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Significance of Branches and Leaves as Feed Components for Captive Western Lowland Gorillas

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Abstract

Branches and leaves are routinely provided to captive gorillas; however, their forging and antioxidant contents are not well understood. In this study, branches and leaves of various tree species provided to a family of five captive western lowland gorillas (*Gorilla gorilla gorilla*) at the Ueno zoological gardens, Tokyo Metropolitan Government, were evaluated (Figure 2B). The branch and leaf collection status for each individual was checked for six different tree species over 4 days in July and November, 2017. Leaf and bark consumption was observed for all individuals. For each type of tree species and each plant part (i.e., leaves and barks), the concentration of the antioxidants was measured using Oxygen Radical Absorbance Capacity (ORAC) values. The antioxidant concentrations were higher in the leaves than in the bark for all tree species and the concentrations in the leaves of deciduous trees in the fall foliage season were considerably higher than those in the non-fall foliage period. In standard gorilla care at zoos, branches and leaves are regarded as bedding materials. However, the detection of antioxidants in both leaves and bark and their observed consumption by gorillas indicates that these materials should be considered as feed components from a nutritional perspective.

Keywords: Antioxidation ability; Captive gorillas; Branch and leaf; Feeding program

Introduction

Although wild Western Lowland Gorillas (*Gorilla gorilla gorilla*) have a strong preference for fruits when they are abundant, they also show a preference for young and mature leaves and bark, depending on the season. Furthermore, they consume ginger, native to wetlands, which has high antioxidant activity [1].

Currently, the standard manual for gorilla care at zoos recommends providing different types of feed, mainly plants and vegetables [2]. However, the feeding program is not focused on the antioxidant content. In addition, substantial data regarding the antioxidation ability of commercialized vegetables, fruits, dairy products and pasture grass are available; however, data on the concentrations of antioxidants in branches and leaves of various tree species in the gorilla diet are lacking. Therefore, in this study, we evaluated the concentrations of antioxidants in the branches and leaves of various tree species, including plants in different seasons, fed to Western Lowland gorillas held in captivity. Consumption was confirmed based on feeding marks on the bark and the roles of branches and leaves in gorilla captivity were considered.

Methods

For each tree species and plant part consumed based on direct observations of foraging behavior and feeding marks were sampled (approximately 300 g to 500 g). In particular, six species (*Quercus myrsinifolia, Castanopsis sieboldii, Ligustrum japonicum, Quercus serrata, Zelkova serrata* and *Acer buergerianum*) were provided to five western gorillas, one male (34 years old at the time of the survey) and four females (39 years, 34 years, 8 years and 4 years old at the time of the survey) held captive at the Ueno Zoo in Tokyo on 4 days (i.e., July 11th, 17th and 26th and 17 November, 2017). The leaves were sampled with the rachis attached and the bark was sampled by scraping off using a cutter, retaining parenchymal parts. Samples for each species and plant part were sealed in plastic bags with zippers and stored at 7°C to 8°C. The antioxidant concentration was measured using the oxygen radical absorbance capacity (orac) method within 7 days after collection. The results are reported in units of μmolte/g (te, trolox equivalents) [3,4].

Results

Five gorillas were allowed to forage freely in the same enclosure. The gorilla family is free to forage in the enclosure from 9:30 to 13:15 and from 13.30 to 16.00. Between 13:15 and 13:30, the gorillas once enter the behind room, during which time vegetables, fruits, grains and abundant branches with leaves are placed around the enclosure by the keepers. At 13:30, the gorillas move back into the enclosure to eat their favorite food. In the case of mother and child, they may eat the same branches and leaves together (Figure 1).

Figure 1: Female and infant (female) eating same branch and leaves (*Ligustrum japonicum*).

The tree species consumed on each day were as follows; 11 July, *Zelkova serrata* and *Quercus myrsinifolia*; 17 July, *Castanopsis sieboldii, Quercus serrata* and *Quercus myrsinifolia*; 26 July, *Zelkova serrata, Quercus myrsinifolia, Ligustrum japonicum, Quercus serrata* and *Acer buergerianum*; and 17 November, *Acer buergerianum*, *Castanopsis sieboldii* and *Ligustrum japonicum*. Approximately 1 month prior to the survey on 17 November the 34-year-old female gave birth to a male baby. The female foraged on branches and leaves; however, the baby was held on the mother's chest and foraging could not be observed. In addition to branches and leaves, on the day of the survey, animals fed on grass, vegetables (more than 20 types, such as broccoli, cabbage, celery, cauliflower, carrot and tomato) grains (such as barley) and small amounts of fruits and yogurt.

All the gorillas foraged on both leaves and bark that were provided on each day. In the survey in July, several branches and leaves were collected and animals sat down and ate the leaves directly using their mouth or hands; when most of the leaves were eaten, they ate the barks by gnawing. These findings indicated that there was a preference for leaves over branches. In addition, there was a difference in foraging marks on barks among tree species (Figure 2). November is the fall foliage season for deciduous trees; however, all the individuals foraged on the leaves and barks of both *Zelkova serrata* and *Acer buergerianum*.

The concentrations of antioxidants were 80 µmolTE/g to 1500 µmolTE/g in leaves and 23 µmolTE/g to 410 µmolTE/g in bark (i.e., they tended to be higher in leaves than in bark). In particular, *Acer buergerianum* leaves had the highest antioxidant concentration during the fall foliage season. The concentration in evergreen trees tended to be higher than that in deciduous trees (Table 1).

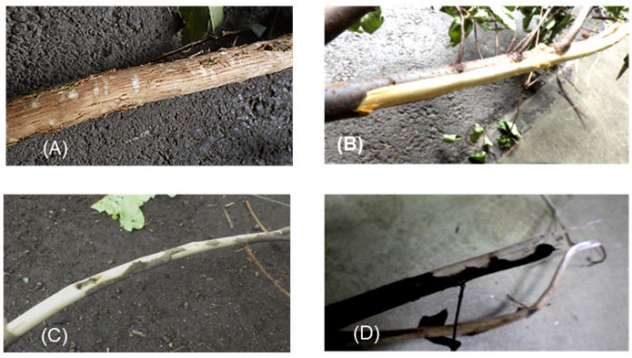

Figure 2: Examples of gnaw marks by gorillas or scrapped off with their teeth or fingers. **Note:** (A) *Quercus myrsinifolia* bark: Multiple gnaw marks can be seen; (B) *Zelkova serrata* bark: Smooth splitted by finger/teeth; (C) *Ligustrum japonicum* bark: Remained in some places; (D) *Quercus serrata*: Not much scrapped off.

Discussion

The ORAC method is an established technique endorsed by the United States Department of Agriculture (USDA) for assessing the antioxidant activities of food and various improvements to this method have been reported [5]. The ORAC method facilitates the comparison of the total antioxidant content per weight among tree species and plant components. However, it is not possible to identify the antioxidants specific to each tree species and compare the distribution; the method is limited to assessing the overall antioxidant capacity.

In a study of the antioxidant concentrations of parts of trees in the family Fagaceae, the concentrations of polyphenols, a type of antioxidant,

Scientific name of Feeding trees	Deciduous (D) or Evergreen (E)	Object of measurement		Date of collection	Date of measurement
		Leaves	Barks		
Acer buergerianum	D	1500		17 Nov, 2017	19 Nov, 2017
Zelkova serrata	D	680		11 July, 2017	19 July, 2017
Castanopsis siboldii	E	590		17 Nov, 2017	19 Nov, 2017
Quercus serrata	D	580		26 July, 2017	28 July, 2017
Quercus serrata	D	530		17 July, 2017	19 July, 2017
Castanopsis siboldii	E	290		17 July, 2017	19 July, 2017
Quercus myrsinifolia	E	210		26 July, 2017	28 July, 2017
Ligustrum japonicum	E	130		17 Nov, 2017	19 Nov, 2017
Acer buergerianum	D	80		26 July, 2017	28 July, 2017
Zelkova serrata	D		410	11 July, 2017	19 July, 2017
Quercus myrsinifolia	E		260	26 July, 2017	28 July, 2017
Quercus serrata	D		180	26 July, 2017	28 July, 2017
Ligustrum japonicum	E		23	26 July, 2017	28 July, 2017

Table 1: Concentrations of antioxidants of feeding trees for Gorillas at Ueno Zoo. Concentration units are µmolTE/g.

were higher in the branches than in the leaves and pericarp [6]. Therefore, animals should be fed whole branches, rather than leaves that are cut and separated from the branches, irrespective of their preference for leaves. In addition, when the gorillas were seen gnawing the bark, they stripped the bark off lengthwise without gnawing all around the branch, including the cambium layer. However, woody plants distribute antioxidants in the inner side of the bark to protect the parenchyma and there is evidence that the bark has a higher antioxidant concentration than those of other tissues [7,8].

In addition, the ORAC value of Acer leaves in November was 20 times higher than that in July; however, anthocyanins produced during the fall foliage season may function as antioxidants [9]. It is important to understand the changes in antioxidant concentrations in leaves across seasons.

Extensive research has focused on the production and function of antioxidants in tree species, including research on antioxidant activity and function in Fagaceae species and applied research on antioxidants contained in nuts of Quercus [10,11]. Using these findings as a reference, we believe that information on the amounts of branches and leaves collected by animals in captivity, not limited to gorillas, will enable us to quantitatively understand dietary antioxidants.

In the widely recommended gorilla care manual, branches are regarded as environmental enrichment elements and manipulative objects, e.g., for bedding [2]. However, if the bark introduced as bedding material is eaten, it may also contribute to antioxidant activity in animals. For branches and leaves provided as food to animals in captivity in zoos in Japan, in addition to studying their preferences, quantitative nutrient analyses have been performed [12]. In the future, detailed analyses of antioxidants are needed.

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