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ERRATUM

Erratum to: Seasonal Variation in the Activity and Dietary Budgets of Cat Ba Langurs (*Trachypithecus poliocephalus*)

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The original version of this article unfortunately contained mistakes.

Following statistical analysis using day as the unit of analysis rather than scans, two statistical tests (diet x group and sex x behavior) are now non-significant. Additionally, three *post hoc* tests are now non-significant (social x group, locomotion x group, inactivity x season). All other analyses show the same pattern as the original article and the interpretation of our results remains similar. We are grateful to an anonymous reader for bringing this statistical error to our attention.

Given the said changes, the Abstract, Statistical Analysis, Results, Discussion, Conclusion, Tables, Figures, and References sections should be corrected as follows (bold text indicates corrections):

Abstract:

Primate activity budgets are dictated by food availability and distribution, thus primates living in seasonal environments must adapt their behaviors to accommodate fluctuations in

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resources. Cat Ba langurs (*Trachypithecus poliocephalus*), a Critically Endangered Asian colobine and a member of the limestone langur group (*francoisi* superspecies group within genus *Trachypithecus*), live only in fragmented and disturbed habitats on Cat Ba Island, northeastern Vietnam. This study aimed to assess the behaviors and diet of Cat Ba langurs by group, age, sex and season. We predicted they would have high proportions of inactivity and foraging, low proportions of social behaviors, with seasonal variation that reflects an energy maximising strategy. We conducted behavioral observations through scan sampling over an 11 month period and found that Cat Ba langurs spent a significant portion of their day inactive **(55 ± 1.3%)** followed by foraging **(19 ± 1.1%),** locomoting **(12 ± 0.9%),** engaging in social behavior **(12 ± 0.7%),** and engaging in 'other' behaviors **(2 ± 0.2%)**. Their diet was made up primarily of leaves **(84 ± 2.8%)** followed by fruit **(8 ± 2.8%),** flowers **(5 ± 1.7%),** and stems **(3 ± 1.2%). Activity budget** differed between groups, which is likely due to differences in demographics and home range between groups. Seasonally, the animals ate more leaves and spent more time foraging in the dry season than the wet season, suggesting that they are energy maximisers. Cat Ba langurs have similar activity and dietary budgets to other limestone langurs, and respond to a presumed seasonal fluctuation in food availability similarly.

Statistical Analysis:

We calculated activity and dietary budgets based on 541 contact hours, across 180 days of observation spanning 11 months in the field (Table II). **We calculated daily activity budgets as the proportion of scans that included each specific behavior category and daily dietary budgets as the proportion of feeding records that included a specific dietary item. Following similar studies (Teichroeb et al. 2003; Hu 2007; Zhou et al. 2007) we treated days as independent data points. To assess whether activity or dietary budgets vary with season, group, age, and sex, we fitted separate linear models with arcsine transformed proportions of daily behavior or food items eaten as the dependent variable. The independent factors were (i) behavior or food, and (ii) age, sex, group, or season (each in a separate model), and the interaction between the two. If we found that the overall activity or dietary budget differed significantly by age/sex/group/season, we assessed the differences between categories for each behavior or food item separately using a binomial logistic model, accounting for overdispersion. As we found no significant interaction effect of (season) x (behavior or food) x (age, sex, or group), we pooled groups for seasonal analysis.** We removed newborns from all analyses because their behaviors were non-independent. While the foraging category included water drinking (N=26), we did not analyse this as part of the dietary budget. We used SPSS 23 for Windows for all analyses, with significance set to $P<0.05$ for two-tailed tests.

Results:

Overall Activity and Dietary Budget

Of a total of 10,879 scans in which we identified behavior (excluding newborns), inactivity was the most common behavior, occupying a mean of **55 ± 1.3% of the daily**

activity budget. Foraging was the next most common activity, **with a daily mean of 19 ± 1.1%, followed by locomotion (12 ± 0.9%), social behaviors (12 ± 0.7%), and 'other' behaviors (2 ± 0.2%)**. Of a total of 746 scans in which we observed feeding and identified the consumed items, **the mean daily dietary budget was primarily leaves (84 ± 2.8%), followed by fruit (8 ± 2.8%), flowers (5 ± 1.7%), and finally stems (3 ± 1.2%)**. We saw the langurs drink ocean water, lick rocks, and lick cavities of rock pools, spending 0.3% of scans engaged in these drinking/licking behaviors.

Group Differences

The two groups differed in their activity **(linear model: χ^2=24.261, df=4, P<0.001; Fig 2), but not their dietary (linear model: χ^2=3.442, df=3, P=0.328) budgets**. The larger group, A, spent significantly more time **inactive, and engaging in 'other' behavior than the smaller group (Table III).** The smaller group, B, spent significantly more time foraging **than the larger group (Table III). The groups did not differ in their proportion of time spent in locomotion or social behaviors (Table III). There was no significant effect of group by season on behaviors (linear model: χ^2=3.329, df=4, P=0.504) or diet (linear model: χ^2=5.814, df=3, P=0.121).**

Age Differences

Behaviors were significantly different between age classes **(linear model: χ^2=108.722, df=8, P<0.001; Fig 3), although dietary budgets were not (linear model: χ^2=4.585, df=6, P=0.598)**. Posthoc analyses indicate that this is true for each individual behavior **we assessed (Table III). We could not assess inactivity and foraging statistically, but adults were the most inactive and subadults foraged the most. Adults were significantly more social than young langurs, and young animals used locomotion and 'other' behaviors significantly more than adults and subadults (Table IV). There was no significant effect of age by season on behaviors (linear model: χ^2=9.123, df=8, P=0.332) or diet (linear model: χ^2=4.929, df=6, P=0.553).**

Sex Differences

Neither activity (linear model: χ^2=0.042, df=4, P=0.060) nor dietary (linear model: χ^2=0.796, df=3, P=0.851) budgets were significantly different between the sexes. There was no significant effect of sex by season on behaviors (linear model: χ^2=5.808, df=4, P=0.214) or diet (linear model: χ^2=1.031, df=3, P=0.794).

Seasonal Differences

Activity **(linear model: χ^2=18.643, df=4, P=0.001; Fig 4)** and **dietary (linear model: χ^2=19.422, df=3, P<0.001; Fig 5)** budgets varied significantly by season. In the wet season (May-Oct), the langurs spent **more time engaged in social behaviors, and they consumed significantly more fruit, than the dry season (Table III). In the dry season (Nov-April), langurs spent significantly more time foraging, engaging in 'other' behaviors, and consuming leaves, than in the wet season (Table III). Inactivity and**

locomotion, and flower and stem consumption, did not differ significantly between seasons (Table III).

Discussion:

We found the activity budgets for Cat Ba langurs to be similar to those of other, closely related limestone langurs with proportions of inactivity, foraging and locomotion fitting well within the range for the group (Table V). The high percentage of time inactive supported our prediction, and is likely due to the langurs' emphasis on leaf-eating (Clutton-Brock and Harvey 1977; Dasilva 1992; Kirkpatrick 2007; Newton 1992; Oates 1977), as a high proportion of inactivity is expected given the processing time required for breaking down fibrous cell walls into usable energy (Edwards and Ullrey 1999). Feeding is also expected to dominate folivore activity budgets, given that leaf eating requires more processing time compared to other food sources (Clutton-Brock and Harvey 1977; Decker 1994). Our findings support this as leaves were the most common food item ingested and inactivity was the most common behavior, followed by feeding.

As we predicted, time spent in social behaviors is low for Cat Ba langurs compared to fruit-eating species such as macaques. We found that social behavior occupied a similar portion of the activity budget as those reported for white-headed langurs, but much higher than seen in Delacour's or François' langurs (Table V). Often social interactions of Asian colobine females are centered around newborns, as they are known to interact because of their attraction to young, and high rates of young transfer (Jin et al. 2015; Kumar et al. 2005; Yao et al. 2012). Accordingly, the high social budget of Cat Ba langurs in our study may be a result of the high number of young present in the study groups. This may have also resulted in higher levels of social play than in other studies, as we also included social play in the social behavior category.

As with activity, the dietary budgets of Cat Ba langurs fell within the range of other limestone langurs (Table VI). Leaves, especially young leaves, are an important source of protein for folivores (Hladik 1978) especially as colobines select leaves with a high protein-to-fibre ratio (Fashing et al. 2007b; Milton 1979; Workman 2010b; Workman and Le Van Dung 2009). The combination of a specialised digestive tract (Caton 1999; Oates and Davies 1994), and the nutritional value, and availability, of leaves explains the extremely high proportion of leaf eating by Cat Ba langurs. However, despite their moniker, leaf-eating colobines consume a wide range of plant parts (e.g. fruit, flowers, seeds, bark, gum and sap, stems and pith, and roots), fungi (e.g. lichen and mushrooms), and animal matter (e.g. insect galls) (Kirkpatrick 2007), which we saw in this study, with animals eating fruits/seeds, flowers, and stems.

We found that flowers made up 5% of the Cat Ba langurs' diet. Flowers generally have a higher percentage of water (Oftedal 1991) and nitrogen (Waterman and Kool 1994) than mature leaves, and are also relatively high in copper (Behie and Pavelka 2012). **The flower** eating may therefore be a method of meeting macronutrient or mineral needs or to serve as a way to increase water consumption.

Fruits are an energy-rich resource, but they contain less protein than leaves (Oftedal 1991; Waterman and Kool 1994). In our study Cat Ba langurs primarily ate green, unripened fruits, which is common among colobines because their gut flora cannot handle the large amount of sugar present in mature fruits (Davies et al. 1999; Waterman and Kool 1994; Workman 2010a; Workman and Le Van Dung 2009). We also found that Cat Ba langurs ate more fruit in the wet season than the dry season. Similarly, white-headed (Li and Rogers 2006) and Delacour's (Workman 2010a) langurs eat more fruit at this time of year, when it is more available in karst habitats (Workman 2010a; Zhou et al 2009), compared to times when food is scarce. This suggests that, as with closely related species, Cat Ba Langurs are eating fruit in accordance with its availability.

We found group differences in activity and dietary budgets to likely be the result of differences in group size, demographics, and variation between home range size and quality between the two groups. Group A had a higher ratio of adults than Group B (46-60% vs. 43%), which may explain the higher **proportion of inactivity.** We found Group B to forage more than Group A, which may be due to the fact that only Group B had subadults, the group found to forage for the highest proportion of scans. This could, however, also represent differences in food tree density between the ranges of the two groups; for example white-headed langur groups in poor quality habitat **fed more than those in higher quality habitat** (Li and Rogers 2004). Group B's higher population density (0.227 individuals/ha) compared to Group A's (0.120 individuals/ha), may necessitate Group B to travel further to find adequate food resources, as in other taxa (Fashing et al. 2007a; van Schaik et al. 1983; van Schaik and van Noordwijk 1988).

In other limestone langur habitats, fewer preferred foods and fruits are available in the dry season than in the wet season (Li and Rogers 2006; Workman 2010a; Zhou et al. 2009). Primates have several approaches to dealing with decreased resource abundance. One approach is to reduce energy expended in search of food, and the other is to put more time into increasing energy intake compared to when food is abundant (Hemingway and Bynum 2005; Schoener 1971). Supporting our prediction, our results suggest that more effort may be needed for foraging in a resource poor environment, as foraging increases, and **social behaviors decrease**, in the dry season compared to during the wet season. This has been documented for other limestone langurs (Huang et al. 2000, 2003; Yang et al. 2007; Zhou et al. 2007, 2010). For example, François' langurs spend significantly more time feeding in the dry season than the wet season (26% vs. 19%) (Zhou et al. **2007). This** is most likely due to the poorer quality foods available in the dry season (more nutritious young leaves are more common in the wet season than the dry season: Workman 2010a), when langurs use 'fall back foods' such as mature leaves (Hu 2007; Li and Rogers 2006; Workman 2010a; Zhou et al. 2009). Conversely, in the wet summer season, when more preferred foods are available than in the **dry season, François'** langurs groom more at this time (3% wet season vs. 2% dry season) (Zhou et al. 2007).

Conclusion:

Cat Ba langurs had activity and dietary budgets similar to closely related species living on limestone karst throughout Southeast Asia and southern China. As we

predicted, the majority of their day was spent inactive and foraging, with relatively little social time. Cat Ba langurs had a high proportion of social behavior compared to other limestone langurs, possibly due to the high percentage of immature animals in one of the groups (which serve as an attractant for transfers of young and interactions among adult females). Alternatively, this may be due to the variable definitions of 'social' behavior across studies. The Cat Ba langur diet was predominantly leaves, but other foods played an important role throughout the year, including fruit/seeds, flowers, and stems. **Groups showed significant differences in activity patterns, likely due to demographic differences.** To accommodate the presumed drop in preferred, valuable resources in the dry season, activity and dietary budgets change for Cat Ba langurs, as we had predicted. The monkeys fall back on a higher proportion of leaf eating and foraging in general in the dry season than the wet season, at the **expense of social time**. This qualifies this species as energy maximisers.

Tables:

Table I and II are unchanged. Tables III and IV have been added below. In Tables V and VI the top row (activity and dietary budgets for Cat Ba langurs) is corrected below.

Table III Results of *post hoc* binomial logistic models (df=1) comparing Cat Ba langur (*Trachypithecus poliocephalus*) behaviors and food items by group, age, and season. Data collected in Cua Dong (southeastern Cat Ba Island, northeastern Vietnam) Feb 2014 - Jan 2015. A * denotes significant differences

		Behaviors					Diet			
		Inactive	Forage	Locomote	Social	Other	Leaves	Fruits	Flowers	Stems
group	p=	0.010*	<0.001*	0.064	0.222	0.001*				
	χ^2=	6.553	18.331	3.441	1.492	34.411				
age	p=			<0.001*	<0.001*	<0.001*				
	χ^2=			71.463	23.730	110.016				
season	p=	0.062	0.001*	0.416	0.014*	<0.001*	0.029*	<0.001*	0.732	0.901
	χ^2=	3.494	10.988	0.660	6.074	17.749	4.774	20.605	0.117	0.016

Table IV P-values for pairwise comparisons of behavior between age classes in Cat Ba langurs (*Trachypithecus poliocephalus*) in Cua Dong (southeastern Cat Ba Island, northeastern Vietnam) Feb 2014 - Jan 2015. A * denotes significant differences

	Social	Locomote	Other
adult vs. subadult	P=0.062	P=0.078	P=0.150
adult vs. young	P<0.001*	P<0.001*	P<0.001*
subadult vs. young	P=0.388	P=0.006*	P<0.001*

Table V Annual activity budgets for limestone langurs (*francoisi* superspecies group in genus *Trachypithecus*) living in Vietnam and China in percentage (%) of observations. Totals may not be exactly 100% due to rounding

Species	Inactive	Forage/Feed	Locomote	Social	Other	Source
T. poliocephalus	**55**	**19**	**12**	**12**	**2**	This study
T. leucocephalus	52	13	15	14[1]	7[3]	Li and Rogers 2004
	46	20	29		4[4]	Zhou et al. 2010
T. delacouri	61	29	4	6		Workman 2010a
	75	21	2	2	<1	Agmen 2014
T. francoisi	50[2]	27[2]	13[2]	<1[1]	10[2,3]	Yang et al. 2007
	41	25	17	5[1]	12[3]	Hu 2007
	52	23	17	2[1]	6[3]	Zhou et al. 2007

[1]grooming only
[2]averaging of two groups
[3]includes play and/or huddling, which could also be social
[4]combination of social and 'other' behaviors

Table VI Annual dietary budgets for limestone langurs (*francoisi* superspecies group in genus *Trachypithecus*) living in Vietnam and China in percentage (%) of observations. Percentages may not add up to 100% due to rounding

Species	Leaves	Fruits	Flowers	Other	Source
T. poliocephalus	**84**	**8**	**5**	**3**	This study
T. leucocephalus	88	7	2	3	Li et al. 2003
	87	8	2	3	Zhou et al. 2011[1]
	88	9	3		Yin et al. 2011
	91			6-9[2]	Zhou et al. 2010
	63-95	5-35	0-6		Huang et al. 2000
	92	4	<1	4	Zhou et al. 2013
T. delacouri	80		5	15[2]	Workman 2010a
T. francoisi	64	26	4	7	Hu 2007
	95	3	1	2	Huang et al. 2008
	87	9	1	3	Li et al. 2009
	53-71	~9-17	~7-8	~8-22	Zhou et al. 2009

[1] mean between two groups reported
[2] combination of fruit and all other food items

Figures:

Figure 1 is unchanged. The original Figs. 3 and 5 are now removed as the linear model indicated the results are nonsignificant. Figure 2 and corrected Figs. 3, 4, and 5 have been updated with the corrected percent of activity and dietary budgets by groups, age, sex, and season.

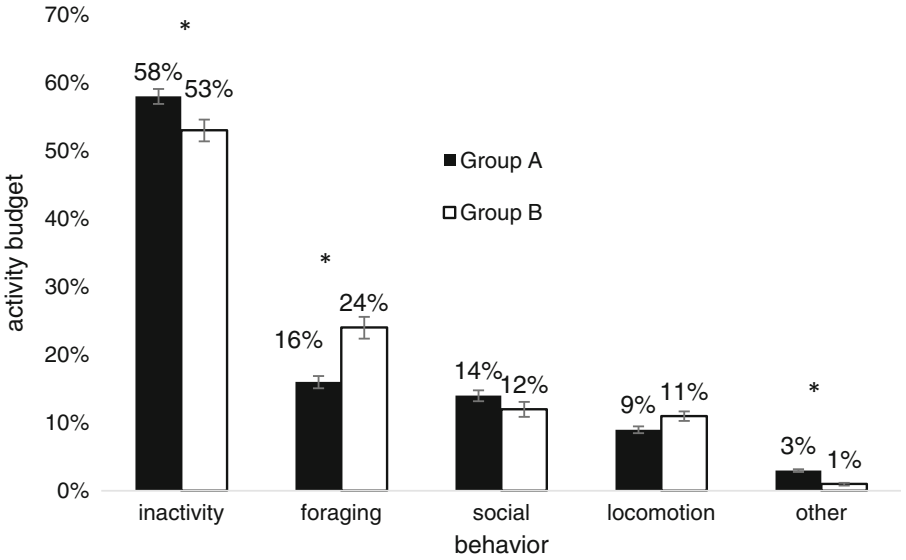
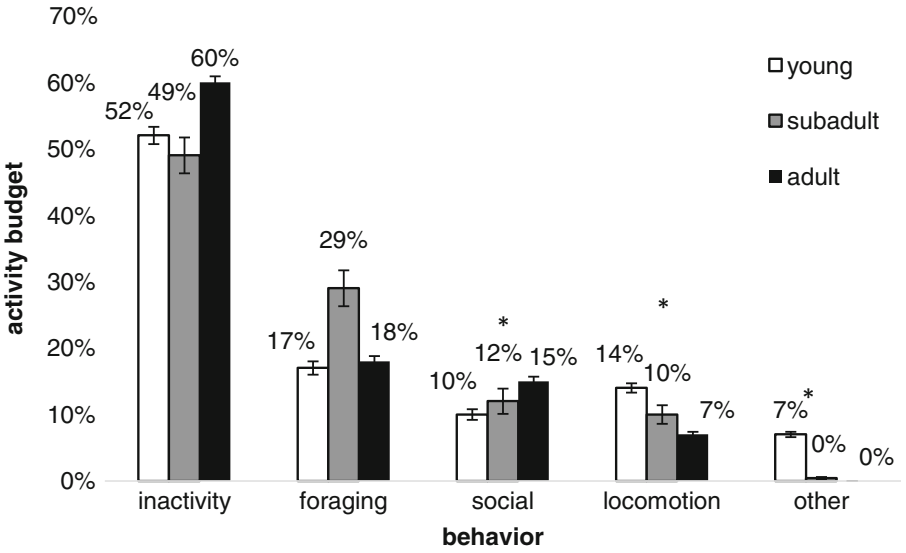
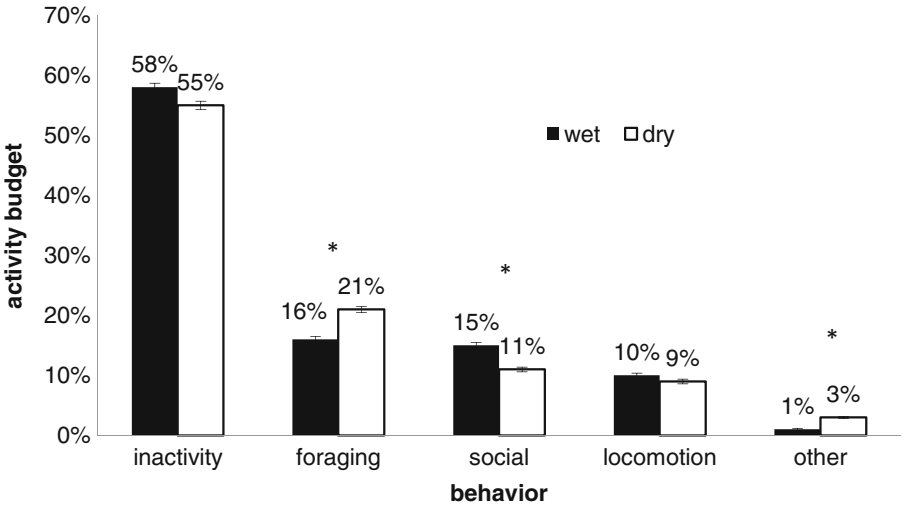


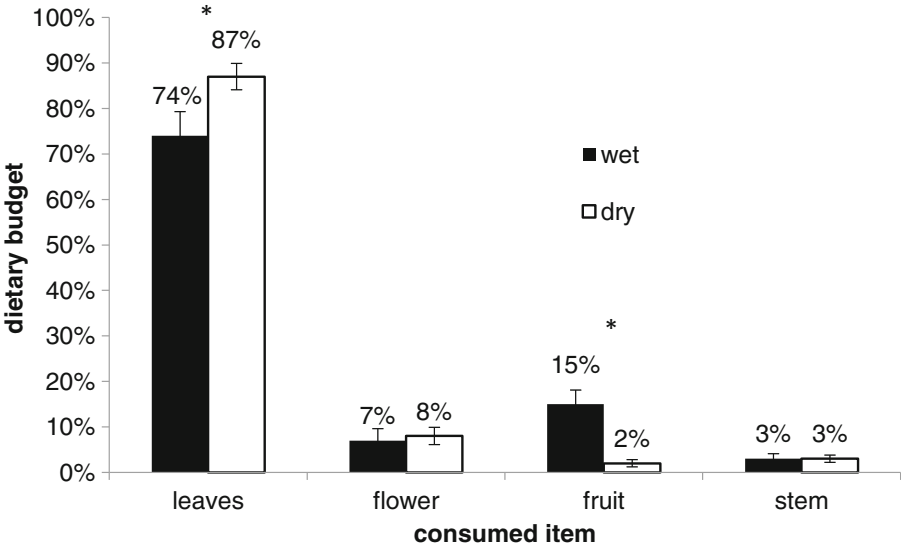
Fig. 2 Percentage of activity budget (± standard error) for each behavior by two groups of Cat Ba langurs (*Trachypithecus poliocephalus)* living in Cua Dong (southeastern Cat Ba Island, northeastern Vietnam) Feb 2014- Jan 2015. A * indicates significant group differences for that activity category as demonstrated through *post hoc* analyses, which were conducted following an initial analysis for activity budgets that indicated significant group variation.



Corrected Fig. 3 (Originally Fig. 4) Percentage of activity budget (± standard error) across ages (adult, subadult, young) for each behavior of Cat Ba langurs (*Trachypithecus poliocephalus)* living in Cua Dong (southeastern Cat Ba Island, northeastern Vietnam) Feb 2014- Jan 2015. A * indicates significant age differences for that activity category as demonstrated through *post hoc* analyses, which were conducted following an initial analysis for activity budgets that indicated significant age variation.



Corrected Fig. 4 (Originally Fig. 6) Percentage of activity budget (± standard error) for each behavior of Cat Ba langurs (*Trachypithecus poliocephalus*) living in Cua Dong (southeastern Cat Ba Island, northeastern Vietnam) in the wet (May-Oct) and dry (Nov-April) seasons Feb 2014-Jan 2015. A * indicates significant seasonal differences for that activity category as demonstrated through *post hoc* analyses, which were conducted following an initial analysis for activity budgets that indicated significant seasonal variation.



Corrected Fig. 5 (Originally Fig. 7) Percentage of dietary budget (± standard error) for each item consumed by Cat Ba langurs (*Trachypithecus poliocephalus)* living in Cua Dong *(*southeastern Cat Ba Island, northeastern Vietnam) in the wet (May-Oct) and dry (Nov-April) seasons of Feb 2014- Jan 2015. A * indicates significant differences between seasons for that consumed item as demonstrated through *post hoc* analyses, which were conducted following an initial analysis for dietary budgets that indicated significant seasonal variation.

References:

One citation to add:

Teichroeb, J.A., Saj, T.L., Paterson, J.D., & Sicotte, P. (2003). Effect of group size on activity budgets of *Colobus vellerosus* in Ghana. *International Journal of Primatology, 24*, 743-758.