Does Altering a Gorilla's Diet Alter Their Activity Budget? A preliminary study

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ABSTRACT

Gorillas represent recognizable megafauna in both the wild and in zoos. Knowing the activity budgets of wild gorillas immeasurably helps keepers care for gorillas in zoos. Researchers study major behaviors among gorillas, such as time spent foraging. Wild individuals, for example, must routinely travel longer distances for food than their captive counterparts. While wild individuals can seek out and consume preferred items, zoo-housed individuals must eat the diet choices made by their care staff. Some gorillas' diets under human care provide a higher source of sugars and starches than that found in the wild, which can lead to behavior and medical issues, including regurgitation and reingestion (RR) or obesity. This study sought to see if changing the long-standing diet of a troop of zoo-housed gorillas impacted their activity budget. Some behaviors did change significantly, but most did not, though clear patterns occurred due to this change.

INTRODUCTION

Gorillas (*Gorilla spp.*) are the largest primate. There are two main species of gorilla: Western gorillas (*Gorilla gorilla ssp.*) typically reside in lowland swamp areas, while Eastern gorillas (*Gorilla beringei ssp.*) live at higher elevations and montane forests. These species are composed of four subspecies: western lowland gorillas (*G. gorilla gorilla*), Cross River gorillas (*G. g. diehli*), mountain gorillas (*G. beringei beringei*), and Grauer's gorillas (*G. b. graueri*).

In the wild, western lowland gorillas are seasonal frugivores, which means they seek out ripe fruit to consume first over other available produce. When fruit is scarce, gorillas seek out and consume high-fiber, low-energy plant material including browse leaves, herbaceous foliage, and root vegetables (Doran-Sheehy et al., 2009; Masi et al., 2009). Fibrous produce is typically available year-round, but gorillas generally consume other food items when available (Doran-Sheehy et al., 2009). In comparison with other primate species, the large body mass of gorillas, as well as their longer hind-guts, may allow them to consume the lower energy fibrous foods (Doran-Sheehy et al., 2009; Masi et al., 2009; Remis & Dierenfeld, 2004).

Gorillas under human care depend on their animal care staff to determine the best selection of produce, what items are in season and how to make the diet nutritionally sound. The American Association of Zoos and Aquariums (AZA) provides Animal Care Manuals (ACM) that have been crafted and reviewed by experts in the field for certain species, including gorillas **(**AZA Gorilla Species Survival Plan, 2017**)**. Within zoos and other animal care facilities, staff feed gorillas a variety of produce year-round, eliminating seasonal foraging concerns faced by gorillas in their native range.

Two notable problems that occur for gorillas under human care are obesity and regurgitation and reingestion (RR) (Lukas, 1999). Male gorillas, especially, are prone to heart disease, therefore it is important for zoos to formulate a diet that supports their large size but contains low amounts of sugars and starch (Less et al., 2014). RR is best defined when a gorilla regurgitates food a short time after consuming it initially, and then, in turn, consumes the regurgitation (Hill, 2018; Less et al., 2014; Lukas, 1999). This phenomenon, while common in gorillas in zoos, is not observed for gorillas in their native range (Less et al., 2014). One culprit might be the primate chow biscuits that are prevalent in most gorilla diets, which can be high in sugars and starches. Some zoos shifted to a "biscuit-free" diet to try to eliminate the RR and obesity issues that could be caused by the primate chow, with varying success (Less et al., 2014). The produce offered to gorillas under human care could also potentially add to the obesity and RR issues if the animals are being provided high sugar/starch items such as fruits, corn, sweet potato, etc (Hill, 2018; Less et al., 2014; Lukas, 1999). RR is widely studied with gorillas to pinpoint the cause, though there seem to be many reasons why gorillas perform this action (AZA Gorilla Species Survival Plan, 2017). Some researchers believe RR could have some positive connotations, for example, an individual wishing to consume the food it has just eaten over and over (Lukas, 1999). Regardless, there is potential that RR could be damaging to gorillas' digestive tract, and it is an unsightly behavior for zoo guests (Hill, 2018; Less et al., 2014; Lukas, 1999).

Another discrepancy between wild and zoo-housed gorillas is their activity budgets, or the quantification of general behaviors. In the wild, gorillas can spend up to 45-75% of their time foraging for their next meal, sometimes traveling many miles during the fruiting season (Doran-Sheehy et al., 2009). Since their food is not scarce in zoos and other animal care facilities, gorillas do not need to travel to acquire their meals, which reduces their time spent foraging. In addition, through husbandry and enrichment, animal care professionals manipulate the timing and presentation of animal diets to increase naturalistic foraging behavior and decrease the time that gorillas are resting or out of view of the public (Charmoy et al., 2015). Providing a proper diet also means having enough preferred foods for all individuals, especially if feeding in a group setting, to limit aversive behaviors like stockpiling or fighting (Charmoy et al., 2015; Fuller et al., 2018; Masi et al., 2009).

The purpose of this exploratory study was to see if the activity budgets of the western lowland gorilla troop at the Buffalo Zoo changed significantly when a nutritionist altered their diet.

Table 1. Chart depicting names, sex and ages of gorillas in the study

Name	Sex	Age in 2019	Age in 2022
Koga	M	32	35
Sidney	F	22	25
Lily	F	19	22
Nyah	F	6	9
Kayin	M	3	6

Table 2. Pre-Diet information
Gorilla Diets, Buckets Only

1,700g Mazuri Primate L/S Biscuit Cinnamon	
5,000g romaine **(9)** 3,200g kale **(9)**	
2,800g endive **(6)**	
Sunday	**Thursday**
1.95kg cucumber	1.0kg Carrot
.75kg sweet potato	2.8kg pepper
1.8kg green bean	1.05kg celery
1 kg broccoli	1kg green beans
Monday	Friday
1.2 kg corn	1.5kg corn
1.05 kg celery	1.4 kg pepper
.65kg Cucumber	1.3 kg cucumber
.75kg sweet potato	1.05 kg celery
Tuesday	
2.1kg celery	**Saturday**
1 kg Sw. Pot.	.25kg Sweet potato
1kg bell pepper	2.4 kg green bean
Wednesday	.7 kg pepper
2.1kg celery	.65 kg cucumber
1.75kg carrot 2kg zucchini	2.78kg Romaine **(5 heads)**

METHODS

Study Site and Diet Information

This study included all five gorillas housed at the Buffalo Zoo in Buffalo, NY. The individuals included one adult silverback male (Koga), two adult females (Sidney and Lily), one sub-adult female (Nyah), and one juvenile

Table 3. Post-Diet information

Gorilla Diets (fed as a group on exhibit)	Update 8/19/2021
High Energy Vegetable (broccoli, carrot, green bean, kale)	3150 g
Low Energy Vegetable (bell pepper, celery, cucumber, yellow squash, zucchini)	4950 g
Lettuce Greens (endive, escarole, romaine)	11400 g

male (Kayin).

The study took place from January 2019 until September 2022. The diet switchover officially occurred on November 18, 2021, under the care of Dr. J. Jason Williams of Comparative Nutritional Counseling Services. The two diet sheets (Pre-Diet and Post-Diet) are listed in Table 2 and Table 3, respectively. The new gorilla diet was originally given to the animal care staff as individualized regimens, but due to the social structure of the zoo's troop, the animal care staff chose to consolidate the new diet sheets into one.

The Pre-Diet (Table 2) was different each day and was recorded on a calendar. Each day's diet equated to about 8600 kcal of vegetables (excluding the greens), in accordance with the AZA Gorilla Animal Care Manual (AZA Gorilla Species Survival Plan, 2017). The variety was fairly consistent throughout due to what we could order from our produce suppliers, but variety was chosen daily by discretion of the keeper preparing the diets to account for scarcity in our commissary kitchen.

The Post-Diet (Table 3) eliminated the structured variety, but allowed us to choose produce based on high energy and low energy vegetables available, so long as they equated to 4950 g and 3150 g, respectively daily. The variety for this diet also changed depending on staffing levels and holiday/inclement weather days when time was limited. For example, one day might include one high energy and one low energy vegetable, but another day may include two or three high and low energy vegetables. High and low energy vegetables were recorded on a calendar.

The diets for the gorillas at the Buffalo Zoo were split into six 5-gallon buckets, which were fed out four to six times a day. Quantity of times fed fluctuated with holidays, staffing and during the COVID-19 closure of the zoo. The gorilla troop received their meals between 1000 h and 1530 h. The troop also received a variety of scattered items separate from their diet, which were not considered as part of the current study as the amounts given each day did not change between the Pre-Diet and Post-Diet observations. Weights of individuals of the troop were taken monthly to ensure any changes needed, but as of this writing no changes have been made.

Observation and Analysis

Students of Canisius University's Animal Behavior, Ecology, and Conservation program formed the observation team. Observations for this project were conducted from January 2019 to September 2019 for the Pre-Diet change and then from January 2022 to September 2022 for the Post-Diet change. All observations used instantaneous focal sampling (Altmann, 1974). Observations were conducted three to five times per week, either in the morning (between 1000 h and 1230 h) or the afternoon (between 1245 h and 1600 h). One gorilla would be observed for 20-minutes. Sometimes, all five gorillas were observed sequentially in one session. Using an ethogram (Table 4), the researcher recorded the observed gorilla's activity at one-minute intervals. Reliability for observations was based on the observers passing their inter-observer reliability assessment with a minimum of 90% agreement.

Data were analyzed with the program R. Nonparametric. Wilcoxon rank sums tests were conducted to evaluate individual differences in behavior between the 2019 data (Pre-Diet) and the 2022 data (Post-Diet). Another Wilcoxon test was conducted on all data combined to evaluate overall changes in behavior across the two study periods. Alpha was set at 0.05.

Table 4. Ethogram of activity recorded during research sessions.

Behavior	Description
Forage	Actively searching for, or eating substrate, or other food materials.
Inactive	Sitting, standing, or laying while not active in physical activity.
Locomotion	Moving across the ground, climbing either on the exhibit walls, or the climbing structure located in the middle of the exhibit.
OOV	The focal individual gorilla is beyond the observer's field of view.
RR	Regurgitation and re-ingestion, seen when a gorilla regurgitates a substrate for the intent of consuming it again.
Self care	Scratching, itching, rubbing, or any other self-manipulations with the intention of cleaning
Social Play	Initiating or engaging in play behaviors, wrestling or chasing (non-aggressive) with other troop members.
Manipulate Object	Grabbing, moving, or touching, an inanimate object within the enclosure.
Orient Humans	Displaying, banging on exhibit glass, throwing objects, or any other activities directed at guests, zookeepers or other zoo employees.

RESULTS

Overall, the troop's only statistically

Figure 1.

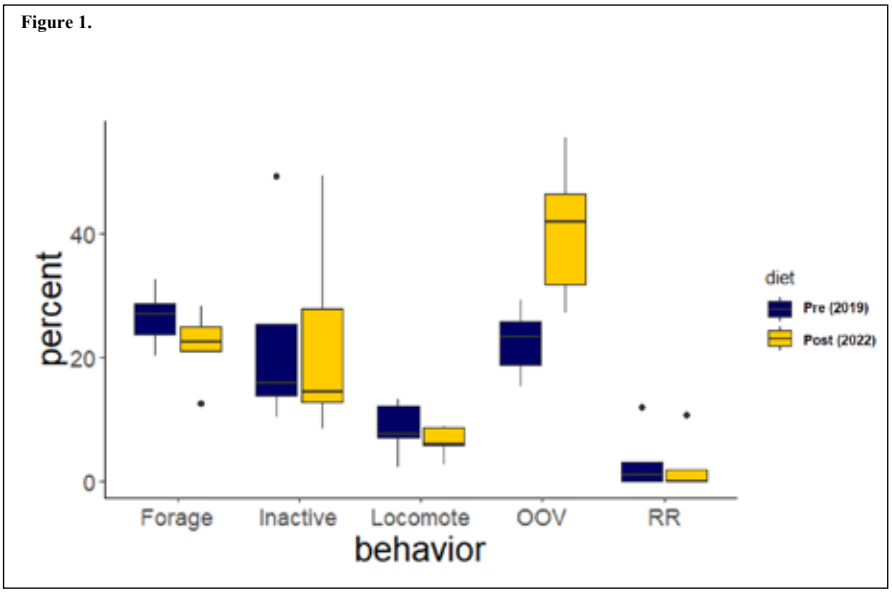

Figure 1. Graph depicts overall time spent in each behavior for the troop as percentages during observations for the Pre and Post-Diet change (2019 and 2022, respectively).

Figure 2.

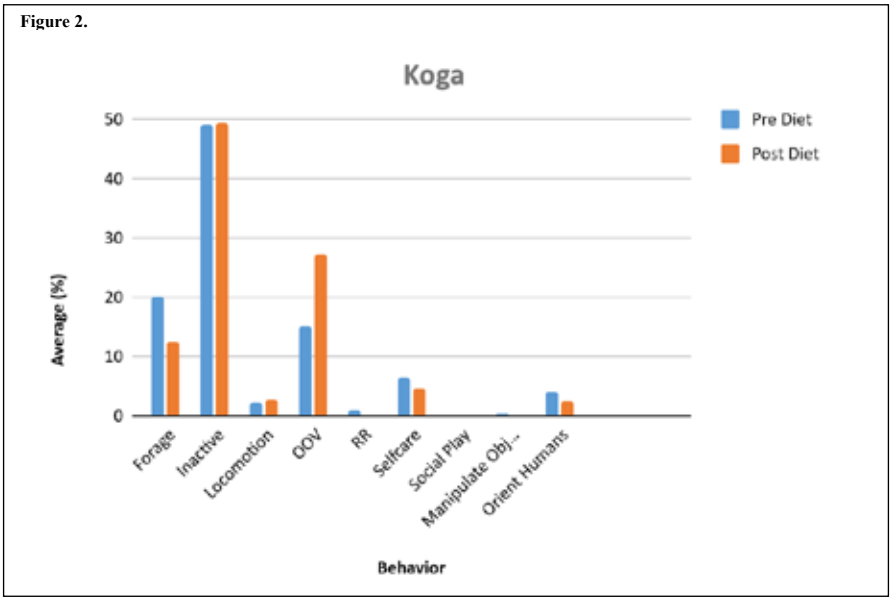

Figure 2. Individual activity budgets for Koga displayed as percentage of behaviors during the 2019 (Pre-Diet) and 2022 (Post-Diet) observations. Bars indicate averages.

significant change in behavior between the observations for the Pre-Diet versus the Post-Diet change was their time spent out of view (OOV), which increased in 2022. While not significant, some other noticeable changes occurred in behavior for the troop as a whole as outlined in Figure 1. Apart from the increase in the troop being OOV, the only other increase in behavior overall was inactivity. Foraging, locomoting and RR all decreased for the whole troop.

Individually, there were quite a few significant differences between the Pre and Post-Diet changes for behavior. Koga (Figure 2) spent significantly less time foraging in 2022 during the Post-Diet change (Wilcoxon rank sum test, W = 4035.5, p-value = 0.03). He spent significantly more time OOV during the Post-Diet change (Wilcoxon rank sum test, W = 2786, p-value = 0.03). Sidney (Figure 3) showed a significant decrease in her time spent foraging during the Post-Diet change (Wilcoxon rank sum test, W = 6321, p = 0.02). She spent significantly less time inactive during the change in diet (Wilcoxon rank sum test, W = 6530, p-value = 0.01). She also spent significantly less time locomoting during the diet change (Wilcoxon rank sum test, W = 6245, p-value = 0.03). Sidney spent less time engaging in RR after the diet change (Wilcoxon rank sum test, W = 5864.5, p-value = 0.03). She spent significantly more time OOV of the public during the Post-Diet change observations (Wilcoxon rank sum test, W = 3107.5, p-value = 1.507e-07). Lily (Figure 4) spent significantly less time foraging after the diet change (Wilcoxon rank sum test, W = 5897, p-value = 0.04). She spent significantly less time locomoting during the diet change (Wilcoxon rank sum test, W = 6068, p-value = 0.01). Lily spent a significant amount of time OOV during the diet change (Wilcoxon rank sum test, W = 4013, p-value = 0.01). Nyah (Figure 5) spent significantly less time locomoting after the diet change (Wilcoxon rank sum test, W = 5714, p-value = 0.01). She spent significantly more time OOV of the public during the Post-Diet observations (Wilcoxon rank sum test, W = 2875.5, p-value = 1.791e-06). Kayin (Figure 6) spent significantly less time locomoting during the Post-Diet change (Wilcoxon rank sum test, W = 6752, p-value = 0.001). He spent significantly more time OOV after the diet change (Wilcoxon rank sum test, W = 3260.5, p-value = 9.544e-07).

Discussion

While OOV increased significantly for all of the gorillas in the troop, gorillas being OOV to the public and researchers has been an on-going issue over the years (Masman et al., 2022). It is also important to note that the zoo was closed to the public during quarantine procedures for COVID-19 for a portion of this study. Future research is needed

Figure 3.

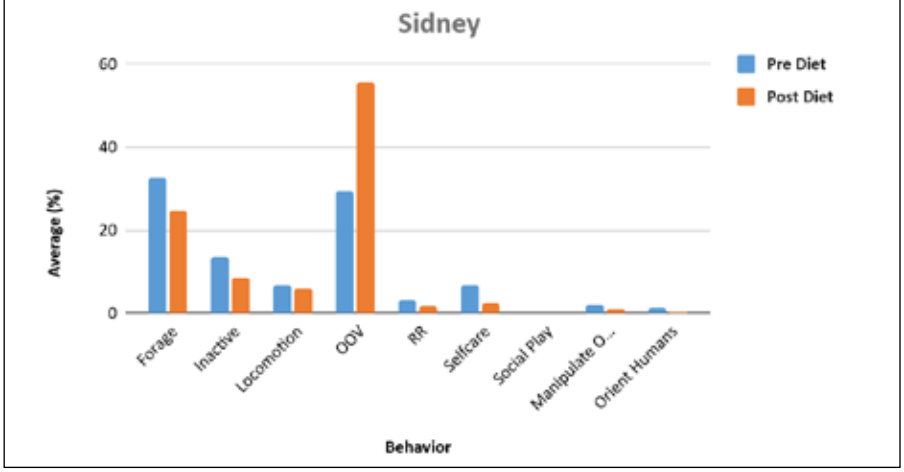

Figure 3. Individual activity budgets for Sidney displayed as percentage of behaviors during the 2019 (Pre-Diet) and 2022 (Post-Diet) observations. Bars indicate averages.

Figure 4.

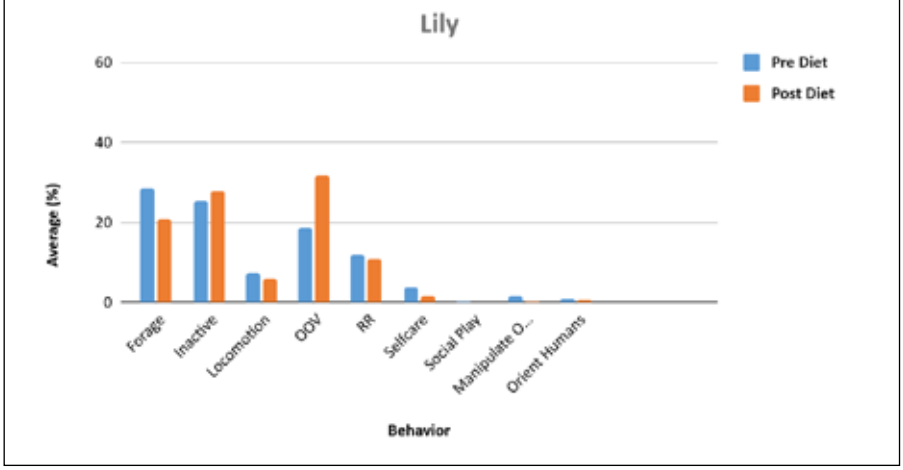

Figure 4. Individual activity budgets for Lily displayed as percentage of behaviors during the 2019 (Pre-Diet) and 2022 (Post-Diet) observations. Bars indicate averages.

Figure 5.

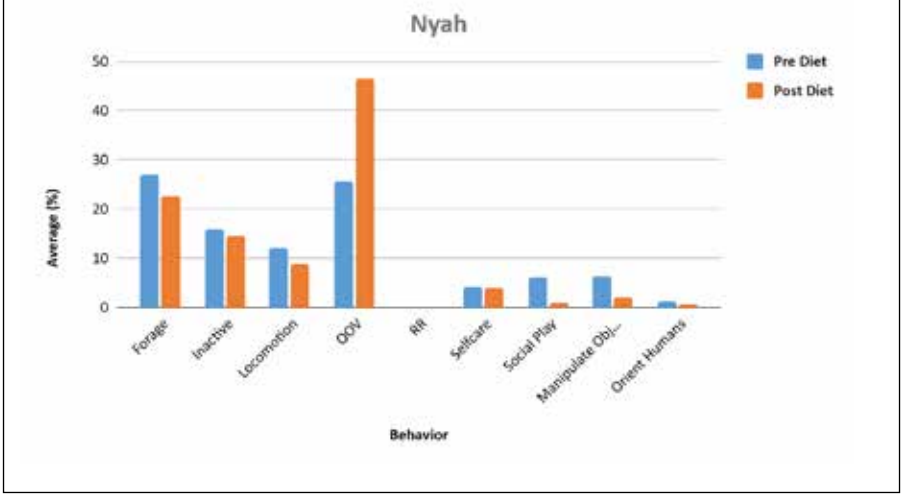

Figure 5. Individual activity budgets for Nyah displayed as percentage of behaviors during the 2019 (Pre-Diet) and 2022 (Post-Diet) observations. Bars indicate averages.

to understand this behavior and ways to encourage the troop to be viewable when locked on exhibit. Since the frequency of feeds weren't changed, we believe that our troop may be reliant on a routine with feeding. One major indicator that a feeding is about to occur is the presence of keeper staff entering the gorilla kitchen area, which is visible to the troop while on exhibit (Lenczewski et al., 2017).

The decrease in RR was not significant among individuals in the troop as well, but did decrease during the diet change, excluding Nyah and Kayin, who did not display the behavior of RR at all during observations. This is consistent with the research done by Cabana et al., (2018), Less et al., (2014), and Lukas (1999) with regards to diet being a cause of RR in zoo-housed gorilla populations. One of the biggest changes in the diet was the limiting of starches (corn, sweet potatoes) which were once a staple of their diet. Lily has always been observed RR-ing more compared to the other adults, especially after high-value food items are offered, which may make the behavior reflective of consuming a favored food rather than detrimental for her (Lukas, 1999).

Having little to no significant changes in behavior suggests that the change from the Pre-Diet to the Post-Diet wasn't drastic. The frequency of feeds and the presentation of diets did not change between the two observation periods, thus it isn't too surprising to see that foraging behaviors weren't significantly altered besides Koga and Sidney, which are currently the two most dominant of the troop, which makes them better at monopolizing diet items. Time spent foraging and feeding is still below the 45-75% as observed in wild populations of western lowland gorillas, regardless of the diet offered (Doran-Sheehy et al., 2009). This is a behavior the animal care staff is hoping to increase following this study to better align the troop's activity budget with their wild counterparts as

Figure 6.

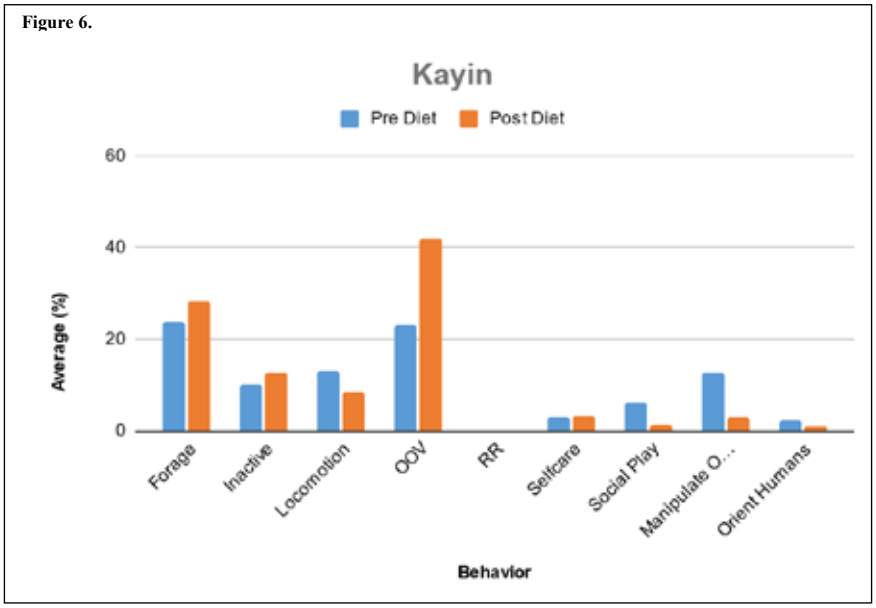

Figure 6. Individual activity budgets for Kayin displayed as percentage of behaviors during the 2019 (Pre-Diet) and 2022 (Post-Diet) observations. Bars indicate averages.

best as possible (Doran-Sheehy et al., 2009; Masi et al., 2009).

CONCLUSION

There were some significant changes in behavior for individual gorillas between the two diets. Activity budgets for the zoo-housed troop does not meet expectations for activity as it is viewed in their wild counterparts. Diet presentation and timing/randomizing times for distributing diets are two things we would like to explore more going forward. Lukas (1999) stresses the importance of browse options in addition to regular diets in gorillas. While Buffalo isn't able to produce natural browse year-round due to our cold, northern climate, we do have other alternatives such as the canopy of the exhibit for growing space, as well as a large separate greenhouse on grounds. Other possible research ideas for the future include diet preferences between the individuals, and new ways to decrease their time out of view and inactivity, as well as increasing their locomotion and foraging times. RR is an unsightly behavior, but we have yet to witness detrimental effects for our troop when seeing it, so reducing that behavior is low on my priority list. If you are interested in connecting to discuss similar studies in other zoos, please contact me at shurst@buffalozoo.org.

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