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Losses of Cd, Hg, and Zn During Metamorphosis in the Beetle *Tenebrio molitor* (Coleoptera: Tenebrionidae)

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Insects occur in great numbers and are important for the transport of metals between trophic levels in food webs. Therefore, processes influencing metal concentrations in insects are important for the distribution of metals in ecosystems. The metamorphosis in holometabolous insects is of importance for metal concentrations. During this process some organs undergo an extensive breakdown as new organs are built up (Wigglesworth 1974). In the course of this process, concentrations of Cd were found to be altered (Aoki and Suzuki 1984; Lindqvist and Block 1995).

The impact of the metamorphosis on concentrations of other metals has been less studied. Nuorteva and Nuorteva (1982) found that Hg concentrations were lower in adult blowflies than in larvae, which suggests that Hg concentrations are altered during metamorphosis. Zn is an essential metal and is subject to homeostatic regulation (Chapman 1982). If no changes in metabolic pathways are needed, the optimal concentration of Zn may remain unchanged.

The aim of this study was to measure the loss of Cd during metamorphosis in an insect and to determine whether Hg and Zn undergo a similar type of decrease. Hg was studied in both inorganic and methylated forms in order to reveal how the chemical form of this metal influences its metabolism. *Tenebrio molitor* was used in this study because adults and larvae share the same diet. Since this study lasts from the larval stage to the adult stage, the type of food is not changed. A shift in diet could influence the metabolism of the metals.

MATERIALS AND METHODS

The metals were accumulated during the larval period in *Tenebrio molitor*. Pre-ultimate instar larvae of *T. molitor* were kept in darkness at 20°C and 65% R.H. For each treatment, 10 larvae were reared individually in glass boxes and given wheat bran as food. The larvae were also given a piece of potato containing ^{109}Cd, ^{203}Hg, Methyl-^{203}Hg or ^{65}Zn. The potato pieces, approximately 2*5*10 mm, had been incubated 30 min in a 0.9% NaCl solution containing one of the metals. After the incubation, the potato pieces were dried on a paper towel for 1 hr and thereafter given to the larvae. The potato pieces were replaced by untreated potato after one week.

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The following chemicals were used: $^{109}CdCl_2$, specific activity 1.76 mCi/mg, $^{65}ZnC1_2$, 1.62 mCi/mg, $^{203}Hg(NO_3)_2$, 1.37 mCi/mg; all of which were purchased from Du Pont Scandinavia, Stockholm, Sweden. Methyl-^{203}Hg was synthesized according to Naganuma et al. (1985).

Metal contents were measured in the larvae in vivo during the last larval stage using a gamma-counter (Searle model 1185). Thereafter contents of the metals were monitored every third day throughout metamorphosis and for 27 days following eclosion of adults.

RESULTS AND DISCUSSION

Contents of all the studied metals declined at pupation when the exuvium was cast off and the pupal stage began. The ^{109}Cd content of newly eclosed adults was 76% of that of the last instar larvae. For ^{65}Zn it was 87%, for ^{203}Hg 65% and for methyl-^{203}Hg 83% (Fig. 1).

In various insect larvae Cd was found to be accumulated mainly in the gut epithelium (Aoki et al. 1984; Suzuki et al. 1984). This was also true for Cd and inorganic Hg in adults of the carabid beetle *Pterostichus niger*, whereas Zn and rnethyl-Hg were found to be distributed throughout the body (Lindqvist et al 1995). In this study, concentrations of ^{65}Zn were less affected by metamorphosis compared with those of ^{109}Cd and ^{203}Hg. It is obvious that metamorphosis-associated losses of metals which have penetrated the gut epithelium and entered into the body cavity are lower than losses of metals that mostly remain in the midgut epitheliums which is reformed.

In contrast to our results, concentrations of Zn in adults of various insect species were found to differ markedly from those of the corresponding larvae (Lindqvist 1992; Gintenreiter et al. 1993). However, in those cases the larvae and adults have different diets, whereas immature and adult *T. molitor* share the same diet.
For 27 days after adult eclosion, contents of ^{109}Cd, methyl-^{203}Hg and ^{65}Zn in adults of *T. molitor* decreased to approximately half of the initial contents, whereas the decline in ^{203}Hg content was larger. This difference can be attributed to the low ability of ^{203}Hg to penetrate the gut epitheliums. ^{203}Hg is shed into the lumen of the midgut and excreted when the cells of the epithelium are renewed.

Based on the data presented in this study, it was not possible to conclude whether ^{65}Zn lost from the adults was replaced by non-radioactive Zn from the food. It is likely that this was the case, because insects can regulate the concentration of Zn in the body (Chapman 1982).

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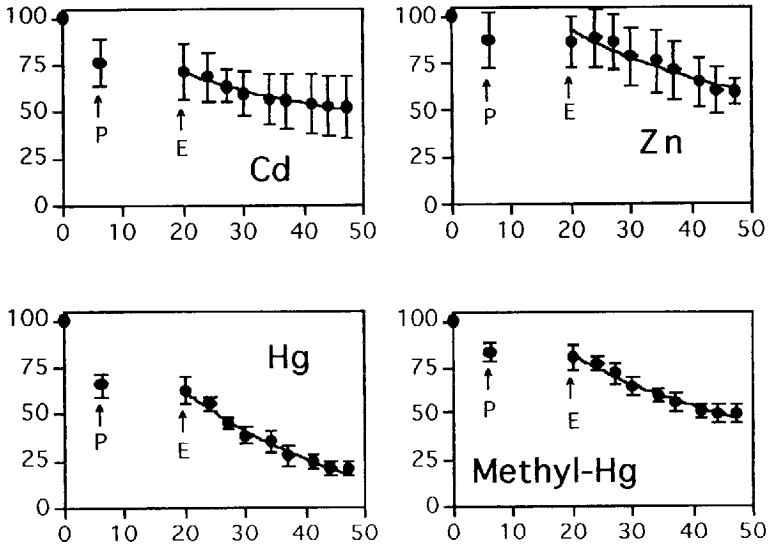

Figure 1. Metal contents, mean ± S.D., in *T. molitor* are given on the y-axis. Contents expressed as percent of that of the larvae before metamorphosis (day 0), mean value ± SD. Time (days) is given on the x-axis. Pupation is designated by a "P" and eclosion from the pupae by an "E". Equations for lines
Cd: y=-54.5*logx+141.6 r^2=0.96, Zn: y=-85.4*logx+203.8 r^2=0.90,
Hg: y=–119.5*logx+217.4 r^2=0.98, MeHg: y=–93.7*logx+203.8 r^2=0.98,
p<0.001 in all cases.

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