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Accumulation of Heavy Metals by a Common Water Mite *Hydrodroma despiciens* (O.F. Müller, 1776) in Laboratory Condition

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A B S T R A C T

The objective of this study was to determine the resistance level of *Hydrodroma despiciens* which is a common water mite species against various heavy metals and manifest their ecological impact levels. Water mite samples were collected from Karamık Lake (Afyonkarahisar, Turkey) on a seasonal basis during 2013-2014 to this end. An equal number of samples were placed into separate aquariums to study each metal salt. Increasing concentrations of heavy metal nitrate salts such as $Ni(NO_3)_2$, $Cu(NO_3)_2$, $Cd(NO_3)_2$, $Hg(NO_3)_2$ and $Pb(NO_3)_2$ were added periodically into the aquaria. The ICP (Inductively Coupled Plasma-optical Emission Spectroscopy ICP-OES; Spectro Genesis, Germany) analysis of the lake water revealed medium and low levels of heavy metal ratios. It was observed that this mite absorbed each different heavy metals $Ni(NO_3)_2$, $Cu(NO_3)_2$, $Cd(NO_3)_2$, $Hg(NO_3)_2$ and $Pb(NO_3)_2$ in different ratios and that very low concentrations of Hg had the most severe negative impact, while high concentrations of Ni appeared to have the least negative impact.

INTRODUCTION

Today the uncontrolled release of industrial waste water causes major pollution of many streams and lakes. High levels of heavy metals in water are a significant indicator of pollution in internal waters. Even the presence of very low concentrations of many heavy metal salts in internal waters has a fatal impact on aquatic organisms. This impact is systematically more pronounced in the invertebrate species on the lower ranks of the ecosystem than the impact on vertebrate species (Proctor and Pitchard, 1989; Posthuma and Van Straalen, 1993; Siepel, 1995; Skubala and Kafel, 2004; Stamou and Argyropoulou, 1995; Van Straalen and Denneman, 1989; Van Straalen *et al.*, 1989).

Water mites have been especially chosen for this study because these are a diverse and abundant group of arthropods that play a significant role in aquatic community dynamics and are overlooked in most environmental studies. Consequently, a great deal of information is lost considering that often there are up to 5000 mites per m^2 in stream substrata. Moreover, water mites are parasitic and predatory for many aquatic invertebrates, especially insects that are frequently used in biomonitoring studies. Additionally, water mite community composition may be useful as an indicator of pollution (Smith and Cook, 1991).

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Toxicological studies regarding mites (*Acari*) are very few and studies regarding water mites are practically negligible. The study by Skubala and Zaleski (2012), involved the different reactions of oribatid species regarding heavy metal pollution. Some studies have been done on the concentration of cadmium, zinc and copper in the oribatid species (Tyler *et al.*, 1989; Burrows and Whitton, 1983; Greig *et al.*, 1976; Dallinger, 1994).

The aim of this study is to determine the danger level of heavy metal pollution which may create in the lake in terms of water mites.

Our study focused on the impact of heavy metals taking into consideration the ecological significance of water mites. The impact of nitrate salts of various heavy metals (Cu, Cd, Ni, Hg and Pb) on *Hydrodroma despiciens* (Müller, 1776), was studied on a morphological and molecular level.

MATERIALS AND METHODS

Collecting water mite samples

The samples were collected seasonally in 2013 from Karamık Lake (Afyon, Turkey). Work stations were determined on a map of the lake beforehand. These points were sampled with regular intervals. The collection was concentrated particularly on the coastal zones with a rich vegetation. Special scoops were used for sampling. A part of the samples were collected with pipettes and small sieves. Furthermore, aquatic plants collected from the lake environment were put into bags and then into white sinks in the laboratory where the samples were sorted with the help of pipettes. Subsequently these samples were placed into six aquaria five for experimental purpose and one as a control in the laboratory, each filled with 30 litre lake water and plants from the lake, to create micro lake ecosystem at 18°C. Living organisms (500) were distributed equally into each aquarium.

Chemical applications

Heavy metal nitrate salt was added into each aquarium in the first application as $1x10^{-5}$ molar ($10.2x10^{-3}$ g for $Hg(NO_3)_2 \cdot H_2O$; $7.23x10^{-3}$ g for $Cu(NO_3)_2 \cdot 3H_2O$; $8.72x10^{-3}$ g for $Ni(NO_3)_2 \cdot 6H_2O$; $10.4x10^{-3}$ g $Pb(NO_3)_2 \cdot H_2O$; $9.25x10^{-3}$ g for $Cd(NO_3)_2 \cdot 4H_2O$). In the second third, fourth and fifth an additional amount of $1x10^{-4}$, $1x10^{-3}$, $1x10^{-2}$ and $1x10^{-1}$ molar of metal salt was added, respectively. These processes were repeated separately for both the water mite samples as well as the aquarium water.

At the end of each week 100 individuals were collected randomly from the control and experimental aquaria washed and treated with 3 ml of concentrated nitric acid (HNO_3) with slight heating and hydrolysate analyzed at ppm level with an ICP (Inductively coupled plasma-optical emission spectroscopy ICP-OES; Spectro Genesis, Germany). The heavy metal concentration was also measured from the water samples by the same method.

RESULTS

The absorption rates of the organisms with Hg(II)nitrate application were 0.74, 0.75 mg/L respectively. No Hg was found in the organisms or the water when the control group was examined for mercury (Hg) (Table I). An observation of the samples revealed no abnormalities. However in the second week when $1x10^{-4}$ molar was loaded it was observed that the normal size of the samples had doubled with morphological swelling and the next day all had perished.

The amount of Cu absorbed by the organisms was 0.225, 0.628 and 0.729 mg/L, respectively. As a result of the Cu(II)NO_3 application the live samples died by the end of the third week. The amount of copper in the live samples of the control group was 0.146 mg/L. It was observed that under normal circumstances this value did not lead to any morphological and anatomical abnormalities in our samples.

The organisms were observed and at the end of the first week no difference was observed in the morphology and movements of the samples. In the second week the amount of the copper nitrate salt was increased to $1x10^{-4}$ molar but samples revealed no difference. In the third week $1x10^{-3}$ molar of copper salt was added all organisms had died.

Table I shows that all live organisms had absorbed 1.147, 2.243, 8.416 and 9.713 mg/L of the Pb. All live samples were dead by the end of the fourth week.

Table I shows that the amounts of cadmium (Cd) absorbed by the organisms was in line with the increasing concentrations of cadmium. By the end of the third week all live samples had died.

Nickel showed values of 4.02, 4.11, 4.24 and 4.64 mg/L, respectively. The amounts of nickel in the aquarium water and organisms of the control group were 2.165 (0.165 or 2.165 see Table) and 3.0 mg/L respectively. The analysis results of this control group show that nickel is more prevalent in natural lake environments compared to other metals.

DISCUSSION

There are very few studies on accumulation of heavy metals in aquatic mice. El-Sharabasy and Ibrahim (2010) carried out a study in which the heavy metal accumulation in oribatid mites and the mite species in the agricultural lands of Egypt were analyzed. It was determined that the heavy metals in the soil of agricultural lands were below limit values however the levels in the water used for irrigation were high. Cd, Pb, Cu, Zn metals were analyzed and it was determined that the amounts absorbed by oribatid mites was Zn>Pb>Cu>Cd respectively. In a study by Kahle and Zauke (2002), the concentrations of Cd, Co, Cu, Ni, Pb, and Zn were determined by an atomic absorption spectrometer in *Calanus propinguus, Rhincalanus gigas, Metridia curticauda* which are mite species in the Antarctic Sea. In conclusion it was determined that the highest rate of metal was for Cd while the least amounts were indicated for Co.

In our study we have used the most common water mite species which is *Hydrodroma despiciens.* According to the results of this study even the lowest concentration of mercury (Hg) had a lethal impact on the samples.

Table I shows that the acquired Hg values even in very low concentrations of this metal ($1x10^{-4}$ molar) had a violent negative impact on *Hydrodroma despiciens* in a very short time (Table I). When the parameters obtained with this metal application were assessed with the interpolation method the fact that the R^2 values of the curves in both graphs was 1.0 indicated that the samples absorbed the mercury at a rate which paralleled the increasing rate of mercury in the water and that the rate of mercury in the body of the living organism was the same.

The negative impact of mercury in the cells takes the following form, Mercury binds itself to the sulfur

Table I.- Concentration of heavy metal in mites (mg/g) and aquaria water (mg/L).

Weeks	Hg		Cu		Pb		Cd		Ni	
	Mites	Water	Mites	Water	Mites	Water	Mites	Water	Mites	Water
1	0.74	0.306	0.225	0.362	1.147	0.293	0.419	0.42	4.02	0.419
2	0.75	0.316	0.628	0.691	2.243	0.387	0.734	0.76	4.11	0.465
3	-	-	0.729	0.876	8.416	0.432	1.258	1.32	4.24	0.751
4	-	-	-	-	9.713	0.734	-		4.64	0.864
Control	<0.041	<0.001	0.146	<0.002	1.125	0.272	0.029	<0.002	3.00	0.165

atoms in enzymes and stops biochemical reactions as well as intracellular activities in the body. As a result cells are unable to fulfill membrane duties and the cells perish (Gündüz, 1994).

The copper (Cu) absorption values of *Hydrodroma despiciens* species calculated with the interpolation method were R^2 = 0.893. Although this value is rather low for copper metal for the mercury absorption point rate of the samples the R^2 value is similar to the others. No abnormalities were observed in terms of morphological changes and in the daily life cycles of the samples during the periodically executed copper loading in our study. However, at the end of the third week the toxicity of the copper caused the death of all the samples.

It was determined that the accumulation of lead absorbed by the body during the progressively increasing application of lead salts was rather high. Nevertheless, no abnormalities were observed in morphological and vital movements. It was observed that the lethal amount of lead absorbed by the body was 9.713 mg/L while the amount of mercury with the same effect was 0.75 mg/L (Table I).

According to this data it is clear that the same negative impact of mercury is more harmful than lead for vertebrate and invertebrate species alike. Zauke and Schmalenbach (2005), carried out an analysis of Cd, Cu, Pb and Zn in the zooplankton and crustaceans (*Pandalus borealis*) in the Barents Sea. The results of the analysis showed that Pb values were below the limit. The other metal values displayed seasonal differences.

At the end of the third week of cadmium salt applications it was determined that the amounts of cadmium absorbed by the living organisms was 1.258 mg/L (Table I). This amount appeared to have a lethal impact on the samples of the studied species. A proportional perspective in terms of cadmium shows that its negative impact is close to that of Hg, in other words the study showed that almost the same amounts (Hg and Cu) had the same lethal impact on the organisms. No morphological changes were observed in the organisms. No metal was observed in the water or the organisms of the control test group (Table I). The potential hazard level of this metal will vary in accordance with the amount of industrial waste. This is due to the fact that the amount of this heavy metal in natural environments is very low.

Seniczak and Seniczak (2002), carried out a study to examine the impact of cadmium under laboratory conditions on *Archegozetes longisetosus* which is a mite species. In this study the mites were fed with green algae which had been contaminated with $Cd(NO_3)_2$. The study revealed that low concentrations of cadmium such as 121 µg Cd g^{-1} had no impact on the mites, 247 µg Cd g^{-1} of cadmium had harmful effects and concentrations of 340 µg Cd g^{-1} and more were lethal.

Skubala and Kafel (2004) studied the accumulation of heavy metals in oribatid mite communities and forest ecosystems. The results showed that the accumulation level among the analyzed metals was the highest for Cd and Cu metals.

Another study by Seniczak *et al.* (2006), focused on the long term impact of Cd in a laboratory environment on *Archegozetes longisetosus* which is an oribatid mite species. The heavy metal was added into food in increasing concentrations. In conclusion the reproduction parameters of groups consisting of mite species were compared. All studies executed with cadmium mentioned above are in compliance with the results of our study.

Nickel (Ni) which is another heavy metal used in our study did not display any serious vital negativities. Nickel applications were carried out during four weeks in progressively increasing loadings ($1x10^{-5}$, $1x10^{-4}$, $1x10^{-3}$, $1x10^{-2}$, $1x10^{-1}$). At the end of each week the samples were analyzed with ICP and the absorbed amounts were found to be 4.02, 4.11, 4.24, 4.64 mg/L respectively (Table I). This amount was determined as 3.00 in the natural lake environment. The results show that the rate of nickel in natural lake environments is higher than the other heavy metal salts. Nickel had not been absorbed by the organisms in increasing amounts. The absorption amount appeared to be almost static with all loadings. In conclusion it can be said that this metal is not absorbed by organisms in increasing amounts and that it does not have a very significant impact.

Both this study as well as the studies of other researchers show that heavy metal salts have an impact on live species on very different levels (cell, tissue, organ, system). The impact levels are mostly negative. More studies done in the future will ensure a better understanding of this subject. It is clear that this information will contribute to the proper execution of ecological studies in aqueous environments as well as conserve the diversity of the species.

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