Journal of the Egyptian
German Society of Zoology

Entomology

J. Egypt. Ger. Soc. Zool. ISSN 1110-5364
Http: www.egsz.com
Email: info@egsz.org.
Vol. (40E): Entomology 53-62, Jan. 2003 January, 2003
Rec. 20/10/2002

TRANSPORT OF CADMIUM FROM TREATED LARVAL MEDIA TO THE BLOWFLY *CHRYSOMYA ALBICEPS* (WIEDEMANN) LIFE STAGES (DIPTERA: CALLIPHORIDAE)

Fahad A. M. AL- Misned
Department of Zoology, College of Science, King Saud University,
P.O.Box 2455, Riyadh 11451, Saudi Arabia.

Key words: *Chrysomya albiceps;* Cadmium; Content; Accumulation.

ABSTRACT

Larvae of the blowfly *Chrysomya albiceps* were reared on media containing 0, 100 and 200 µg cadmium/g dry media. The concentration of cadmium in the feeding and wandering larvae, pupae, pupal shells and adults were increased with the increase of cadmium concentration in prepared food. Cadmium concentration was lower in the feeding larvae than in the devoured food. Body concentration of cadmium was usually lower in every stage than in the preceding one. Pupae discharged about 33-37% of cadmium in their pupal shells. Concentration of cadmium in adult bodies at emergence, were higher in females than in males. Adults eliminated about 67% of their cadmium load within their first three days (72 hours). Excretion of accumulated cadmium in faeces, in sloughed off larvae and pupa exuviae was indicated.

INTRODUCTION

In the last two decades, it is quiet clear that cadmium concentration has been increased to toxic levels in respect to several organisms (Quimby et al., 1979; Martoja et al., 1983; Schmidt et al., 1991, 1992 and Schmidt and Ibrahim, 1994). At the same time, it is well known that cadmium is easily transferred and biomagnified in the food chain (Lindqvist, 1988), and could therefore lead to serious problems, such as high mortality rate, deformations and toxic effects in higher trophic levels.

The life cycle of the blowfly *Chrysomya* from egg to adult stage takes from 10 to 28 days. The eggs are laid in masses on carcases; they hatch within 24 hours, and the larvae mature in a period of 4 to 12 days. The pupal stage lasts from 5 to 15 days (Zumpt, 1965; Prins, 1982 and Al-Misned et al., 2002). *Chrysomya albiceps* occurs in different regions of the world: Africa, Southern Europe, South West Asia and East and North West India (Zumpt, 1965), South America (Baumgartner and Greenberg, 1985). It is ubiquitous in Saudi Arabia, commonly in different places such as

hospitals, homes, slaughterhouses, markets, garbage and gardens (Buttiker et al., 1979). *C. albiceps* is essentially scavenger and could be considered as beneficial biological control agent because of its ability in reducing populations of carrion flies, which are of medical and veterinary importance (Omar, 1995). This species is of veterinary importance as it is a carrion-breeder, and also causes secondary myiasis in sheep (Zumpt, 1965; Oldroyd and Smith, 1973; Erzinclioglu and Whitcombe, 1983, and Leite et al., 1983). The third instar larvae have been found to be predacious upon dipterous larvae (Zumpt, 1965), and larvae of *C. marginalis* (Coe, 1978), meanwhile the third instar of this species behave as a predator on the pupae of their own species (Tantawi et al., 1996).

Various studies dealing with transport of cadmium in life stages of insects have been notated (Lindqvist, 1988; Andrzejewska et al., 1990; Postma et al., 1994; Postma and Davids, 1995 and Rayms- Keller et al., 1998). Cheng (1980) fed larvae of *Drosophila melanogaster* on media mixed with cadmium > 1000 ppm and noticed that the adult flies died early without laying eggs. Studies of the grasshopper *Aiolopus thalassinus* reported that high concentrations of cadmium affect significantly the development throughout the whole life stages (Schmidt *et al.*, 1991; 1992; and Schmidt and Ibrahim, 1994).

Biological effects of larval media treated with 100, 200, 400, 800 and 1600 µg Cd/g dry media on the developmental time, mortality and weights of pupal and adult of *C. albiceps* were previously studied by Al-Misned (2001). Total developmental time was extended and the percentage of larval and pupal mortality were increased with increasing cadmium concentration in larval media. This was accompanied by loss in pupal and adult weight. Under similar conditions, the influence of larval media treated with 100 and 200 µg Cd/g dry media on adult longevity and fecundity of the same species were investigated (Al-Misned, 2002). Moreover, the life span was shortened and the total number of eggs per female was decreased with increasing cadmium concentration in the larval media. On the other hand, to the best of my knowledge no studies have been carried out on the transport of cadmium throughout the life stages of the blowfly *C. albiceps* yet.

Therefore the present work was carried out and based primarily on bioaccumulation studies of blowflies' *C. albiceps* stages, larvae reared on media contaminated by varying amount of cadmium. In addition to the excretion of cadmium from pupae during the whole period of their activity.

MATERIALS AND METHODS

Rearing of the Insect:

Egg-batches of 6th generation of the blowflies *C. albiceps* were obtained from the adult fly colony from Entomology Laboratory, Department of Zoology, King Saud University, Riyadh City, Saudi Arabia within 0-6 h. of egg

deposition. The colony was maintained in the laboratory in an environmental chamber at 25 °C, 60 - 65% RH, and a 15: 9 (L: D) h photoperiod as described by Amoudi *et al.* (1992). Larvae of *C. albiceps* were reared in cadmium contaminated ground beef as described by Al-Misned (2001).

One hundred first - instar blowfly larvae were removed from the colony within (0 - 6) h of egg hatching and placed into rearing beakers (11 cm diameter) containing contaminated ground beef. The ground beef was artificially contaminated by mixing of fresh ground media with solutions containing different concentrations of cadmium to obtain the following series: 0 (control), 100 and 200 µg Cd /g dry ground beef. The toxicants were mixed homogeneously with the fresh ground beef. After 4 days covered 3 - 4 cm deep moistened sawdust with distilled water were added to the rest media to allow pupation. The beakers were covered by cotton clothes held by rubber band to permit ventilation. Five replicates sampling beakers were used at each cadmium concentration.

Larvae were checked during wandering phase through the sawdust strata at 12-h intervals until pupation takes place. The fresh pupae were daily collected for each group, isolated and kept in clean beakers, which were provided with moistened sawdust. Beakers were covered with a cloth held by rubber bands until the emergence of adults. Upon adults flies were held in plastic

One hundred feeding larvae were collected at the 4th day, and at the 6th day, other one hundred wandering larvae were also collected from each concentration then transferred into clean beakers, killed by hot distilled water and washed.

After pupation, one hundred fresh pupae were collected from each concentration, transferred into clean beakers, washed by distilled water, then by fresh 95% ethanol, and lastly by distilled water again. Washed pupae were dried for 48 h at 85 °C.

Cadmium analysis

All materials used in preparation of specimens and analyses were cleaned in a three step procedure. Starting with an acid detergent treatment, materials were soaked in 0.1 N HNO_3 for 24 h, and finally rinsed at least three times with distilled water.

Insect specimens of larvae, pupae and exuviae were washed with distilled water in glass containers to remove dust particles, then washed with fresh 95% ethanol and again with distilled water to remove surface cadmium from the specimens (Middleton et al., 1972). Then specimens were placed in petri-dishes and oven dried for 48 h at 85 °C. The adult insects were dried directly without washing. They were weighed together directly from the oven. Samples were ground, divided into convenient portions and reweighed, before digestion. It was impossible to count insects included in each sample.

concentrated nitric acid (Analar) and allowed to stand for 24 h. The samples were digested at 85 °C, heated to near dryness and after cooling, brought to 10 ml with distilled water (Donald, 1979). Finally the solutions were filtered and stored in plastic vials until the analysis. All samples collected for this study were analyzed for cadmium content using a flame atomic absorption spectrometer (module Perkin-Elmer 380). Standard solutions with appropriate concentrations were prepared from 1000 µg AAS stock standards. The Cd content were determined on the basis of dry weight.

Statistical methods

Statistical analyses were conducted using the MINITAB Computer Program. Relationships between the cadmium concentrations in larval media and the cadmium content in immature and adult stages were tested using correlation coefficients. For univariate models, significance of the correlation coefficient, r, was tested with analysis of variance (Edwards, 1985).

RESULTS AND DISCUSSION

The results obtained in the present study showed that Cd accumulated in the bodies of feeding (4 days age) and wandering (6 days age) larvae. Regarding pupae and pupa shells this was dependent on the concentration of Cd in the larval food (Table 1). The concentrations of Cd in the feeding and wandering larvae, 0.93,p>0.05), (r = 0.97,p>0.05) and (r = 0.94,p>0.05), respectively.

Concentration of Cd was usually lower in the feeding larvae than in the devoured foods. It was 82.9 and 137.5 ppm at 100 and 200 ug Cd/g dry food, respectively, compared to 82.9% and 68.8% of Cd concentration in larval food, respectively. Seidman *et al.* (1986) found the same results in his study dealing with accumulation of Cd in *Chironomus thummi* (Europ. lab. strain). He exposed the larvae to 10 and 250 µg radiolabled Cd/L (ppb) for up to four days. After four days, average cadmium accumulation was 6.6 and 177 ng Cd/g dry weight (ppb), respectively

The concentration of cadmium in wandering larvae (at 6 days age) was lower than that in feeding larvae (at 4 days age). Wandering larvae may excrete cadmium accumulated during wandering in the sawdust with faeces or discharged it in sloughed off larvae exuviae. Amounts of cadmium were discharged to outside throughout the pupa shells of pupating larvae. These shells contained 37.0 and 32.9% of the analyzed cadmium found in pupae at 100 and 200 µg Cd/g dry food respectively. These results are similar to that found by Andrzejewska *et al.* (1990) in their experiments on caterpillars.

The amount of cadmium content accumulated in the bodies of adults were dependent on the concentration of Cd in the larval food

Cd concentration in larval media ($r= 1.00, p<0.01$), ($r= 0.97, p>0.05$) and ($r= 0.98, p>0.05$), respectively.

Vogel (1986) determined heavy metals concentration (Cd, Pb, Mn, Zn) in bark and wood of *Picea abies* Karst. from different locations and compared them with that of the bark-beetles feeding on it. In case of cadmium and zinc, a positive correlation of metal concentration between beetles and food were observed. This was in agreement with the present study.Cadmium concentration in adult bodies combined sexes at emergence was 50.3 ppm and 75.5 ppm at 100 and 200 µg Cd/g dry food, respectively which represent 50.3% and 37.8% of cadmium concentration in larval food respectively. On the other hand Lindqvist (1988) analyzed the cadmium content in 14 herb species and 6 adult insects species and one in larval stage, from two Central Swedish sites with equal cadmium burdens. The Cd concentration of herbivorous insects were about twice as high as those recorded from herbs. Differences between insect species in metals content could be due to a number of factors such as differences in food types, the period of feeding, size, age, developmental stage and sex, bioavailable form (Hare, 1992).

Concentrations of accumulated cadmium were higher in females than in males (Table 1) for both groups of contaminated rearing media (100 and 200 µg/g). Concentration of cadmium in females were 3.7- fold that in males for group 100 µg Cd/g and 2.5- fold for group 200 µg Cd/g. The differences in cadmium concentration between male and female emergent blowflies may have resulted from differences in their developmental time and body composition. Al-Misned (2001) described the effects of cadmium on developmental time of this species, and he found that the larval developmental time of females was longer than that of males at all cadmium concentrations applied in his study. Phillips (1980) and Smock (1983) found that the differences in the growth rates, rates of feeding, metal uptake and partitioning within the body could partly account for differences in metal content between sexes. Dukerschein *et al.* (1992) found that the differences in Cd concentrations between sexes in mayflies may have resulted from different factors including body composition.

At cadmium concentration 200 µg/g dry media, the mean concentration of cadmium in pupae, pupal shells and adults (combined sexes) were 61.4, 45.9 and 75.5 µg/g dry weight respectively. The mean dry weight of pupal, pupal shells and adults (combined sexes) were 10.1, 3.9 and 6.1 mg, respectively. The mean of cadmium content of the whole body was calculated to be 0.616, 0.179 and 0.463 µg for pupal, pupal shells and adult, respectively (calculated by multiplying the mean concentration of cadmium by the mean dry weight of life stages). These results indicated that the pupal stage eliminated about 29.1% of their cadmium content in their pupal shells.

The results of this study indicated that adult blowflies have a surprising ability to decrease their

cadmium content. There was significant negative correlation ($r = -0.95$, $P<0.05$) between adult age per hour and cadmium concentration in adults. Within their first three days (72 hrs), as adults, they eliminated about 67.9% of their cadmium load (Fig. 1). Cadmium accumulated in the bodies of adult insects, may be excreted with faeces. Nuorteva and Nuorteva (1982) have stated that the rapidity of mercury excretion in adult blowflies is, however, an artifact, because of the true excretory functions occurred during the pupal stage, and the role of the adult fly is restricted to emptying the excrement reservoirs (meconium from the intestine). It is clear from the results obtained in the present study that *C. albiceps* may not be used for monitoring purposes due to their ability to dispose cadmium.

ACKNOWLEDGEMENTS

I express my great appreciation to Mr. Salah Salem M. Abou-Fannah for his technical assistance.

REFERENCES

AL- MISNED, F. A. M. (2001): Biological effects of cadmium on life cycle parameters of *Chrysomya albiceps* (Wiedemann) (Diptera: Calliphoridae). **Kuwait J. Sci. Eng., 28:** 179-188.

AL- MISNED, F. A. M.; (2002): The effect of cadmium mixed with the larval media on longevity and fecundity of the blowfly *Chrysomya albiceps* (Wiedemann) (Diptera : Calliphoridae). **Kuwait J. Sci. & Eng.,** (In Press).

AL- MISNED, F. A. M.; AMOUDI, M. A. AND ABOU- FANNAH, S. S. M. (2002): Development rate, mortality and growth rate of immature *Chrysomya albiceps* (Wiedemann) (Diptera : Calliphoridae) at constant laboratory temperatures. **J. King Saud Univ. Sci., 15:** 49-58.

AMOUDI, M. A.; LECLERCQ, M. AND RICHET, R. (1992) : Rearing of a newly recorded Dipterous Fly *Parasarcophaga* (*Liopygia*) *ruficornis* (Fabricius) (Diptera: Sarcophagidae) from Saudi Arabia under laboratory conditions. **Pakistan J. Zool., 24 (3):** 181-186.

ANDRZEJEWSKA, L.; CZARNOWSKA, K. AND MATEL, B. (1990): Distribution of heavy metal pollution in plants and herbivorous *Spodoptera littoralis* L. (Lepidoptera). **Ekol. Pol., 38 (2):** 185-199.

BAUMGARTNER, D. L. AND GREENBERG, B. (1985): Distribution and medical ecology of the blow flies (Diptera: Calliphoridae) of Peru. **Ann. Entomol. Soc. Am., 78 (5):** 565-587.

BUTTIKER, W.; ATTIAH, M. D. AND PONT, A. C. (1979): Insects of Saudi Arabia Diptera: Synanthropic flies. **Fauna of Saudi Arabia, 1:** 352-367.

CHENG, L. (1980): Incorporation of cadmium into *Drosophila*. ***Environ. Pollut. (Ser. A)* 21:** 85-88.

COE, M. (1978): The decomposition of elephant carcases in the Tsavo (East) National Park, Kenya. **J. Arid Environ., 1:** 71-86.

DONALD, R. C. Jr. (1979): Lead concentrations: Bats rs. terrestrial small mammals collected near a major highway. **Environ. Sci. Technol., 13:** 338-340.

DUKERSCHEIN, J. T.; WIENER, J. G.; RADA, R. G. AND STEINGRAEBER, M. T. (1992): Cadmium and mercury in emergent mayflies *(Hexagenia bilineata)* from the Upper Mississippi River. **Arch. Environ. Contam. Toxicol., 23:** 109-116.

EDWARDS, A. L. (1985): Multiple regression and the analysis of variance and covariance. Freeman, New York.

ERZINCLIOGLU, Y. Z. AND WHITCOMBE, R. P. (1983): *Chrysomya albiceps* (Wiedemann) (Dipt., Calliphoridae) in dung and causing myiasis in Oman. **Entomol. Month. Magaz., 119:** 51-52.

HARE, L. (1992): Aquatic insects and trace metal: bioavilability, bioaccumulation and toxicity. **Critical reviews in Toxicol., 22** (5/6): 327-369.

LEITE, A.; MADEIRA, N. G.; GUIMARAES, M. P. AND LIMA, W. S. (1983): Primeira ocorrencia no Brasil de milase em Bezerro por *Chrysomya albiceps* (Diptera; Calliphoridae). **Arq. Bras. Med. Vet. Zool., 35:** 287-288.

LINDQVIST, L. (1988): Transport of cadmium from herbs to insects in a terrestrial environment. **Ent. Tidskr., 109 (3-4):** 119-122.

MARTOJA, R.; BOUQUEGNEAU, J. M. AND VERTHE, C. (1983): Toxicological effects and storage of *Locusta migratoria* (Orthoptera). **J. Invertebr. Pathol., 42:** 17-32.

MIDDLETON. S. G.; GILES, F. E. AND GRAU, J. G. (1972): Preparation of insect specimens for analysis by means of atomic-absorption spectrophotometry. **Ann. Entomol. Soc. Amer., 66:** 226-227.

NUORTEVA, P. AND NUORTEVA, S. L. (1982): The fate of mercury in Sarcosaprophagus flies and in insects eating them. **Ambio, 11:** 34-37.

OLDROYD, H. AND SMITH, K. G. V. (1973): Eggs and larvae of flies. In: Smith, K. G. V. (Ed). Insects and other arthropods of medical importance. British Museum (Natural History), London, pp. 289-323.

OMAR, A. H. (1995) : Cannibalism and predation behaviour of the blowfly, *Chrysomya albiceps* (Wiedemann) larvae (Diptera : Calliphoridae). **J. Egypt. Soc. Parasit., 25(3):** 729-743.

PHILLIPS, D. J. H. (1980): Quantitative aquatic biological indicators: Their use to monitor trace metal and organochlorine pollution, Applied Science Publishers Ltd, London, pp.280-281.

POSTMA, J. F. AND DAVIDS, C. (1995): Tolerance induction and life cycle changes in cadmium exposed *Chironomus riparius* (Diptera) during consecutive generations. **Ecotoxicol. Environ. Saf., 30(2):** 195-202.

POSTMA, J. F.; BUCKERT-DE JONG, M. C.; STAATS, N. AND

toxicity of cadmium to *Chironomus riparius* (Diptera: Chironomidae) at different food levels. **Arch. Environ. Contam. Toxicol., 26(2):** 143-148.

PRINS, A. J. (1982) : Morphological and biological notes on six South African blow-flies (Diptera, Calliphoridae) and their immature stages. **Ann. So. Afr. Mus., 90(4):** 201-217.

QUIMBY, P. C. JR.; FRICK, K. E.; WAUCHOPE, R. D. AND KAY, S. H. (1979): Effect of cadmium on two biocontrol insects and their host weeds. **Bull. Environ. Contam. Toxicol., 22:** 371-378.

RAYMS-KELLER, A.; OSON, K. E.; MCGAW, M.; ORAY, C.; CARLSON, J. O. AND BEATV, B. J. (1998): Effect of heavy metals on *Aedes aegypti* (Diptera: Culicidae) larvae. **Ecotoxicol. Environ. Saf., 39(1):** 41-47.

SCHMIDT, G. H. AND IBRAHIM, N. M. M. (1994): Heavy metal content (Hg^{2+}, Cd^{2+}, Pb^{2+}) in various body parts: its impact on cholinesterase activity and binding glycoproteins in the grasshopper *Aiolopus thalassinus* adults. **Ecotoxicol. Environ. Saf., 29:**148-164.

SCHMIDT, G. H.; IBRAHIM N. M. M. AND ABDALLAH, M. D. (1992): Long-term effects of heavy metals in food on developmental stages of *Aiolopus thalassinus* (Saltatoria: Acrididae). **Arch. Environ. Contam. Toxicol., 23:** 375-382.

SCHMIDT, G. H.; IBRAHIM, N. M. M. AND ABDALLAH, M. D. (1991): Toxicological studies on the long-term effects of heavy metals (Hg, Cd , Pb) in soil on the development of *Aiolopus thalassinus* (Fabr.) (Saltatoria: Acrididae). **Sci. Total Environ., 107:**109-133.

SEIDMAN, L. A.; BERGSTROM, G. AND GINGRICH, D. J. (1986): Accumulation of cadmium by the fourth instar larvae of the fly *Chironomus thummi*. **Tissue Cell, 18:** 395-405.

SMOCK, L. A. (1983): Relationships between metal concentrations and organism size in aquatic insects. **Freshwat. Biol., 13:** 313-321.

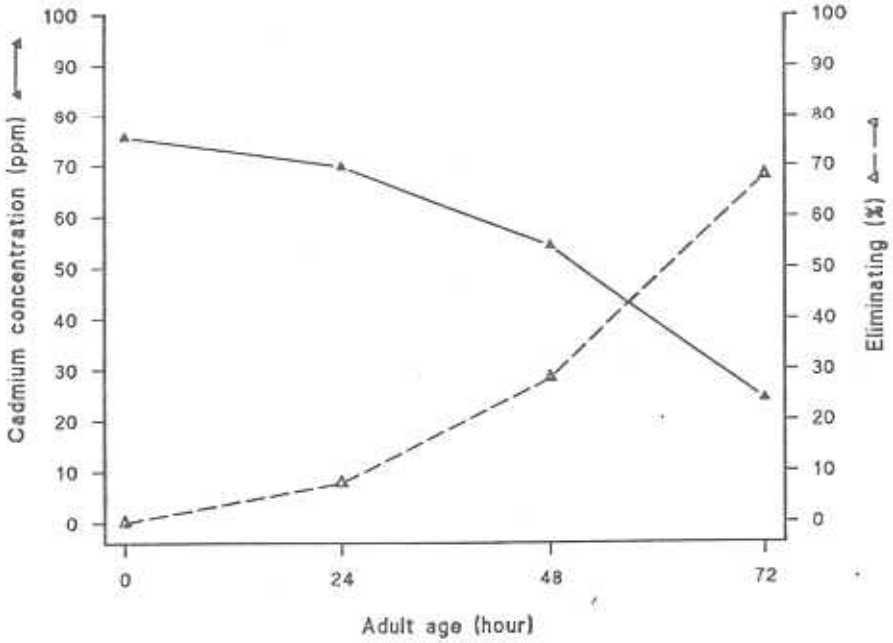
TANTAWI, T. I.; EL-KADY, E. M.; GREENBERG, B. AND EL-GHAFFAR, H. A. (1996): Arthropod succession on exposed rabbit carrion in Alexandria, Egypt. **J. Med. Entomol., 33(4):** 566-580.

VOGEL, W. R. (1986): Zur Schwermetallbelastung der Borkenkifer. **Entomol. Exp. Appl., 42:** 259-269.

ZUMPT, F. (1965): Myiasis in Man and Animals in the Old World. Butterworths, London. 267p.

Table 1. Mean cadmium concentration (ppm dry weight) in the different developmental stages of ***C. albiceps***, larvae reared on media containing various concentrations of cadmium.

Stage	Cadmium concentration µg/g dry media		
	Control	100	200
Feeding larvae (4 days age)	0	82.9	137.5
Wandering larvae (6 days age)	0	70.1	82.3
Pupae	0	44.7	61.4
Pupa shells	0	37.4	45.9
Adults ♂ + ♀	0	50.3	75.5
♂	0	22.5	45.2
♀	0	82.9	114.8



ISSN 1110-5364
Http: www.egsz.com
Email: info@egsz.org.

المجلة المصرية الألمانية لعلم الحيوان
العدد الأربعون (E)
يناير ٢٠٠٣

إنتقال الكادميوم من الغذاء اليرقي المعامل الى الاطوار المختلفة لذبابة كريزومايا ألبيسيبس *Chrysomya albiceps* (Wiedemann) التابعة لعائلة الذباب الملون من رتبة ثنائية الأجنحه

فهد بن عبدالمحسن محمد المسند
قسم علم الحيوان – كلية العلوم – جامعة الملك سعود
ص. ب. 2455– الرياض 11451– المملكة العربية السعودية

ملخص البحث : تم في هذا البحث تغذية يرقات ذبابة *Chrysomya albiceps* على غذاء معامل بالكادميوم بتركيزين مختلفين (١٠٠، ٢٠٠ ميكروجرام كادميوم/جرام من الوزن الجاف بالإضافة للمجموعة الضابطة وذلك لدراسة انتقال عنصر الكادميوم من الغذاء اليرقي الى الأطوار المختلفة لدورة الحياة. وقد اثبتت الدراسة ان تركيزات الكادميوم في كل من الطور اليرقي المتغذي والطور اليرقي المتجول والطور العذري واغلفة العذارى والطور اليافع تزداد بزيادة تركيزه في الغذاء اليرقي. كما بينت الدراسة ان تركيز الكادميوم في الطور اليرقي المتغذي (عمر ٤ أيام) اقل من تركيزه في الغذاء اليرقي وان التركيز كان يقل في كل طور عن الطور الذي يسبقه. كما وجد ان العذارى قد تخلصت من ٣٣-٣٧% من الكادميوم في اغلفتها. وبتحليل الذباب اليافع بعد بزوغه مباشرة من اغلفة العذارى وجد ان تركيز الكادميوم في الإناث اعلى منه في الذكور. كذلك وجد أن الذباب اليافع قد تخلص من حوالي ٦٧% من كمية الكادميوم خلال الثلاثة ايام الأولى من البزوغ . وقد اشارت جميع النتائج الى أن الاطوار المختلفة للحشرة كانت تتخلص من الكادميوم المتراكم في البراز وكذلك من خلال اغلفة كل من اليرقات والعذارى.