Estrogenic plants linked to altered hormones, possible behavior changes in monkeys

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A red colobus monkey prepares to munch on the bark of *Eucalyptus grandis*, a non-native estrogenic tree in Kibale National Park. Greater consumption of estrogenic plants is linked to altered hormone levels and changes in behavior, according to a new UC Berkeley-led study. Credit: Julie Kearney Wasserman

Eating certain veggies not only supplies key nutrients, it may also influence hormone levels and behaviors such as aggression and sexual activity, says a new study led by researchers at the University of California, Berkeley, that could shed light on the role of diet in human evolution.

The research is the first to observe the connection between plant-based estrogenic compounds, or phytoestrogens, and behavior in wild primates—in this case, a group of red colobus monkeys in Uganda.

The more the male monkeys dined on the leaves of *Millettia dura*, a tropical tree containing estrogen-like compounds, the higher their levels of estradiol and cortisol. The researchers also found that with the altered hormone levels came more acts of aggression and sex, and less time spent grooming—an important behavior for social bonding in primates.

The study, published in the current issue of the journal Hormones and Behavior, suggests how potentially important consuming phytoestrogens is in primate ecology and evolution.

"It's one of the first studies done in a natural setting providing evidence that plant chemicals can directly affect a wild primate's physiology and behavior by acting on the endocrine system," said study lead author Michael Wasserman, who conducted the research as a graduate student at UC Berkeley's Department of Environmental Science, Policy and Management. "By altering hormone levels and social behaviors important to reproduction and health, plants may have played a large role in the evolution of primate—including human—biology in ways that have been underappreciated."

For 11 months, the researchers followed a group of red colobus monkeys in Uganda's Kibale National Park and recorded what the primates ate. For behavioral observations, the researchers focused on aggression, as marked by the number of chases and fights, the frequency of mating and time spent grooming.

To assess changes in hormone levels, the researchers collected fecal samples once a week from each of 10 adult males in the group (a separate study examining phytoestrogens in females is ongoing). More

than 407 samples were collected and analyzed for estradiol and cortisol levels.

The researchers found seasonal variation in the consumption of estrogenic plants, which made up 0.7 percent to as much as 32.4 percent of the red colobus diet in any given week. For red colobus adult males, higher consumption of estrogenic plants corresponded to higher levels of estradiol and cortisol, two steroid hormones important to reproduction and the stress response.

Phytoestrogens are also found in human foods, especially soy and soy-based products. *Millettia dura*, the tropical tree that was most important to red colobus monkey hormone levels and social behaviors, is a close relative of soy.

"With all of the concern today about phytoestrogen intake by humans through soy products, it is very useful to find out more about the exposure to such compounds in living primates and, by analogy, human ancestors," said study co-author Katharine Milton, professor in UC Berkeley's Department of Environmental Science, Policy and Management and an expert on the dietary ecology of primates. "This is particularly true when determining the influence of phytoestrogens on reproductive behavior, which is the whole keystone of natural selection."

The study authors cautioned against overinterpreting the power of phytoestrogens in altering behavior, however. They emphasized that estrogenic plant consumption is just one of multiple factors influencing primate hormone levels and behavior. Notably, the primates' own endogenous hormone levels were the stronger predictor of certain behaviors, while phytoestrogens played a secondary role.

The researchers noted that the tendency for certain behaviors to occur can be affected by complex interactions between endogenous hormones

and phytoestrogens, in addition to factors such as the quality and quantity of food, competition for resources and mates and predation.

Nonetheless, previous research in laboratory and agricultural settings found that eating estrogenic plants could disrupt fertility and affect behavior in animals such as rodents, monkeys and sheep. Effects of phytoestrogen consumption in other studies have included more aggression, less body contact, more isolation, higher anxiety and impaired reproduction.

To expand on this possibility, Wasserman and his colleagues are now examining the relationship between phytoestrogens and other primate species, including our closest-living relative, the chimpanzee, to determine how common estrogenic plants are in the diets of wild primates.

"Human ancestors took most of their diet from wild tropical plants, and our biology has changed little since this time, so similar relationships as those found here are expected to have occurred over our evolutionary history," said Wasserman, now a post-doctoral scholar at McGill University's Department of Anthropology in Montreal, Canada.

However, the researchers noted that the red colobus diet contains a high percentage of leaves, while the diet of chimpanzees, other apes and human ancestors consists primarily of fruits. Thus, one of Wasserman's current goals is to compare the presence of phytoestrogens in wild leaves and fruits.

"If phytoestrogens make up a significant proportion of a fruit-eating primate's diet, and that consumption has similar physiological and behavioral effects as those observed in the red colobus, then estrogenic plants likely played an important role in human evolution," said Wasserman. "After studying the effects of phytoestrogens in apes and

fruit-eating primates, we can then get a better sense of how these estrogenic compounds may influence human health and behavior."

Provided by University of California - Berkeley