4-12-2024

Implications of Iron Oxide Nanoparticle Exposure on the Auditory Physiology and Iron Bioaccumulation in House Sparrows (Passer domesticus)

Shae Johnston
Hope College

Peyton Hallemann
Hope College

Olivia Sprys-Tellner
Hope College

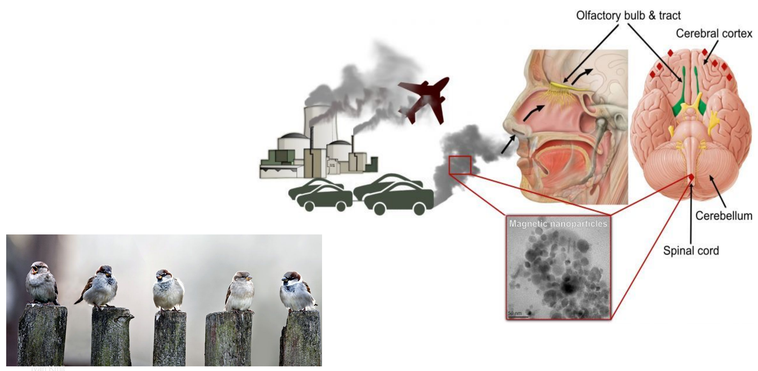
Implications of Iron Oxide Nanoparticle Exposure on the Auditory Physiology and Iron Bioaccumulation in House Sparrows (*Passer domesticus*)

Shae Johnston, Peyton Hallemann, Olivia Sprys-Tellner, Dr. Natalia Gonzalez-Pech, and Dr. Kelly Ronald

Hope College, Holland, MI 49423

INTRODUCTION

- Urbanization has drastically increased in the past few decades, leading to an increase in air pollution[1]
- Air pollution is made up of particulate matter (PM) of sizes PM_{10} and $PM_{2.5}$ (microns)[2]
  - Nanoparticles are the most dangerous portion of PM at around 10 nm in size
  - They are able to bypass the blood-gas-barrier and blood-brain barrier[3,4]
    - Entry of nanoparticles into the circulatory and respiratory systems can result in bioaccumulation
    - Increased nanoparticle exposure has been linked to decreased auditory sensitivity in model organisms[5]
- Birds are an ideal model for research due to their efficient gas exchange[4,6]
  - Birds have unique unidirectional airflow and cross-current blood flow
  - House sparrows are used due to their social behavior and the habituation of urban areas



QUESTION

What effect does iron oxide nanoparticle (IONP) exposure have on the iron bioaccumulation and the auditory physiology in the house sparrow?

Predictions

1. Exposure to IONPs will result in house sparrows having greater iron concentrations in their respective organs
2. Exposure to IONPs will cause a decrease in auditory sensitivity measured via auditory brainstem responses (ABR).

METHODS

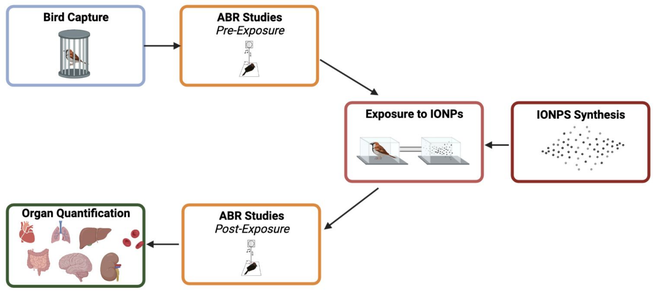


Figure 1. Experimental Design Wild-caught house sparrows (N = 48) were brought into the lab, and baseline Auditory Brainstem Response (ABR) tests were conducted. Birds were then exposed to IONPs (N = 24) or Milli-Q water (N = 24). Post-exposure, ABR tests were conducted. Finally, organs (N = 31) were collected and assessed for iron bioaccumulation via inductively coupled plasma (ICP) spectroscopy.

RESULTS

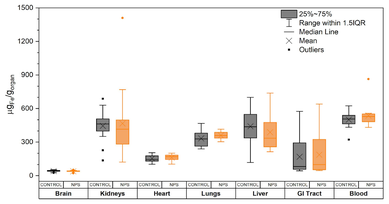
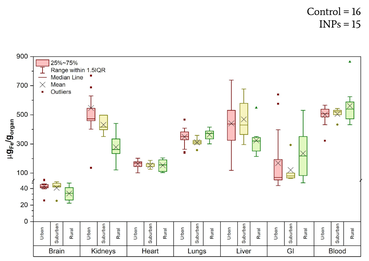


Figure 2. Comparison of iron concentration in the organs of control and exposed animals. Organs were collected via gross dissection and analyzed using ICP spectroscopy to determine iron concentration. No observable differences between treatment and control birds were found.

Figure 3. Comparison of iron concentration in the organs of male and female house sparrows in control and exposed animals. Organs were collected via gross dissection and analyzed using ICP spectroscopy to determine iron concentration. No observable differences between treatment and control birds were found.



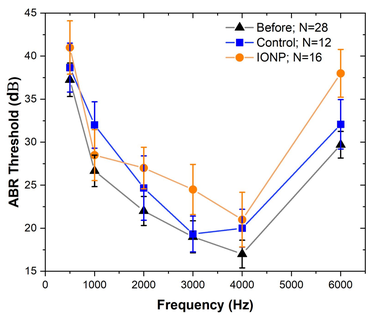


Figure 4. Comparison of IONP treatment and frequency of presented tone on ABR threshold. Exposure to treatment impacts sensitivity at different frequency tones. Error bars are +/- SEM.

DISCUSSION

ABRs

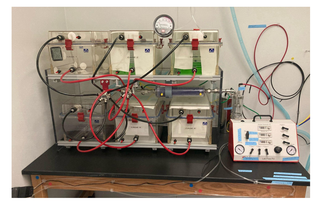
- Nanoparticle exposure impacts the ABR thresholds across the frequencies tested.
- Birds exposed to nanoparticles were found to have decreased hearing sensitivity, or higher ABR thresholds, at many presented frequencies. This could contribute to the recent decline in avian populations as it could increase their susceptibility to predators due to the potential inability to hear predator cues.
  - We hypothesize that exposure to nanoparticles could impact the medial superior olive (MSO) in the brain.[5]

Bioaccumulation

- We observed no differences between treatment birds and control birds regarding iron bioaccumulation.
- Statistical Analyses have been done.

Future Directions

- To our knowledge, this is the first study to determine the impacts of air pollution on wild-caught animals utilizing nanoparticles. Further experimental testing is needed in order to understand the role of air pollution on wildlife ecosystems.
- Future experiments will also include a longer exposure time to determine if chronic exposure impacts bioaccumulation and hearing in house sparrows.



ACKNOWLEDGEMENTS

We express our gratitude to John Wenderski, Jacob Bergstrom, Sarah Grimes, Linda Nduwimana, Molly McLinden, Lindsay Jankowski, Emma Yonker, Natalie Leake-Jara, and Andrew Reiffer for their contributions.

We would also like to thank the Hope College Biology and Chemistry Departments, the National Science Foundation, the Michigan Space Grant Consortium, the Schaap Endowed Funds for Undergraduate Research, the Herbert H. and Grace A. Dow Foundation, the Jacob E. Nyenhuis Faculty Development Grant, and the Wettack Fellowship.

LITERATURE CITED

1. Wang Q. (2018). Urbanization and Global Health: The Role of Air Pollution. *Iranian journal of public health*, *47*(11), 1644–1652.
2. Kelly F. & Fussell J. (2012). Size, Source, and Chemical Composition as Determinants of Toxicity Attributable to Ambiant Particulate Matter. *Atmospheric Environment,* 60, 504-526.
3. Sawicki, K., Czajka, M., Matysiak-Kucharek, M., Fal, B., Drop, B., Męczyńska-Wielgosz, S., Sikorska, K., Kruszewski, M. & Kapka-Skrzypczak, L. (2019). Toxicity of metallic nanoparticles in the central nervous system. *Nanotechnology Reviews*, *8*(1), 175-200
4. Watson R. R., Fu Z., & West J. B. (2007). Morphometry of the extremely thin pulmonary blood-gas barrier in the chicken lung. *American journal of physiology. Lung cellular and molecular physiology*, *292*(3), L769–L777.
5. Calderón-Garcidueñas L., González-González L., Kulesza R. J., Tatiana M. Fech, Pérez-Guillé G., et al. (2017). Exposures to fine particulate matter (PM2.5) and ozone above USA standards are associated with auditory brainstem dysmorphology and abnormal auditory brainstem evoked potentials in healthy young dogs. *Environmental Research*. Volume 158, 324-332.
6. Brown R. E., Brain J. D., & Wang N. (1997). The avian respiratory system: a unique model for studies of respiratory toxicosis and for monitoring air quality. *Environmental health perspectives*, *105*(2), 188–200.
7. Rosenberg K. V., et al. Decline of the North American Avifauna. *Science (American Association for the Advancement of Science)*, vol. 366, no. 6461, 2019, pp. 120–24.