Feeding Traits, Nutritional Status and Milk Production of Dairy Cattle and Buffalo in Small-scale Farms in Terai, Nepal

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ABSTRACT : Twenty small-scale farms of two villages (A and B) were surveyed to identify the feeding traits, milk productivity and nutritional status of lactating cattle and buffalo in Terai, Nepal. Constituents and dry matter (DM) of feed supplied, body condition score (BCS), heart girth (HG), bodyweight (BW), milk yield (MY) and plasma metabolites were obtained in the pasture-sufficient, pasture-decreasing and fodder-shortage periods. Milk yield of 305-day lactation was estimated by the daily MY. The supplies of rice straw and native grass were lower and higher in the pasture-sufficient period than in the other periods, respectively (5.5 kg/day vs. 9.8 kg/day and 3.2 kg/day vs. 0.4 kg/day, respectively, $p<0.01$). The roughage–supplement rates of the animals were higher in village A than in village B (5.0 vs. 2.2 in cattle and 9.3 vs. 1.8 in buffalo, $p<0.01$). The variance of feed constituents among the periods and between the villages induced different supplies of CP, NDF and TDN. The concentrations of CP and TDN in the cattle feed were higher in the pasture-sufficient period than in the other periods (9.1% vs. 7.3% and 57.4% vs. 51.0%, respectively, $p<0.01$). The supplies of CP for cattle and buffalo, and of TDN for buffalo were lower in village A than in village B (7.5% vs. 8.7% and 6.6% vs. 9.1% [$p<0.01$], and 53.1% vs. 56.2% [$p<0.05$], respectively). The BCS, HG and BW of the animals were lower in village A than in village B (2.51 vs. 2.86, 156 cm vs. 170 cm and 300 kg vs. 318 kg, respectively in cattle, 2.83 vs. 4.00, 186 cm vs. 216 cm and 429 kg vs. 531 kg, respectively in buffalo, $p<0.01$). The cattle yielded more milk in the pasture-sufficient period than in the other periods (7.9 liters/day vs. 6.6 liters/day, $p<0.01$). The 305-day MY of cattle that calved in the fodder-shortage period was lower than that of cattle that calved in the other periods (1,900 liters vs. 2,251 liters, $p<0.01$). The MYs of cattle and buffalo were lower in village A than in village B (6.2 liters/day vs. 8.1 liters/day and 3.7 liters/day vs. 7.7 liters/day, respectively, $p<0.01$). The 305-day MY of cattle was lower in village A than in village B (1,935 liters vs. 2,409 liters, $p<0.01$). The concentrations of plasma albumin and urea nitrogen in cattle were lower in village A than in village B (3.2 g/dl vs. 3.4 g/dl [$p<0.01$] and 7.4 mg/dl vs. 10.2 mg/dl [$p<0.05$], respectively). The different supplies of CP, NDF and TDN among the periods and between the villages might have affected MY and nutritional status in cattle and buffalo. It was likely that the lower supplies of CP and TDN for cattle that calved in the fodder-shortage period and in village A lowered the 305-day MY of cattle. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 2 : 189-197)***

Key Words : Buffalo, Cattle, Feeding Trait, Milk Production, Nepal

INTRODUCTION

The agriculture sector contributed 40.6% of Nepalese growth domestic product (GDP), equivalent US$5.9 billion in 2003 (World Bank, 2004). Livestock was an important agriculture sub-sector in the country, accounting for about 30% of the agricultural GDP. The country raised about 7.0 million cattle and 3.8 million buffaloes. Nationwide in 2004 small-scale farmers mainly practiced dairy production and yielded about 1.2 million t of milk, of which 28.1% was from cattle and 65.7% was from buffalo (FAO, 2004).

Terai is a low-altitude, southern plain region of Nepal and the country's main granary, even though it constitutes only about 14% of the country's total area. Dairy farming integrated with crop production is a preference of farmers in the region, and in 2003 had provided about 35% of the national milk production from improved breeds of cattle and buffalo (AICC, 2003). Although the dairy in the region contributes much to the domestic milk production, expensive rations and fodder shortages are common constraints due to small farm size (0.6 ha/farm) (Karki et al., 1993; Sharma et al., 1994). However, there are limited reports on the details of feeding status and dairy production in small-scale farms in the region (Pant et al., 1994; Kolachhapati et al., 1994; Hayashi et al., 2005). Hence, the present study was conducted to identify the feeding traits for lactating cattle and buffalo in small-scale farms, and the relationships among feeding traits, milk productivity and nutritional status of lactating cattle and buffalo in Terai, Nepal.

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MATERIALS AND METHODS

Location and climate

Twenty small-scale farms with an adequate number of lactating cattle and buffalo from two villages (A and B) in Chitwan district, Nepal, were selected for the survey from April 2002 to August 2003. The villages A and B were situated about 170 km and 160 km southwest of Kathmandu, respectively. The milk production accounted for a large part of the local economy.

This survey area was in a subtropical climate with temperatures ranged from 13.8°C in January 2003 to 30.0°C in June 2002 during the research. Its total rainfall from April 2002 to March 2003 was 2653 mm, and its average relative humidity was 87.0%. The monthly lowest and highest precipitations during the survey were 0 mm in December 2002 and 830.5 mm in July 2002, respectively (Meteorology data of National Maize Research Center in Rampur, Chitwan, Nepal). There are three periods based on environments of pasture and fodder: the pasture-sufficient period, characterized by increased pasture from June to October; the pasture-decreasing period, characterized by decline of pasture due to rainless and cool climate from November to February; and the fodder-shortage period, characterized by scarcity of fodder with dry climate from March to May.

Data and sample collection

The lactating cattle and buffalo were tethered in cowsheds and hand-milked twice daily. Number, parity, breed and last calving date of the animals were recorded in April 2002. Average head and parity of the lactating cattle in village A were 2.6 ranging from 1 to 6 and 3.0 ranging from 1 to 6, respectively. The corresponding values in village B were 3.2 ranging from 0 to 7 and 3.2 ranging from 1 to 7, respectively. Breeds of the cattle were Holstein-cross and Jersey-cross. Average head and parity of the lactating buffalo in village A were 0.6 ranging from 0 to 1 and 3.9 ranging from 2 to 5, respectively. The corresponding values in village B were 0.2 ranging from 0 to 2 and 2.5 ranging from 2 to 3, respectively. Breeds of the buffalo were Murrah-cross and an indigenous breed. Milk yield (MY) of each animal was recorded daily from April 2002 to March 2003. Milk yield of 305-day lactation from each animal was estimated by the equation of Wood (1969):

$$y_n = An^b e^{-cn}$$

where y_n is the average daily MY (liter) in nth week, and A, b and c are constants.

Dry matter (DM) of feed supplied, body condition score (BCS) (Ferguson et al., 1994) and heart girth (HG) of the animals were obtained in June, September and December 2002, and March 2003. Bodyweight (BW) of cattle and buffalo was estimated by their HG using the following equation developed by Kumagai et al. (2003):

$$\text{BW of cattle (kg)} = 605/(1+243e^{-0.035HG(cm)})$$

$$\text{BW of buffalo (kg)} = 603\ (1+321e^{-0.036HG(cm)})$$

Feed resource samples from representative farms were collected in November 2002, March and August 2003. The samples were dried to measure DM content and ground to pass through a 1-mm sieve. Composite representative samples of feed resource were made by mixture of the same amount of the original samples. Concentrations of DM and crude protein (CP) in the representative samples were analyzed by the method of AOAC (1990). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents of the samples were determined by the method of Van Soest (1973) and Van Soest et al. (1991), respectively. Total digestible nutrient (TDN) of the samples were estimated by the equations reported by Martin (1985) and Chandler (1990):

$$\text{TDN (\%) in straw} = 96.35-1.15\times\text{ADF (\%)}$$

$$\text{TDN (\%) in native grass} = 105.2-0.68\times\text{NDF (\%)}$$

$$\text{TDN (\%) in supplemental resources} = 81.41-0.48\times\text{NDF (\%)}$$

Concentrations of CP, NDF and TDN in total feed supplied for each animal were calculated from the representative concentrations of feed resources in each period.

Blood sampling was conducted in December 2002, April and August 2003. Blood plasma was obtained by a centrifugation and stored at -20°C until analyses of the metabolites. Total protein concentrations were determined by a refract meter (SPR-Ne, Atago Co., Ltd., Japan). Concentrations of albumin, blood urea nitrogen (BUN), glucose, total cholesterol, non-esterified fatty acid (NEFA) and β-hydroxybutyrate (BHB) were analyzed using diagnostic kits (Albumin-HRII, L type Wako UN, Glucose-HRII Wako, L type Wako CHO·H and NEFA–HR, Wako Pure Chemical Industries, Ltd., Japan, and TKB-L, Kainosu Co., Ltd., Japan, respectively). Globulin concentrations were calculated by subtracting the concentrations of albumin from total protein.

Statistical analysis

The effects of time and village, and the interaction effect between time and village, on DM of feed supplied, rate of roughage to supplements, parity, BCS, HG, BW, lactation days and MY in cattle and buffalo were analyzed by the following mathematical model:

$$Y = M+T_i+V_j+(TV)_{ij}+E_{ijk}$$

where Y is an each value, M is the overall mean, T_i is the effect associated with time surveyed, V_j is the effect associated with village surveyed, $(TV)_{ij}$ is the interaction effect between time and village, and E_{ijk} is the experimental error.

The effects of calving period, parity, breed and village

Table 1. Dry matter (kg/day) and rates of roughage to supplements (R/S) supplied for cattle and buffalo

	Cattle				Buffalo			
	Jun. 2002	Sep. 2002	Dec. 2002	Mar. 2003	Jun. 2002	Sep. 2002	Dec. 2002	Mar. 2003
Village A	n = 16	n = 22	n = 22	n = 23	n = 5	n = 3	n = 3	n = 3
Rice straw	0^{c}	5.1^{b}	10.0^{a}	9.9^{a}	0^{c}	9.0^{b}	12.6^{a}	12.0^{a}
		(0-7.2)	(7.2-12.6)	(7.2-12.6)		(7.2-10.8)	(10.8-13.5)	(10.8-12.6)
Native grass	8.6^{a}	4.9^{b}	0.5^{c}	0.9^{c}	9.9^{a}	3.6^{b}	0.5^{c}	1.3^{c}
	(7.4-9.6)	(3.4-8.5)	(0-4.3)	(0-5.7)	(7.1-13.3)	(3.4-4.0)	(0-1.4)	(0-2.3)
Corn stover	2.4^{a}	0^{b}	0^{b}	0^{b}	2.7^{a}	0^{b}	0^{b}	0^{b}
	(0-4.6)				(0-6.4)			
Wheat bran	1.9	1.9	1.8	1.8	1.2	1.0	1.2	1.6
	(0.4-3.5)	(0.9-3.5)	(0.9-3.0)	(1.3-2.6)	(0.9-1.7)	(0.9-1.3)	(0.9-1.7)	(1.3-1.7)
Corn flour	$0.18^{b,ef}$	$0.22^{b,e}$	0.52^{a}	$0.08^{b,f}$	0.03^{a}	0^{b}	0.73^{a}	0.07^{a}
	(0-0.87)	(0-0.87)	(0-1.75)	(0-0.66)	(0-0.17)		(0-1.75)	(0-0.22)
Rice polish	0.06^{a}	0^{b}	0^{b}	0.03^{a}	0.09^{a}	0^{b}	0^{b}	0.07^{a}
	(0-0.44)			(0-0.22)	(0-0.44)			(0-0.22)
Mustard oil cake	0.10	0.08	0.06	0.09	0^{b}	0^{b}	0^{b}	0.07^{a}
	(0-0.21)	(0-0.21)	(0-0.21)	(0-0.21)				(0-0.13)
Commercial feed	0.11	0.24	0.17	0.15	0.04^{a}	0.25^{a}	0^{b}	0^{b}
	(0-0.37)	(0-1.48)	(0-1.11)	(0-0.74)	(0-0.18)	(0-0.74)		
Total	13.1	12.4	13.0	12.9	14.0	13.8	14.9	14.9
	(7.8-16.2)	(8.5-16.4)	(9.4-16.5)	(9.4-16.3)	(10.8-17.5)	(12.8-15.1)	(12.1-16.6)	(12.5-16.7)
R/S	5.9^{a}	4.3^{b}	4.6^{b}	5.5^{a}	9.7^{ef}	10.9^{e}	9.1^{ef}	7.3^{f}
	(2.4-16.9)	(2.8-7.4)	(3.0-10.3)	(3.2-9.6)	(6.2-16.3)	(6.9-16.3)	(5.2-10.3)	(6.3-8.1)
Village B	n = 24	n = 25	n = 22	n = 25	n = 0	n = 1	n = 2	n = 2
Rice straw	4.9^{c}	10.3^{a}	9.6^{b}	9.2^{b}	-	10.1	8.3	10.9
	(0.5-10.2)	(6.8-13.1)	(7.1-12.9)	(7.0-11.3)			(7.7-8.9)	(10.4-11.3)
Native grass	3.0^{a}	$0.3^{b,e}$	$0.1^{c,f}$	$0.2^{bc,f}$	-	1.8	0	0
	(1.8-4.3)	(0-1.0)	(0-0.9)	(0-1.4)				
Wheat straw	0.3	0.3	0.5	0.3	-	0	0	0
	(0-2.9)	(0-2.5)	(0-2.5)	(0-2.5)				
Wheat bran	3.0^{a}	2.4^{bc}	2.3^{c}	2.5^{b}	-	3.1	2.7	3.2
	(1.9-5.3)	(2.0-3.0)	(1.8-3.1)	(1.8-3.2)			(2.6-2.9)	(3.1-3.3)
Commercial feed	2.0	1.9	2.1	2.3	-	3.0	2.3	2.8
	(0.9-3.0)	(0.9-2.7)	(1.5-2.6)	(1.7-3.0)			(2.1-2.4)	(2.6-3.0)
Total	13.2^{b}	$15.2^{a,e}$	$14.6^{a,ef}$	$14.5^{a,f}$	-	18.0	13.3	16.8
	(7.1-18.6)	(12.2-17.9)	(11.4-17.7)	(11.6-17.9)			(12.5-14.1)	(16.5-17.2)
R/S	1.7^{d}	2.6^{a}	2.4^{b} (1.6-3.3)	2.1^{c}	-	2.0	1.7	1.8
	(0.5-3.0)	(1.3-4.0)		(1.6-3.2)			(1.6-1.7)	(1.7-1.9)

Mean (Minimum-maximum): Means within the same row in each species of animals with different superscripts significantly differ.
$^{a, b, c, d}$ $p<0.01$; $^{e, f}$ $p<0.05$.
Roughage: rice straw, native grass, corn stover and wheat straw.
Supplements: wheat bran, corn flour, rice polish, mustard oil cake and commercial feed.

on the 305-day MY of cattle and buffalo were analyzed by Student t-test and Duncan's multiple range test (1955) for mean separation. The data of calving period, parity, breed, village, BCS, HG, BW and 305-day MY of cattle were pooled, and a multiple regression equation to estimate 305-day MY was developed by a stepwise method. All calculations were made using a commercially available computer program (Excel Statistics™, Esumi Co., Ltd., Japan).

RESULTS

Dry matter and rates of roughage to supplements supplied for the cattle and buffalo are presented in Table 1. Although the amount of rice straw supplied was lower in June and September than in the other periods (5.5 kg/day vs. 9.8 kg/day, on an average, $p<0.01$), the amount of native grass was higher in the pasture-sufficient period than in the other periods (3.2 kg/day vs. 0.4 kg/day, on an average, $p<0.01$). Despite a small feeding amount, corn stover and wheat straw were supplied occasionally in villages A and B, respectively. Wheat bran was fed as a main supplemental feed throughout the survey in both villages. Although the various supplemental resources, such as wheat bran, corn flour, rice polish, mustard oil cake and commercial feed, were used in village A, only wheat bran and commercial feed were supplied in village B. The rate of roughage to supplements in the feed for cattle and buffalo were higher in

Table 2. Concentrations of crude protein (CP), neutral detergent fiber (NDF) and estimated total digestible nutrient (TDN) of feed resources for cattle and buffalo (% on a dry matter basis)

	Nov. 2002			Mar. 2003			Aug. 2003		
	CP	NDF	TDN	CP	NDF	TDN	CP	NDF	TDN
Village A									
Rice straw	2.6 (10)	73.9 (10)	44.8 (10)	3.5 (10)	78.0 (10)	42.6 (10)	1.7 (6)	75.1 (6)	45.6 (6)
Native grass	-	-	-	24.5 (3)	46.0 (3)	73.9 (3)	10.1 (4)	67.1 (4)	59.6 (4)
Corn stover	-	-	-	-	-	-	4.4 (3)	81.3 (3)	49.9 (3)
Wheat bran	16.2 (10)	39.1 (10)	76.3 (10)	17.3 (10)	43.0 (10)	76.1 (10)	15.8 (2)	39.3 (2)	76.4 (2)
Corn flour	9.2 (1)	26.5 (1)	79.6 (1)	-	-	-	10.2 (5)	35.2 (5)	80.3 (5)
Rice polish	9.6 (2)	40.7 (2)	77.6 (2)	-	-	-	-	-	-
Mustard oil cake	35.3 (3)	23.6 (3)	71.9 (3)	38.7 (4)	22.6 (4)	71.3 (4)	35.1 (4)	23.1 (4)	71.3 (4)
Commercial feed	22.6 (4)	29.6 (4)	76.9 (4)	28.3 (3)	38.2 (3)	76.0 (3)	19.1 (1)	28.5 (1)	76.4 (1)
Village B									
Rice straw	3.2 (8)	74.8 (8)	47.3 (8)	3.1 (10)	76.3 (10)	41.1 (10)	3.2 (10)	79.0 (10)	45.0 (10)
Native grass	-	-	-	-	-	-	13.6 (2)	64.7 (2)	61.2 (2)
Wheat straw	-	-	-	-	-	-	3.8 (3)	84.0 (3)	38.0 (3)
Wheat bran	16.6 (10)	39.9 (10)	76.6 (10)	18.3 (9)	41.1 (9)	76.1 (9)	18.4 (2)	39.4 (2)	76.2 (2)
Commercial feed	19.9 (8)	27.8 (8)	77.0 (8)	21.4 (9)	33.1 (9)	75.9 (9)	14.4 (1)	24.0 (1)	77.1 (1)

Figures in parentheses show sample numbers.

Table 3. Estimated concentrations of crude protein (CP), neutral detergent fiber (NDF) and total digestible nutrient (TDN) in total feed supplied for cattle and buffalo (% on a dry matter basis)

	Times	n	CP	NDF	TDN
Cattle					
Village A	Jun. 2002	16	$10.4\pm0.9^{a,e}$	63.9 ± 3.2^{c}	61.2 ± 2.0^{a}
	Sep. 2002	22	$8.0\pm1.6^{ab,e}$	64.5 ± 2.3^{c}	57.4 ± 2.8^{b}
	Dec. 2002	22	5.6 ± 1.5^{c}	65.7 ± 2.3^{b}	51.9 ± 2.3^{c}
	Mar. 2003	23	$7.4\pm2.3^{b,f}$	69.9 ± 3.8^{a}	50.1 ± 3.7^{d}
Village B	Jun. 2002	24	11.3 ± 2.6^{a}	57.1 ± 6.7^{c}	61.7 ± 5.3^{a}
	Sep. 2002	25	7.3 ± 0.8^{c}	65.4 ± 2.8^{a}	54.3 ± 2.0^{b}
	Dec. 2002	22	7.5 ± 0.7^{c}	61.8 ± 2.3^{b}	54.6 ± 1.6^{b}
	Mar. 2003	25	8.4 ± 0.6^{b}	62.5 ± 1.8^{b}	51.3 ± 1.2^{c}
Significance					
Time			**	**	**
Village			**	**	NS
Time×village			*	**	**
Buffalo					
Village A	Jun. 2002	5	9.6 ± 1.1^{a}	$66.7\pm3.2^{b,e}$	59.4 ± 2.2^{a}
	Sep. 2002	3	$5.3\pm0.9^{b,e}$	$69.5\pm1.9^{ab,d}$	52.1 ± 1.6^{b}
	Dec. 2002	3	$4.3\pm0.8^{b,f}$	$69.8\pm1.0^{a,d}$	47.7 ± 2.3^{d}
	Mar. 2003	3	$5.4\pm1.5^{b,e}$	$71.0\pm1.7^{a,d}$	48.7 ± 2.4^{c}
Village B	Jun. 2002	0	-	-	-
	Sep. 2002	1	8.9	61.7	57.2
	Dec. 2002	2	9.0 ± 0.1	59.6 ± 0.4	58.4 ± 0.3
	Mar. 2003	2	9.2 ± 0.3	62.5 ± 0.9	53.5 ± 0.7
Significance					
Time			**	NS	**
Village			**	**	*
Time×village			**	NS	**

Mean±SD. Means within the same column in each village with different superscripts significantly differ ([a, b, c, d] $p<0.01$, [e, f] $p<0.05$).
** $p<0.01$, * $p<0.05$ and NS: not significant.

village A than in village B (5.0 vs. 2.2 and 9.3 vs. 1.8, respectively on an average, $p<0.01$). In village A, the roughage-supplements rate in the feed for buffalo was higher than that for cattle (7.3 vs. 3.5, on an average, $p<0.01$).

Concentrations of CP, NDF and estimated TDN in feed resources for the cattle and buffalo are presented in Table 2. Native grass had the highest concentrations of CP and TDN, and the lowest NDF content among the roughage resources (15.5%, 64.0% and 60.6%, on an average, respectively).

Table 4. Parity, body condition score (BCS), heart girth (HG, cm), bodyweight (BW, kg), lactation days (LD) and milk yield (MY, liter/day) of cattle and buffalo

	Times	Parity	BCS	HG	BW	LD	MY
Cattle							
Village A	Jun. 2002	2.8±1.8 (16)	2.57±0.35 (7)	158±10 (7)	310±51 (7)	169±157[b,cd] (16)	7.1±3.0[a] (16)
	Sep. 2002	3.1±1.8 (22)	2.50±0.22 (9)	156±10 (9)	299±54 (9)	133±115[b,d] (22)	7.4±2.2[a] (22)
	Dec. 2002	3.2±1.8 (20)	2.50±0.24 (10)	155±9 (10)	294±47 (10)	172±78[b,c] (21)	5.4±1.6[b] (22)
	Mar. 2003	3.0±1.7 (22)	2.47±0.15 (9)	156±9 (9)	298±46 (9)	307±120[a] (23)	5.1±2.6[b] (23)
Village B	Jun. 2002	2.8±1.8[b] (24)	2.92±0.78 (24)	168±10[b,d] (24)	356±50[b,d] (24)	164±84 (23)	9.2±3.1[a,c] (24)
	Sep. 2002	3.2±1.8[ab] (25)	2.74±0.65 (25)	169±10[ab,d] (25)	365±49[ab,d] (25)	177±92 (25)	7.7±2.8[b] (25)
	Dec. 2002	3.3±1.7[ab] (22)	2.89±0.81 (22)	170±9[ab,cd] (22)	370±45[ab,cd] (22)	186±100 (22)	7.5±2.4[b] (22)
	Mar. 2003	3.5±1.8[a] (24)	2.93±0.81 (24)	173±10[a,c] (24)	381±48[a,c] (24)	179±112 (25)	8.2±2.5[ab,d] (25)
Significance							
Time		NS	NS	NS	NS	**	**
Village		NS	**	**	**	NS	**
Time×village		NS	NS	NS	NS	**	NS
Buffalo							
Village A	Jun. 2002	3.5±1.3 (4)	2.83±0.52 (3)	184±2 (3)	421±7 (3)	220±72 (5)	4.0±1.5[cd] (5)
	Sep. 2002	4.0±1.4 (2)	2.83±0.52 (3)	188±6 (3)	441±24 (3)	267±49 (3)	3.8±2.1[cd] (3)
	Dec. 2002	4.5±0.7 (2)	2.50 (1)	190 (1)	449 (1)	222±190 (3)	2.2±1.2[d] (3)
	Mar. 2003	4.0±1.4 (2)	3.00±0.35 (2)	182±3 (2)	413±13 (2)	202±179 (3)	4.5±3.8[c] (3)
Village B	Jun. 2002	-	-	-	-	-	-
	Sep. 2002	2 (1)	4.00 (1)	215 (1)	529 (1)	49 (1)	9.5 (1)
	Dec. 2002	2.5±0.7 (2)	4.00±0.00 (2)	215±4 (2)	529±10 (2)	113±37 (2)	7.6±0.1 (2)
	Mar. 2003	2.5±0.7 (2)	4.00±0.00 (2)	218±4 (2)	535±8 (2)	136±71 (2)	7.0±0.4 (2)
Significance							
Time		NS	NS	**	**	NS	NS
Village		NS	**	**	**	NS	**
Time×village		NS	NS	NS	NS	NS	NS

Mean±SD. Means within the same column in each village with different superscripts significantly differ ([a, b] p<0.01; [c, d] p<0.05).
** p<0.01 and NS: not significant. Figures in parentheses show sample numbers.

Mustard oil cake had the highest concentration of CP, and the lowest NDF content among the supplements (36.4% and 23.1%, on an average, respectively). The highest concentration of TDN among the supplements was in corn flour (80.0% on an average). Wheat bran and commercial feed had higher concentrations of CP (17.1% and 21.0%, on an average, respectively) than corn flour and rice polish (9.7% and 9.6%, on an average, respectively). Rice straw in village A and commercial feed in both villages had the lowest CP content in August. Native grass in village A had lower concentrations of CP and TDN, and higher NDF content in August than those in March.

Estimated concentrations of CP, NDF and TDN in total feed supplied for the cattle and buffalo are presented in Table 3. For cattle, the highest concentrations of CP and TDN, and the lowest NDF content were found in June in both villages. The lowest concentrations of CP and TDN for cattle were respectively in December and March in both villages. The concentration of CP supplied was lower in village A than in village B (7.5% vs. 8.7%, on an average, p<0.01). The content of NDF supplied was higher in village A than in village B (66.7% vs. 61.7%, on an average, p<0.01). No significant difference of TDN feeding between village A and B was obtained. For buffalo, the similar variance of supply for the cattle was observed in village A.

Parity, BCS, HG, BW, lactation days and MY of the cattle and buffalo are presented in Table 4. Neither cattle nor buffalo had significant difference of parity among the survey times and between the villages. The BCS, HG and BW of cattle were lower in village A than in village B (2.51 vs. 2.86, 156 cm vs. 170 cm and 300 kg vs. 318 kg, on an average, respectively, p<0.01). The corresponding values of buffalo in village A were also lower than those in village B (2.83 vs. 4.00, 186 cm vs. 216 cm and 429 kg vs. 531 kg, on an average, respectively, p<0.01). The BCS, HG and BW in cattle were lower than those in buffalo (2.77 vs. 3.25 [p<0.05], 166 cm vs. 196 cm [p<0.01] and 349 kg vs. 466 kg [p<0.01], on an average, respectively). The lactation days of cattle in June and September tended to be shorter than those in the other periods in both villages. The cattle in both villages yielded more milk in June than in December and March (p<0.01). The MYs of cattle and buffalo were lower in village A than in village B (6.2 liters/day vs. 8.1 liters/day and 3.7 liters/day vs. 7.7 liters/day, on an average, respectively, p<0.01).

Plasma metabolite concentrations of the cattle and

Table 5. Plasma metabolite concentrations of cattle and buffalo

	Times	n	TP	AL	GLO	BUN	GLU	TC	NEFA	BHB[1]
Cattle										
Village A	Dec. 2002	23	6.7±0.5^{b}	3.2±0.3	3.5±0.6^{ab,e}	5.3±3.1^{b}	50±6^{a}	199±44^{a}	0.20±0.05	0.47±0.10
	Apr. 2003	19	7.0±0.7^{a}	3.2±0.3	3.8±0.9^{a,d}	10.6±4.4^{a}	50±7^{a}	156±30^{b}	0.16±0.16	0.53±0.35
	Aug. 2003	14	6.6±0.7^{b}	3.3±0.3	3.3±0.8^{b,e}	6.2±3.5^{b}	46±4^{b}	158±44^{b}	0.17±0.12	0.54±0.23
Village B	Dec. 2002	26	6.8±0.5^{b,e}	3.5±0.3^{a}	3.3±0.5^{b}	10.0±4.4	52±5^{a,d}	207±46^{a}	0.19±0.06^{ab,e}	0.54±0.17
	Apr. 2003	29	7.1±0.5^{a,d}	3.4±0.3^{b}	3.7±0.5^{a}	10.3±6.1	49±5^{b,e}	167±42^{b}	0.14±0.10^{b,f}	0.50±0.15
	Aug. 2003	27	7.0±0.7^{ab,d}	3.3±0.2^{c}	3.7±0.7^{a}	10.2±4.8	51±7^{ab,d}	132±45^{c}	0.24±0.21^{a,d}	0.57±0.33
Significance										
Time			*	NS	*	NS	NS	**	NS	NS
Village			NS	**	NS	*	NS	NS	NS	NS
Time×village			NS	*	NS	NS	NS	NS	NS	NS
Buffalo										
Village A	Dec. 2002	5	6.8±0.5^{e}	3.6±0.4	3.2±0.3^{b,e}	4.5±3.2^{b,e}	57±6	84±14	0.26±0.11	0.44±0.08^{a}
	Apr. 2003	5	7.6±0.6^{d}	3.3±0.3	4.3±0.8^{a,d}	10.9±5.1^{a,d}	57±6	98±37	0.19±0.11	0.49±0.13^{a}
	Aug. 2003	4	7.3±0.9^{de}	3.6±0.3	3.7±0.9^{ab,e}	8.7±2.9^{ab,d}	56±11	108±34	0.18±0.10	0.79±0.09^{b}
Village B	Dec. 2002	0	-	-	-	-	-	-	-	-
	Apr. 2003	2	6.9±0.1	3.5±0.1	3.4±0.0	10.2±0.6	62±11	81±8	0.14±0.04	-
	Aug. 2003	0	-	-	-	-	-	-	-	-
Significance										
Time			NS	NS	NS	NS	NS	NS	NS	**
Village			NS	NS	NS	NS	NS	NS	NS	-
Time×village			NS	NS	NS	NS	NS	NS	NS	-

Mean±SD. Means within the same column in each village with different superscripts significantly differ ($^{a, b, c}$ $p<0.01$, $^{d, e, f}$ $p<0.05$).

TP: total protein (g/dl), AL: albumin (g/dl), GLO: globulin (g/dl), BUN: urea nitrogen (mg/dl), GLU: glucose (mg/dl).

TC: total cholesterol (mg/dl), NEFA: non-esterified fatty acid (mEq/l) and BHB: β-hydroxybutyrate (mmol/l).

** p<0.01, * p<0.05 and NS: not significant.

[1] The number of observation used in Dec., Apr. and Aug. were 19, 17 and 11 in village A, 25, 25 and 16 in village B for cattle, and 5, 2 and 2 for buffalo, respectively.

buffalo are presented in Table 5. The concentrations of total protein and globulin in cattle were highest in April in both villages (p<0.05). The cattle in village A showed the highest BUN content in April (p<0.01). The buffalo in village A also showed the highest contents of total protein (p<0.05), globulin (p<0.05) and BUN (p<0.01) in April. The concentrations of albumin and BUN in cattle were lower in village A than in village B (3.2 g/dl vs. 3.4 g/dl [p<0.01] and 7.3 mg/dl vs. 10.1 mg/dl [p<0.05], on an average, respectively). Total cholesterol content of cattle was higher in December than in the other periods (p<0.01). The concentration of total cholesterol was higher in cattle than in buffalo (171 mg/dl vs. 99 mg/dl, on an average, p<0.01).

Effects of calving period, parity, breed and village on 305-day MY of the cattle and buffalo are presented in Table 6. The 305-day MY of cattle that calved from March to May was lower than that of cattle that calved in the other periods (p<0.01). The cattle above the fourth lactation had higher 305-day MY than those below the fourth. The Holstein-cross and Murrah-cross produced more milk than the other breeds of cattle and buffalo (p<0.05). The cattle in village B showed higher 305-day MY than those in village A (p<0.01).

A positive correlation coefficient between 305-day MY and BW were observed in cattle (r = 0.59, p<0.01). The following regression equation to estimate 305-day MY of cattle was developed by selecting BW, village B, parity and Jersey-cross breed as independent valuables in order;

$$\text{305-day MY} = 1.89\times\text{BW}+504.35\times\text{village B}+118.96\times\text{parity}-381.03\times\text{Jersey-cross breed}+1227.45$$

(R^2 = 0.62, SEE = 347.0, BW: (kg), village B and Jersey -cross breed: dummy values)

DISCUSSION

A plentiful amount of rice straw was utilized as the main diet for the lactating cattle and buffalo, especially when it was in the pasture-decreasing and fodder-shortage periods, because rice was harvested twice a year, in June and November, in both villages (Table 1). Native grass was used as the major roughage resource in the pasture-sufficient period due to the presence of the grass with higher temperature and more rainfall in this period. Thus, the feeding amount of rice straw was probably controlled by the availability of the other roughage resources. Wheat bran was used as the main supplemental feed throughout the survey in both villages. Additional resources, such as corn stover, wheat straw, corn flour, rice polish, mustard oil cake and commercial feed, were probably supplied occasionally

Table 6. Effects of calving period, parity, breed and village on 305-day milk yield of cattle and buffalo (liter)

Source	Cattle	Buffalo
Calving period		
Jun. - Oct.	2,252±468[a] (29)	1,628±752 (4)
Nov. - Feb.	2,249±710[a] (5)	1,365±219 (3)
Mar. - May	1,900±353[b] (9)	1,733 (1)
Parity		
1	2,042±604[b,d] (10)	-
2	2,141±540[ab,d] (14)	2,301 (1)
3-4	2,132±302[ab,d] (7)	2,253 (1)
5-6	2,382±443[a,c] (10)	1,176±357 (2)
Breed		
Holstein-cross	2,604±243[c] (6)	-
Jersey-cross	2,108±485[d] (37)	-
Murrah-cross	-	1,852±403[c] (5)
Local	-	1,026±99[d] (3)
Village		
A	1,935±417[a] (21)	1,350±326 (5)
B	2,409±444[b] (22)	1,863±719 (3)

Mean±SD. Means within the same source in each species of animals with different superscripts significantly differ ([a, b] $p<0.01$; [c, d] $p<0.05$). Figures in parentheses show sample numbers.

when they were available. Fodder trees and a homemade concentrate mixture, locally known as *kundo* that was common in some areas in Nepal, were not utilized in the survey area.

The feed constituent was different among the pasture-sufficient, pasture-decreasing and fodder-shortage periods (Table 1). The variance induced different supplies of CP, NDF and TDN (Table 3). The supplies of CP and TDN were likely to be higher in the pasture-sufficient period than the other periods. This can be attributed to the higher availability of native grass and wheat bran in the pasture-sufficient period than in the other periods. However, the supplies of CP and TDN for cattle were lower than the requirements (13% CP and 63% TDN in diet on a DM basis for lactating cattle with BW less than 400 kg and daily MY less than 8 liters, NRC, 1989) throughout the survey. These low nutrient intakes were likely to affect the lower concentrations of plasma total protein and BUN in cattle of village A than the normal ranges (6.8-8.6 g/dl in total protein and 8-23 mg/dl in BUN, Whitaker et al., 1995, Table 5).

Two reasons were considered for the higher MY of cattle in the pasture-sufficient period. Firstly, the supplies of CP and TDN were higher, and secondly, 67.4% of the total cows were in an early lactation stage in this period. On the other hand, the 305-day MY of cattle that calved in the fodder-shortage period was significantly lower than that of cattle that calved in the other periods (Table 6). Since most of the cows that calved in the fodder-shortage period had lactation peaks in the same period, the lower supplies of CP and TDN were considered to have caused the lower 305-day MY.

The variance of feed constituent between village A and B probably resulted in the different supplies of CP and NDF (Tables 1 and 3). The lower supply of CP in village A probably led to the lower nutrient trait in this village than village B. Concentrations of plasma albumin can be affected by a dietary protein supply (Whitaker et al., 1999). The lower contents of the albumin in village A supported the difference of nutrient condition between the villages. Consequently, the BCS, HG, BW and MY of cattle in village A were significantly lower than those in village B. In the multiple regression equation for estimating the 305-day MY in cattle, the difference between the villages was chosen as a second independent variable followed by BW. Since animal factors, such as parity and breed, were selected as the other independent variables, some environmental factors, such as the traits of nutrient supply in the villages, were considered to affect the 305-day MY.

Even in the cases of buffalo, the variance of feed constituent among the three periods caused the difference of nutrient supply (Tables 1 and 3). The supply changes of CP, NDF and TDN for buffalo were similar to the cases of cattle. The daily requirement of NDF for buffalo was reported in the following equation:

$$\text{NDF (g/day)} = 8{,}864.3-198.92\times\text{MY}$$

(Bartocci et al., 2002)

The corresponding TDN for lactating buffalo was 35.3 g/kg $BW^{0.75}$ for maintenance, and 406 g/kg for 1 kg milk of 6% fat (Paul et al., 2002). The NDF and TDN supplies for buffalo were higher than the requirements in village A (10.0 kg vs. 8.1 kg and 7.5 kg vs. 4.8 kg, on an average, respectively). The daily requirement of CP for lactating buffalo was 5.4 g/kg $BW^{0.75}$ for maintenance, and 90.3 g/kg for 1 kg milk of 6% fat (Paul et al., 2002). The supplied amount of CP for buffalo in June in village A was higher than the requirement (1,344 g vs. 863 g on an average). However, the CP supplies in September, December and March were lower than the requirements (731 g vs. 863 g, 641 g vs. 725 g and 805 g vs. 901 g, on an average, respectively). Thus, the CP intake of buffalo was probably lower than the requirement in the periods, except in the first half of the pasture-sufficient period. This low CP intake possibly has caused the lower concentration of BUN in buffalo in village A than the normal range (10-30 mg/dl, Patel et al., 1971, Table 5). Given the small number of buffaloes used in this survey, the significant effects on MY in buffaloes were difficult to identify. The buffaloes were considered to have ingested more amount of roughage, such as rice straw, than cattle. Ranjhan (1992) reported that buffalo had a higher efficiency of roughage utilization than cattle.

The 305-day MY was significantly higher in the cattle than the buffalo (2,178 liters vs. 1,542 liters, on an average, $p<0.01$), though the cattle was physically smaller, and ingested less amounts of feed than the buffalo (Tables 1, 4 and 6). Thus, the efficiency of milk production was considered to have been higher in the cattle than in the buffalo in the survey area. Besides, cattle might be utilized as a major dairy animal in the surveyed area.

The concentration of plasma total cholesterol was higher in cattle than in buffalo ($p<0.01$), though similar feed constituents were supplied to both the animal species. Barraza et al. (1991) reported that the addition of whole cottonseed to the diet of lactating cows significantly increased the concentrations of plasma cholesterol. In contrast, Ferguson et al. (1990) reported that plasma cholesterol content was not affected by the addition of fat to the diet of lactating cows. The exact reason for the higher concentration of plasma cholesterol in cattle in the survey was unclear. Whitaker et al. (1995) reported that the BHB concentration was used as a measure of energy balance and the content more than 0.6 mmol/l was the outside reference range for pre-calving dairy cows. Although the average contents of plasma BHB contents in cattle were in normal range, nine or ten cows with the higher values than 0.6 mmol/l were observed in every collection period. Those cows had higher parity, HG and BW than the average in each data collection period (4.2, 161 cm and 324 kg in village A, and 5.2, 175 cm and 395 kg in village B, on an average, respectively). Thus, the cattle above the forth lactation with large body size might have been liability in negative energy balance.

In conclusion, the periods divided by the environments of pasture and fodder caused the variance of feed constituent. The variance induced the difference in supplies of CP, NDF and TDN, and consequently affected the physical traits and milk production in cattle. Additionally, the tendency of parturition changed the cattle MY in each period, and the calving period affected the cattle 305-day MY. Since the lower nutrient feeding was observed in the survey, the nutrient supply of CP in particular should receive further attention. There is also a need to study and review how management skills affect the traits of lactating cattle and buffalo.

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REFERENCES

AICC. 2003. Agriculture Information and Communication Center. Ministry of Agriculture, Kathmandu, Nepal.

AOAC. 1990. Official Methods of Analysis. 15th edn. Association of Official Analytical Chemist, Arlington, Virginia.

Barraza, M. L., C. E. Coppock, K. N. Brooks, D. L. Wilks, R. G. Saunders and G. W. Jr. Latimar. 1991. Iron sulfate and feed pelleting to detoxify free gossypol in cottonseed diets for dairy cattle. J. Dairy Sci. 74:3457-3467.

Bartocci, S., C. Tripaldi and S. Terramoccia. 2002. Characteristics of foodstuffs and diets, and the quanti-qualitative milk parameters of Mediterranean buffaloes bred in Italy using the intensive system. An estimate of the nutritional requirements of buffalo herds lactating or dry. Lives. Prod. Sci. 77:45-58.

Chandler, P. 1990. Energy prediction of feeds by forage testing explored. Feedstuffs 62 (36):12.

Duncan, D. B. 1955. Multiple range and multiple F test. Biometrics 11:1-42.

FAO. 2004. FAO Statistical Database. Food and Agriculture Organization of the United Nations. [cited 8 March 2005] Available from URL: http://faostat.fao.org/

Ferguson, J. D., D. Sklam, W. V. Chalupa and D. S. Kronfeld. 1990. Effects of hard fats on *in vitro* and *in vivo* rumen fermentation, milk production, and reproduction in dairy cows. J. Dairy Sci. 73:2864-2879.

Ferguson, J. D., D. T. Galligan and N. Thomsen. 1994. Principal descriptors of body condition score in Holstein cows. J. Dairy Sci. 77:2695-2703.

Hayashi, Y., S. Shah, S. K. Shah and H. Kumagai. 2005. Dairy production and nutritional status of lactating buffalo and cattle in small-scale farms in Terai, Nepal. Livestock Research for Rural Development. Vol. 17, Art. #64 Available from URL: http://www.cipav.org.co/lrrd/lrrd17/6haya17064.htm

Karki, U., M. R. Kolakchhapati and N. Paudyal. 1993. Impact of crossbred cows on the economy of small farmers and their performance in Gitanagar village development committee, Chitwan, Nepal. IAAS Research Report (1985-1991), Institute of Agriculture and Animal Science, Rampur, Nepal. pp. 600-608.

Kolachhapati, M. R., M. Sharma and B. K. Karna. 1994. Performance of Murrah crossbred buffaloes in rural areas of Chitwan. IAAS Research Report (1992-1993), Institute of Agriculture and Animal Science, Rampur, Nepal. pp. 143-150.

Kumagai, H., K. L. Maharjan and T. Nakao. 2003. Surveys of age, live weight and heart girth of cattle and buffalo in Chitwan, Nepal. In Proceedings of the 102nd Japanese Society of Animal Science Congress (Jpn). p. 45.

Martin, N. 1985. Agricultural extension service, no. 2637. University of Minnesota, Minneapolis, Minnesota.

NRC. 1989. Nutrient Requirements of Dairy Cattle. 6th edn. National Research Council, Nutrient requirements of domestic animals, no. 3. National Academic Press, Washington, DC. pp. 138-147.

Pant, S. S., N. P. Joshi and K. P. Gajurel. 1994. Feeding practices for lactating buffaloes in Saradanagar village, Chitwan. IAAS Research Report (1992-1993), Institute of Agriculture and Animal Science, Rampur, Nepal. pp. 116-126.

Patel, B. M. and S. L. Anaokar. 1971. Effect of feeding urea on the levels of true protein, NPN in the blood of cow and buffalo calves. Indian Vet. J. 48:278.

Paul, S. S., B. M. Asit and N. P. Nitya. 2002. Feeding standards for lactating riverrine buffaloes in tropical conditions. J. Dairy Research 69:173-180.

Ranjhan, S. K. 1992. Nutrition of river buffaloes in southern Asia. In Buffalo Production. (Ed. N. M. Tulloh and J. H. G. Holmes). Elsevier Science Publishers, Amsterdam, the Netherlands. pp. 111-134.

Sharma, M., M. Kharel, M. R. Kolachhapati, I. P. Dhakal, N. P. Joshi and K. P. Gajurel. 1994. Comparative performance of local and Murrah buffaloes with their crossbreds under farmers' management in Mangalpur, Chitwan. IAAS Research Report, Institute of Agriculture and Animal Science, Rampur, Nepal. pp. 130-136.

Van Soest, P. J. 1973. Collaborative study of acid detergent fiber and lignin. J. Assoc. Off. Anal. Chem. 56:781-784.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber. Neutral detergent fiber and non-starch polysaccharide in relation to animal nutrition. J. Dairy Sci. 74:3584-3597.

Whitaker, D. A., J. M. Kelly and H. F. Eayres. 1995. Use and interpretation of metabolic profiles in dairy cows. Department of Veterinary Clinic Studies, University of Edinburgh, Midlothian, UK. p. 13.

Whitaker, D. A., W. J. Goodger, M. Garcia, B. M. A. O. Perera and F. Wittwer. 1999. Use of metabolic profiles in dairy cattle in tropical and subtropical countries on smallholder dairy farms. Preventive Vet. Med. 38:119-131.

Wood, P. D. P. 1969. Factors affecting the shape of the lactation curve in cattle. Anim. Prod. 11:307-316.

World Bank, 2004. World Development Indicators Database. The World Bank Group. [cited 8 March 2005] Available from URL: http://devdata.worldbank.org/ data/