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Review

Milking performance of China yak (*Bos grunniens*): A preliminary report

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Yak milk plays a very important role in Tibetan's daily life. Milk and milk products are the major dietary ingredients as well as family incomes of Tibetan herders in China. Yak milk yield and composition are seasonal and affected by the breed, age, parity and body condition of cow, pasture growth and quality, milking time, milking methods and environmental factors. In this paper, milk production and composition of different breeds are documented, and effects of feeding level, milking time, milking method, environmental factors on milking performance are discussed. It is found that Batang yak from Qinghai Province peaks and Jiali yak from Tibet Autonomous Region bottoms milk production, with 487.2 and 147.6 kg fresh milk per lactation respectively. Comparatively, milk of Jiulong yak and Sibu yak has higher dry matter and fat contents, and milk of Tianzhu White yak contains more protein and lactose. Winter supplementation on dams can improve calf production and milk yield of mother yaks in the following warm season. Compared with once-a-day milking, twice-a-day milking stimulates yak female to give about one third more milk, which, however negatively affect the growth of calves. Yak produces less milk at too high temperature with strong solar radiation on clear days, but more milk within short periods of cloudy or rainy time.

Key words: China; yak, breeds, milk performance.

INTRODUCTION

Domestic yaks are found grazing throughout the high elevation areas of the Hindu Kush and Karakoram in Afghanistan and Pakistan, the Himalayas in India, Nepal and Bhutan, the Tibetan Plateau and Tian Shan Mountains of Northern China, Western and Northern Mongolia and also the adjoining areas of Russia and some of the Central Independent States of the former U.S.S.R (Miller, 1996). More yaks live in China than any other countries in the world. Approximately 13 million of these large, high altitude bovines occupy China's rangelands, comprising 92.8 per cent of the gross number of yaks on this planet (Huang, 1996). The yaks are inextricably linked to the lifestyle, culture, and religion of Tibetan people and are the fundamental means of subsistence for Tibetan in harsh areas. Yaks and yak-hybrid crosses provide milk, milk products (butter and milk residues), meat as the important food source, hair and hides as textile and leather materials, and dung as the fuel for Tibetan herders, and they are also used as pack and drought animals and for riding.

Milk and milk products are the major ingredients of daily diets of Tibetan herders, particularly the weak, ill and old people and children in the areas where yaks graze on the alpine meadows and mountain pastures. Owing to shortage of vegetables, yak milk is a vital source of vitamin for Tibetan Herders (Dong et al., 1999). Butter and cheese are two of the major sources of nutrition for Tibetan Herders (Huang, 1996). Milk and their products are used also for many purposes other than food, such as fuel for family lamps by herders and scared lamps by lamas or lubricant assisting hand milking (Cai and Wiener, 1995). With the good market price, milk products contribute greatly to the family income of local herders besides beef, hair and hide (Pu et al., 1997; Lei and Xu, 1997; Dong et al., 1999).

Milk yield of China yak is low and the lactation and milk composition are seasonal and closely related to the

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Table1. Milk yield of yak females of different breeds at various locations.

Localities	Breed	No.	Lactation length (d)	Milk yield per lactation (kg)	Daily milk yield (kg)	Source
Gansu	Tianzhu White	223	135	304.0	2.25	Zhang, 1989
Gansu	Shandan	21	180	464.0	2.57	Zhang, 1989
Gansu	Gannan	13	177	315	1.78	Zhang, 1989
Qinghai	Datong	181	153	214.5	1.40	Zhang, 1989
Qinghai	Batang	91	153	487.2	3.18	Zhang, 1989
Qinghai	Guoluo	20	153	162.1	1.06	Li et al., 2000
Sichuan	Jiulong	72	150	347.0	2.31	Cai et al., 1980
Sichuan	Maiwa	20	150	365.0	2.43	Chen et al., 1981
Tibet	Heihe	19	105	280.8	2.67	Zhang, 1989
Tibet	Jiali	48	180	147.6	0.82	Ji et al., 2000
Tibet	Pali	25	180	199.8	1.11	Ji et al., 2000
Tibet	Sibu	36	180	179.7	0.99	Ji et al., 2000
Xingjiang	Bazhou	23	120	307.2	2.56	Zhang, 1989
Yunnan	Zhongdian	-	120	202-216	1.68	He et al., 1997

breed, age, parity and body condition of cow, pasture growth and quality, milking time, milking methods and environmental factors (Zhang, 1989; Cai and Wiener, 1995). It is necessary to know what the differences are among various yak breeds in different raising areas in China. As a sequence, this paper provides some basic information about milking performances of China yaks under different influencing factors.

Breeds

Two main types of domestic yak are recognised in China (Zhang, 1989; Cai, 1992; Cai and Wiener, 1995), that is, the Qinghai-Tibet Plateau type ('Plateau' or 'Grassland' type) and the Henduan Alpine type ('Alpine' or 'Valley' type). There are at least three generally recognised breeds of the Plateau type - Qinghai Plateau, Maiwa (of Sichuan Province) and Tianzhu White (of Gansu Province) - and two main recognised breeds of the Alpine type - Alpine yak of Tibet and Jiulong yak of Sichuan province. Several other breeds or strains are, however, recognised and named in different localities but not necessarily ascribed to a 'type'. There is, at present, no breed or strain of yak developed especially for milk production. All breeds are kept more or less to produce milk in addition to their other uses and products.

Breeds at different localities differ greatly from each other in the milk yield. The amount of milk produced by the yak cow is considered as no more than the amount needed for the normal growth and development of its calf. When considering estimates of the milk yield of yak, milk consumed by the calf has to be taken into account - which can only be estimated - and the quantity harvested by the herders. The estimated milk yield shows that Batang yak from Qinghai Province peaks but Jiali yak from Tibet Autonomous Region bottoms the milk production among all the breeds recorded by literatures, 487.2 and 147.6 kg fresh milk per lactation respectively (Table 1). As Lactation length, precisely the milking period, differs significantly within different localities, daily milk yield is more meaningful in predicting milking abilities of yak females. Averagely, daily milk yield of yak cow ranges from 1 to 2.5 kg, and the yield of the breeds of Plateau type are slightly higher than that of the breeds of Alpine type. Assuming calving interval of yak cow is 540 days (roughly, yak cow gives 2 calves every 3 years), yearly milk production of lactating yak shifts from 100 to 325 kg. As for difference of milk yield, other factors including pasture growth and quality, climatic conditions, milking methods (once-daily milking or twice-daily milking) and grazing management are rather closely associated with the breed.

Milk composition also varies among different breeds, which may be greatly attributed to different chemical composition and feeding value of forages from the swards of grazing lands (it is generally accepted that the quality of forage from pastures of Jiulong areas is better than that from the pastures of other areas). Generally, the Alpine type, like Jiulong yak and Sibu yak, give milk richer in dry matter and fat contents, the Plateau type, like Tianzhu White yak produces milk richer in protein and lactose contents (Table 2). Comparatively, dry matter and fat contents in the milk of yak is higher than that in the milk of Frisian dairy cattle, China yellow cattle, and yak-cattle crosses, but close to that in the milk of the Buffalo (Table 2).

Milking time

Milking time, here, includes age, parity of yak females and lactation period (lactation month and year). Although milk yield of yak increases with the age of the female and

Table 2. Milk composition of different breeds of China yaks.

Breed	No.	Drymatter (%)	Fat (%)	Protein(%)	Lactose (%)	Ash (%)	E/N* ratio	Source
Tianzhu White	15	16.91±0.68	5.45±0.64	5.24±0.38	5.41±0.56	0.77±0.05	0.78:1	Zhang, 1989
Jiulong	40	17.76±0.72	7.23±0.52	4.85±0.73	4.71±0.64	0.79±0.07	-	Zhong et al.,1996
Maiwa	39	17.51±0.92	6.34±0.63	4.92±0.49	5.43±0.62	0.82±0.06	0.70:1	Chen et al., 1981
Jiali	48	16.26±0.73	6.75±0.55	5.01±0.59	3.56±0.32	0.95±0.02	0.79:1	Ji et al., 2000
Pali	25	16.32±0.44	5.95±0.36	5.73±0.53	3.77±0.28	-	0.64:1	Ji et al., 2000
Sibu	36	17.11±0.36	7.50±0.55	5.27±0.13	3.49±0.31	-	0.72:1	Ji et al., 2000
Crosses	-	14.95	5.31	3.99	4.88	0.69	-	Zhang, 1989
Yellow cattle	-	12.75	3.90	3.40	4.75	0.70	-	Zhang, 1989
Frisian	-	12.00	3.45	2.79	4.97	0.79	-	Zhang, 1989
Buffalo	-	17.96	7.60	4.36	4.83	1.17	-	Zhang, 1989

*E/N means ratio between essential amino acid and non-essential amino acid.

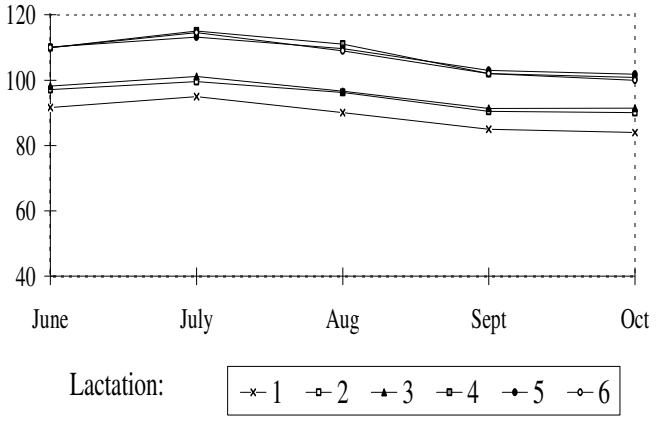

Figure 1. Milk yield (kg) of yak females in 5 (warm) months of the year in 6 separate lactations (Source: Cai and Wiener, 1995). (Number females per lactation: 1:20;

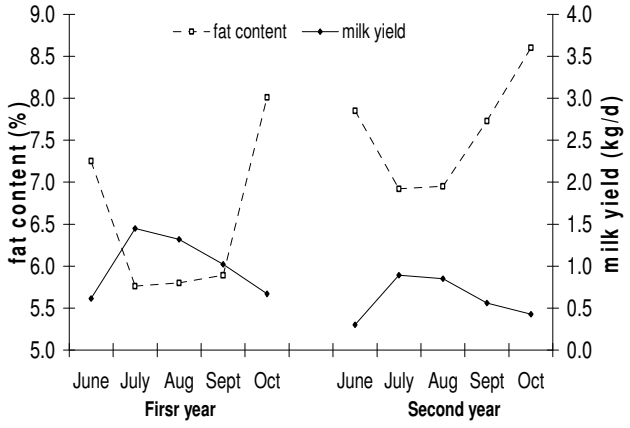

Figure 2. Relationship between milk yield and fat content (Source: Cai, 1989) (Number of females: 25) 2:20; 3:13; 4:10; 5:10; 6:18)

the number of calving old (Normally first calving of yak female occurs at 3 - 4 years old, and the last ends at 11-12 years old), as well as with the associated effects of these two factors (Zhang et al., 1983; Xu et al., 1983), there is no much difference of milk yield between 4, 5, and 6 lactation periods (Figure 1). No strong evidence is available to show whether yak cows have a lactation peak in relation to calving date - as in dairy cattle; and an over-riding effect on milk yield in the yak seems to be that of pasture growth, reflected by month in Figures 1 and 2. All lactating yaks, irrespective of age, parity, or breed type, and even location, tend to peak in yield in July and August when grass is at its best in terms of quality and quantity (Cai and Wiener, 1995). Female yaks can still produce milk in harsh winter, but the herders do not milk them in order to keep them and their calves healthy. Non-pregnant yak females with 1-year-old calves can produce milk in the second year of calving, though their milk yield is 1/2 or 1/3 to that in the first year of calving, and also peaks in July and August (Figure 2). These females are thus called “half-lactation cows” by local herders (the lactating yaks in the year of calving are normally called “full-lactation cows”).

Fat content in yak milk is negatively correlated to the milk yield (Cai, 1989; Zhang, 1989). Milk fat increases as the milk yield declines with the progress of the lactation month (Figure 2 and Table 3). Milk protein and lactose increase at the early lactation, peak at the mid lactation and drop at the late lactation (Table 3). This variation may result from the seasonal changes of the chemical composition of grazing swards. Long et al. (1999a) reported that increasing age at harvesting led to significant decrease in nitrogen ($P<0.01$) and increase in neutral detergent fibre (NDF) contents of native Tibetan forages ($P<0.05$). 48h *in vitro* dry matter degradability decreased with increasing maturity of the Tibetan forages ($P<0.05$). The increased fibre (also shown in Table 4), after being fermented in the rumen, can produce more volatile fatty acids, such as acetic acid and butyric acid, the fat content in yak milk increased correspondingly (Zhang, 1989).

Table 3. Milk composition of 10 Tianzhu White yak in 3 lactation periods (Source: Zhang and Pu, 1986).

Lactation period	Dry matter (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
Early lactation (12th, June)	16.06	5.11	5.24	4.88	0.79
Mid lactation (25th, July)	17.77	5.44	5.68	5.86	0.75
Late Lactation (20th, Sept.)	16.31	5.77	4.71	5.02	0.77

Table 4. Chemical composition of fresh grass on the meadow in different months over the warm season (source: Grassland Institute of Sichuan Province, 1982).

Date	Dry Matter	Crude Protein	Crude fibre	Ash	N-free extract	Calcium	Phosphorus
June,9	24	4.50	6.70	1.20	10.50	0.12	0.06
June, 30	28	3.29	8.37	1.43	13.64	0.12	0.07
July, 30	33	4.06	9.11	2.01	16.76	0.14	0.11
Aug., 30	38	3.88	11.67	3.11	18.15	0.23	0.10
Sept., 29	42	3.36	13.99	2.44	21.20	0.26	0.06
Oct., 31	62	2.98	21.58	3.10	33.16	0.33	0.10

Table 5. Milk performance and body weight change of Maiwa yak under different feeding strategies over 180 days in winter (source: Wen et al., 1993).

Year	Treatment Group	No. of cows	Milk yield(kg)		Fat %		No. of cows	Weight loss(kg)	
			mean	SD	mean	SD		mean	SD
1989/90	Hay**	54	229.0	53.3	6.0	1.3	58	33.5	14.8
	Paddock grass***	55	220.6	54.7	5.8	1.6	58	34.5	15.5
	Control****	113	218.3	49.9	5.4	1.6	110	35.5	14.5
1990/91	Hay	50	235.4	53.6	5.9	1.3	59	39.9	18.0
	Control	137	224.1	47.6	5.4	1.2	150	42.7	17.4

The estimated milk yield is derived from measured amounts milked three times per month and does not include, as far as is known, milk sucked by the calves; ** Hay, fed hay from mid-December to the end of April; *** Paddock grass, allowed access to conserved grass paddocks from 1 April for 45 days; **** Control, unsupplemented

Feeding level

As grazing animals, yaks feed themselves on the native forages all year round without any supplementation, or in some cases with small amounts of oat supplementation for the lactating yaks in harsh winter. Table 4 provides the information on the composition of native forages from samples taken on grazing lands of yaks at an elevation of 3,600 m (alpine region) in Hongyuan County of Sichuan Province. From early June to middle September, the "golden age" for yak production in alpine region, lactating yaks can meet their requirement for dietary nutrients from grazing swards, and they thus achieve most of their lactation during this period. From October to the following May, with the declining of native forages both in quantity and quality, the yaks face up to food deficiency. And they give milk to their calves at the cost of decreasing body condition or losing body weight. The imbalance between feed supply and animal requirement in winter is a main limit hindering milk production of yak in alpine region.

Supplementary feeding may improve the body condition of yak cows in winter and lead to improved calf production, reproductive rate, and milk yield in the following warm season. The supplementary experiment on Maiwa yak conducted at Longri farm in Sichuan Province should be seen in that context (Table 5). It can be seen from the result of this experiment that supplementary feeding had small but positive effects on milk yield of yak in the following warn season ($P<0.01$) and, unexpectedly because of the increase in milk yield, there was also an increase in the fat percentage of the milk by approximately 0.5% (from below 5.5% to nearly 6.0%) ($P<0.05$). The cows given supplements lost slightly less weight over winter than the unsupplemented controls ($P<0.05$).

Milking method

Only is hand milking existing in yak-raising areas of China. Milking takes place at the campsites of the herders. If the calf is tethered the cow will be tethered up too, but not if the calf is kept in a closed corral. The cows that are not tethered usually graze all day and yield more milk than those tied up for the day.

Table 6. Live-weight gain of calves in summer under different calf rearing methods.

Age (month)	Sex	Not milked		Milked once daily		Milked twice daily	
		Live weight (kg)	Daily gain (g)	Live weight (kg)	Daily gain (g)	Live weight (kg)	Daily gain (g)
Birth	Male	16.3	-	15.5	-	16.3	-
	Female	16.4	-	16.2	-	15.8	-
6	Male	117.2	560.6	102.4	482.8	57.3	227.8
	Female	112.9	536.1	98.8	458.9	54.0	212.2
12	Male	142.0	349.2	118.6	286.4	87.6	198.1
	Female	127.4	308.3	110.5	261.9	85.7	194.2
18	Male	255.5	442.9	231.6	400.2	164.4	274.3
	Female	222.5	381.6	213.3	365.0	154.8	257.4

(Source: Zhang, 1989).

Yak female gives about one third more milk, in total, if stimulated by milking twice daily compared with once-a-day milking as the calf takes about one third of the available milk if the yak cow is milked twice daily and about half of the available milk once-a-day milking (Cai and Wiener, 1995). However, too much milking on dams can negatively affect the growth of calves. In Table 6, the report (Table 6) from Zhang (1989) shows that daily gain of the calves with the dams milked twice-a-day was significantly lower than that milked once-a-day and not milked ($P<0.01$), and that gain of the calves with the dams milked once-a-day was lower than that not milked ($P<0.05$).

Skillfulness or/and milking speed of milkman also influence milk yield. It was reported that daily milk yield was 2.7 ± 0.22 kg at the milking speed of 146.2 times per minutes, but only 0.75 ± 0.15 kg at 97.8 times per minute (Zhang, 1989). In addition, milking interval contributes to the difference of the milk yield of yak females when they are milked twice-a-day, the average daily milk yield of 55 yak females was about 0.89 ± 0.12 kg per cow at 8 hours milking interval and that of 57 yak females was about 1.25 ± 0.08 kg per cow at 12 hours milking interval (Zhang, 1989).

Also, Zhou (1984) found that supplements of 4 kg silage per yak female per day resulted in a rise of milk output from 150 to 350 g after 7 days of feeding, and to 500 g of milk after 15 days of feeding for yak cow in Sichuan Province. Long et al. (1999b) reported that lactation length of the grazing Tianzhu White yak cows supplemented with oat hay and highland barley straw was significantly higher than that of the animals without supplements ($P<0.01$), but there was no significant difference of lactation length between the cows supplemented with oat hay and those with highland barley straw ($P>0.05$).

Alpine climate

Yaks live on the alpine grassland all year round and have to adapt to extreme coldness, high altitude, low oxygen and high solar radiation. The environmental factors affecting the distribution and production of yaks are altitude, annual temperature, annual precipitation, relative humidity, annual sunshine. In general, temperature is the most important factor determining the distribution and stocking density of yaks, followed by annual precipitation.

In warm season, variable temperature affects the milk yield of yak grazing on pastures. Yak produces less milk at too high temperature with strong solar radiation on clear days, but more milk within short periods of cloudy or rainy time. It has been reported that on pasture of Aba prefecture of Sichuan Province, the average milk yield of 19 yak cows at 9.27°C on the cloudy-to-rainy day of 13th of June was 0.07 kg higher than that at 13.1-13.5°C on the clear days from 8th to 12th of June ($P<0.01$), and the total milk yield of same yak cows at 12.5°C on the day of 21st of June was only 22.54 ± 0.08 kg, but at 8.0 and 6.7 °C on the days of 22nd and 23rd of June was 24.11 ± 0.11 kg and 24.70 ± 0.23 kg respectively (Zhang, 1989). This tendency can be explained that high temperature might prevent cows from producing heat, thus the milk yield dropped with the decreased metabolism. Inversely, low temperature might cool down the cow, so the milk yield goes up with the increased metabolism.

Precipitation can also influence milk yield to some extent. It has been recorded (Xu et al., 1983) in Batang areas of Qinghai Province, the average daily milk yield of 30 yak females was 48.16 ± 1.62, 49.06 ± 1.97 and 51.86 ± 1.63 kg on clear, cloudy and rainy days, and there were significant difference among them ($P<0.01$). However, in Hongyuan County of Sichuan Province, compared with the averages, the precipitation in July of 1961 increased by 26.43%, the fat content in yak milk decreased 7.55% with the increase of yearly milk yield (Zhang, 1989). Decreased temperature caused by raining might be the main contributor to the increased milk yield as above explained

Prospect

With the increasing demand for fresh milk and milk prod-

ucts both in urban and rural areas, free trade on market, good economic policies from Chinese government, yak milk is possessing good economic potential in China. On this basis, the authors would like to stress that milking performance of yak should be improved by minimizing the negative effect of influencing factors through the following options:

- Developing good yak breeds for dairy production or cross-breeds between yak and Simmental, Fresian, and Brown Swiss cattle.
- Improving native pastures through re-seeding, fertilization and introduction of fine grass species with high nutritive values.
- Supplementing lactating yaks with high quality forage, concentration and urea multi-nutrients blocks in harsh winter.
- Milking the cows once-a-day to keep calves and dams health.
- Improving milking methods through training the milkman or machine-milking.
- Housing the milking females under the shed or in the pens on hot days to cool them down. The perspective of yak milk production is bright if all or most of these options are adopted timely and properly.

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REFERENCES

Cai L (1989). Sichuan yak. Chengdu: Sichuan Publishing House. pp. 4-113.

Cai L (1992). China yak. Beijing: China Agric. Pub. Press. pp. 1-54.

Cai L, Wiener G. (1995). The yak. Published by the Regional Office for Asia and the Pacific of the Food and Agriculture Organisation of the United Nations, Bangkok, Thailand pp. 1-105.

Cai L, Chen ZH, Wen YL (1980). Agriculture and Livestock Bureau of Ganzi Tibetan Autonomous Prefecture of Sichuan Province and South-West College of Minority Nationalities). The good meat-purpose yak-the investigation and study of Jiulong Yak. J. China Yak, 1: 14-40

Chen XF, Lei DG, Liu SJ (1981). Investigation on Maiwa yak. Investigative reports on the resources of livestock and poultry breeds in Aba Tibetan Autonomous Prefecture,.

Dong SK, Long RJ, Dikken GD (1999). Yak farming on the Qinghai-Tibetan Plateau of China. NCTR Livestock Newsletter . 1 and 2: 10-14.

Grassland Institute of Sichuan Province and Longri Breeding Stock Farm of Sichuan Province, (1982). A fattening trial on yak and Pien Niu of Holstein-Frisian bull and female yak on grassland. J. China Yak. 1:29-33.

He SY, Tian YB, Ge CR, Xiao WJ (1997). Zhongdian Yak. J. China Yak. 1: 1-5.

Huang WX (1996). Conservation and management of yak genetic diversity in the Tibetan Autonomous Region. In: Miller DJ, Craig SR, Rana GM (eds). Conservation and Management of Yak Genetic Diversity – Proceedings of a Workshop in ICIMOD, Oct.29-31, 1996, Kathmadu, Nepal.

Ji QM, Pu Q, Da WYL, Ci RDJ, Da WQJ (2000). Analysis on milk output and milk quality of three good types of yak in Tibetan. J. Gansu Agric. Univ. 35 (3): 269-276.

Lei HZ, Xu JT (1997). Study on improvement of productivity of yak. In: Yang RZ, Han XT, Luo XL (eds). Yak Production in Central Asian Highlands - Proceedings of the Second International Congress on Yak. Sept., 1-6, 1997, Xining, China.

Li Q, Luo XL, Xu JT Li ZQ (2000). Measurement of milk performance in domestic yak in Guoluo Prefecture. Chinese Qinghai J. Anim. Vet. Sci. 30(3): 10-11.

Long RJ, Apori SO, Castro FB Ørskov ER (1999a). Feed value of native forages of the Tibetan Plateau of China. Anim. Feed Sci. Technol. 80: 101-113.

Long RJ, Zhang DG, Wang X, Hu ZZ, Dong SK (1999b). Effect of strategic feed supplementation on productive and reproductive performance in yak cows. Preventive Vet. Med. (38): 195-206.

Miller DJ (1996). Conserving and Managing Yak Genetic Diversity: An Introduction. In: Miller DJ, Craig SR, Rana GM (eds). Conservation and Management of Yak Genetic Diversity – Proc Workshop in ICIMOD, Oct.29-31, 1996, Kathmadu, Nepal.

Pu JB, Shi YJ, Ben ZK (1997). Yak subject in development. In: Yang RZ, Han XT, Luo XL (eds). Yak Production in Central Asian Highlands - Proceeding of the Second International Congress on Yak. Sept., 1-6, 1997, Xining, China.

Wen YL, Chen ZH, Chen Y, Zhao CL, Chen YK, Wang JF (1993). Influences of two simple methods of supplement during the winter on the performances of female yaks. J. South-west Nationalities College (Natural Science Edition), 19(3): 236-241.

Xu GL, Wang GS, Shi AJ (1983). Analysis of factors concerned with the milking performance and milk quality of yak. J. China yak. 1:21-29.

Zhang RC (1989). Yak of China. Lanzhou: Gansu Sci. Technol. Pub. House pp.1-98.

Zhang RC, Kong LL, Jin Y, (1983). The milking characters of yak and Pien Niu. J. China Anim. Husb. 2: 14-18.

Zhang RC, Pu FT (1986). Determination on the main composition in milk of Tianzhu White yak. J. China Yak, 2: 23-26.

Zhou SR (1984). Study on the forage and feeding habits of yak. A research on the utilization and exploitation of grassland in the north-western part of Sichuan Province. Chengdu: Sichuan National Publishing House. pp. 134-137