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EFFECTS OF PREFERENCE AND NUTRITIONAL VALUES OF LOCAL BAMBOO TOWARDS GROWTH PERFORMANCE OF CAPTIVE GIANT PANDAS (*AILUROPODA MELANOLEUCA*) IN ZOO NEGARA, MALAYSIA

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Abstract: Two captive giant pandas *(Ailuropoda melanoleuca)* were observed for nutritional preferences over a period of seven months from 21st May until 31st December 2014 at the Zoo Negara Malaysia. Nutritional analyses were conducted on six local bamboo species which were fed to both pandas. It is evident in the present study that they prefer the culms of *Dendrocalamus asper* followed by culms of *Bambusa vulgaris* and bamboo leaves from *Dendrocalamus asper*, *Bambusa vulgaris* f. *waminii* and *Thyrsostachys seamensis*. Their preferences towards these local bamboo species correspond to the different nutrient values which contained high fibre in the culms and high protein and fat in the leaves. The overall feeding behaviour were well established and the growth performances were satisfactory suggesting that they have successfully adapted to the feeding regime. The pandas were observed to be in good health, active and alert with these bamboo diets throughout the study period.

Keywords: Captive giant panda, *Ailuropoda melanoleuca*, local bamboo, food preferences, nutritional values.

Introduction

The giant pandas *(Ailuropoda melanoleuca)* are members of the order Carnivora due to their unique and simple gastrointestinal tract which is relatively the same as other carnivores. More than 99% of the food consumed by the free-ranging giant panda consists of bamboo (Schaller *et al*., 1985). Anatomically, the giant panda exhibits several features specially adapted for processing and utilising bamboo. For example, they have flattened molars and extensive jaw muscles (Owen, 1980; Eisenberg, 1981). A few modifications were observed on the alimentary tract designed specifically for a bamboo diet which includes horny lining of the esophagus for protection from shards as well as a muscular pyloric region of the stomach for mixing consumed food before it enters the small intestine (Chorn & Hoffmann, 1978; Schaller *et al.,* 1985). The small intestine is a much-reduced segment of the gastrointestinal tract, suggesting that limited digestion occurs in this region (Chorn & Hoffmann, 1978). Overall, the intestinal length ranges from 4.1 to 5.5 times the length of the total length of the head and body (Raven, 1937; Davis, 1964; Schaller *et al.*, 1985). It makes the bamboo passage rate approximately 6-8 hours (Dierenfeld *et al.*, 1982). Histological examination of the giant panda gastrointestinal tract revealed that the large intestine has a significant number of mucous cells (Wang *et al*., 1982), allowing the faecal boluses of giant panda coated with a thin layer of mucus.

Bamboo is in the grass family Poaceae, and has a wide distribution throughout the tropics and subtropics region. In Peninsular Malaysia, 59 species of native bamboo are currently known (Wong, 1989, 1995). However, industrial utilisation of bamboo as a minor forest product

in Malaysia remains low compared to other countries in Asia and ranked second to rattan in terms of commercial importance (Wong, 1989). Several studies on the potential uses of bamboo in Malaysia has been conducted but focuses more on the utilisation for commercial purposes (Wong, 1989, 1995; Mohamed *et al*., 2007). Chongtham *et al*. (2011) provided a review on the nutritional value studies conducted on several species of bamboo but limited studies have been conducted on our local bamboo species looking into their nutritional contents. Thus, the need to study the nutritional values of local bamboos are needed.

On the 21st May 2014, Malaysia commemorated the arrival of two giant pandas, namely Fu Wa and Feng Yi for the purpose of conservation. The animals were housed in dedicated accommodation at the Zoo Negara, Kuala Lumpur. Pandas in wild or in captivity are selective of their diet especially preferring particular parts of the bamboo plant. This selective intake is of particular concern when evaluating nutrients supplied by bamboo because bamboo components (i.e. shoots, leaves, branches, and culms) differ appreciably in nutritional composition. In captivity, the giant panda can eat up to 14 kg of bamboo per day, spending 19-28% of their time feeding.

The purpose of this study was to determine the nutritional values of each of the Malaysian local bamboo species fed to the two pandas and at the same time evaluate the effect of bamboo feeding on their growth performance throughout 2014.

Methodology

Fu Wa (male) and Feng Yi (female), the subject of this nutritional study were both born in 2006 (nine years old). They are currently housed at the Zoo Negara and kept in separate exhibits and night dens.

Diet Management

The nutritional management of the giant pandas were conducted as advised by the experts from China Wildlife Conservation Association

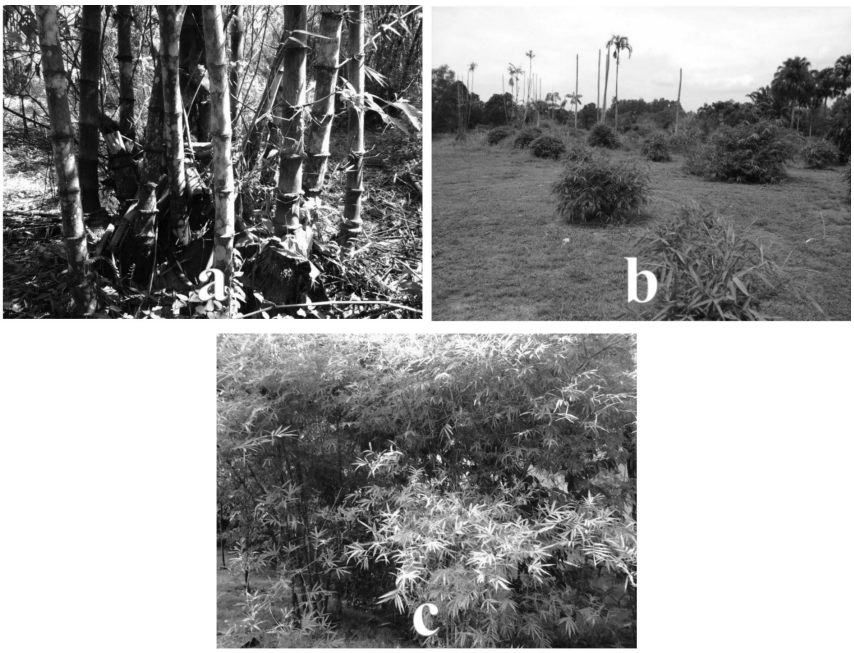

Figure 1: Local bamboo species included in the giant panda's diet. (a) *Dendrocalamus asper*, (b) *Bambusa. vulgaris* f. *waminii*, (c) *Thyrsostachys siamensis*

(CWCA), Department of Wildlife and National Parks (DWNP), Forest Research Institute Malaysia (FRIM), and Zoo Negara. On 17th to 23rd March and 4th to 6th November 2013, food testing was carried out on the pandas at Bifengxia Panda Base, Ya'an, People's Republic of China using six Malaysian bamboo species (*Bambusa multiplex*, *B. heterostachya*, *Dendrocalamus asper*, *Gigantochloa albociliata*, *B. vulgaris var Wamin* and *Thyrsostachys siamensis*. It was observed that both pandas ate four out of six bamboo species tested; *B. multiplex*, *B. Heterostachya, D. asper*, and *G. albociliata*. At the Zoo Negara, the pandas were fed with all six bamboo species including *B.vulgaris var Wamin* and *Thyrsostachys siamensis*.

Bamboo Sampling and Nutritional Analyses

D. asper and *B. vulgaris* were harvested from local villages in Kampung Kundur Hulu, Negeri Sembilan while other species of bamboo were harvested at the Forest Research Institute Malaysia (FRIM) and Paya Indah Wetlands (PIW), Selangor three times per week. Whole culms and leaves of healthy bamboos aged around 1-2 years were selected and cut at ground level. The bamboo culms were further cut into pieces of 100cm long, rinsed and kept in a cold room before being fed to the giant panda.

For nutritional analyses, a total of 1kg of each bamboo culms and leaves were cut into small pieces and kept into separate zip lock bags before being sent immediately to the Veterinary Public Health Laboratory, Salak Tinggi, Selangor following the FAO standard and Quality Assurance for Animal Feed Analysis Laboratories manual (FAO, 2011).

Feeding

As bamboo is low in nutritive value, the pandas need to eat significant amount of bamboo every day to meet their energy requirements. At least 20-40kg of bamboo culms and leaves from the seven local species were fed alternately to both pandas. Each bamboo stem was cut into small pieces estimated half meter long and cleaned before fed to the pandas. Additonally, 1-2 kg of supplementary food such as fruits and panda cake were also given every day together with the main diet. To maintain the freshness of the bamboo, at least three times or more frequent feeding were given to giant pandas daily especially in the elevated ambient temperatures (David *et. al,* 2006). In Zoo Negara, the animals were fed five times daily as shown in Table 1. The feeding regimes was according to the recommendations of the Standard Operating Procedure (SOP) of Giant Panda Conservation Centre, Zoo Negara.

Table 1: Feeding routine for the two captive giant pandas

Time	Food type	Quantity (kg)
0800hrs	Bamboo	6.0
	Leaves	2.0-3.0
	Panda cake	0.3
	Carrot	~0.1
	Apple	~0.1
1130hrs	Bamboo stem	2.0-3.0
	Panda cake	0.3
1430hrs	Bamboo	7.0
	Leaves	2.0-3.0
	Panda cake	0.3
	Carrot	~0.1
	Apple	~0.1
1700hrs	Bamboo	7.0-8.0
	Leaves	2.0-3.0
	Panda cake	0.3
	Carrot	~0.1
	Apple	~0.1
2200hrs	Bamboo	7.0-8.0a, 6.0-7.0b
	Leaves	2.0-3.0a
	Panda cake	0.3

[a] given to Fu Wa
[b] given to Feng Yi

Results

The observation was made from the day of arrival on 21st May until 31st December 2014. Both pandas were observed to eat culms of

D. asper most of the time because of their soft structure and also their favourable taste. This was also observed during food testing at the Bifengxia Panda Base where the pandas preferred this bamboo compared to other bamboos. The nutritional composition of bamboo leaves provided a variety of nutrients for the pandas. The most preferred bamboo leaves were from *D. asper, B. vulgaris* f. *waminii* and *T. seamensis* species. The details of nutritional values for each bamboo species is shown in Table 2.

Fu Wa and Feng Yi consumed between 20-40kg fresh bamboo culms and leaves to meet their nutrient requirements. The total amount of food consumption throughout the year together with the growth performances are shown in Table 3. Fu Wa showed an increase in body weight in accordance with the increase of food consumption throughout the year 2014. Feng Yi on the other hand showed slight fluctuation of body weight and food consumption due to her selective food behaviour.

Table 2 shows the nutritional values for the culms and leaves of each bamboo species as analysed by the Veterinary Public Health Laboratory, Selangor. Six of local bamboo species from four genus were tested i.e. *Dendrocalamus*, *Bambusa*, *Thyrsostachys* and *Gigantochloa*. The most preferred culms were *D. asper* and *B. vulgaris* as both species contains high crude fibre values as compared to another four species. *D. asper* leaves was the most preferred compared to other species followed by *B. vulgaris* f. *waminii* and *T. seamensis* species.

Table 3 shows the comparison of growth performances and food consumption between both panda, the first 7 months. Fu Wa showed increase in body weight in accordance with the increase of food consumption. Although the food consumption fluctuated every month, it was noted that the growth performance increased at the end of the year. Feng Yi showed slight fluctuation of body weight throughout the seven months of observation. This fluctuation is due to her selective food behaviour and pseudo pregnancy behaviour which was exhibited in August 2014 echoeing her first experience giving birth in August

Table 2: The nutritional values (in percentages, %) of culms and leaves from local bamboo species. Values for *B. vulgaris* leaves were not analysed. (*NFE= Nitrogen free extract)

Species	*D. asper*		*B. vulgaris*		*B. vulgaris f. waminii*	
	Culms	Leaves	Culms	Leaves	Culms	Leaves
Dry mater	54	42.1	45.6	-	30.7	38.7
Crude protein	4.3	22.5	3.6	-	3.5	14
Crude fat	0.2	4.4	0.1	-	0.2	2.4
Crude fibre	51.6	24.9	60.9	-	52.6	28.6
Ash	2.9	11.5	3.4	-	4.6	12.4
*NFE	42.4	37	31.9	-	39	42.6

Species	*T. siamensis*		*B. multiplex*		*G. albociliata*	
	Culms	Leaves	Culms	Leaves	Culms	Leaves
Dry mater	38.7	34.5	43.1	44.3	54.4	41.4
Crude protein	3.8	17.1	1.8	9.9	2.1	14.2
Crude fat	0.2	2.6	0.4	4.7	0.3	2.09
Crude fibre	59.3	25.8	53.1	25.9	54.7	29.2
Ash	4.8	14.4	3.3	15.8	3.4	12.6
*NFE	31.9	40.1	41.3	43.7	39.5	41.9

Table 3: Comparison on the growth performances, food consumption and faecal output (wet basis) between Fu Wa (♂) and Feng Yi (♀) from 21st May to 31st December 2014

Month	Body Weight		Total food given		Food consumption		*Faeces output*	
	♂	♀	♂	♀	♂	♀	♂	♀
May	119.57	96.51	39.72	29.22	11.46	7.83	4.65	2.93
June	120.93	100.62	34.66	32.54	18.90	16.94	8.70	7.43
July	123.78	106.76	37.18	32.80	19.89	19.34	8.60	8.31
Aug	126.96	105.17	39.76	22.08	19.12	6.98	8.93	3.63
Sep	128.80	107.48	39.07	23.68	28.40	12.23	9.42	5.35
Oct	132.04	108.83	38.33	31.42	23.05	14.01	9.76	6.13
Nov	133.10	109.43	40.11	29.69	24.55	12.26	9.42	5.19
Dec	134.27	108.95	40.60	30.16	25.28	10.40	9.91	4.29

2013. Food intake was reduced and a lot of time was spent on resting and sleeping, but no feeding problem was observed before and after August 2014. There were variations in food consumption and body weight throughout the observation period.

In terms of preferred bamboo species, it was observed that for the first few months, both panda preferred to eat culm of *D. asper*. The preference to *D. asper* bamboo over the other species is possibly due to its higher nutritive values compared to other species. However, from July to September, they prefer to eat more *B. vulgaris* rather than *D. asper.* From October onward, they again preferred *D. asper.* These two bamboo species contain almost similar nutritional values.

Leaves from *D. asper*, *B. vulgaris* f. *waminii* and *T. seamensis* species were the most preferred. Although leaves from *D. asper* contains higher dry mater percentage, both pandas preferred it and can be attributed to the lower crude fibre and higher crude protein content as compared to others species. *B. vulgaris* f. *waminii* and *T. seamensis* leaves were the second and third choice respectively, possibly attributed to its lower dry mater and higher in crude protein as compared to *B. multiplex* and *G. albociliata*. This diet provided the pandas with sufficient nutrition, thus having minimal feeding and defecation problems. They were able to eat and drink and the faeces were well-formed in terms of structure, shape and consistency.

Discussion

In evaluating the nutritional and overall health status of giant pandas, body mass and body condition are two important criteria to be look after (David *et al.,* 2006). Giant panda preferences to local bamboo were satisfactory based on the nutrient content in each bamboo species and in accordance with the body weight changes as shown by both pandas. These observations indicated that, Fu Wa and Feng Yis' feeding behaviour were well established and successfully adapted to living in Malaysian conditions for the first year.

The most preferred local bamboo contained high fibre in culms and high protein and fat in leaves. Culm is known to have less fat and protein than leaves, is much higher in fibre, and is less digestible by a carnivore alimentary tract (He *et al.*, 2000; Long *et al.*, 2004; Sims *et al.*, 2007; Wei *et al.*, 1999, 2000). The SOP was made based on similarity of feeding regime provided in other places for example at Bifengxia Giant Panda Base (Sichuan, China), Adelaide Zoo (South Australia), and Ocean Park Cooperation (Hong Kong). For comparison, pandas in Bifengxia Giant Panda Base were fed with 15-20kg of bamboo including bamboo stems, leave, and shoots every day. China have between 15-20

species of bamboo that can be consumed by the pandas. At least three local bamboo species were given to giant panda everyday and these bamboo species will be changed every week. The local bamboo species given to giant panda are *Pleioblastus amarus, B. blumeana, Phyllostachys heteroclada, P. bissetii, P. edulis*, *Chimonobambusa quadrangularis,* and *Fargesia spathacea*. All bamboo species were planted around Bifengxia Giant Panda Base area and they have no problem with bamboo supply. A total of 1.5-2.0 kg of supplementary food such as apple and carrot were given every day together with 1.5-2.0 kg panda cake. All main diet and supplementary food were fed four times per day to each giant panda (pers. comm Thang Chunxiang). Meanwhile in Adelaide Zoo, South Australia, Australia, a total of 20 kg of bamboo were fed everyday i.e. 5 kg and 15 kg during day time and night time respectively. A total of 11 bamboo species were available for feeding the pandas and usually 4-5 bamboo species were given each day. Those bamboo species include *Phyllostachys aurea*, *B. lako*, *B. oldhamii*, *B. multiplex*, *Phyllostachys pubescens*, *Pseudosasa japonica*, *Bambusa multiplex*, *B. ventricosa*, *B. multiplex*, and *B. textilis*. Pandas in Adelaide Zoo, Australia were also fed with supplementary food such as fruits (apple, pear and carrot) between 150-500 g per day and panda cake 1-2 kg per day (pers. comm. Simone Davey). On the other hand, feeding management of giant panda in Ocean Park Corporation was divided into two catagories since they have two different ages group of giant panda. The younger pandas were fed with 20-30 kg of bamboo together with 1 kg of fruits and biscuit while the olders pandas were fed less bamboo but more fruits and biscuit. There are 12 types of bamboo species available here including *B. vulgaris* var. *striata, B. vulgaris* var. *wamin, B. vario striata, D. latiflorus munro, D. brandisii, B. oldhamii Munro, B. beecheyana, Pseudosasa japon, Phyllostachys bambusoides, Phyllostachys vivax, Phyllostachys nigra*, and *Pseudosasa hindsii* (pers. comm. Lee Foo Khong).

The most limiting factors to dietary husbandry of the giant panda are the logistical efforts required in cultivating, harvesting, transporting and presenting bamboo, and selecting the most appropriate species (David *et al.,* 2006). In Zoo Negara, these problems do not arise since the location of bamboo plantations were not far away from the zoo. Selection of appropriate bamboo species with adequate and sustainable quantities of high-quality bamboos should be well prepared and ready for the next ten years because these pandas will be staying in Malaysia for another ten years. The SOP of feeding management also should be continuously monitored in order to ensure the cleanliness and freshness of the bamboo. This initiative can control and eliminate the risk of infection in pandas, and ensuring the pandas living healthily in Malaysia.

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