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Heavy metal effects on bird morphometry: A case study on the house sparrow *Passer domesticus*

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Highlights

- Effects of heavy metal accumulations on bird morphometry were detected.

- Positive or negative correlations were found between some heavy metals and some bird morphometric characters.
- Zn and Cu in the muscle and the liver were the most correlated heavy metals with bird morphometry.

Abstract

We examined some possible effects of heavy metal accumulations on bird morphometry. House sparrows *Passer domesticus* were caught in unpolluted and polluted areas having a thermal power plant, in Turkey. Fifteen different morphometric characters were compared with the heavy metal accumulations of Cu, Co, Zn, Mn, Ni, and Cr in samples from muscle, kidney, and liver. We found positive or negative correlations between some heavy metal accumulations in some tissues and the length of some morphometric characters of sparrows ($p<0.01$). The most correlated heavy metal with as many characters was Zn in muscle and liver, followed by Cu in liver and Cu in muscle. We found mainly negative coefficient values of some heavy metal bioaccumulation for morphometry using stepwise linear regression analysis. Negative coefficient values of Zn accumulation in muscle and the liver for body mass and feathers were found ($p<0.01$). Length of bill and claws were affected by the bioaccumulation; the positive coefficient values of Zn in the muscle and the liver and negative coefficient values of Cu in the

kidney for the length of the bill, positive coefficient value of Cu in muscle and the negative coefficient value of Mn in the kidney for length of the claws were found respectively ($p<0.01$). The heavy metal accumulations in the tissues were found to affect morphometric characters' length. The effects of heavy metal accumulations in tissues should be considered in further morphometrical studies of a bird species, especially in polluted areas.

Introduction

Harmful substances in urban areas are produced in quantities that can have disruptive effects on the development, reproduction, and survival of organisms (Kekkonen, 2011). Heavy metal accumulations threat ecosystems and biodiversity (Deng etal., 2007; Ek etal., 2004). Natural and anthropogenic processes, mainly industrial activities and fuel-burning, increase the toxic heavy metals into the ecosystems (Albayrak and Mor, 2011; Alleva etal., 2006). Heavy metal toxicity affects animals' life quality and health, such as axing breeding success (Eeva etal., 2009) or increasing mortality rates (Sanpera etal., 2008).

Birds are taken as study objects of biological monitoring in ecosystems, especially in polluted sites (Burger etal., 2004; Lebedeva, 1997). Avian feathers were considered a bioindicator in polluted areas (Gushit etal., 2016). Bird reproduction, egg hatchability, hatchling survival throughout the food chain are most probable with resulting health problems (Mora, 2003; Tsipoura

etal., 2008; Uba etal., 2009). Breeding success of great tit *Parus major* is crippled by heavy metals (Eeva etal., 2009). Relatively higher metal concentration was detected in the first brood because the female can excrete mercury at her first egg-laying (Pan etal., 2008). Bioaccumulation of heavy metals was researched in different tissues, but researchers detected them usually in muscle, kidney, liver, brain, bone and feathers and Cr, Cu, Pb, Zn, Ni, Cd were mainly used for bioaccumulation studies (Burger etal., 2004; Gushit etal., 2016; Suljevic etal., 2019; Suljević etal., 2020).

Morphometric characters might be affected by biological accumulations of heavy metals. Although researchers investigated the relationship between heavy metal accumulation and mammal morphometry (e.g., Sánchez-Chardi etal., 2009; Wajdzik etal., 2017), little is known about bird morphometry and heavy metal accumulation. For example, Vincent (2005) found a negative correlation between body mass and air pollution in the house sparrow, *Passer domesticus.* However, other morphometric characters such as bill, tarsus, wing have not been studied.

House sparrow is one of the most intimate birds to humans in many parts of the world (Schrey etal., 2011). It is strongly human-associated and found in huge cities as well as in small isolated farms, whereas it is absent in uninhabited areas (Kekkonen, 2011; Schrey etal., 2011). It is one of the most successful animals in adapting themselves to urban environments and one of the most widely distributed bird species in the world (Anderson, 2006; Cramps and Perrins, 1994; Schrey etal., 2011; Swaileh and Sansur, 2006). House sparrows are distributed nearly across all continents

as native or introduced (Schrey et al., 2011). Sparrows are an ideal bioindicator species due to their global distribution (Albayrak and Mor, 2011; Bichet et al., 2013; Swaileh and Sansur, 2006). Body mass, tarsus length, and wing length are the leading morphometric indicators to understand birds' the health status (Dauwe et al., 2006).

Previous studies showed that some heavy metal concentrations in some sparrows' tissues (Albayrak and Mor, 2011) and some morphometric characters (Albayrak, 2017) were significantly different between polluted and unpolluted areas where are close to each other. Albayrak (2017) hypothesizes that this morphometric differentiation may have been caused by heavy metal accumulation in tissues. Morphometric data is not sufficient for screening heavy metal effects, but it may offer crucial hints on why the morphometries are different in areas close to each other. In this study, we used the value of accumulations in selected tissues and lengths of the morphometry of house sparrow, which are caught from two close areas to teste whether heavy metals caused the morphological differentiation or not. Our work aimed to test the following hypothesis: heavy metal accumulations will influence the bird morphometry. Specifically, we predicted that the morphological differentiation in close areas may be due to the accumulation of different heavy metals of birds in these areas.

Section snippets

Study areas

Two study areas in Turkey, close to each other (approx. 230km), were selected to investigate the relation between heavy metal concentration and bird morphometry. While the first area, Yatağan-Muğla, is polluted by a thermal power plant and there is no thermal power plant or polluting factors in the second area, Çığlık-Antalya.…

Sampling

We caught eight male and 12 female sparrows from the polluted area and 12 male and ten female sparrows from the unpolluted area using 16mm mesh of mist nets.…

Results

A Shapiro-Wilk's test ($p>0.05$) and a visual inspection of Q-Q plots showed that the data scores were approximately normally distributed. This study discusses changes of the house sparrow's morphometry by heavy metal accumulation effects in tissues. Fifteen morphometric traits (**BM, TA, BL, BW, BH, LBaHb, LNBa, W,**

AL, 8P, TL, HC, IC, CC, and OC) and six heavy metal (Cu, Co, Zn, Mn, Ni, Cr) concentrations in the tissues were investigated. We did not find any difference between male and female…

Discussion

There are many reports on heavy metal accumulations in different organs such as liver, kidney, muscle and feathers of different birds (Chao etal., 2003; Kim etal., 1998; Naccari etal., 2009; Taggart etal., 2006) and many other vertebrates (Kuba etal., 2007; Yamamoto etal., 1987). However, comparison reports on heavy metal accumulations and their morphometric effects are minimal, especially on birds. Dauwe etal. (2006) did not find any significant effect of heavy metals on morphological…

Conclusions

We found that higher value of some heavy metal accumulations in some tissues appears in shorter morphometry. Body mass was negatively affected by Zn accumulation in the muscle and the liver but bill length was positively affected by Zn accumulation in the muscle and the liver and negatively affected by Cu accumulation in the kidney. Claw length was positively affected by Cu accumulation in the muscle and negatively affected by Mn accumulation in the kidney. Feather length was negatively…

CRediT

Tamer Albayrak: Conceptualization, field work, data analysis, software, writing. Asuman Karadeniz Pekgöz: Data analysis, writing, editing.…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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> …Morphological characteristics are important indicators of survival and reproductive success and can be affected by heavy metal contaminants (Takekawa et al., 2002; Albayrak and Pekgöz, 2021). In contrast to other studies (Vincent, 2005; Albayrak and Pekgöz, 2021), we found a similar association between heavy metal pollution and morphological characteristics of tree sparrow. This study found a significantly smaller body size of adult sparrows in BY than in LJX.…

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2021, Ecotoxicology and Environmental Safety

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> …It can be the target organ for Cu, Zn, and Ni accumulation, whereas the kidney can be utilized to assess Cr, Pb, and Cd accumulation (Soliman et al., 2020). In the last decade, many studies have focused on heavy metals in bird liver and kidney and discussed toxicity and bioaccumulation of heavy metals in the liver and kidney of aquatic birds (Kim et al., 2009; Osičková et al., 2014; Salamat et al., 2014; Ali and Khan, 2019; Soliman et al., 2020; Albayrak and Pekgöz, 2021). However, few studies have used spatial analyses to evaluate the risk.…

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