

Protein and fibre content in petiole choice of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Khu Ca area, Ha Giang province

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Received 09 September 2011

Abstract. Studies of folivorous primates are notably interesting. In this group, the ratio of protein to fibre in mature leaves is a significant predictor of biomass. The protein and fibre content of food is important to all colobine species. To understand the effects of the protein and fibre content in plant species on petiole choice in the diet of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*), we collected leaves (never observed to be eaten) and petioles (a large portion in the monkey's diet) of 9 plant species most frequently consumed by *R. avunculus*. Crude protein (CP) and fibre content including acid detergent fibre (ADF) were measured. *R. avunculus* tended to choose petioles (with lower protein and fibre content) over leaves (with higher protein and fibre content), the ratio of CP/ADF in petioles was not significantly higher than that in leaves. Although the ratio of CP/ADF is generally regarded as a good indicator of colobine monkeys' food choice but for the *R. avunculus*, the fibre content in petiole may function as a predictor of *R. avunculus*'s food choice.

Keywords: *Rhinopithecus avunculus*, folivorous, protein, fibre, the protein to fibre ratio.

1. Introduction

A fundamental ecological question is what determine the abundance of animals. Answering this question is vital in the formulation of effective management plans for endangered or threatened species. A fundamental issue in ecology is determining factors that regulate animal abundance. A variety of potential factors

have been identified, including external factors such as food resources, weather, predation and disease, and internal conditions such as territoriality and aggressive behaviours [1]. Understanding the determinants of animal abundance has become increasingly important as ecologists are required to apply their knowledge to develop management plans for endangered or threatened species. However, understanding and predicting factors that determine the abundance of particular species have been proven extremely difficult, and there

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have been few general hypotheses addressing this topic. Studies of folivorous primates are notably interesting. Year-round availability of digestible mature leaves, which are used by colobus monkeys when others prefer food that is not easily available, controls colobine populations [2]. Therefore, based on the abundance of digestible mature leaves in an area, one can predict the size of colobine populations living there. By measuring overall mature leaf quality by the ratio of protein to fibre, several studies have found positive correlations between colobine biomass and this ratio [3, 4].

Each primate species has a protein threshold, below which it cannot maintain physical functions. As for fibre, there is substantial evidence that colobines can digest some fibre components, but not lignin [3]. Thus, an increase of fibre content inflates the amount of indigestible mass in ingested food and slows down the rate of passage of digesta through the stomach. This also reduces the efficiency of bacterial enzyme action, causing a reduction in protein uptake [4, 5].

While correlative studies suggested that ratio of protein to fibre in available foods may control colobine populations, although this seems to be sceptical. This scepticism is due to a number of factors. Firstly, there is controversy over the importance of protein to primates. With respect to colobines, protein demand might be lower, because blood urea can be recycled by secreting it into saliva or diffusing it across the wall of the foregut. This nitrogen source can then be used by microbes for protein synthesis, then the microbes are digested in the small intestine of the monkeys [6]. Secondly, while some studies have found folivorous primates to select foods that are high in protein and low in fibre [2, 7], other studies have not [7].

Many researchers have demonstrated that the ratio of protein to fibre of the mature leaves in primate habitats is a good predictor of folivore abundance at regional and local scales across Africa and Asia. Food choice in colobines is believed to be primarily dependent on protein and fibre content and they appear to select rare but protein-rich resources during critical periods of growth and reproduction. The protein-to-fibre ratio (CP/ADF) can be a solid predictor of food suitability for colobines. This ratio also explains variation in colobine biomass across different study sites [7-10]. To understand the effects of the protein and fibre content of plant species on petiole choice in the diet of the *R. avunculus*, we collected leaves (never observed to be eaten) and petiole (a large portion of the diet) of 9 plant species that most frequently consumed by *R. avunculus*.

2 Materials and Methods

2.1. Samples collection and analysis

We collected leaf lamina and petiole of nine food plants most frequently consumed by TSNMs at Khau Ca area (22°51' N; 105°08' E) (Fig.1.) in December 2010 and March 2011. These samples were collected from different elevations and transects (Table 1). All leaf lamina and petiole samples were air-dried at about 30°C.

Air-dried samples were further dried in the lab at 40°C overnight to remove residual moisture. All analyses are reported on a 100% dry matter basis. After being dried, samples were ground and stored in desiccators at room temperature. We then analysed samples for crude protein (CP), acid detergent fibre (ADF).

We calculated CP content by multiplying total nitrogen by 6.25 using a macro-Kjeldahl method with a Cu catalyst, and ADF using detergent methods [11].

2.2. Data analysis

Raw data were statically analysed by using Microsoft Excel software.

3. Results

Based on observations, only petiole but not leaf lamina of some plant species was consumed by *R. avunculus*. Petiole and fruits are the most common part of *R. avunculus*' diet (27.78%) [12]. Therefore, we analysed protein and fibre content in leaf lamina and petiole of the same species to explain why they choose petiole (Table 1).

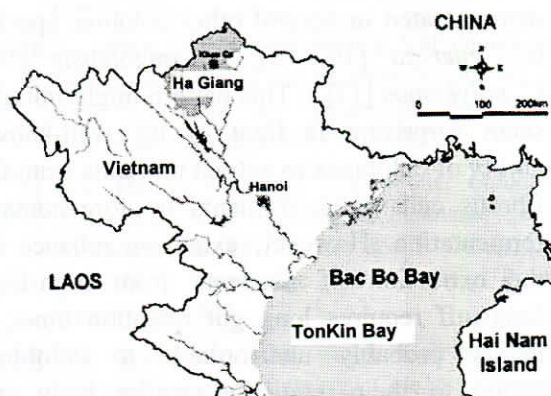


Fig.1. Study site: Khu Ca area, Ha Giang province.

Table 1. Crude Protein (CP), Acid Detergent Fiber (ADF) content and ADF/CP ratio of leaf lamina and petiole of plants most frequently consumed by *R. avunculus* in Khu Ca area, Ha Giang Province

No.	Family	Species	Transect	Plant parts	CP	ADF	ADF/CP
	Aceraceae	<i>Acer tonkinensis</i>	C1400	Petiole	35.13	16.99	2.07
				Leaves	18.56	17.04	1.09
		<i>Garcinia bracteata</i>	B850	Petiole	4.65	19.77	0.24
				Leaves	7.64	24.14	0.32
Clusiaceae		<i>Garcinia fagraeoides</i>	H1600	Petiole	3.65	23.23	0.16
				Leaves	6.69	26.29	0.25
		<i>Garcinia paunervis</i>	B1200	Petiole	3.86	21.54	0.18
				Leaves	7.47	20.58	0.36
Araliaceae		<i>Schefflera palmiformis</i>	B250	Petiole	4.07	22.61	0.18
				Leaves	7.07	20.0	0.35
		<i>Schefflera aff. velunosa</i>	B200	Petiole	5.09	15.57	0.33
				Leaves	9.56	24.91	0.38
Asclepiadaceae		<i>Goniostemma punctatum</i>	B150	Petiole	12.22	18.66	0.65
				Leaves	16.5	17.84	0.92
Icacinaceae		<i>Iodes seguini</i>	B50	Petiole	15.27	21.71	0.70
				Leaves	16.97	44.03	0.39
Sapotaceae		<i>Sinosideroxylon racemosum</i>	H1800	Petiole	2.82	18.95	0.15
				Leaves	7.16	16.6	0.43

Comparison of protein content between lamina and petiole, in eight out of nine plant species, the protein content was at least 39% higher in the lamina than in the petiole of the same plant respectively. Fibre levels tended to

be different in the lamina and petiole. In seven out of nine plant species, the CP/ADF ratio was greater in the lamina while in other two the ratio was lower than that in the petiole (Table 1).

Mean crude protein in leaf lamina (10.85) tended to be the higher than in petiole (9.64), but the difference was not significant. Notably, the mean ADF in petioles (19.89) was lower than that in leaf lamina (23.49). The mean CP/ADF ratio of leaf lamina was 0.46 (0.25-1.09), lower than that in petiole, 0.48 (0.15-2.07). *R. avunculus* tended to choose petiole with lower ADF content (Fig. 2) because the difference in the CP/ADF ratio resulted primarily from the difference in ADF content.

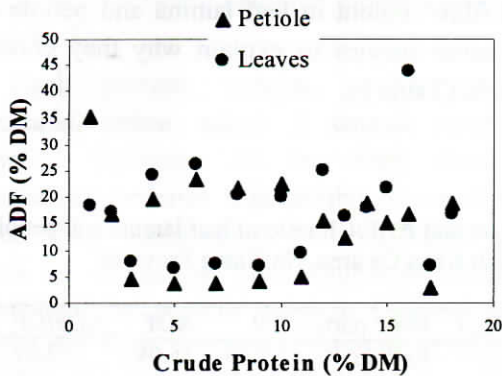


Fig. 2. Acid detergent fibre and nitrogen ($\times 6.25$) in petiole selected and lamina leaves rejected by *R. avunculus* at Khau Ca area, Ha Giang province.

4. Discussion

For some colobines, petiole forms a specific and important dietary item. The petiole can be selected as food, when the lamina can be discarded. According to optimal foraging theory [13], animals attempt to maximize their calorie and nutrient intake by seeking the highest quality foods: they will choose food with high protein and low fibre content. It seems clear that *R. avunculus* do not select petioles for protein content, and it appears that they may select petioles based on fibre content. This trait seems to be particularly important for

the red colobus (*Procolobus badius*) at Kiabale [14]. Dietary comparisons of a number of species have confirmed that protein content was generally much lower in the petiole than in the lamina [4]. This phenomenon has been demonstrated in several other colobine species (*C. guereza* [10, 15]; *C. angolensis* [16]; *C. polykomos* [17]). This pattern might initially seem surprising in light of the well-known ability of colobines to extract nutrients from the fibrous cell walls of plants by fore-stomach fermentation. However, extensive reliance on the extraction of nutrients from high-fibre foodstuff requires long gut retention times, a luxury probably unaffordable to colobines owing to their relatively smaller body and shorter gut compared to other foregut fermenters such as cattle. Unlike large-bodied ruminants such as cows and buffaloes, which have the capacious guts necessary to digest fibrous, low energy foodstuff, colobines appear to adopt a more selective feeding strategy that limits their reliance on foregut fermentation for nutrition [18]. To confirm our results, further studies are needed to be conducted across different sites. A comparative study is also required for analysis of all diet components and selected major food species. One possible explanation for petiole eating would be that it is a response to specific mineral needs. Another possible explanation is that the petiole, which is the highway into and out of the leaf, might not be as rich in qualitative defences as the leaf. The role of minerals on dietary selection of *R. avunculus* should also be in focus, as minerals can be as important as protein to primates.

Acknowledgments

This study was supported by Hanoi University of Science (TN-11-19) and Nagao Natural Environment Foundation.

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Hàm lượng protein và chất xơ trong sự lựa chọn cuống lá của Vượn mũi hếch (*Rhinopithecus avunculus*) tại khu vực Khu Ca, tỉnh Hà Giang

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Nghiên cứu về thú linh trưởng ăn lá là một nghiên cứu đáng chú ý. Trong nhóm này, tỷ lệ protein với chất xơ của lá trưởng thành là một yếu tố dự báo quan trọng của sinh khối. Hàm lượng protein và chất xơ trong thức ăn rất quan trọng đối với tất cả các loài khi colobine. Để hiểu về ảnh hưởng của hàm lượng protein và chất xơ của các loài thực vật lên sự lựa chọn cuống lá trong thức ăn của Vượn mũi hếch (VMH), chúng tôi đã thu phiến lá (VMH không ăn) và cuống lá (là thức ăn ưa thích của VMH) của 9 loài thực vật được VMH ưa thích nhất tại khu vực Khu Ca, tỉnh Hà Giang. Hàm lượng Protein (CP) và chất xơ (ADF) đã được đánh giá. Với kết quả phân tích, chúng tôi nhận thấy VMH có xu hướng lựa chọn cuống lá với hàm lượng protein và chất xơ thấp hơn phiến lá; tỉ lệ CP/ADF trung bình của cuống lá (0.48) cao hơn không đáng kể so với phiến lá (0.46). Mặc dù tỉ lệ CP/ADF được xem là chất chỉ thị đối với sự lựa chọn thức ăn ở nhóm colobine nhưng đối với VMH, sự lựa chọn ăn cuống lá có tỉ lệ CP/ADF không cao, khác với các kết quả nghiên cứu trước.

Từ khóa: *Rhinopithecus avunculus*, ăn lá, protein, chất xơ, tỉ lệ protein/xơ.