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Feeding Behavior and Food Preferences of Bornean Orang utan (*Pongo pygmaeus*) at Gembira Loka Zoo Yogyakarta

Fajar Sanintan Jati[1]*, I Made Oka Riawan[1], Moh Jafron Syah[1]
[1]Biology Study Program, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Ganesha, Singaraja, Indonesia

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*Corresponding Author:
Fajar Sanintan Jati,
Biology Study Program, Faculty Mathematics and Natural Sciences, Universitas Pendidikan Ganesha, Singaraja, Indonesia;
Email: nifajarsani@gmail.com

Abstract: Feeding management is crucial in the care of orangutans in captivity, particularly the understanding of individual feeding preferences as a key factor in animal welfare. This study aims to review feeding management, identify preferences, and analyze the feeding behavior of Bornean orangutans (*Pongo pygmaeus*) at Gembira Loka Zoo, Yogyakarta. Observations were conducted on four accommodation individuals and two display individuals from May to July 2025, focusing on feeding position, technique, timing, and activity. The method used was descriptive observational with scan sampling from 08:00 to 15:00 local time, along with recording of feed types, weights, and leftovers. Preferences were analyzed using Jacobs' Index (Di), categorized as highly preferred, preferred, less preferred, and not preferred, along with palatability assessment. Results showed that the main diet consisted of vegetables (64.90%), fruits (18.47%), and tubers (15.32%), with melon, tubers, and corn being the most preferred foods, while pumpkin and bok choy were less favored. Feeding behavior varied according to age, sex, social status, and activity level, dominated by sitting positions and techniques that demonstrated fine motor skills as well as adaptation to artificial environments. These findings are particularly beneficial for feeding management at Gembira Loka Zoo to minimize leftovers based on individual preferences, while also serving as a reference for improving animal welfare and the effectiveness of other ex situ conservation efforts.

Keywords: Diet, Feeding behavior, *Pongo pygmaeus*, Preference, Management.

Introduction

Biodiversity is a vital foundation for the sustainability of global ecosystems as well as an invaluable heritage for human civilization. Great apes occupy a special position as flagship species and keystone species that maintain the ecological balance of tropical forests by acting as seed dispersers and supporting the regeneration of rainforests. Within the frameworks of zoology and conservation, studying animal behavior, including feeding behavior, provides a scientific basis for nutritional management, animal welfare, and conservation strategies.

Orang utans in Indonesia consist of three species, the Bornean orang utan (*Pongo pygmaeus*), the Sumatran orang utan *(Pongo abelii*), and the Tapanuli orang utan (*Pongo tapanuliensis*) (Dalimunthe *et al.,* 2020). Their populations are now confined to Sumatra and Borneo, totaling approximately 71,820 individuals, with around 57,350 located in Borneo (Forina, 2023). However, these numbers have drastically declined by up to 86% over the last three generations, leading to the Bornean orang utan being classified as critically endangered by the IUCN (2025). The main threats include deforestation, habitat loss, illegal hunting, and wildlife trade (Ridadiyanah & Subekti, 2022; Sugianto *et al.,* 2023). With a slow reproductive cycle, where

females give birth only every 7–8 years, population recovery becomes increasingly difficult (Magfirah, 2023).

Ex situ conservation in zoo provides an important alternative for protecting endangered species, including the Bornean orang utan (Muslimah *et al.,*2020). But, the main challenge lies in how to maintain animal welfare within an artificial environment. Gembira Loka Zoo Yogyakarta is one of the conservation institutions that houses Bornean orang utans, while also serving educational, research, and recreational functions. Its management follows the Regulation of the Director General of Forest Protection and Nature Conservation No. 9 of 2011, which governs environmental enrichment, nutritional management, protection from stressors, and health care. However, the feeding management at Gembira Loka Zoo Yogyakarta is still based on general standards, with a uniform diet applied to other great apes such as chimpanzees and siamangs, without considering the specific dietary preferences of each species or individual. In fact, research indicates that feeding behavior and food preferences are influenced by age, sex, activity level, metabolic status, and social hierarchy (Munawira *et al.* 2025,). For example, adult male orangutans with larger body mass tend to require higher energy intake compared to females (Mason, *et al.,* 2021). Similarly, individuals housed in display enclosures with higher physical activity levels need more energy than those in quarantine or accommodation enclosures (Schmidt, 2004). Therefore, feeding management should not be standardized. Lack of attention to this variability may result in food waste, disrupted metabolism, and a decline in the long-term welfare of orangutans, a species with a slow reproductive cycle and critical conservation status (Kusnanda, 2020). Studying the feeding behavior and preferences of each individual is essential to design effective and tailored feeding management.

Feeding behavior at Gembira Loka Zoo has previously been studied by Qothrunnada (2021), during the pandemic, focusing on aspects of feeding duration and feeding posture. The study revealed variations in feeding behavior based on age and sex, as well as a decrease in fruit consumption during the pandemic. However, the study was limited to individuals in the display enclosure. To date, no post-pandemic study has specifically examined feeding behavior in more detail (such as posture, technique, frequency, and feeding time) or food preferences. Yet, such information is crucial for developing effective feeding strategies to minimize food waste and improve animal welfare. Therefore, this study aims to fill this gap by providing current post-pandemic data through a comprehensive analysis of feeding behavior, describing dietary management, and analyzing the individual food preferences of Bornean orang utans at Gembira Loka Zoo in both display and accommodation enclosures, while considering biological and behavioral variations that influence nutritional needs. This research generates scientific data that can serve as the basis for developing adaptive and efficient nutritional management strategies, taking individual preferences into account to minimize food waste while supporting the long-term welfare.

Materials and Methods

Time and Place

This study applied a descriptive research design aimed at documenting feeding behavior and food preferences, conducted from May to July 2025. The research took place at Gembira Loka Zoo, Yogyakarta (Jl. Kebun Raya No. 2, Kotagede). Data collection was performed six days per week from 07:00 to 15:00 local time. Feeding management were recorded between 07:00–09:00 in the nutrition section, followed by leftover feed weighing and pre-feeding behavioral observations from 09:00–09:40 in the accommodation enclosure. Feeding behavior and food preference observations were then conducted from 09:41–15:00.

Research Population and Sample

The population included all orangutan species at Gembira Loka Zoo, Yogyakarta. The study sample consisted of 2 individuals in the display enclosures and 4 individuals in the accommodation enclosures, namely Bety (adult female), Boy (adult male), Pretty (adult female), Noa (juvenile male), Moni (Adult female), and Hope (adult female).

Tools and Materials
The research instruments included stationery, a digital scale, a camera, tally sheets, and a stopwatch.

Data Collection Procedure
Habituation
To minimize observer effects, a habituation phase was carried out for seven consecutive days (09:00–15:00). During this period, daily behaviors such as feeding, foraging, locomotion, resting, and social interactions were documented using ad libitum sampling to capture both common and rare events.

Feeding Behavioral Observation
Behavioral data were recorded using scan sampling at one-minute intervals with 10 repetitions per subject per day, between 09:00–15:00. Recorded behaviors included food acquisition, chewing, termination of feeding, and food transport between sites (Yantoko *et al.*, 2022). Feeding Position categorized into four postures; hanging, sitting, standing, and lying down, following Iqbar *et al.,* (2024). Feeding Techniques documented following (Yohana, 2004), covering plucking, peeling, leaf stripping, juice extraction, and insect foraging. Data were tabulated as durations and converted into percentages of total feeding activity.

Feeding Management Data
Feeding management was recorded for two months, including schedules, feeding methods, types, and quantities of food provided and consumed. Food items were grouped into categories (fruits, young leaves, mature leaves, other vegetative parts, bark, water, and soil) following Zulfa (2006). Leftover food was weighed daily to calculate actual consumption.

Food Preference
Food preference compares food availability with consumption to determine preference or avoidance.

Data Analysis
Food preference was analyzed using Jacobs' Index (Di) (Jacobs, 1974):

$$D_i = \frac{r_i - p_i}{r_i + p_i - 2r_i p_i}$$

where :
r_i : proportion of a food type consumed
p_i is the proportion offered.

Values were classified as highly preferred (0.51–1.00), preferred (0.01–0.50), less preferred (–0.51–0.00), and avoided (–1.00– –0.50).

Results and Discussion

Daily Activity
Further observations of six Bornean orangutans identified 11 daily activities, including feeding, social interaction, locomotion, drinking, defecation, urination, hanging, resting, sleeping, nesting, and other behaviors. Among these, feeding was the most dominant activity, particularly in the accommodation enclosure, with Bety (27%), Boy (25.1%), Pretty (20.5%), and Noa (15.9%).

The orangutans in the sleeping enclosure (Noa, Pretty, Boy, and Bety) exhibited concentrated feeding activity between 09:00–11:00 a.m. (WIB). Afterward, they consumed only the browse provided. This pattern is consistent with the findings of (Saputra *et al.*, 2023) which explained that limited space and feeding schedules entirely regulated by the keepers resulted in resting activity dominating outside of the main feeding hours. Meanwhile, in the display enclosure, the highest feeding activity was observed at 14:00 p.m., coinciding with the public keeper talk session that included the provision of young coconuts. Younger individuals such as Noa and Hope were more active in feeding, playing, and exploring, which is consistent with Yantoko *et al.*, (2022)), while adults (Boy, Bety, Pretty, and Moni) displayed longer resting periods. In contrast, orangutans in the display enclosure showed lower feeding percentages (Moni 16.5% and Hope 6.7%). This difference is largely attributable to management patterns: individuals in the accommodation enclosures received their main diet in the morning, whereas those in the display enclosures (Moni and Hope) were provided only browse and coconut enrichment during the public keeper talks, with their main diet distributed later in the evening. However, according to Dalimunthe *et al.*, (2020), in the afternoon orangutans tend to rest until night, so providing food during this period may trigger obesity due to reduced activity.

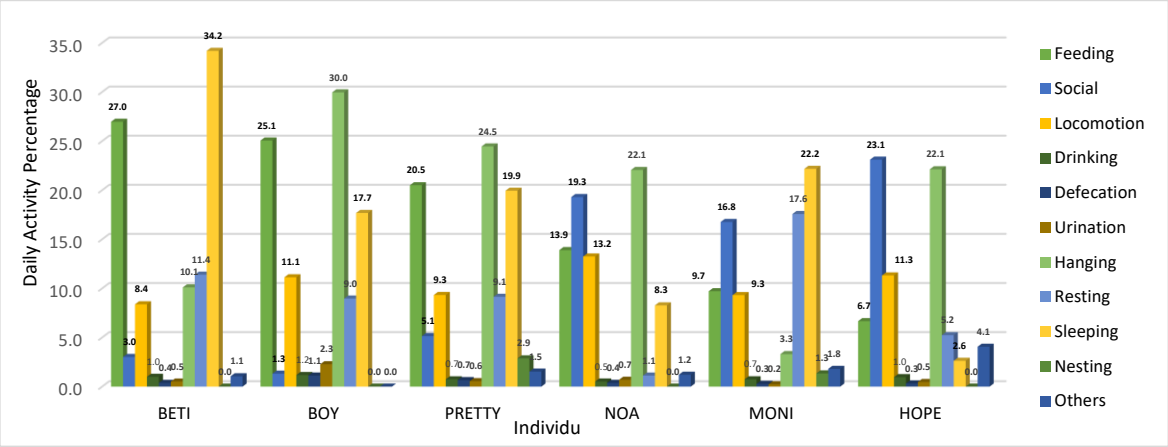

Figure 1. Daily Activity Percentage of Orang Utan

Table 1. Orang Utan in Gembira Loka Yogyakarta

Enclosure		Sleeping Enclosure		Display Enclosure	
					
AF1 (Bety) 40 year	AM1 (Boy) 21 year	AF2 (Pretty) 21 year	JM1 (Noa) 4 year	AF3 (Moni) 32 year	JF1 (Hope) 5 year
05 – 15 May	16-27 May	28 May – 07 June	09 – 19 June	20 June – 1 July	02 – 12 July
Darker skin color, and has the largest umbilical cord	Has cheek pads with matted hair covering parts of the body	Has a forehead bulge, with the widest forehead	Eyes are dark yellowish in color	Mouth is more protruding, with a triangular-shaped head	Darker fur color, with a slightly rounded head shape

Description: A = adult, J = juvenile, M = male, F = female

Feeding Management and Dietary Composition

Feeding management at Gembira Loka Zoo has shifted from assumption-based practices (e.g., sweetened tea, tempe bacem) toward a standardized nutrition-focused system involving procurement, preparation, distribution, and enrichment starting at 07:00 WIB. Feed is delivered by a three-wheeled vehicle at 09:00, with portions averaging 3.2–4.6 kg per individual, matching the zoo's feeding standards (4.5 kg for adult males, 4 kg for adult females, and 2.5–3.5 kg for juveniles). This approach follows bioenergetic principles emphasizing sex- and age-based calorie requirements (Campbell *et al.,* 2003). Modifications for special conditions, such as increased egg and fruit during lactation in Moni or boiled pumpkin and tempeh during diarrhea in Pretty and Noa, highlight the integration of nutrition and health, in line with Dalimunthe *et al.,*, (2020); Muslimah *et al.,* (2020).

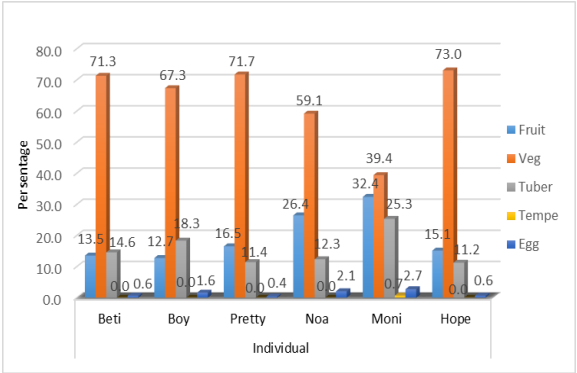

Figure 2. Percentage Types of Food Given to Orang utans

Diet composition comprised 13 fruits, 17 vegetables, 3 tubers, and 2 protein-rich supplements (boiled tempeh and eggs). Vegetables dominated the distribution (64.9%), followed by fruits (18.47%), tubers (15.32%), eggs (1.29%), and tempeh (0.02%). The provision of fruit for orangutans at Gembira Loka Zoo is usually limited to melon and papaya, although other varieties such as mandarin oranges, pears, and other fruits are occasionally given. However, the fruits are generally provided in a semi-ripe state, particularly papaya and other sweet fruits, and in smaller quantities compared to tubers and vegetables, in order to prevent excessive sugar intake that could lead to obesity in orangutans. The vegetables used at Gembira Loka are typically organic and fresh, while bok choy is usually split into two parts before being offered, as some individuals do not prefer the stem portion due to its bitter taste.

Supplementary feed was also provided, including browse (foliage) such as guava leaves, banana leaves, and others. In addition, eggs were periodically given as an additional source of protein, consistent with the findings of Campbell *et al.,* (2003), which emphasized the importance of supplementary items such as eggs in fulfilling the protein requirements of animals. Kusnanda (2020) noted that supplementary feeding for captive orangutans also included food enrichment items such as palm sugar, coconuts, and weekly boiled eggs. They were also provided with natural materials such as grass or bamboo leaves as part of physical enrichment, similar to the methods applied at Gembira Loka Zoo.

In the accommodation enclosures, enrichment was carried out periodically using natural materials such as fruits and vegetables wrapped in leaves. These leaf-wrapped bundles were then placed in various positions, such as being hung, buried in the soil, or combined with specific sensory elements like itchy leaves or thorns. The variations in shape, texture, and aroma of these objects were designed to stimulate the orangutans' cognitive responses, sensory perception, and exploratory behaviors.

Table 2. Types of Food Given to Orang utans

No	Latin Name	Scientific Name	Feeding Frequency
Fruit (Fr)			
1	Melon (M)	*Cucumis melo* L.	Always
2	Papaya (Mm)	*Carica papaya* L.	Always
3	Starfruit (M)	*Averrhoa carambola*	Additional (Nursing)
4	Apple (M)	*Malus sieversii*	Rarely, Additional
5	Sunkist Orange (M)	*Citrus sinensis* (L.) Osbeck	Rarely, Additional
6	Pumpkin (M)	*Cucurbita moschata*	Rarely, Additional
7	Bandung Banana (M)	*Musa paradisiaca*	Often
8	Dragon Fruit (M)	*Selenicereus undatus*	Rarely, Additional
9	Watermelon (M)	*Citrullus lanatus*	Rarely, Additional
10	Persimmon (M)	*Diospyros kaki*	Rarely, Additional
11	Guava (M)	*Psidium guajava*	Rarely, Additional
12	Peer(M)	*Pyrus*	Rarely, Additional
13	Mango (M)	*Mangifera indica*	Rarely, Additional
Vegetable (Veg)			
1	Long beans	*Vigna unguiculata* ssp.	Always
2	Cucumber	*Cucumis sativus*	Always
3	Tomato	*Solanum lycopersicum*	Always
4	Carrot	*Daucus carota* L	Always
5	Sweet Corn	*Zea mays saccharata Sturt*	Always
6	Flint Corn	*Zea mays indentata*	Always
7	Cauliflower	*Brassica oleracea var. botrytis*	Rarely, Additional
8	Broccoli	*Brassica oleracea var. italica*	Rarely, Additional
9	Green Beans	*Phaseolus vulgaris* L.	Variable (Friday, Sunday)
10	Bok Choy	*Brassica rapa subsp. chinensis*	Selalu
11	Mustard Greens	*Brassica juncea*	Sering

12	Chayote	*Sechium edule*	Variable (Tuesday, Thursday, Saturday)
13	Spinach	*Amaranthus tricolor*	Always
14	Water Spinach	*Ipomoea aquatica*	Rarely, Additional
15	Papaya Leaves	*Carica papaya floss*	Variable (Wednesday)
16		*Solanum melongena*	Rarely, Additional
17	Eggplant	*Raphanus sativus*	Rarely, Additional
Umbi			
1	Yelow Sweet Potato (M)	*Ipomoea batatas*	Always
2	Purple Sweet Potato (M)	*Ipomoea batatas* L. Poir	Allways
3	Potato (M)	*Solanum tuberosum*	Rarely, Additional
Others			
1.	Boiled Tempe		Rarely, Additional
2.	Boiled Egg		Always

Description: M= ripe, Mm= half ripe, m= unripe

Feeding Peaks and Temporal Patterns

Feeding peaks occurred at 10:00 WIB, with the longest feeding durations recorded for Boy (338 minutes), Bety (332 minutes), and Noa (276 minutes). After 11:00–13:00, feeding declined as main items became depleted, and orangutans turned to browse. In contrast, Moni and Hope exhibited feeding peaks at 14:00 during the keeper talk, as their morning diet was restricted to browse.This demonstrates how feeding schedules shape temporal activity patterns. The anticipatory behaviors observed in Moni, such as restlessness before feeding, indicate cognitive ability to recognize time patterns, consistent with Dalimunthe *et al.,* (2020), Enrichment through browse and young coconut during public sessions also stimulated activity in otherwise passive individuals, supporting Saputra *et al.,* (2023) who emphasize enrichment's role in maintaining behavioral diversity.

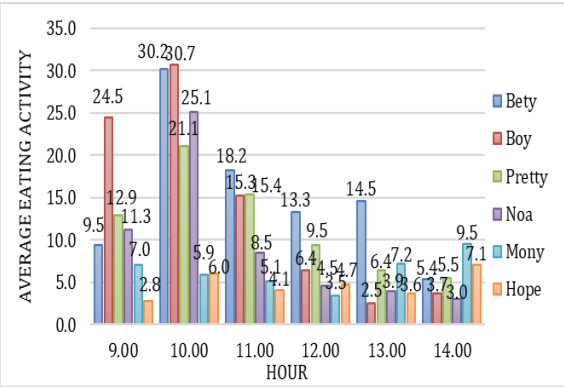

Figure 3. Average Eating Activity in Minute

Feeding Postures and Techniques

Feeding postures varied with age and enclosure use. Adults primarily fed in sitting or lying positions, reflecting stability and efficiency (Magfirah, 2023; Muslimah, *et al.,*2020), whereas juveniles preferred hanging positions, consistent with their arboreal nature and mobility (Iqbar *et al.,* 2024). The occurrence of lying postures during feeding, especially in Bety and Pretty, is rare in the wild (Roth *et al.,* 2020) but appears more frequently under captive conditions where food is abundant and risk is reduced. In contrast to the adult individuals, Noa (a juvenile male) exhibited a dominant hanging position during feeding, totaling 355 minutes (57.3% of the overall feeding time). This hanging posture is consistent with the natural arboreal behavior of young orangutans, who possess higher mobility and a physiological need to develop motor skills and body balance.

Table 3. Orang utan Feeding Position

Individual	Feeding Position (minute)				Total
	Standing	Sitting	Hanging	Lying	
Bety	77	386	5	533	1001
Boy	50	594	38	232	914
Pretty	47	380	27	324	778
Noa	64	192	355	9	620
Moni	51	217	86	66	420
Hope	44	109	143	16	312

Feeding behavior was dominated by chewing, with Boy exhibiting the highest proportion (79.3%) and Moni the lowest

(48.1%). Chewing accounted for the majority of activity, reflecting the high fiber content of the diet and supporting earlier findings by Iqbar *et al.,* (2024) and Samudra *et al.,* (2020). Food extraction behaviors such as peeling and pounding were most frequent in Moni (15 %) and Hope (11 %) due to access to coconuts. Probing behaviors were most common in juveniles like Noa, indicating developmental learning and exploratory tendencies.

Spitting behavior was frequently observed in Bety, Pretty, and Moni, who often spat out coconut fiber and corn cobs. A similar phenomenon was reported by Yanti *et al.*, 2023) in the individual Kelly, who not only spat out corn cobs and coconut fiber but also more frequently chewed bark before discarding the residue.

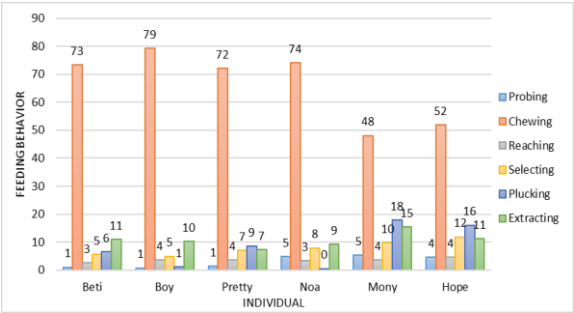

Figure 4. Percentage Feeding Behavior

Several individuals demonstrated complex feeding strategies involving tool use and food processing. Bety used nails or twigs to extract soil invertebrates, while Pretty, Hope, and Moni washed food at artificial water sources, showing hygiene-related cognition (Yohana, 2004). Pretty displayed further cognitive sophistication by cracking eggs on her forehead before peeling, highlighting problem-solving skills. These behaviors support the role of captivity in eliciting cognitive expression when enrichment opportunities are available (Clark *et al.,* 2021). However, instances such as Hope using discarded plastic as a tool highlight potential welfare risks when non-natural materials are accessible.

When feeding on browse leaves, Bety tended to pick the leaf tips, whereas Boy and Pretty pulled the leaves directly using their mouths. In consuming long beans, Bety and Pretty separated the seeds from the pods, while Boy employed a technique known as leaf stripping with the hand, namely holding and pulling the leaves with his hand. This technique is consistent with Yohana (2004), who described leaf stripping as involving the simultaneous use of the hands and mouth to separate the edible parts of food.

During feeding, Pretty exhibited a unique behavior known as remastication, a behavior commonly observed in ruminants. Remastication occurs when forage or other food is forced back into the mouth to be further chewed and mixed with saliva, allowing the food bolus to be re-swallowed and passed into the reticulum (Datta, 2023).In several observations, Pretty was seen rubbing or inserting her fingers into her nose, then regurgitating chewed food such as tubers, carrots, eggs, and corn into her palm. She subsequently selected the food items one by one with her mouth and consumed them again, repeating this process up to three times.

Food Preferences

Food preference analysis using Jacobs' Index revealed that orangutans strongly preferred certain fruits and vegetables, particularly melon, papaya, mandarin orange, Bandung banana, cucumber, corn, tomato, mustard greens, carrots, boiled eggs, and sweet potatoes. Some foods, such as pumpkin, were consistently rejected (Di = –1) by several individuals. This is consistent with the findings of Zahro *et al.,*(2022), who reported that fruits are the most preferred plant parts by orangutans (51%) due to their higher fat and carbohydrate content compared to other dietary components, while young leaves serve as an important source of protein (Fawzi *et al.,*2020).

Bety showed a strong preference for tubers and corn, which is presumed to have been shaped by her past experiences. The intensity of her consumption was evident from her habit of eating corn until the cob was completely unrecognizable. On the other hand, several types of vegetables, including long beans, spinach, bok choy, broccoli, and cauliflower, tended to fall into the less preferred category (score 3), as indicated by leftover food. Some individuals also displayed specific feeding preferences, such as consuming only small-sized bok choy and leaving behind the stem, or rejecting spinach altogether, leading to a reduced frequency of its

provision. Social dynamics further influenced feeding opportunities. Hope often lost access to food due to Moni's monopolization, occasionally hiding to avoid competition. This reflects Syah *et al.,* (2024), who noted that high captive density intensifies intraspecific competition

Table 4. Jacob Index Food Preference

Group	Variation	Jacob Index Food Preference					
		Bety	Boy	Preti	Noa	Moni	Hope
Fruit	Melon	2	2	2	2	2	2
	Papaya	2	2	2	2	2	2
	Starfruit	0	0	0	0	2	0
	Apple	2	2	0	2	0	0
	Mandarin Orange	2	2	2	2	2	2
	Pumpkin	2	2	4	4	4	2
	Bandung Banana	2	2	2	2	2	2
	Mango	2	0	0	2	0	2
	Pear	0	0	0	2	2	2
	Guava	0	0	0	2	0	0
	Persimmon	0	0	0	2	0	0
	Watermelon	0	0	0	2	2	2
	Dragon Fruit	0	0	0	2	0	0
Vegetable	Long Bean	3	3	2	3	3	2
	Cucumber	3	3	2	3	3	3
	Field Corn	2	2	2	2	2	2
	Sweet Corn	2	2	2	2	2	3
	Tomato	2	2	2	2	2	2
	Broccoli	3	3	0	3	3	0
	Cauliflower	3	3	3	3	0	0
	Jicama	0	0	0	0	0	2
	Eggplant	0	2	2	3	0	2
	Papaya Leaf	0	2	2	3	2	2
	Spinach	3	3	3	2	3	3
	Chayote	2	2	3	3	3	3
	Mustard Greens	2	2	3	2	3	2
	Bok Choy	3	3	3	3	4	4
	Green Bean	2	3	2	3	3	2
	Lettuce	0	0	0	0	0	3
	Carrot	2	2	2	2	2	2
Processed	Boiled Tempeh	0	0	0	0	2	0
	Boiled Egg	2	2	2	2	2	2
Tubers	Potato	0	2	0	2	2	2
	Yellow Sweet Potato	2	2	2	2	2	2

Description: 0 = food was not provided, 1 = the most preferred food, 2 = preferred food, 3 = less preferred food, and 4 = not preferred.

Conclusion

The feeding management of Bornean orangutans (*Pongo pygmaeus*) at Gembira Loka Zoo Yogyakarta is carried out systematically and individually, taking into account age, sex, and health status in accordance with animal welfare standards. Daily food portions range from 2.5–3.5 kg for juveniles and 4–4.5 kg for adults, dominated by vegetables, fruits, and tubers. The diet is structured into main feed, scheduled supplementary feed, and incidental feed, with enrichment regularly provided through food variation, feeding schedules, and presentation methods. Jacobs' Index analysis shows that orangutans generally prefer fruits such as melon, papaya, mandarin orange, and banana, as well as vegetables such as cucumber, corn, tomato,

spinach, chayote, mustard greens, and carrot, while certain items such as pumpkin and bok choy are consistently avoided by some individuals. Feeding behavior varies according to age, sex, social status, and enclosure conditions, with adult females showing more stable morning feeding patterns, adult males chewing for longer durations, and juveniles consuming food more quickly before engaging in exploratory activities. Feeding positions are predominantly sitting, reflecting energy conservation, while juveniles more often exhibit suspensory postures in line with arboreal behavior. Overall, feeding patterns in captivity are shaped by a complex interaction of biological, social, and environmental factors, serving as important indicators of animal welfare and the effectiveness of ex situ management strategies.

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