal dose of selenium. The decrease in oxygen consumption is accompanied by a significant decrease in the rate of heart beat at lethal dose of selenium exposure. This might be due to selenium stress reduced suppression of acetyl cholinesterase activity altering in the function of pacemaker ganglia.

The result on the effect of selenium on the growth is significantly decreased when exposed to selenium at lethal dose. Many researchers reported that reduced intake of food ingesta cause severe fall in the total carbohydrate level and ultimately lead to low energy and affected proteins synthetic mechanism [31, 32]. It is known that under stress conditions decreased proteins in the hameolymph were also observed [33, 34]. However no significant changes were observed except hyper excitable movements of silkworms exposed to sub lethal dose of selenium at the initial hours of exposure.

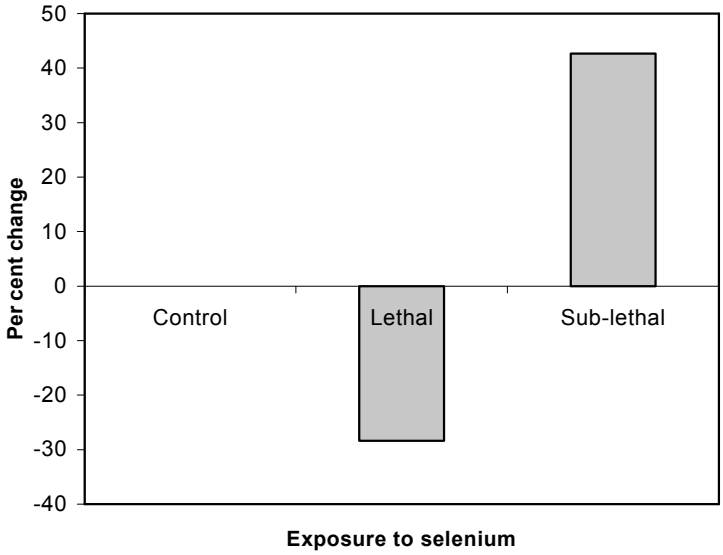

Fig. 3: Percent change over control in growth of V instar of PM x NB_4D_2 race of silkworm, *Bombyx mori* exposed to selenium at different doses.

The results on the whole indicate that, selenium at sub lethal doses act as a growth stimulant These results coincides with the work done byDeka *et.al.* [13] on the effect of sodium selenite on Eri silkworm in the silk production. Many research studies regarding selenium deficiency in animals which ultimately lead to metabolic disorders have been reported [35, 7 ,9]. Selenium acts as an accelerator in sub lethal dose. The respiratory rate in the sub lethal dose is perhaps the most of over conformed fact in insect physiology. Selenium at sub lethal dose might have stimulated central nervous centre directly or reflex via respiratory chemo receptors such as acetyl Cholinesterase. In the present investigation the rate of heart beat is significantly increased. This can be attributed to stimulation of neurogenic heart of silkworm *Bombyx mori* L. Many authors described about the heart beat in different insects [36-39].

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