

## SELECTED EUCALYPTUS PREFERENCE BY THE KOALAS (*PHASCOLARCTOS CINEREUS*) AT THE SAN DIEGO ZOO

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### ABSTRACT

The San Diego Zoo has the largest group of Queensland koalas in captivity outside Australia. Many of these koalas are on loan in different facilities through North America. Due to the large number of koalas, San Diego Zoo Global maintains an over 4 ha plantation of eucalyptus. A preliminary study conducted at the San Diego Zoo found a variability in the nutritional composition of 13 *Eucalyptus* species during a six month period. However, no further studies has been performed to stablish a preference for *Eucalyptus* species. The purpose of this project was to determine intake and preference for 4 selected *Eucalyptus* species. In order to test if there were preferences between the *Eucalyptus* species, species dry matter intake was analyzed using a 4 x 12 factorial analysis (4 species and 12 months). The 4 *Eucalyptus* species were chosen according to a historical consumption from excellent (*E. camadulensis*), good (*E. robusta*), to sporadic (*E. sideroxylon*) and poor (*E. dalrympleana*). Total daily dry matter intake was analyzed using a one-way analysis of variance to evaluate changes in monthly intake. There was a significant interaction ( $P < 0.05$ ) between *Eucalyptus* species and month. Except for the months of September and December, koalas consumed more *E. camadulensis* ( $P < 0.05$ ) than *E. dalrympleana*. Total daily eucalyptus dry matter intake averaged 177 g over the entire study with similar ( $P > 0.05$ ) intakes each month.

### Introduction

It has been well established that koalas (*Phascolarctos cinereus*) have a highly selective feeding behavior (Hume and Esson 1993). In fact, koalas are one of the four marsupials that forage mainly on *Eucalyptus* (Wallis et al., 2002). More than 600 species of *Eucalyptus* are present, but koalas only feed from approximately 5% of the total species (Martin and Handasyde, 1999). Many authors (George, 1977; Hindell et al., 1985; Hindell and Lee, 1990; Lee and Martin, 1988; Moore and Foley, 2000; Ullrey et al., 1981; Zoidis and Markowitz, 1992) have reported koalas have preference for *Eucalyptus* species in captivity and in the wild. The San Diego Zoo has the largest group of Northern Queensland koalas in captivity outside of Australia. The majority of these animals (40 animals) are on loan to facilities throughout North America. To provide adequate eucalyptus foliage to feed this increasing number of animals, both in house and on loan, San Diego Zoo Global maintains an over 4 ha (10 ac) plantation of *Eucalyptus* including 35 species. A preliminary study conducted at the San Diego Zoo demonstrated variability in the nutritional composition of 13 *Eucalyptus* species during a six month period (Ullrey, 1981). However, no further studies have been conducted at this institution to determine if there are

*Eucalyptus* species preferences. Some studies attempting to correlate eucalyptus composition and food preference have produced conflicting results (Zoidis and Markowitz, 1992). Hindell (1979) found no relationship between *Eucalyptus* species preference and composition, but other studies (Hume, 1982; Ullrey et al., 1981) did find correlations. At the San Diego Zoo, few reports document nutrients in Eucalyptus; they were sporadic in sample collection and not consistent with species across seasons and keeper speculation was used to determine browse acceptance or rejection by koalas. The goal of this project was to determine intake and preference for the selected 4 *Eucalyptus* species.

## Methods

Four species of *Eucalyptus* (*E. camadulensis*, *E. robusta*, *E. sideroxylon*, and *E. dalrympleana*), were selected to feed 4 adult male koalas in this study. The *Eucalyptus* species were chosen according to a historical consumption from excellent (*E. camadulensis*), good (*E. robusta*), to sporadic (*E. sideroxylon*) and poor (*E. dalrympleana*).

The animals received 4 fresh browse bundles daily (each averaged 1198 g) with each bundle representing one of the 4 species of *Eucalyptus* being tested. The collection period took place over 4 consecutive days each month with 4 weeks between collection periods from June 2008 to May 2009. The eucalyptus browse was taken from the cooler at 7.5°C (45°F) each morning. Each species bundle was broken into smaller bundles to be fed to the 4 koalas and one to act as a control. The control for each *Eucalyptus* specie was established and treated exactly as the ones offered to the koalas. The purpose of the control was to determine a factor for water weight loss in the browse that was offered to the koalas.

The smaller bundles were homogenous groups with similar leave quality (red tips, leaf cover) and similar branch lengths. The similarity of branch length allows the koalas complete access to the browse, except for the control; the leaf uniformity produced groups that represent the uniqueness of the browse. The *Eucalyptus* species bundles offered to the animals were rotated between four different feeding stations each day within each animal enclosure (concrete floor pen; 3.53 m x 2.93 m) to eliminate the influence of perching preference. Each browse bundle was weighed and then the leaf tips were hosed to provide additional water to the animals prior to being offered. The following morning, the bundles were removed and weighed; all the leaves and petioles that had fallen on the floor of each animal enclosure were collected and weighed with their respective species bundle. All the enclosures were cleaned to remove any debris or fecal matter, to prepare them for the supply of new eucalyptus bundles.

After all the eucalyptus bundles were weighed and recorded, the control bundles were labeled and placed in black trash bags (30 gal.) for processing later in that day. The control bundles were transported to the lab and the leaves and petioles removed. The leaves and petioles were freeze dried (Labconco Free Zone 6, Freeze Dryer System) to a constant dry weight to determine dry matter content. The freeze-dried leaf and petiole samples were stored in plastic bags in an area protected from sunlight to prevent nutrient degradation for future analysis.

A water correction factor for each control bundle was determined by dividing the 'dry' bundle weight by the fresh bundle weight to determine the percent of water loss. Within each month and *Eucalyptus* species, an average correction factor was calculated. If an individual bundle

correction factor was greater or less than 3 standard deviations from the mean of all correction factors, that correction factor was not included in the monthly average.

As-fed intake was determined as the difference between the initial species bundle weight and the species ort weight multiplied by the water correction factor to account for water loss over the previous 24 h (Equation 1). Dry matter intake then was determined by multiplying the as-fed intake by the Control bundle's leaf and petiole dry matter content (Equation 2). Total daily dry matter intake was determined by adding the 4 species dry matter intake.

Equation 1

As-fed intake per species bundle, g = Initial bundle wt. – (Orts wt \* Correction factor)

Equation 2

Dry matter intake, g = As-fed intake per species bundle \* Control bundle dry matter percentage

Species dry matter intake was analyzed using a 4 x 12 factorial analysis (4 species and 12 months) using JMP (rel. 5.0.1.2, SAS Institute, Inc., Cary, NC). When main effects were significant, means were separated using a Tukey test. If there was a Species by Month interaction, means were separated within species and within month using a Tukey test. The level of significance used was  $P < 0.05$ . Total daily dry matter intake was analyzed using a one-way analysis of variance to evaluate changes in monthly intake. Monthly means were separated using a Tukey test.

## Results and Discussion

There was a significant interaction between species and month ( $P < 0.05$ ). Species within month comparisons are shown in Table 1. Except for September and December, koala consumed *E. camadulensis* more ( $P < 0.05$ ) than *E. dalrympleana*. The consumption of *E. robusta* and *E. sideroxylon* were intermediate. This agrees with the observations made by the koala keepers.

Total daily eucalyptus dry matter intake averaged 177 g over the entire study with similar ( $P > 0.05$ ) intakes each month. Based on an average dry matter content (38.3% DM) for all four Eucalyptus species over the year-long study, koalas in the current study consumed 462 g of Eucalyptus (as-fed). This amount of eucalyptus consumption agrees with previous studies in free-ranging and zoo koala (Eberhard et al., 1975; Nagy, 1985; Zoidis et al., 1992). Based on these results, browse production of *E. camadulensis* should be increased and *E. dalrympleana* phased out. Further nutrient analysis for the *Eucalyptus* species will be completed and it would be interesting to focus on the months of September and December to find out the similarity of these two months compared with the rest of the year.

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**Table 1.** Monthly koala (*Phascolarctos cinereus*) dry matter intake of four selected *Eucalyptus* species.

Month, Year	Dry matter intake of <i>Eucalyptus</i> species, g			
	C <sup>1</sup>	D <sup>2</sup>	R <sup>3</sup>	S <sup>4</sup>
June, 2008	70.8 <sup>a</sup>	37.5 <sup>b,c</sup>	26.4 <sup>b,c</sup>	65.8 <sup>a,b</sup>
July, 2008	59.4 <sup>a</sup>	16.3 <sup>b</sup>	27.7 <sup>a,b</sup>	32.4 <sup>a,b</sup>
August, 2008	71.1 <sup>a</sup>	13.6 <sup>b</sup>	54.9 <sup>a</sup>	32.8 <sup>b</sup>
September, 2008	56.5 <sup>a</sup>	32.2 <sup>a</sup>	45.3 <sup>a</sup>	56.9 <sup>a</sup>
October, 2008	83.3 <sup>a</sup>	11.9 <sup>c</sup>	61 <sup>a,b</sup>	38.0 <sup>b,c</sup>
November, 2008	60.8 <sup>a</sup>	20.2 <sup>c</sup>	54.1 <sup>b</sup>	28.5 <sup>a,b,c</sup>
December, 2008	49.8 <sup>a</sup>	25.3 <sup>a</sup>	46.2 <sup>a</sup>	48.5 <sup>a</sup>
January, 2009	68.7 <sup>a</sup>	18.8 <sup>b</sup>	50.7 <sup>a,b</sup>	46.3 <sup>a,b</sup>
February, 2009	80.1 <sup>a</sup>	14.3 <sup>c</sup>	34.4 <sup>b,c</sup>	59.6 <sup>a,b</sup>
March, 2009	70.8 <sup>a</sup>	19.7 <sup>b</sup>	49.7 <sup>a,b</sup>	40.9 <sup>a,b</sup>
April, 2009	55.7 <sup>a</sup>	19.8 <sup>b</sup>	44.8 <sup>a,b</sup>	44.3 <sup>a,b</sup>
May, 2009	70.1 <sup>a</sup>	32.0 <sup>b</sup>	33.3 <sup>b</sup>	38.9 <sup>a,b</sup>
<b>Average</b>	66.4	21.8	44.0	44.4

<sup>1</sup>*Eucalyptus camadulensis*.

<sup>2</sup>*Eucalyptus dalrympleana*.

<sup>3</sup>*Eucalyptus robusta*.

<sup>4</sup>*Eucalyptus sideroxylon*.

<sup>ab</sup>Within a row, means without a common superscript differ (P < 0.05).