Our Nature (2006)4:20-28

Diet Analysis of Gaur, *Bos gaurus gaurus* (Smith, 1827) by Micro-Histological Analysis of Fecal Samples in Parsa Wildlife Reserve, Nepal

M. Chetri

Hariyo Kharka, Pokhara
E-mail: *mchetri@yahoo.com*

Received: 7.11.2006; 12.12.2006

Abstract

The uses of food plants by gaur *Bos gaurus gaurus* were studied by micro-histological analysis of fecal samples in Parsa Wildlife Reserve, Nepal with an aim to explore the diet composition, preferable food plants and monthly variation in plants consumption. The results have shown that the diet of gaur consisted of diverse species of plants (49 species). On an average, grass comprises a major proportion (66%), followed by browse (25%) and herb and others (5%). Although gaur consumes variety of food plants, six plant species: four grass- *Themada* sp., *Phragmites karka*, *Imperata cylindrica* and *Vetiveria zizanoides* and two browse – *Wendlandia exserta* and *Phaulopsis imbricata* are highly preferred. The highest browse to grass ratio (1.27) was estimated during January and least (0.7) during June.

***Keywords*:** *Bos gaurus gaurus,* Food habits, Micro-histological analysis

Introduction

The gaur known as gauri gai (in Nepali) is the largest wild bovid in the world. It has been listed as an endangered species in the National Red Data Book (NRDB) threat category (BPP 1995) and protected by His Majesty Government of Nepal (HMG/N) under schedule 1 (Section 10) of the National Parks and Wildlife Conservation Act, 2029 (HMG/NPWC 1973). Gaur is essentially a hill animal but they travel to lowlands during certain seasons in search of pasture (Schaller, 1967; Prater, 1971; Ranjitsinh, 1991). In Nepal, they were distributed in less-distributed forested areas of the eastern Tarai and Churia hills. Habitat degradation and epidemic diseases like rinderpest are the major threats for survival of gaur in the wild (Schaller, 1967; Krishnan, 1972; Gurung, 1983; Ranjitsinh, 1991). Little effort has yet been made to investigate the ecology of gaur. One of the first steps towards the conservation of this species is to identify the food habits. Knowledge of diet composition is essential to take management decisions for viable population maintenance in the wild. No quantitative information on this species in Nepal is available.

Much of the information available on food habits of gaur is through the work of Schaller (1967), Krishnan (1972), Srivastava et al., (1989) and Shukla and Khare (1978). Previous volume of this journal describes the food habits of gaur and livestock (cows and buffaloes) through direct observation. This paper describes the food plants used by gaur through microhistological analysis of fecal samples collected during January to June 1998

in Parsa Wildlife Reserve, and is part of broader research on gaur ecology in Nepal.

Study Area

The study was conducted in Parsa Wildlife Reserve located between 84°41'-84°58'E and 27°15'-27°33'N in Central lowland Nepal. This reserve was established in 1984 with an area of 499 km^2 by the Department of National Parks and Wildlife Conservation. It lies at an altitude of 100m-950m a.s.l and is surrounded by four districts: Chitwan, Makwanpur, Parsa and Bara (Figure 1). The research study area spans over Tarai and the Churia foothills (approx. 13.1 km^2) at an altitude of 250m-450m a.s.l.The climate is sub-tropical. Mean annual rainfall recorded during 1986-1996 at the nearest weather station (Simara Airport) was 1721 mm. Precipitation was highly variable and more than 83% occurred from June to October. Average maximum temperature reaches 35.2°C during May and gradually dropped to 7.7°C during January. Winter was relatively cold with heavy mist in the morning.

Vegetation of the study area is sub-tropical type ranging from early successional stages on the dry riverbeds and floodplains with colonizing *Saccharum spontaneum*, *Imperata cylindrica* to a mature climax type of Sal (*Shorea robusta*) forest on the upper drylands. As altitude increases in the north along the Churia hills, the Sal forest is gradually replaced by pine forest (*Pinus roxburghii*).

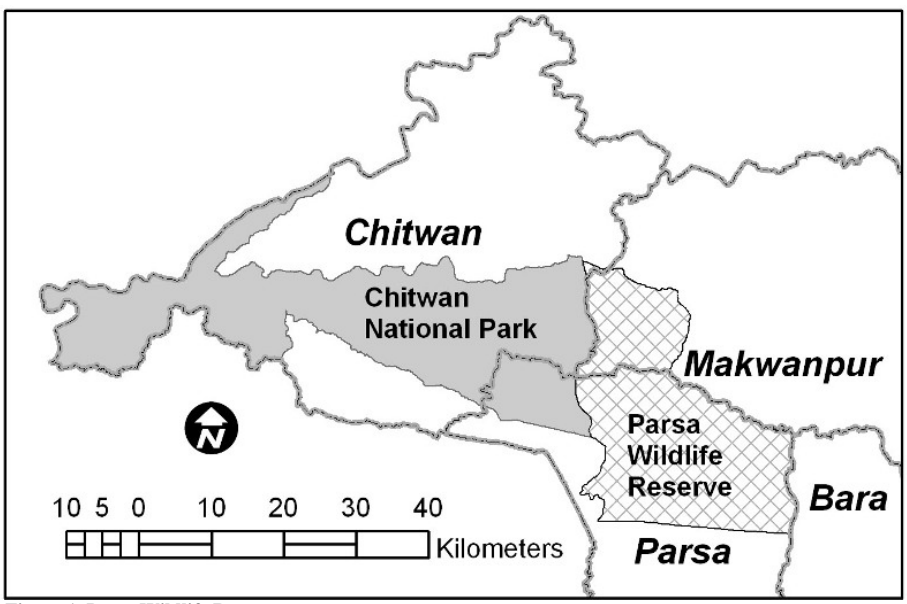

Figure 1. Parsa Wildlife Reserve

In the Reserve, gaur shares its habitat with domestic livestock (cows and buffaloes), Asiatic elephants (*Elephas maximus*), Bengal tigers (*Panthera tigris*), leopard (*Panthera pardus*), wild dog (*Cuon alpinus*), striped hyaena (*Hyaena hyaena*), sloth bear (*Melursus ursinus*), four-horned antelope (*Tetraceros quadricornis*), barking deer (*Muntiacus muntjak*), spotted deer (*Axis axis*), sambar deer (*Cervus unicolor*), Wild boar (*Sus scrofa*) and a variety of reptiles and birds. Rambhori and Bhata are two important settlements of subsistence farmers in the western part of the reserve, where as in the northern part, illegal settlers (*Ghotalas*) herd a large number of livestock from the adjoining villages. The gaur inhabiting these areas is threatened by habitat degradation from overgrazing, human disturbances, and poaching.

Materials and methods

Micro-histological analysis

This study was based on the microscopic recognition of indigestible plant fragments mainly the epidermal features that are characteristic of different plant groups (Metcalfe, 1990). It is a widely used method for studying diets in ungulates (Anthony and Smith, 1974; Baumgartner and Martin, 1939; Holechek and Gross, 1982; Kiley, 1966; Robins et al., 1975) and is the most accurate of all the methods for estimating diets of herbivores (Dearden et al., 1975). The method has a major limitation- no definite quantification of the forage consumed can be made. However, it is useful in ascertaining the food habit of endangered and secretive species such as the gaur.

The fecal analysis requires the collection, preservation and preparation of fecal samples and reference slides. Fresh fecal samples (N=71) were collected by following fresh tracks of gaur and recording their feeding and resting sites from different habitats. Twenty-one samples were collected in January, 19 in February and 11 in March. Similarly 9, 7 and 4 samples were collected in April, May and June respectively. Individual samples collected were air-dried separately for a minimum of 72 hours, ground by hand and mixed thoroughly to make a monthly sample. The samples were later analyzed in the laboratory of Central Department of Zoology, Tribhuvan University.

Fifty-nine plant species were selected for the preparation of reference slides on the basis of their abundance and which appeared to have been eaten by the animals. The collected plant species were identified at Central Department of Botany, Tribhuvan University. Slides were prepared following the method used by Fjellstad and Steinheim (1996).

Five permanent slides were made per composite fecal sample of every month. Reference slides of fresh leaves; stems and fruits were prepared separately for each plant species. The reference slides were studied thoroughly as recommended by Holechek and Gross (1982). Distinguishing histological features (e.g. cell wall structure, shape and size of cells, hairs and trichomes, shape and size of stomata and inter-stomatal cells, fibre structure and arrangement of veins) were sketched to match with the fecal plant fragments. Five horizontal transect lines were drawn randomly on each slide and the first 12 non-overlapping fragments which intercepted the fields per scale line were recorded and identified under compound microscope at X 200 or at X 400 magnification with an ocular measuring

scale. A total of 60 fields per slide were examined for a total of 300 fields per sample.

The examined fragments were grouped into 3 - grass (plants of the grass and sedge families), browse (all woody plants) and herb and others (broad-leafed herbaceous plants, pteridophytes and fruits). The plants, which could not be identified to species or genera, were grouped into "unidentified grasses", "unidentified browse" and "unidentified herbs and others".

The relative percentage frequency of each species in the fecal sample was estimated using the following formula:

$$Rf\,\% = \frac{n_1 + n_2 \ .....}{N} \times 100$$

Where,

Rf % = Relative percentage frequency,

n = Total number of fragments identified for a given food species or forage category, and

N = Grand total number of fragment counts made in the sample.

Results and discussion

The diet of gaur consisted of a diverse species of food plants. Forty nine plant species (23 grasses, 17 browse and 9 herbs and others) were recorded (Table 1), but >70% of the volume in the diet was contributed by 12 species (nine grasses: *Apluda* sp., *Cymbopogon microtheca*, *Cymbopogon* sp., *Imperata cylindrica*, *Paspalidium punctatum*, *Phragmites karka, Saccharum spontaneum*, *Themeda* sp. and *Vetiveria zizanoides* and three browse: *Phaulopsis impbricata*, *Tharotherthere* and *Wendlandia exserta*). On an average, grass species comprised of 66%, browse 26% and herbs and others 5% (Figure 2). The mixed proportion of the diet confirms those gaurs are both grazers and browsers (Schaller, 1967; Krishan, 1972; Shukla and Khare, 1998).

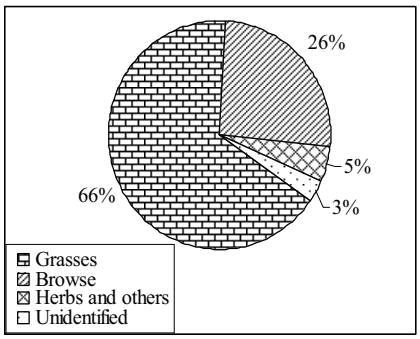

Figure 2. Proportions of three groups of food plants in the diet of gaur

Fruits of *Phyllantus emblica* and *Terminalia chebula* were also recorded in the diet of gaur in a proportion of 1.3% and 0.7% respectively in January. These species were not recorded in other months mainly due to unavailability of fruits. The fruits of *T. chebula* fall completely during the last part of January whereas that of *P. emblica* remains until February in some areas. A higher proportion of *P. emblica* is probably due to its availability in all the areas in comparison with *T. chebula* (Chaudhary, 1995). Krishnan (1972) also reported those gaurs are fond of the fallen fruits of *Cassia fistula*, *Gmelina arborea, Aegle mormelos, Phyllanthus* sp., and *Terminalia bellerica*.

Monthly diet composition

During January the diet of gaur was dominated by browse species (49 ± 4.6 %) while the bulk of animal's diet was dominantly composed of grasses from

February to June (Table 1). In January, due to relatively low supply of high quality of grass species gaur utilized more browse species. Krishnan (1972) reported that grasses that had matured fully were avoided by gaur. The preference to browse species declined as the month advances with the least in June (7.3 ± 0.5 %). The grass species were least preferred in the month of January (38.7 ± 1.9 %) and most preferred in the month of June (88.3± 8.6 %). A higher preference for grass during June is due to the abundant growth of new grass stimulated by the pre-monsoon. Schaller (1967) reported that the bulk of animal's diet consisted of 85% coarse, semi-dry to dry grasses in the four-rumen samples examined during the hot seasons in Kanha National Park, India. The results of the present study are in close agreement with the generalization made by Schaller (1967). Although January and June were the two extreme months when the browse and grass species respectively were pre-dominantly preferred as diet by the gaur, the consumption of grass species (88.3%) in June was about double of browse (49.0 ± 4.6 %) in January. The consumption of herb and other species was relatively low.

Of the six important food species (Figure 3), *Themeda* sp. was the most preferred ($\bar{X}$ =17.11±1.69%, Table 2). Its proportion was highest during June (32%) when new shoots were available after the pre-monsoon rains. The low consumption of this species during January, February and March in comparison to the browse species *Wendlandia exserta* in January and February and grass species *Imperata cylindrica* in March is ascribable to its low availability in those months. In January and February, *W. exserta* and *Phaulopsis imbricata* were comparatively more abundant than grass species. Similarly during March, the grazing site of gaur abounds with the new shoots of *I. cylindrica*.

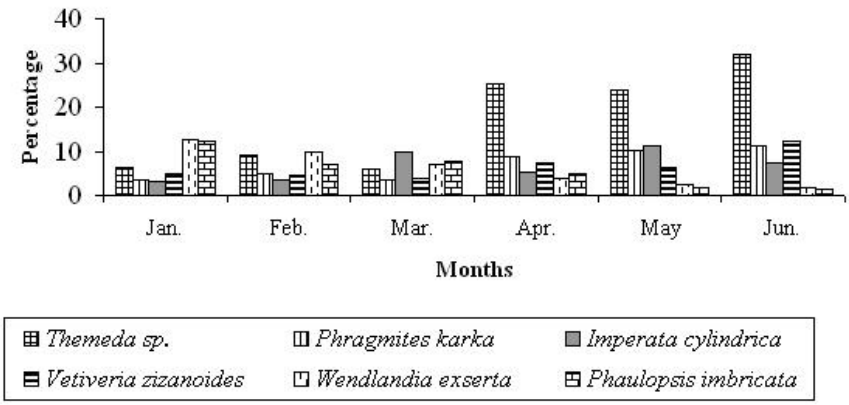

Figure 3. Monthly variation of six most important grass and browse species in the diet of gaur

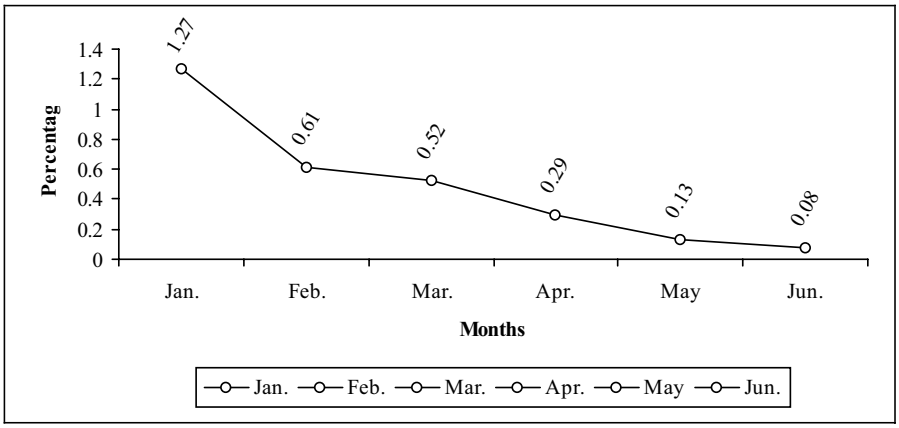

Figure 4. Browse to grass ratio in the monthly diet of gaur during January-June 1998 in the PWR

Table 1. Proportions of three groups of plant species recorded in the diet of gaur during

Months	Grasses	Browse	Herbs and others	Unidentified
January	38.67(1.86)	49.00(4.63)	10.33(1.14)	2.00(0.95)
February	58.67(2.52)	36.00(3.12)	5.33(1.13)	0.33(-)
March	61.33(2.64)	31.67(2.69)	4.67(0.83)	2.33(0.51)
April	68.33(5.79)	19.67(1.59)	6.00(0.47)	6.67(1.89)
May	84.00(5.70)	11.00(0.67)	2.33(0.39)	2.67(0.47)
June	88.33(8.62)	7.33(0.50)	0.33(-)	4.00(1.41)

Table 2. Relative percentage frequency of different plant species recorded in the diet of gaur on the basis of frequency distribution of number of intercepted fragments from micro-histological analysis

Species	Rf %							
	Jan.	Feb.	Mar.	Apr.	May	Jun.	$\bar{X}$	S. E.
Grasses								
Anthrax sp.	0.33	1.00	0.33	1.00	-	-	0.44	0.27
*Apluda s*p.	4.00	5.67	1.00	1.33	3.67	9.00	4.11	0.83
Cyanotis cristata (L.) D.Don	-	-	0.33	-	0.67	-	0.17	0.17
Cymbopogon microtheca (Hook.f.) A. Camus	2.00	7.33	5.67	2.33	6.33	5.00	4.78	0.89
Cymbopogon sp.	3.33	2.00	6.00	3.00	4.67	3.67	3.78	0.79
Cynodon dactylon (L.) Pers.	2.33	1.67	1.67	0.67	0.67	-	1.17	0.44
Cyperus exaltatus Retz.	0.33	0.33	1.33	-	0.33	-	0.39	0.25

Dendrocalamus strictus Ness	0.33	2.67	2.00	0.33	0.33	0.33	1.00	0.41
Erianthus ravennae (L.)P. Beauv.	-	1.67	-	3.00	-	-	0.78	0.36
Fimbristylis miliaceae (L.) Vahl	-	-	0.33	0.67	-	-	0.17	0.17
Imperata cylindrica (L.) P. Beauv.	3.00	3.67	9.67	5.33	11.33	7.33	6.72	1.06
Leersia hexandra Sw.	-	-	5.33	0.67	4.00	1.00	1.83	0.55
Oplismenus burmanii (Retz.) P. Beauv.	1.00	0.67	1.67	0.67	0.33	-	0.72	0.35
Oplismenus compositus (L.) P. Beauv.	1.00	1.33	0.33	1.33	1.67	-	0.94	0.40
Panicum paludosum Roxb.	-	-	-	0.67	3.33	1.33	0.89	0.38
Paspalidium punctatum (Burm.) A. Camus	4.33	6.00	1.67	1.67	2.33	1.33	2.89	0.69
Paspalum scrobiculatum L.	-	1.00	2.33	-	0.33	-	0.61	0.32
Phragmites karka (Retz.) Trin ex Steud.	3.67	5.00	3.67	8.67	10.33	11.33	7.11	1.09
Saccharum spontaneum L.	1.67	3.67	6.33	4.00	2.33	3.00	3.50	0.76
Setaria glauca (L.) P. Beauv.	-	-	0.33	-	0.67	0.67	0.28	0.22
Themeda sp.	6.33	9.00	6.00	25.33	24.00	32.00	17.11	1.69
Thysanolaena maxima (Roxb.) Kuntze.	-	1.33	1.33	0.33	0.33	-	0.56	0.30
Vetiveria zizanoides (L.) Nash	5.00	4.67	4.00	7.33	6.33	12.33	6.61	1.05
Unidentified grasses	0.33	-	1.33	1.67	1.67	1.00	1.00	0.41
Browse								
Albizia sp.	-	0.67	-	-	-	0.33	0.17	0.17
Bauhinia purpurea L.	0.33	4.33	1.33	-	-	-	1.00	0.41
Castanopsis indica A. DC.	2.00	0.67	1.33	-	-	-	0.67	0.33
Coffea benghalensis Heyne ex Roem. & Schult.	-	-	0.67	1.67	-	1.00	0.56	0.30
Colebrookea oppositifolia Sm.	-	-	-	1.00	2.33	0.67	0.67	0.33
Elaegnus parviflora Wall. ex Royel L.	-	0.33	1.00	-	-	-	0.22	0.19
Fiscus subincisa Buch.-Ham. ex Sm.	1.00	-	-	-	-	-	0.17	0.17
Nyctanthes arbor-tristis L.	3.33	3.33	4.67	3.00	1.00	1.33	2.78	0.68
Phaulopsis imbricata (Forssk.) Sweet	12.33	7.00	7.67	5.00	1.67	1.33	5.83	0.99
Randia sp.	0.67	1.00	-	-	-	-	0.28	0.22
Shorea robusta Gaertn.	1.00	1.00	0.33	-	-	-	0.39	0.25
Sterculia villosa Roxb.	1.33	1.00	-	1.00	0.67	-	0.67	0.33
****Tharotherthere***	9.33	6.33	5.00	0.33	-	-	3.50	0.76
Thespesia lampus (Cav.) Dalz. & Gibs.	4.00	0.33	1.67	1.00	1.00	-	1.33	0.47
Urena lobata L.	1.00	0.33	-	0.33	0.67	0.33	0.44	0.27

Viscum album L.	-	-	1.00	2.33	1.33	0.67	0.89	0.38
Wendlandia exserta (Roxb.) DC.	12.67	9.67	7.00	4.00	2.33	1.67	6.22	1.02
Unidentified browse	1.67	-	0.67	4.33	1.00	3.00	1.78	0.54
Herb and others								
Amaranthus spinosus L.	-	-	-	-	0.33	-	0.06	0.10
Asparagus racemosus Willd.	2.33	0.67	0.33	1.00	1.00	0.33	0.94	0.40
Cirsium sp.	-	-	0.67	2.00	-	-	0.44	0.27
[@]*Equisetum* sp.	-	0.33	0.33	-	1.00	-	0.28	0.22
Ipomoea hederifolia L.	2.33	0.33	1.00	1.00	-	-	0.78	0.36
[#]*Phyllanthus emblica* L.	1.33	-	-	-	-	-	0.22	0.19
Piper longum L.	3.67	3.00	2.33	1.33	-	-	1.72	0.54
Sida rhombifoiia L.	-	0.67	-	-	-	-	0.11	0.14
[#]*Terminalia chebula* Retz.	0.67	-	-	-	-	-	0.11	0.14
Unidentified herbs and others.	-	0.33	0.33	0.67	-	-	0.22	0.19
Total	100	100	100	100	100	100	100	24.22

Note: * = Local name, [@] = Pteridophytes and # = Fruit

Browse to grass ratio

The highest browse to grass ratio (1.27) was in January. The ratio declined slowly as the month advanced and reached the lowest (0.7) during June (Figure 4). The main reasons behind this are: a) the low substrate moisture during January retards the growth of nutritious grass until the pre-monsoon rains and b) after the pre-monsoon rains the new succulent shoots of *I. cylindrica, V. zizanoides, P. karka* and *Themeda* sp. become available.

Although as a ruminant, gaur has a high digestive capacity, the fecal analysis was fairly effective in species identification. The number of food plants species recorded through microhistological techniques was higher than the direct observation (see Chetri 2003). However, leaves of delicate species were not recorded from microfecal analysis. Gyawali (1986) also found that herbaceous and delicate species had little chance to appear in the fecal samples due to complete digestion. In this study only a small proportion (3%) of the fragments was recorded as unidentified. Jnawali (1995) also reported that fecal analysis does not incorporate all species in a herbivore's diet. The proportion of unidentifiable fragments was relatively higher during April. During this month the animals were found feeding on new shoots, which have higher digestibility than the mature plants (Jarman and Sinclair, 1979).

Fecal analysis clearly indicates that the gaur has a great flexibility of food habits and consumed a variety of food. Because of their large size and energy demand, they have to swallow large quantities of food during comparatively short feeding hours. So selection of food species is not as strong as compared to other ungulates. Shukla and Khare (1998) also reported that gaur is not a selective feeder. Seasonal availability of plant species could be a major factor governing food consumption.

Acknowledgements

This research was partly sponsored by the WWF Nepal Programs through its small grant scheme. My sincere thanks go to Dr. Khadga Basnet, Associate Professor, TU for his perpetual advice and invaluable inspiration throughout the study. Thanks are also due to Mr. Sashi Nath Jha, Research Scholar, Tribhuvan University, Botany Department for identification of the plant species. The elephant and the army staff of the Amlekhgunj post and the villagers of Bhata and Rambhori deserve special thanks for their cooperation.

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