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Seasons and neighborhoods of high lead toxicity in New York City: The feral pigeon as a bioindicator

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HIGHLIGHTS

- We assessed the feral pigeon as a lead bioindicator in New York City.
- We collected blood lead levels of 825 pigeons over 5 years.
- Blood lead levels were highest in summer.
- Neighborhood pigeon blood lead levels recapitulated in children.

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ABSTRACT

Human-induced rapid environmental change has created a global pandemic of neurobehavioral disorders in which industrial compounds like lead are the root cause. We assessed the feral pigeon (*Columba livia*) as a lead bioindicator in New York City. We collected blood lead level records from 825 visibly ill or abnormally behaving pigeons from various NYC neighborhoods between 2010 and 2015. We found that blood lead levels were significantly higher during the summer, an effect reported in children. Pigeon blood lead levels were not significantly different between years or among neighborhoods. However, blood lead levels per neighborhood in Manhattan were positively correlated with mean rates of lead in children identified by the NYC Department of Health and Mental Hygiene as having elevated blood lead levels (>10 μg/dl). We provide support for the use of the feral pigeon as a bioindicator of environmental lead contamination for the first time in the U.S. and for the first time anywhere in association with rates of elevated blood lead levels in children. This information has the potential to enable measures to assess, strategize, and potentially circumvent the negative impacts of lead and other environmental contaminants on human and wildlife communities.

1. Introduction

Heavy-metal toxicity is a relatively newly identified problem to human health, with leaded paints and gasoline in widespread use up until a few decades ago. Despite the banning of most lead-containing products and abundant information about the hazards of heavy metals, the negative effects of heavy metals on human health persist. Lead paint can be found in older buildings, and demolitions can increase particulate lead levels in the air by several hundred times (Farfel et al., 2003). Before the 1990s, leaded gasoline was used worldwide. It was only prohibited in the United States in 1995, and even later in many countries. Residues from gasoline, however, have left lead contaminants on many roads (García et al., 1988; Hutton and Goodman, 1980; Nam and Lee, 2006; Ohi et al., 1981). This effect is particularly strong on major roadways or in high-traffic, industrial areas. For example, a study by Nam and Lee (2006) found that industrial areas in South Korea had much higher lead concentrations than rural areas due to greater car traffic and emissions. Despite the introduction of unleaded gasoline in 1993, lead still contaminates gravel and soil. In addition to lingering roadside toxicants, lead is still being used in some airplane fuels, which have been reported to be responsible for the release of 100 tons of lead into the atmosphere per year (Kessler,

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2013).

Ever since the discovery of the negative effects of lead on human health, there have been large-scale attempts to reduce human contact with lead. The New York City Department of Health and Mental Hygiene conducts screenings of NYC resident blood lead levels (2014, 2010). Although blood lead levels have declined in NYC and the US in the last few decades, that does not mean lead poisoning is no longer a public health concern. Little is known about the effects of low amounts of lead on human health, but recent studies have shown that lead is harmful at all levels —no matter how low— affecting intelligence, neurodevelopment, social skills, and memory (Lanphear et al., 2000; Schnur and John, 2014). In fact, Canfield et al. (2003) found that at blood lead levels below 10 μg/dl, the USA Centers for Disease Control and Prevention's national acceptable threshold at the time, the inverse relationship between IQ in children and blood lead level is even stronger than at levels above 10 μg/dl. In light of this new information about the negative effects of low-dose lead exposure, the Centers for Disease Control and Prevention lowered their national threshold to 5 μg/dl in January 2012.

Lead poisoning is a considerable problem for not only humans, but wildlife in general. Heavy metals such as cadmium, zinc, and, most notably, lead are toxic in small amounts to both humans and feral pigeons (*Columba livia*) (Cui et al., 2013; Schilderman et al., 1997; Schnur and John, 2014). Pigeons have been presumed to be poisoned from a combination of atmospheric and particulate lead; the former is inhaled from the atmosphere, the latter is consumed. Because pigeons use small rocks and gravel to aid in mechanical digestion, they can ingest contaminated road particles, or particulate lead (Hutton and Goodman, 1980; Nam and Lee, 2006). Caravanos et al. (2006) demonstrated that almost 90% of dust samples taken throughout NYC's five boroughs exceeded the US government's environmental and housing standards for acceptable lead concentration. Dust containing lead from the outdoors can be brought into households by regular foot traffic or air drifting, which can increase human exposure (Caravanos et al., 2006).

In the last few decades, feral pigeons have received considerable attention as possible bioindicators for heavy-metal exposure. Pigeons have a longstanding association with humans that dates back to establishment of the first permanent agricultural settlements. Feral populations have since spread across the world and exist in almost all the different kinds of communities where people live, nesting on top of buildings and along building facades, under bridge overhangs, and on top of garage roofs (Gompertz, 1956; Humphries, 2008). Consequently, feral pigeons have thrived in NYC, where they have even been labeled as pests, with such monikers as "rats with wings" (Jerolmack, 2008; Humphries, 2008). The combination of densely-packed buildings, an abundance of food, and ample greenery, such as that found in Central Park, make NYC an ideal feral pigeon habitat. Compared to many other urban organisms, the pigeon's relatively long lifespan and hardiness, combined with its close relationship to humans, make it a suitable bioindicator, offering up the potential to gauge adverse environmental conditions that may affect humans and other wildlife (Drasch et al., 1987; Liu et al., 2010; Schilderman et al., 1997). The urban pigeon does not only walk the same pavement and live on the same blocks as humans, it also breathes the same air and often eats the same food. In this situation, the pigeon can serve as the proverbial canary in a coal mine.

Studies of pigeons as heavy-metal bioindicators from South Korea, China, Tokyo, Spain, France, the Netherlands, and the UK have indicated clear physiological differences between pigeons living in environments with varying amounts of heavy metals (Cui et al., 2013; Frantz et al., 2012; García et al., 1988; Hutton and Goodman, 1980; Nam and Lee, 2006; Ohi et al., 1981; Schilderman et al., 1997). Pigeons exhibit a high level of site fidelity to birth sites, generally remaining in a small area (<2 km) for their entire lives (Rose et al., 2006). This behavioral characteristic thus permits comparisons of pigeon lead toxicity among micro-urban environments (Frantz et al., 2012). For example, Frantz et al. (2012) measured heavy-metal concentrations in feral pigeon feathers in the urbanized region of Paris, France, and found that the levels contrast sharply between neighborhoods. Despite international attention on the pigeon as a bioindicator, as well as reports and studies investigating high lead level concerns in NYC residents and their environments (Caravanos et al., 2006; New York City Department of Health and Mental Hygiene, 2014, 2010; Schnur and John, 2014), the feral pigeon to our knowledge has never been the subject of a lead bioindication study in the United States. We investigated blood concentration levels of lead in 825 feral pigeons suspected of lead poisoning and collected across different neighborhoods and seasons in NYC over a period of five years (2011–2015). We also examined the relationship between pigeon blood lead levels per neighborhood in Manhattan as compared to mean rates of lead in children identified by the NYC Department of Health and Mental Hygiene as having elevated blood lead levels (>10 μg/dL; 2014). We provide support for the use of the feral pigeon as a bioindicator of environmental lead contamination and in association with rates of elevated blood lead levels in children living in NYC.

2. Materials and methods

Since 2011, citizen scientists have been collecting visibly ill or abnormally behaving feral pigeons throughout New York City and admitting them to the Wild Bird Fund, the only wildlife rehabilitation center in the city. Wildlife rehabilitators routinely sample blood from patients upon their admission via femoral vein puncture. Trained rehabilitators then measure and record lead levels in the blood using a LeadCare® II portable anodic stripping voltammetry (ASV) device.

With permission of the Wild Bird Fund, we analyzed these data, which included: assigned ID number, the location of the pigeon's collection, the date that blood level was tested, and their blood lead level in μg/dl if it fell within range detection (3.3–65.0 μg/dl). The location of the pigeon's collection was classified into neighborhoods according to the New York State Department of Health (New York City Department of Health and Mental Hygiene, 2014). The majority of pigeons admitted to the Wild Bird Fund were from Manhattan. Thus, we concentrated our analyses on neighborhoods within this borough, though we incorporate areas from other neighborhoods within NYC boroughs that offered sufficient data,

Table 1
NYC pigeon sample sizes by year, season, and neighborhood.

Year	N	Neighborhood	N
2011	92	Soho/Greenwich Village	39
2012	161	Lower Manhattan/Lower East Side	63
2013	243	Upper West Side	250
2014	287	Kingsbridge/Riverdale/Inwood/Washington Heights	46
2015	42	Chelsea/Clinton	66
		Upper East Side	81
		Gramercy Park/Murry Hill	65
		Southwest/West/West Central Queens	43
Season	**N**	Park/Southern/Southwest/Central Brooklyn	41
Spring	173	Harlem	30
Summer	263	Bushwick/Williamsburg/Greenpoint/Northwest Brooklyn	42
Fall	178	North Queens	41
Winter	57	Central/South Bronx	18