

Prosimian Nutrition Bites

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Slow Loris Nutrient Recommendations

Background

- *Nycticebus* spp. are illegal yet popular pets
 - When confiscated, sent to rescue centre
 - No budget for pellets
- Diet is a challenge to rehabilitation



Background

- Success rate of reintroduced *N. javanicus* stands at 11% and *N. menegensis* 6% (Moore, 2012)
 - >90% feeding time on fruits and nectar
- Complete disconnect between “captive” and “wild”

Background

- Zoos aren't much better
 - Dental health issues in 51.3% captive lorises (Cabana and Nekaris, 2015)



- Not following wild published feeding ecology

Meet the Slow Lorises

- Pygmy Slow Lorises (*N. pygmaeus*)
 - 30% Exudates
 - 30% Nectar
 - 40% Insects
- Exudates more important during dry season (Starr and Nekaris, 2012)



Meet the Slow Lorises

- Greater slow loris (*N. coucang*)

- 11% Nectar
- 20% Sap
- 66% Gum
- 3% Fruit



- Gum feeding seen more often in dry seasons (Wiens et al. 2006)

Meet the Slow Lorises

- Javan slow loris (*N. javanicus*)
- 3 months only
 - 56% gum
 - 32% nectar
 - 7% insects
 - 5% other

(Rode-Margono et al. 2014)



Meet the lorises

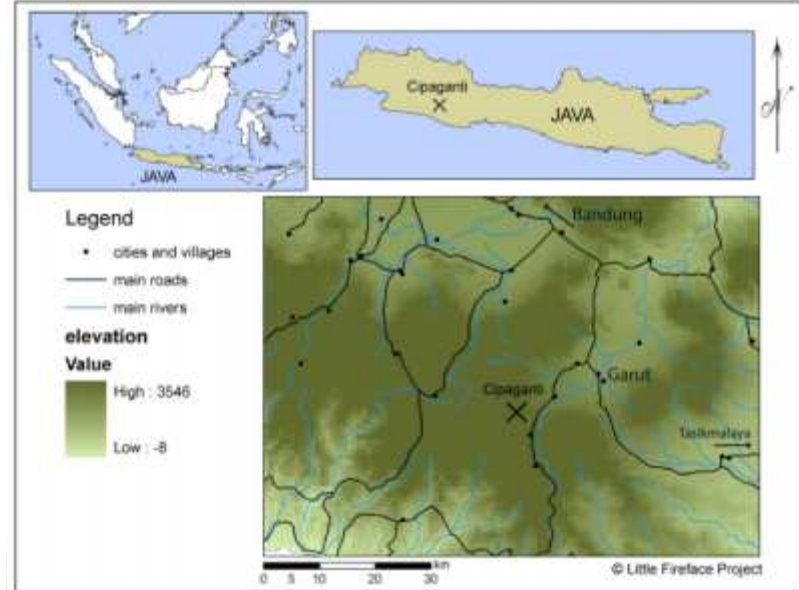
- Bengal Slow Loris (*N. bengalensis*)
 - 12 months study
 - 96% gum
 - 3% leaves
 - 1% insects
- (Das et al. 2014)



Aim

- Increase release success rate
- Use in-situ data to directly influence ex-situ captive care
 - Create evidence based nutrient recommendations for *Nycticebus*

Methods - Wild



Methods - Captive

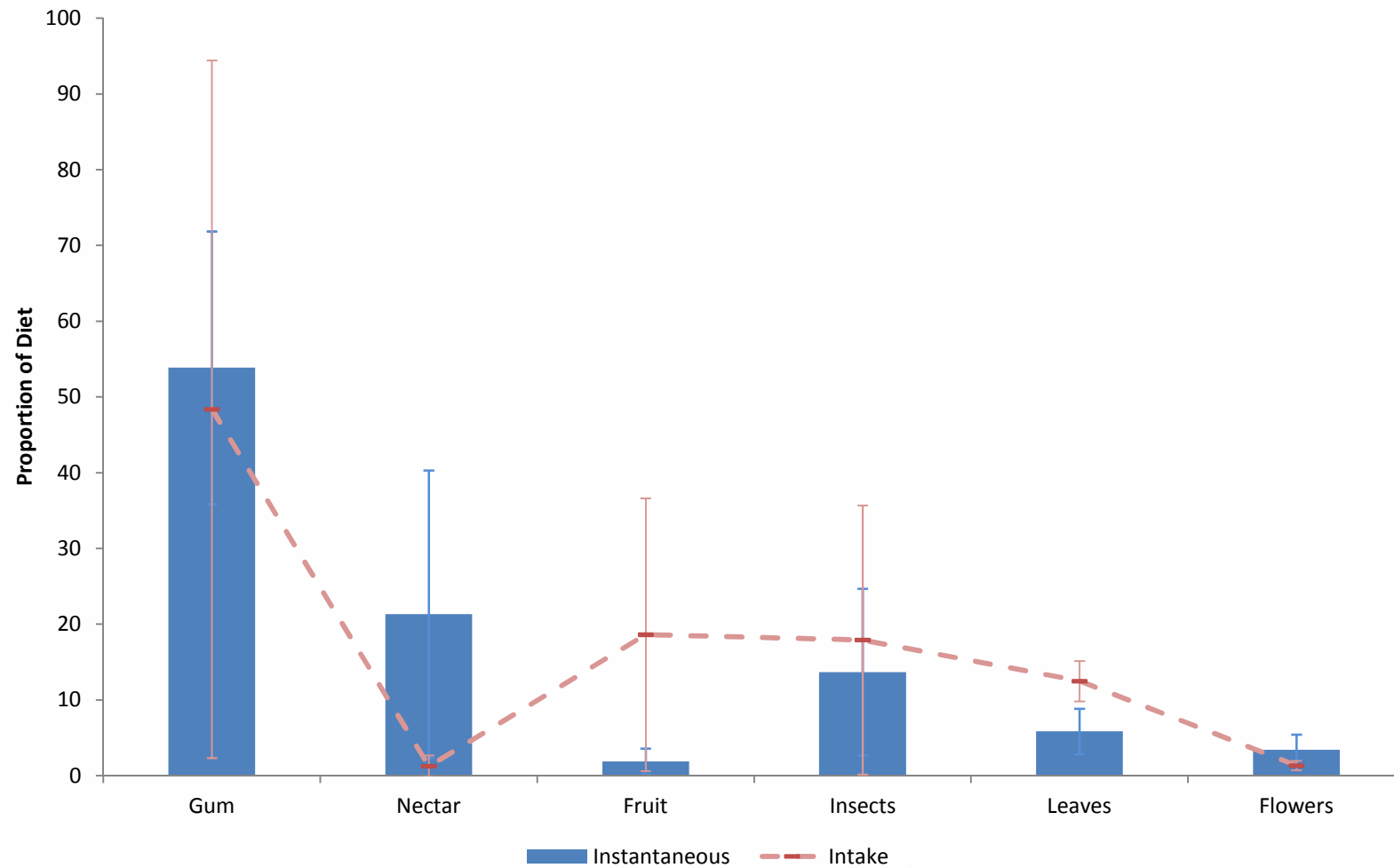
- Species used
 - 15 *N. javanicus*
 - 18 *N. coucang*
 - 4 *N. menegensis*
- Gum intake rate
 - 4 trials of 5.5 *N. javanicus* were given 10 g of gum



Methods - Captive

- Validation techniques
 - Food Intake (Fidgett and Plowman, 2013)
 - Food Passage Rate(Lambert, 2002)
 - Apparent Digestibility (Graffam et al. 1998)
- Different diet treatments
 - 1: Captive diet
 - 2: Wild diet
 - 3: New diet

Wild Feeding Ecology



Wild Nutrient Intake

Nutrient	Concentration (DM basis)	Nutrient	Concentration (DM basis)
Energy (Kcal/g)	3.15 (± 0.48)	Ca:P Ratio	2.8:1
Crude Protein (%)	23.50 (± 8.35)	Cu (mg/kg)	11.22 (± 1.4)
Crude Fat (%)	2.37 (± 1.04)	Fe (mg/kg)	69.16 (± 9.34)
Soluble Fiber (%)	5.67 (± 7.86)	Mg (%)	0.37 (± 0.09)
ADF (%)	10.95 (± 7.02)	Na (%)	0.38 (± 0.10)
NDF (%)	19.14 (± 5.5)	Vit A (IU A/g)	2.06 (± 0.56)
Ash (%)	2.24 (± 0.94)	Vit D (IU A/g)	0.53* (± 0.23)
Ca (%)	0.45 (± 0.23)	Vit E (mg/kg)	0.97* (± 0.36)

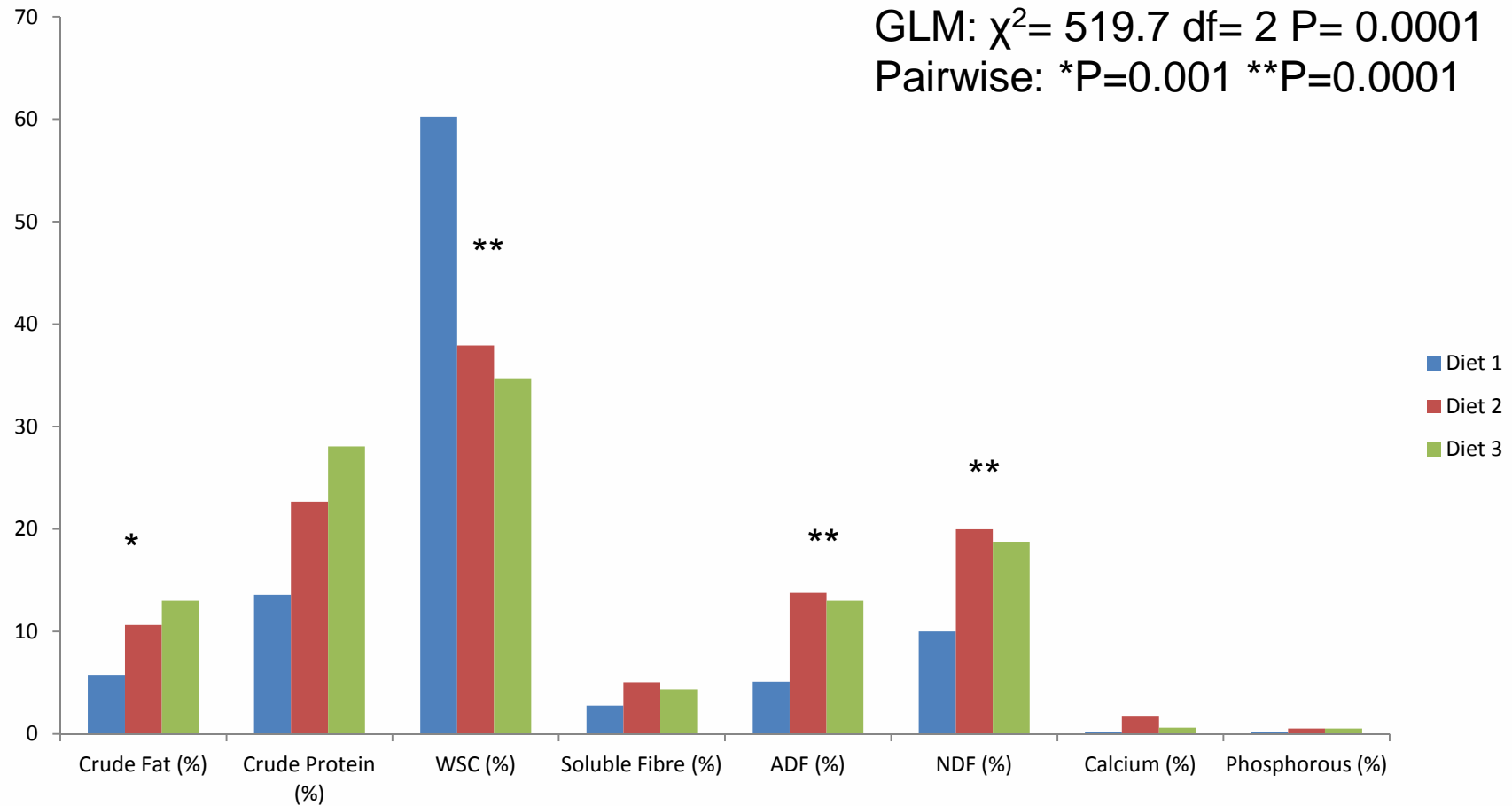
*only <80% of food items had a value

New Diet

- Gum 35%
- Insects 25%
 - Beetle larvae, mealworms, crickets, grasshoppers
- Vegetables 35%
 - Sweet potato, cassava, green beans, carrots, aubergine, pumpkin
- Nectar 5%



Intake Study



Food Passage Rate

	Diet Time	# of trials	<i>N. javanicus</i> n=15	<i>N. coucang</i> n = 18	<i>N. menegensis</i> n = 4
Transit Time (hours)	Diet 1 (± SD) (range)	4	25.6 (±2.6) (23.0-31.5)	25.00 (±3.5) (21.5-29.0)	24.2 (±3.2) (21.0-27.5)
	Diet 2 (± SD) (range)	4	25.6 (±3.4) (24.0 - 29.0)	24.4(±2.1) (24.0 - 26.5)	24.5 (±2.9) (22.5- 27.0)
	Diet 3 (± SD) (range)	4	25.1 (±4.1) (23.0 - 28.8)	24.7 (±2.7) (22.0 - 28.3)	24.4 (±2.3) (22.0- 27.66)
Mean Retention Time (hours) * **	Diet 1 (± SD) (range)	4	33.40(±1.0) (31.0-32.5)	29.70 (±1.5) (27.0-29.5)	32.88(±3.1) (28.0-33.4)
	Diet 2 (± SD) (range)	4	38.50(±2.0) (34.5-39.0)	38.0(±2.5) (34.0-37.5)	34.13 (±4.1) (30.0-34.8)
	Diet 3 (± SD) (range)	4	37.50 (±2.0) (34.0-38.3)	37.60 (±2.0) (33.0-37.75)	34.75 (±3.25) (30.0-34.8)

*Friedman: $\chi^2 = 49.81$ $P = 0.0001$

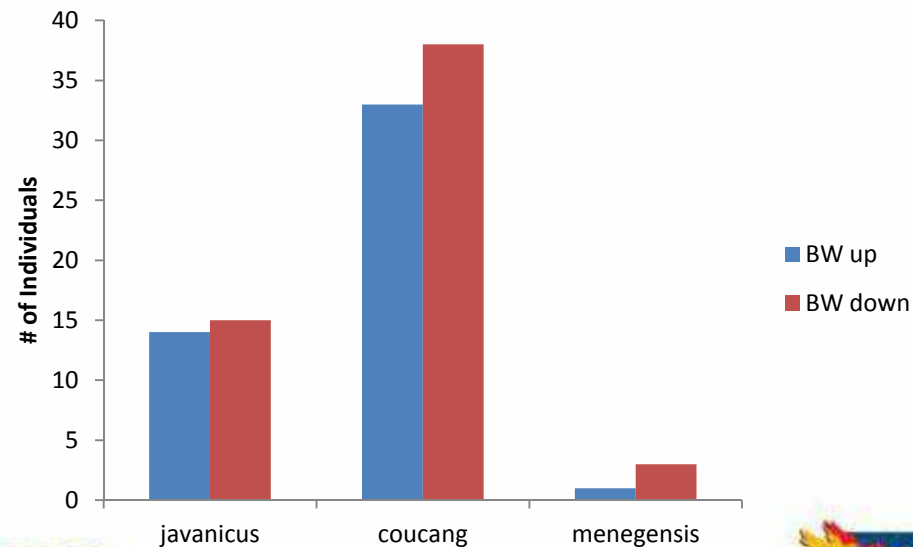
**Wilcoxon SR: $Z = -5.213$ $P = 0.0001$

Apparent Digestibility

		<i>N. Javanicus</i>	<i>N. coucang</i>	<i>N. menegensis</i>
Crude Protein	Diet 1 (%)	82.60	81.80	-
	Diet 2 (%)	80.44	79.28	-
	Diet 3 (%)	73.34	72.05	-
ADF	Diet 1 (%)	38.70	44.60	30.30
	Diet 2 (%)	40.54	47.28	40.46
	Diet 3 (%)	41.40	49.93	42.82
Calcium	Diet 1 (%)	37.60	35.90	-
	Diet 2 (%)	61.03	63.75	-
	Diet 3 (%)	50.07	52.41	-

Monitoring Effectiveness

- Diet 3 fed at rescue centre now for 12 months (n=104)
 - Obese lost weight (77.68 g), underweight gained weight (85.12 g)



Monitoring Effectiveness

- Since diet was implemented, *N. javanicus* were released (n=5) after >6 months on diet
- Success rate 80%
- Feeding proportions
 - Gum 45%, nectar 30%, fruits 20%, insects 5%

Summary

- *N. javanicus* has a diet low in sugars and high in fibres
- The new diet has a similar physiological effect as their wild diet
- Low fat and sugar, high fibre and protein

- Finally, lemurs....

Gut Microbiome of Wild Lemurs

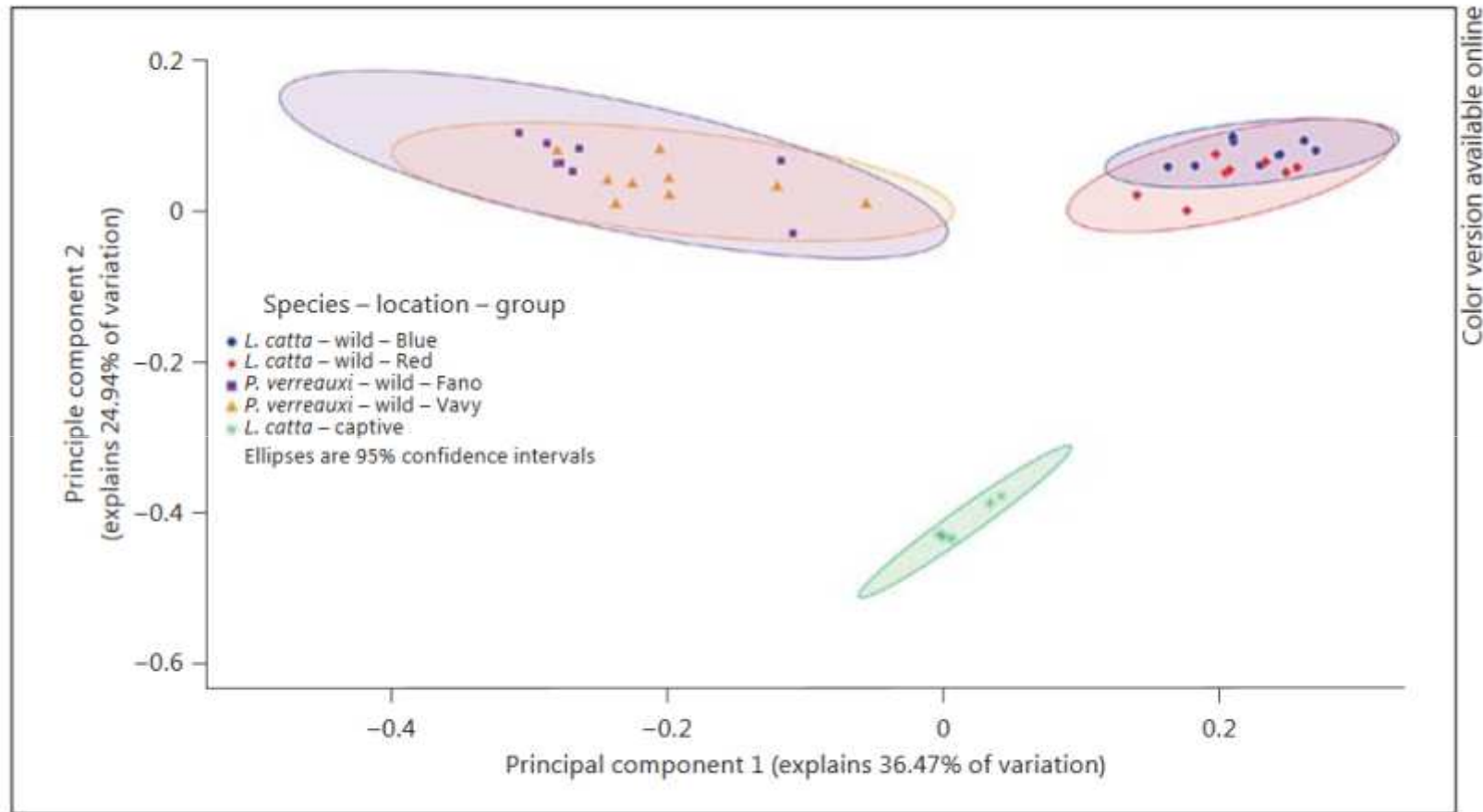
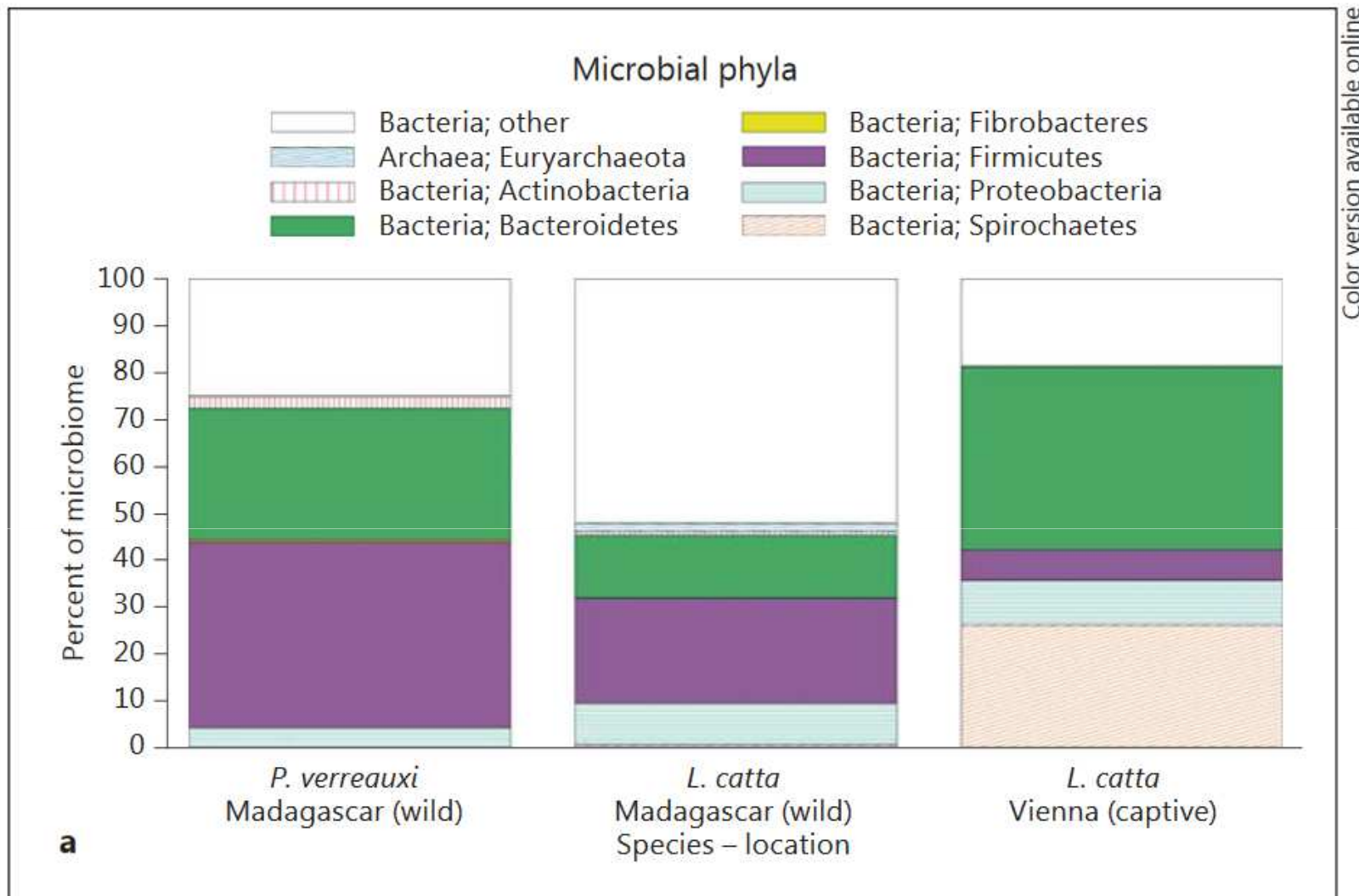


Fig. 1. Gut microbial β -diversity by species and location.

Fogel, 2015



Color version available online

Fig. 2. a Average gut microbial abundance by species and location.

Fogel, 2015

What does this mean?

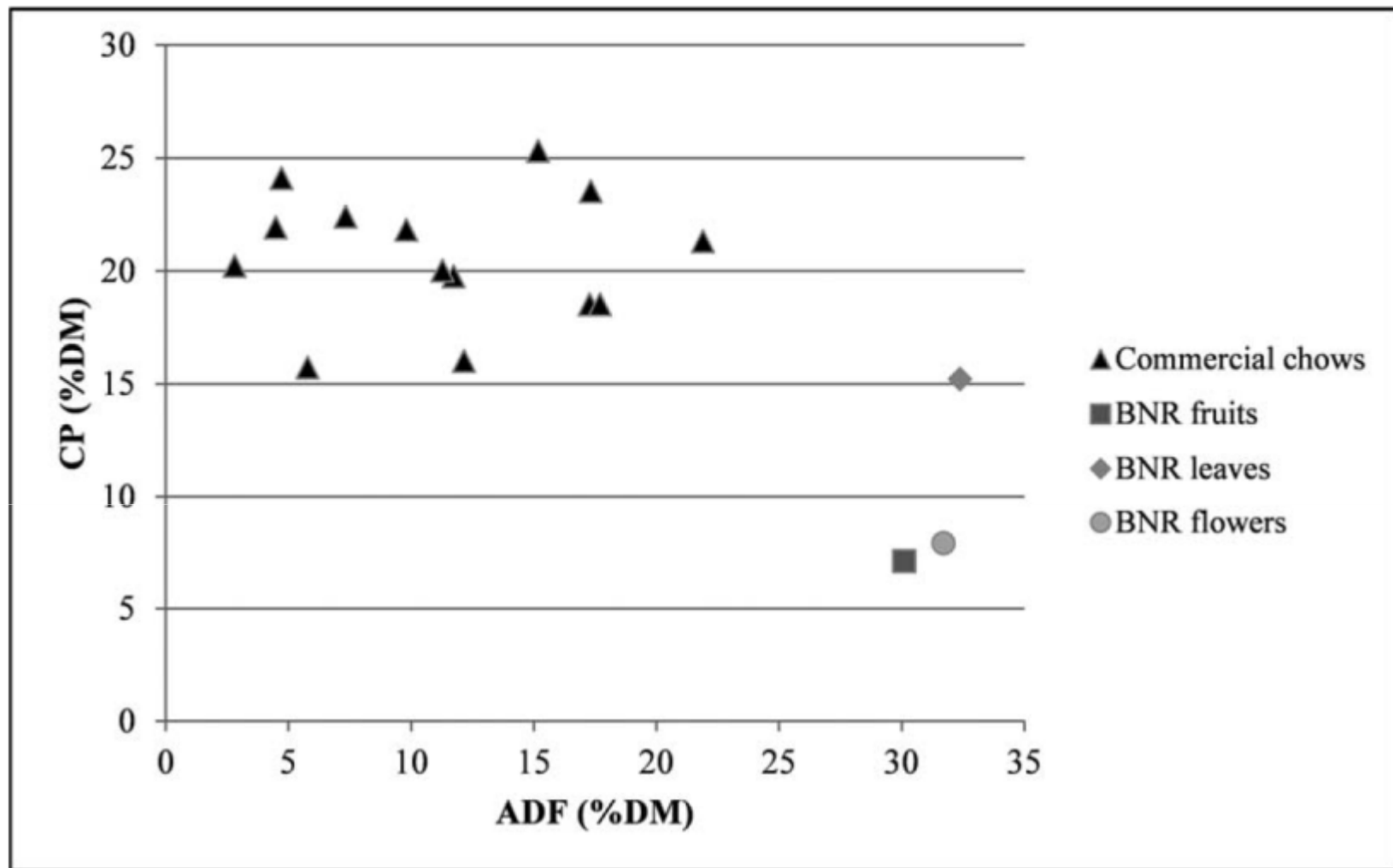
- Captive and wild gut microbe communities are significantly different
- Captive animals are less resistant to disease and less efficient in their energy assimilation
- Higher protein and sugar diets, low fibre diets are a big driver to this change

Donadeo et al. 2016

- Compared ring-tailed lemur diets within AZA because of a huge obesity + kidney disease problem
 - Diets were too high in sugar and protein

Chemical composition on a dry matter basis, GE, and estimated ME content of diet items ^a										
Plant part	DM (%)	OM (%)	CP (%)	Fat (%)	TDF (%)	NDF (%)	ADF (%)	NFE (%)	GE (kcal/g)	ME (kcal/g)
Fruit ^b										
Median	20.9	94.4	6.7	5.8	ND	39.0	29.3	33.4	4.5	2.5
Range	4.5–55.7	87.3–98.2	2.4–21.0	0.3–54.8	ND	6.5–76.2	3.8–60.6	0.0–81.9	2.1–6.7	0.8–5.8
Fruit ^c										
Median	35.1	96.6	8.0	7.9	58.0	59.5	35.7	22.4	5.3	1.9
Range	20.1–50.4	94.0–98.1	4.8–15.1	3.1–23.1	18.7–72.4	27.5–72.4	9.8–56.1	8.9–49.4	4.4–5.7	1.3–4.1
Leaves ^b										
Median	23.1	94.9	14.7	5.1	ND	46.0	31.5	22.5	4.8	2.2
Range	14.1–39.0	92.2–97.8	7.6–28.7	0.8–18.3	ND	21.2–67.3	9.7–54.6	0.0–63.8	2.6–5.3	1.2–3.1
Flowers ^c										
Median	17.3	94.4	7.3	6.7	ND	45.8	31.7	33.6	4.6	2.2
Range	14.6–21.7	93.4–96.3	6.9–10.3	1.9–19.6	ND	33.0–52.3	22.8–40.6	26.5–41.4	4.2–5.2	1.9–3.4

Estimated chemical composition and GE content ^a								
Ingredient	DM (%)	OM (%)	CP (%)	Fat (%)	TDF (%)	NFE (%)	GE (kcal/g)	ME (kcal/g)
Fruits								
Apple	2.9	98.7	1.8	1.2	16.6	79.1	4.23	3.34
Banana	5.0	96.7	4.3	1.3	10.4	80.7	4.20	3.52
Cantaloupe	2.0	93.4	8.5	1.9	9.1	73.8	4.15	3.46
Orange	1.1	96.7	7.1	0.9	18.1	70.6	4.21	3.19
Pear	3.2	98.0	2.3	0.9	19.3	75.5	4.19	3.19
Vegetables								
Broccoli	0.7	91.8	26.3	3.5	24.2	37.8	4.42	2.88
Carrots	0.7	91.7	8.0	2.0	23.9	57.8	4.07	2.81
Corn	1.5	97.4	13.6	5.6	8.3	69.8	4.59	3.84
Green beans	0.6	93.2	18.9	2.3	27.9	44.2	4.31	2.73
Sweet potatoes	1.9	95.6	6.9	0.2	13.2	75.3	4.13	3.31



Overall Recommendations

- *Lemur catta* needs a high fibre, low sugar diet
 - NDF >25%
 - Protein 16%
- Do not feed fruit, dairy or meat items
- Leaf-eater pellets, vegetables and browse

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Thank you!



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