Primate exposure to anthropogenic pollutants: An overlooked conservation concern

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Michael Wasserman of Indiana University discusses research on wild primate exposure to endocrine disruptors, such as pesticides, flame retardants, and phytoestrogens

What are the current threats primates face globally?

Tropical forests are home to the majority of terrestrial biodiversity, regulate climate, and purify air and water. (1) Despite their importance, deforestation continues to threaten these ecosystems, with both their loss and fragmentation leading to declines in primate populations that depend on them for habitat, food, and other resources. (2) As a result of tropical forest loss and fragmentation, along with hunting, infectious diseases (e.g., emerging pathogens and reverse zoonoses), and climate change, more than sixty percent of primate species are vulnerable to extinction. (3) Chemical pollution from increasing agricultural expansion, urbanization, and industrialization is also a threat to primates, but one that has been largely overlooked. (4)

What do we know about chemical pollution exposure in wild primates?

In the tropical forests of Uganda and Costa Rica, we have found significant levels of legacy and current use pesticides (CUPs) and halogenated and organophosphate flame retardants using passive air samplers. (5) We have used non-invasive fecal sampling of primate populations to document exposure to the same chemicals in howler monkeys in Costa Rica and baboons, chimpanzees, red-tailed monkeys, and red colobus living in Uganda. (6) Some of these chemicals include the legacy pesticides hexachlorobenzenes, γ-chlordane, and DDT-related compounds and the CUPs lindane and chlorpyrifos. We also examined relationships between exposure to these chemicals and fecal hormone levels across these primate species, with results indicating significant relationships between exposure and cortisol. (7) Red colobus and red-tailed monkeys excreted significantly more chemicals than chimpanzees and baboons living in the same forest. Primate species differ in many ways, including body size, diet, sociality, terrestrial behavior, metabolism, and detoxification capabilities, and these traits likely influence exposure to and effects from anthropogenic pollutants.

How do primate diets influence the biological effects of chemical pollution exposure?

Diet represents an important selective pressure on primates, influencing adaptations such as gut size and kinetics, body size, social group size and structure, and the endocrine system. Angiosperms have been a main nutrient source for primates throughout their evolutionary history, [8] with almost all species dependent upon the fruits, leaves, and/or seeds of flowering plants to meet nutritional demands. [9] As a result, primates have co-adapted with flowering plants, [10] particularly their most consumed plant families, including figs and legumes. [11] The nutritional content of primate plant foods is well-studied, but the effects of plant secondary metabolites (PSMs) remain less known. There are at least 100,000 different PSMs, which are plant-produced chemicals often used to defend against herbivory, including alkaloids, tannins, and phytoestrogens. [12,13] Many PSMs can trigger direct physiological changes when consumed, and primates may vary in their susceptibility to these compounds based on adaptations in response to past phytochemical consumption. [14] For example, it has been suggested that herbivores might have specific adaptations for dealing with endocrine-active phytochemicals, such as steroid hormone receptors in the mouth and nose to detect these PSMs or higher levels of steroid hormones in the blood to dilute the biological effects of the PSMs. [15] Primates with lower levels of exposure to endocrine-active phytochemicals over evolutionary timeframes may currently be more susceptible to the negative consequences of anthropogenic pollutants. [14,15] Dietary differences among primate species, such as the plant species and parts they consume, likely result in differential exposure to endocrine-active phytochemicals. For example, we have documented regular consumption of phytoestrogens by the folivorous red colobus, with variation in consumption related to their fecal cortisol and estradiol levels. [16,17] This feeding behavior and apparent physiological response may explain why red colobus excrete higher levels of anthropogenic pollutants than other primate species living in their same environment and could indicate differential susceptibility to anthropogenic endocrine disruption. [6,7]

Why is endocrine disruption of particular concern for primates?

The primate endocrine system modulates morphological, physiological, and behavioral responses to development, aging, and external environmental changes, both ecological and social. Steroid hormones, one key group of endogenous signaling chemicals in the endocrine system, bind to their receptors and then move to DNA in the nucleus to bind to a response element that alters the transcription of genes. Endocrine-active phytochemicals or anthropogenic pollutants can act like steroid hormones, thus allowing exogenous chemicals to directly interact with the endocrine system and influence gene transcription and translation through the same receptor-response element pathways. As a result, endocrine-active chemicals can alter morphology, physiology, and behavior through changes in protein production. When an endocrine-active chemical binds with a receptor, it either activates a response (i.e., agonists) or prevents a response (i.e., antagonists). Exogenous chemicals with this type of endogenous activity are called endocrine disruptors. Consumption or absorption of endocrine disruptors can affect health, wellbeing, and reproduction through alterations in hormone signaling. Many studies have been conducted on a range of animal species across laboratories, agricultural settings, and zoos, showing how specific endocrine- active phytochemicals,

such as phytoestrogens, and anthropogenic pollutants, such as pesticides, influence various biological outcomes. [13,14,18] Few studies, however, have examined endocrine disruption in wild primates. [4]

What are the solutions to primate exposure to chemical pollution?

Utilizing wild primates as biosentinels of environmental exposure represents a novel and non-invasive approach that can improve understanding of the interactions between endocrine-active chemicals and morphology, physiology, and behavior relevant to both environmental and public health. First, fecal samples can be used to determine pollutant exposure and biological effects, thus eliminating any interference with the animals and allowing for a relatively straightforward approach. Second, most primates have shorter lives than us, allowing more rapid detection of biological effects of exposure. Third, as our closest living relatives, primates share many aspects of their biology with us. Given these three points and that primates share landscapes with us across many parts of the world, knowing what they are exposed to and the effects of that exposure can inform our own exposure and the potential effects of that exposure. With an increase in such knowledge, we can then make adjustments to our activities on local, regional, and global scales to reduce sources of pollution leading to exposure in us and the millions of other species on Earth, thus improving both environmental and public health in the process.

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