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Exposure of brown hare (lepus europaeus p.) population to harmful effect of lead (Pb) and cadmium (Cd) in the food chain due to anthropogenic factors.

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EXPOSURE OF BROWN HARE (*LEPUS EUROPAEUS P.*) POPULATION TO HARMFUL EFFECT OF LEAD (PB) AND CADMIUM (CD) IN THE FOOD CHAIN DUE TO ANTHROPOGENIC FACTORS

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Abstract: Numerous anthropogenic impacts result in the reduction of some species of game, which inhabit different areas with intensive agricultural production, i.e. agrobiotope. One of these effects is pollution of the environment by heavy metals, i.e. lead and cadmium. An animal species that can be a good bio-monitor in order to define the presence of these heavy metals in the food chain is the hare *Lepus europaeus P*. This paper compares the results of several authors on the presence of heavy metals in the liver in order to determine the significance of anthropogenic effects on the hare. The paper describes the conditions in the environments where hares were exposed to intensive agricultural production, industrial pollution and pollution caused as a result of ore mining. According to the results shown, high concentrations of lead and cadmium can have detrimental effects on the reproductive performance and the number of hare according to (Halecki et al., 2017), especially when it comes to the proximity of the ore exploitation site. From the aspect of industrial pollution, higher levels of presence of heavy metals are evident, but the effects are also dependent on other factors that are not anthropogenic, such as the natural presence of heavy metals in the soil.

Keywords: brown hare, lead, cadmium, anthropogenic factors

Introduction

The hare *Lepus europaeus P*. as a game of steppe plains, is of a high level of distribution especially in Europe. Many natural influences have negative effects on the population of this game, such as: climate factors (Beuković et al., 2013a; Awadi et al., 2018), parasites and diseases (Kornas et al., 2014; Chiar et al., 2016), as well as the increasing number of numerous predators (Chiar et al., 2016; Humel et al., 2017). When it comes to anthropogenic effects, their impact is increasingly important for the populations of hare (Marbotin et al., 1998; Arvil et al., 2014). Anthropogenic factors influence the availability of food (Popović et al.), which is most often associated with loss of natural habitat (Batáry et al., 2011; Pavliska et al., 2018), and intensive agricultural production in terms of increasing arable areas (Smith et al ., 2005), as well as more and more frequent traffic (Heigl et al., 2016). Therefore, measures of sustainable management of hare in the hunting ground (Beuković et al., 2013b, Popović et al., 2014) become very important for the population of hare in agrobiotope. A hare, as a game that has quite well adapted to agrobiotope, can serve as a good bio monitor to detect this bad anthropogenic effect (Beuković et al., 2015). The hare is not migratory species, and therefore it can be a good biomonitor, because if they have enough food they stay where they were born. They also have a fast reproductive cycle that makes them extremely plastic in terms of both natural and anthropogenic influences.

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Sources of contamination

High doses of lead and cadmium may have a lethal and sub-lethal outcome (Iwegbue, 2008; Danieli et al., 2012), regardless of the mechanism of anthropogenic contamination. In the natural environment, cadmium is in the ground, while lead accumulates on the surface of the soil. From the soil, they easily cross into the plant and then into the chain of herbivore species (Kastori, 1995). Cadmium is positioned most often in the above-ground parts of plants, and the level of cadmium in the plant is in high correlation with the level in the soil (Petrović and Kastori, 1994).

In an agrobiotope, if there are no industrial sources of pollution or exploitation of ore, the use of phosphorus fertilizers in intensive agricultural production can be one of the ways of soil contamination. The presence of heavy metals depends to a great extent on the origin of the crude phosphate (Kastori, 1995; Lin et al., 2010). Relatively high concentrations of cadmium ions are found in the raw phosphates from which phosphorus fertilizers are produced, because the phosphate ores contain from 1 to 110 ppm of it (Ubavić et al., 1993).

Determined levels of lead and cadmium in brown hare due to various anthropogenic effects

Determining the presence of lead and cadmium in liver of hare (n 150) in the hunting grounds of Vojvodina, where the habitat of hare is agrobiotope in the presence of intensive agricultural production, Beuković et al., (2015) have found average levels of 165.6 ppb (Pb) and 231.2 (Cd).

The authors mentioned that the values ranged from 0 (without detection) to the maximum value for Pb 900 ppb and Cd 957 ppb. The authors compared the obtained values with the maximum allowed values of 500 ppb defined by the EC (2001) and by MAFW RS (2014). It was found that only in two hunting areas there was established high liver contamination with lead, while observing the entire population in 5% of hare, the value is higher than 500 ppb (Beuković et al., 2014). Analyzing the presence of cadmium in the liver of the hare, Beukovic et al (2016) state that higher contamination was observed in relation to lead, pointing out that in one hunting area 25% of the analyzed population had more than 500 ppb values. In a study by Demirbas et al. (2017), analyses of liver and kidney muscle samples, fifteen adult hare during the hunting season 2013/14 was performed in Kırıkkale, Turkey. In addition to intensive agricultural production, the mentioned area also has industrial complexes in the area where sampling was carried out. The authors state that in 5 of 15 individuals in the liver, and in all 15 individuals in the muscular tissue, a value higher than 500ppb was established, while the cadmium values were below the maximum allowed (Demirbas et al., 2017). Recorded levels of cadmium in livers of hare were 890 ppb and lead 2.190 ppb (Demirbas et al., 2017). Analyzing the correlation association, it was found that there is a strong significant and positive correlation between the concentration of Pb and Cd in the liver and muscles (Demirbas et al. 2017).

In a research of Halecki et al. (2017), three sites with intensive agricultural production were analyzed for the presence of heavy metals (Pb and Cd) in the liver, kidneys and muscle tissue. The research was performed on three different sites with different anthropogenic influences that conditioned the presence of heavy metals in the tissue of hare. The first location was near the lead and zinc mines with more than a decade of exploitation, near Olkusz, Poland.

The second location was exposed to the most industrial pollution, with lower contamination of heavy metals, in the vicinity of Wawrzenczyce, Poland. And at the third location there was no

anthropogenic influence on sources of contamination with lead and cadmium, the environment of Dabrowa Tarnowska, about 70 km east of Krakow. The study was conducted on n= 223 animals. Mean value of lead in the liver for the year 2006/07 were; for locality 1 – 1,830 ppb / 1,550 ppb; locality 2 - 890 ppb / 840 ppb; locality 3 – 1,110 ppb / 830 ppb (Table 1.). When it comes to mean values of cadmium in the liver of the hare for the year 2006/07 on the locality 1, the following values were recorded 1,990 ppb / 1,860 ppb; locality 2 – 1,120ppb / 1,270 ppb and locality 3 – 1,300 ppb / 1,210 ppb (Haleck et al. 2017).

Table 1. Presence of lead and cadmium in the liver of the brown hare, depending on the type of anthropogenic effects

	Serbia 2013/14 (Beuković et al., 2014)		Turkey 2013/14 (Demirbas et al., 2017)		Poland 2006/07 (Halecki et al., 2017)	
	Cd (ppb)	Pb (ppb)	Cd (ppb)	Pb (ppb)	Cd (ppb)	Pb (ppb)
Intensive agriculture	231.2	165.6	-	-	1,300.0 1,210.0	1,110.0 830.0
The presence of industrial pollution and intensive agriculture	-	-	803.0	2,190.0	1,120.0 1,270.0	890.0 840.0
Vicinity of mines	-	-	-	-	1,990.0 1,860.0	1,830.0 1,550.0

Analyzing the results of Beuković et al. (2014); Demirbas et al. and Haleci et al. (2017), which are shown in Table 1, a comparison of the pollution intensity was performed, depending on the type of anthropogenic activity. It should be noted that the methodology in all three studies is basically the same, with certain methodological variations that do not have significant differences. It can be noted that the presence of heavy metals (lead and cadmium) largely depends on the natural properties of the soil. That can be seen as a direct comparison of results in an intensive agriculture area (Beuković et al., 2014; Halecki et al., 2017). A multiple higher concentration of heavy metals in the hunting grounds of Poland compared to the hunting grounds of Serbia in conditions of intensive agricultural production was noted. When comparing results in intensive agricultural production with exposure to industrial pollution (Demirbas et al., Halecki et al., 2017), it can be noticed that the level of cadmium was higher in Poland and the lead level was higher in Turkey. However, in comparison to all the mentioned anthropogenic impacts, the exploitation of ore is the largest pollutant of the environment, as can be seen from the contamination of the liver of the hare, (Haleci et al., 2017), where the highest contamination of both cadmium and lead was recorded.

Conclusion

Based on the analyzed results of contamination of the environment with heavy metals due to anthropogenic factors, it can be concluded that there are significant influences in terms of increasing the level of heavy metals. High concentrations of lead and cadmium can have detrimental effects on the reproductive performance and the number of hare according to (Halecki et al., 2017), especially when it comes to the proximity of the site where the exploitation of the ore is done. From the aspect of industrial pollution, higher levels of presence of heavy metals are evident, but the effects are also dependent on other factors that are not anthropogenic, such as the natural presence of heavy metals in the soil. Intensive agriculture has the least impact on the occurrence of elevated levels of cadmium and lead in relation to other anthropogenic effects, primarily because the natural

factor is the natural contamination of the soil. Some studies mention possible contamination with phosphate fertilizers, which cannot be clearly linked to the effects of declining numbers or reduced reproductive activity of hare, primarily due to the effects of other factors.

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