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Heavy Metal Cadmium and its Implication on the Developmental Stages and Abnormalities in Freshwater Snail *Lymnaea auricularia* (Lymnaeidae: Gastropoda) from Al-Hasa, the Eastern Province of Saudi Arabia

Mohammad A.M. Wadaan
Department of Zoology, College of Science, King Saud University,
P.O. Box 2455, Riyadh 11451, Saudi Arabia

Abstract: The aim of the study was to characterize the abnormalities of the embryos of *Lymnaea auricularia* as a result of exposure to cadmium and to assess the suitability of the snail as a bio-indicator of cadmium pollution in Al-Hasa Oasis. The experiment was conducted in December 2004 for fifteen days at the laboratory conditions. The eggs were treated with different concentrations of cadmium (1.0-5.0 ppm) and the development and abnormalities of the embryos were observed. It was noticed that 2.0-5.0 ppm of cadmium concentration greatly affected the development of the growing embryos.

Key words: Cadmium, *Lymnaea auricularia*, development, abnormalities

INTRODUCTION

In Saudi Arabia, aquatic toxicology is a rather new research field. The development of water and sediment quality criteria in an environment is based on the toxicity bioassays with standard and indigenous test species[1]. This environment is exposed to the mixture of contaminations spread over large area but we have only limited understanding of the effect of these contaminants as ecosystem functioning. However, the current methods of hydrochemical control are not adequate for detecting all possible pollutants and products of their transformation entering the environment[2]. Thus, ecologically meaningful levels of pollution that have detrimental effects on the area can only be assessed by using biological criteria[2-5]. Among the environmental disturbance, heavy metal contamination still remains a potential problem where industrial input are in close proximity to farming[2,6], thus metals may represent an important component of the contaminants load in the water column.

Studies on the influence of toxic pollutants on parasites of aquatic organisms have increased in recent years with much focus on the pollution effects on host parasite interaction[7,8]. So, molluscs are one of the most suitable bio-indicator because they are wide spread and have long life span[9,10]. However, very few studies have dealt with the ability of invertebrate larvae to accumulate contaminants during initial stages of the development[11-13]. To the best of our knowledge, there appears to be no report on the effect of cadmium embodying a simultaneous study and its effects on developmental stages of the molluscans.

Cadmium is relatively the rare metal being 67th in the order of the chemical abundance. It is found in the earth's crust at an average concentration of 0.1 kg^{-1}[14], although some sedimentary rocks and black shales can accumulate higher levels[14,15]. Cadmium may enters in the human body by inhalation, ingestion and by absorption through the skin and cause acute and chronic effect after exposure in both human and animals as well. The primary adverse effects which have been observed are lung cancer and kidney damage[16]. Cadmium is responsible for hypertension and renal tubule damage[1,17]. These chemicals my also effect on the developmental stages in the aquatic animals after accumulation in the body[2]. The sensitivity of early developmental stages of sea-urchins and bivalves to trace metals has been frequently studied[4,18-22]. However, data concerning toxicity of metals on fertilization and embryogenesis are scarce and rare in Saudi Arabia and these information may be the first to see the effect of heavy metal on developmental stages in snail. So, the objectives of the present study was the metal concentration related to the frequency of abnormalities observed within the rearing media in order to look for possible relationship between their bioaccumulation and the toxicity towards their larval development.

Corresponding Author: Dr. Mohammad A.M. Wadaan, Department of Zoology, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia
Tel: 00966 14675917/14675773 Fax: 00966 14678514

MATERIALS AND METHODS

Sampling site: Adult snails of *Lymnaea auricularia* were collected from Al-Hasa Oasis, the Eastern region of Riyadh, Saudi Arabia. This oasis is a long and important canal. It has a natural drainage course for surface water of a large area and has the stony bed and natural water flow with dense vegetation around. It is partially shaded by trees on grass bank. At present this oasis is being exploited with increased demand of the rapidly expanding Saudi Capitals. A part of it is used as a dumping ground for rubbish and other waste materials which pollutes the water itself.

Collection of sample: The snails were collected from the natural environment in the morning hours to avoid any body temperature and store in an aquarium and bring them in the laboratory. The animals accelematized at the laboratory condition adopting the natural environmental condition with certain vegetation, rocks and stone pebbles. The aquaria was placed with white fluorescent tube with automatic timer control system. The animals were fed before the experiment with lettuce. The waste was aerated for a week prior to use.

Metal solution: A stock solution of cadmium was prepared in double distilled water from which a required volume was added to the experimental tank to obtain the test concentration. A control set was also run parallel to each test tank. Test medium was renewed every 24 h. All the glasswares used were acid-washed and rinsed in doubled distilled water before the experiment commenced. During the period of exposure feeding was stopped.

Biological materials: After the acclimatization, the eggs of the specimen for each treatment were immediately placed in test solution having the required concentration of cadmium. Both control and the test solution were continuously aerated and renewed every day in order to maintain a constant concentration of the metal used. The required concentration were ranged from (1.0-5.0 ppm). At hatching the frequency of embryo abnormalities were determined from the sample of each concentration. Observations were made using the binocular and the pictures were taken with camera fitted into a phase contrast microscope that was connected to a PC for each test and to observe the deformation in the developmental stages of the embryos.

RESULTS AND DISCUSSION

The embryonic cells has to be scattered around the periphery but with decreased concentration the way of scattering become centered and the development of the embryo seized (Fig. 1-4). At lower concentration (Fig. 5) the shell appeared but not fully developed as in Fig. 6. Some developmental defects were determined according to morphological criteria. At hatching, the frequency of embryos abnormalities were determined from the samples at each concentration (1.0-5.0 ppm) compared with the control.

The incubation time was noted during the experimental test. In control, the egg capsules of uncleavage egg stage showed a normal growth, faster development and hatching occurred but for those exposed to the cadmium concentration, the embryos were unable to develop or hatch successfully and were stuck to the egg capsule. These observation were succeeded with the increase concentration of the metal (Fig. 2-5). Half of the embryos develop abnormally and higher concentration (5.0 ppm) all the embryos died and their development was stopped. In the study of Bellas *et al.*[2] in *Coina intestinalis* with heavy metal of Hg, Cu, Cd and Cr, observed that the early developmental stages were affected and reduce the rate of embryogenesis. These information are concordant with the present finding in *Lymnaea auricularia* after the exposure with cadmium. Radenac *et al.*[13] and Watzin and Roscigno[23] also observed that the heavy metal can cause the abnormalities of developing larvae of invertebrates. The author suggests that the embryogenesis provided a dose dependent response suitable for toxicity tests. In metal embryo toxicity test, the gastrula stage is the most sensitive stage in the development of invertebrate[2,18,24,25]. Hoare *et al.*[26,27] reported that embryonic development is the most sensitive stage to copper in the life cycle of *Mytilus edulis*. This bio-accumulation of the metal may cause the stress which may results the shortened incubation period and cause the death of the embryos. They may also change the physico-chemical properties of the shell itself through the process of permeable choroin and cause the death of the embryos. These information may also be confirmed with the finding of Suwiti[28] where the author observed the developmental abnormalities in freshwater snail *Physa acuta* after the exposure of zinc. Concurrent study on the embryotoxicity and the obtained results demonstrated rapid response to the presence of heavy metal and the high potential for the accumulation during early developmental stages of the organisms.

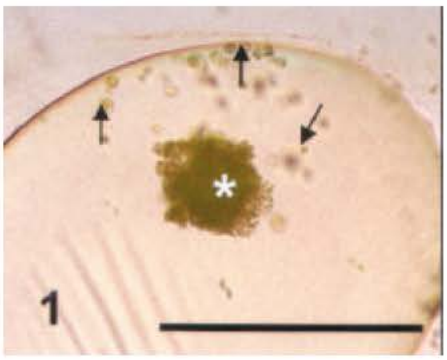

Fig. 1: Embryo of snail exposed to 5 ppm heavy metal of cadmium. Arrows show cells separating from the embryo, star shows scattered of cells representing the embryo (*)

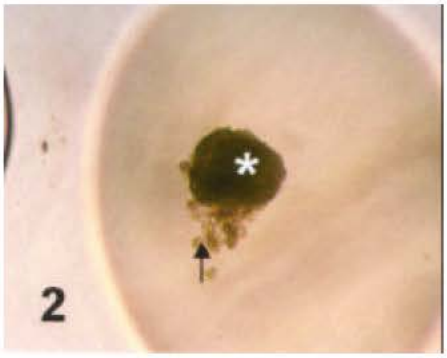

Fig. 2: Embryo of snail exposed to 4 ppm heavy metal of cadmium. Arrows show a slightly separating cells from the embryo, star shows cleaved cells as a compact mass (*)

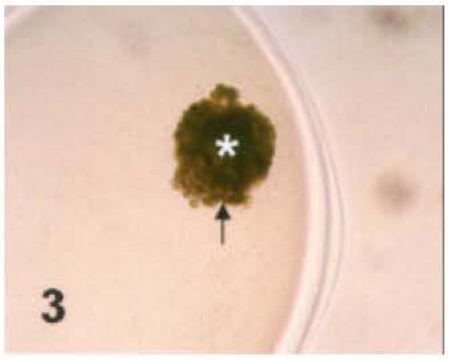

Fig. 3: Embryo of snail exposed to 3 ppm heavy metal of cadmium. Arrows show partly separating cells from the embryo, star shows cleaved cells as a compact mass (*)

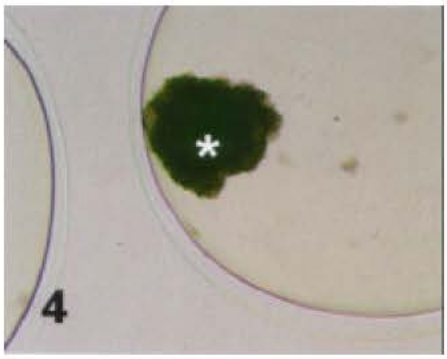

Fig. 4: Embryo of snail exposed to 2 ppm heavy metal of cadmium. Star show undifferentiating developmental cells (*)

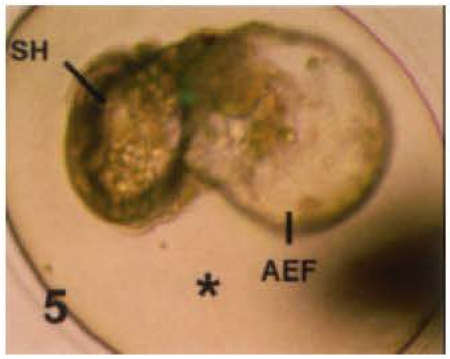

Fig. 5: Embryo of snail exposed to 1 ppm heavy metal of cadmium. Dead abnormal snails (SH - shell; AEF- abnormal enlarged foot)

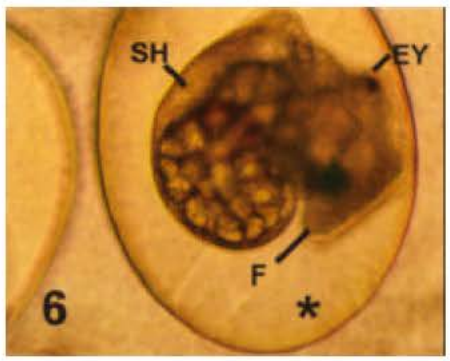

Fig. 6: Photomicrograph of embryonic snail of *Lymnea oricularia* grown in water without cadmium (SH - shell; EY- eye; f- foot)

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