



Limitations distribution and niche segregation of yak on Qinghai-Tibet plateau

Accepted 11th September, 2018

ABSTRACT

Yak has a long documented history stretching into ancient times. Yak originates from the southeast of Qing-Tibetan Plateau (QTP) since the Pleistocene period (3 million years ago), with the Qiangs nomadic activities; it expands to Yunnan, Guizhou, and Sichuan, and even to Jingchu Mountain. In 384 BC, the Qiangs withdrew from lower elevation area to northeast of QTP, and thereafter entered the central high-altitude hinterland of QTP as feared by Qin's power. This was accompanied by rinderpest outbreak in 1860s, and snow disaster resulting in the yaks' distribution diminution. Another branch expanded to Tianshan and Altai Mountains after 1890s. The area of yaks' distribution arrives at maximum ($1.7-1.9 \times 10^6 \text{ km}^2$) from the Yuan Dynasty (1246 AD) until 1939 AD, and then due to the rapid increase of human population, disease and global warming, the yaks' population (6.49×10^6 , in 1998) and distribution area ($6 \times 10^5 \text{ km}^2$, in 1985) gradually decreased. In recent years, yaks' population (1.2×10^7 , in 2013) and distribution area ($8 \times 10^5 \text{ km}^2$, in 1990) was slightly raised. Ecological segregation also has impact on the distribution of yaks; the limitation elevation distribution line of yaks was 1100 to 7200 m, $y=436.81+0.26x-0.31x^2 \times 10^{-4}$ ($r=0.9102$, $P<0.05$); the temperature in summer was under 28°C , $y=78.04-10.98x-1.72x^2$ ($r=0.9362$, $P<0.05$); the annual average sunshine (h) was $y=1236.71+0.99x-0.14x^2 \times 10^{-3}$ ($r=0.6312$, $P<0.05$); the annual average relative humidity (%) was $y=375.63+14.28x-0.11x^2$, ($r=0.8525$, $P<0.05$).

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Key words: Yak population, distribution limitation, ecological segregation line.

INTRODUCTION

Yak, as an herbivore, lives predominantly on the "roof of the world", as the Qinghai-Tibetan Plateau is often called and its adjacent mountainous, sub-alpine areas (George, 1996; Long, 2008; Meng, 2016). The Taxonomy of yak (Olsen, 1991) remains domesticated yak (*Bos grunniens*) and wild yak (*Bos mutus*).

Wild yak was a rare and vulnerable species (IUCN and Berger, 2016; Shi, 2016) of the Bovini tribe (*Bovidae*, *Bovinae*) and an irreplaceable conveyance in an elevation of 6000 to 7200 m (Meng, 2016), which other bovine species find difficult to survive, and its dung is the only natural fuel in the areas above the tree-line. Thus, it accounts for a very small proportion of the world's Bovidae, less than 1% of the world's cattle breeding (including buffaloes). At high altitude area, clear ecological niche segregation (Meng, 2016) from other Bovinae species used the least amount of

natural resources to achieve the herbivore's limitations of life on earth. About 30 million sheep and goats (Miller, 1990) co-exist with yak over large parts of the plateau, but they are not the niche competitors to yak, as yak own the upper incisors grazing and browsing to forage the lowest grass that result in outbreak of Bovines' ecological niche (Meng, 2016) and to achieve an extreme harshness (Jean-Paul, 2006) and deprivation of ecological interregnum (Gerbault, 2011).

MATERIALS AND METHODS

This research was carried out according to the historical records of Tibetic languages literature (1610 to 2014), oral survey (2007 to 2016) and the Chinese Yearbook of

Table 1: Historical record of Yak's distribution area (including Tibetan history data).

Chronology	Historical record of Yak	The area of extension (km ²)
3 million years ago	Since the Pleistocene, the yaks had appeared and distributed in the northeast of Eurasia. Their progenitor roamed to the Qinghai-Tibetan Plateau (when elevation was only about 500 to 1000 m) in the quaternary glaciers and went extinct at the moment.	33500
30000 years ago	Qiangs people began to docile wild yaks in the southeast of Tibetan Plateau.	35440
10000 years ago	Nyatri Tsenpo presided over the first cabinet meeting to discuss tied yaks so as to avoid hurt hominids, the Minister Dagai tamed the yak by the rope through nostrils.	46869
In 2800 BC	Yak breeding appeared in the Longshan culture period of late Neolithic Age.	121769
2100 BC	The Qiangs ancestors have the first "animal herding planning". That plan included the following areas: Dunhuang and Zhangye in Gansu, Daba and Jingchu Mountain, Nanzhang and Xiangyang in Hubei, Bin County in Shaanxi, Shaohua Mountain, Huayin area, and Kangding in Sichuan.	134679
2000 BC	In Xia, Shang Dynasties and Qiangs people broaden yak breeding area, in Changdu, Xichuan and Wenshan.	152132
1100 BC	In Zhou Dynasties, the yaks were mainly kept in Dabashan area with a large number.	155378
841 BC	In Late Western Zhou Dynasty there were lots of yaks in Daba, Shaohua Mountain and Huayin.	158246
571 BC	In the Spring and Autumn Period, the yaks were bred to lower altitude area, in the Dabashan Mountain along the Sichuan, Shannxi, and Hubei, and Jingchu Mountain.	232263
500 BC	In the north of the Qinling Mountain, yaks were present in Milang Mountain and Shaanxi.	482263
384 BC	The Qiangs withdrew to Shaanxi Province with yaks as feared of Qin's power.	462263
220 BC	At the end of the Warring States Period, the word འཇོ (Tibetan) began to appear.	-
135 BC	The Han Dynasty had the earliest farming-pastoral region in Qinghai and Sichuan.	764763
111 BC	The state of yak appeared (west of Mo and Ruoshui, south to Zangke center in Zuodu).	767151
100 BC	The yak state was broke away from Shenli prefecture and entered western Sichuan for trade.	920151
109 BC	Recorded in Ganzi, Mula, Kangding, Jiulong, Daofu, Litang and Muli, Liangshan, Zhongdian, Diqing.	926921
322 AD	Firstly distributed in the east of the Qinghai-Tibetan Plateau.	1180921
700 AD	Naxi yak migrated from Xichuan, Nanzhao, Tubo to Diqing, Lijiang as Tubo war invaded.	1214421
1246 AD	Yaks could be seen everywhere from Xichang to Zhaojue in Dali Kingdom.	1934421
1578 AD	Wild yaks and domesticated yaks are distinguished for the first time.	-
1648 AD	In the Qing Dynasty, Tibetans and their yaks were moved out of most areas except Muli.	1921175
1783 AD	Yaks were recorded in Tibet of China, Britain, India, Europe, North America and Asia.	-
1854 AD	12 yaks migrated in the Cantal province, located in the southern part of the French Central Plains.	-
1862 AD	The yak and hybridization offspring disappeared in France.	-
1860 AD	Rinderpest outbreak in Hongba, resulting in the disappearance of yaks in this area.	1914405
1875 AD	Russian scholars named yak <i>Poepphagus mutus</i> .	-
1890 AD	To be domesticated and bred in the Tian, Altai, and Jing County in the Xinjiang Uygur.	1916950
1900 AD	Wild yaks once occupied the northern slopes of the Himalayas and Tibetan plateau.	1921350
1909 AD	6 Chinese yaks were introduced to Buffalo Park in Canada. One male and three female yaks survived till 1910 and were hybridization with American bison in 1916.	-
1938 AD	Many yaks record were distributed in Daofu, Luhuo, Ganzi counties.	1921365
1939 AD	More than 487 thousand yaks in Kangshu, and 7,000 to 8,000 Yaks in Ningshu, Xikang.	1921372
1943 AD	Professor R. G. Johnson at the University of Oregon once again went to Qianning, Luhuo and Kangnan for investigation in the distribution and population of yaks.	-
1944 AD	The first preliminary survey report on yaks and dzos.	-
1945 AD	There was a yak breeding industry and its product processing industry in Qiangtang.	-
1946 AD	Asian yaks and their hybrids with domestic cattle were mentioned in the "China Livestock Breeding Improvement Project".	-

Table 1: Conts. Historical record of Yak's distribution area (including Tibetan history data).

1947 AD	There were 520.932 thousand dzos in Xikang.	-
1949 AD	There were 1.34 million yaks in Xikang and a total of about 5 million heads in China.	-
1959 AD	As human activities expanded, wild yaks were migrated to higher altitudes for their refuge.	1690000
1971 AD	Yaks were introduced to Soviet Caucasus alpine pastures and Yakutsk for domestication.	-
1973 AD	Wild yaks were only distributed in Kunlun, the Altun, and the Qilian Mountain. Included Nasigang, Jiangtuoshan, Zhongba, Ritu, Gaize, Cuole, Bange, Shuanghu, Ali, Qiangtang, Bamaoqiongong, Zhenquancuo, Geermu, Kunshan, Kekexili, Qumalai, Zhiduo, Zhaduo, Tianjun, Qilian, Altun, Subei, Aksai.	1400000
1976 AD	A total of more than 50,000 Sichuan wild yaks were only distributed in Liangshan Yanyuan, Xichang, Mianning, Yuexi, Xide, Ganluo, Meigu, Leibo, Zhaojue, Jinyang, Puge, Ningnan and Huili, Muli, Aba, Ganzi, Ya'an, Hanyuan, Baoxing, Tianquan, and Shimian.	1200000
1979 AD	2,000 yaks were introduced to the paddocks in Hebei Province and Lingshan in Beijing at altitude of 1500 to 1800m.	-
1985 AD	The Tanggula region suffered heavy snowfall with snow thickness of 80cm. The herds were struggling in the snowfields heading for Kunlun Mountain. During the migration process, many yaks, have died. Since then, no wild yaks could be seen in the Tangula Mountain until the summer of 1987, a few wild yaks came back from the Kunlun Mountain.	600000
1988 AD	There was a huge group of 230 wild yaks in Wutumeiren Mountain in Geermu.	-
1990 AD	Local herds found that many wild yaks in Qilian Mountain increased. Wild yaks competed with domesticated ones for food and sometimes took away domesticated yaks.	800000
1993 AD	It was estimated that there were about 20,000 to 40,000 wild yaks in China in 1993 by experts specializing in wildlife conservation in Qinghai, Tibet, and Gansu.	-

Livestock and Husbandry (1999 to 2015).

area of distribution. **Figure 1** shows that in recent years, yak distribution area slightly raised.

RESULTS

Historical moving of yak distribution area

According to the historical records of Tibetic languages (Feng, 1991; Meng, 2016), the yaks were tamed by the Chinese ancient Qiangs (White, 1946; Olsen, 1990; David, 2007; Qiu, 2015); in the Qinghai-Tibetan Plateau, with the nomadic of the ancient Qiangs' lifestyle, yak moved into the surrounding areas suitable for survival by the eastward extension. The moving area of ancient and modern yaks are mainly affected by the variations of elevation, the lowest temperature in summer, disease, and Qiangs activities by seeking new resources of water and fighting the enemy in the habitat area (Feng, 1991) (**Table 1**).

Table 1 shows that yaks expand to the areas with the Qiangs activities by seeking new settlement area. In 384 BC, the Qiangs withdraw to lower altitude yaks' distribution area as feared by Qin's power. Accompanied by rinderpest outbreak in 1860s (Feng, 1991), resulting in the area of yaks' distribution diminution. Also, it was observed that the area of yaks' distribution continued to expand before the Yuan Dynasty which gradually led to a reduction in yaks'

Ecological niche segregation of yak limitation distribution

Limitation elevation of yak distribution

The elevation of yak distribution line ranges from 1100 to 7200 m. The lowest altitude of yak distribution was also related to the latitude (Barsila, 2014). In the north of 31°N, the lowest altitude of yak survival line is 2500 m, while in the south of 31°N, the line is about 3000 m. The lowest altitude of yak distribution is 1600 m in China, Weichang County, Hebei Province, 42°N to 42°40'N. In the former Soviet Union, yaks were bred at the northmost latitude of 55°N and the east coast of Lake Baikal; the minimum altitude for yak distribution is 1100 m.

In Sichuan, the highest line of yak herding is about 5000 m, while the highest line of summer pasture in the Tibet Autonomous Region of China has an altitude of 5,000 m and the maximum can be 6,000 m of grazing land. The highest altitude at which yaks can reach and can be used as carriage labor is 7200 m (the same altitude as the Camp of the Himalaya Everest mountaineering team).

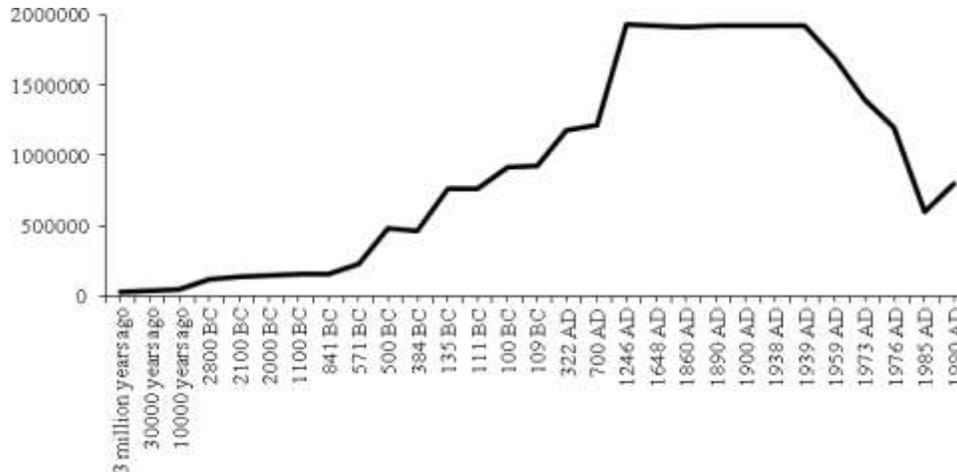


Figure 1: The area of Yak extension (km²).

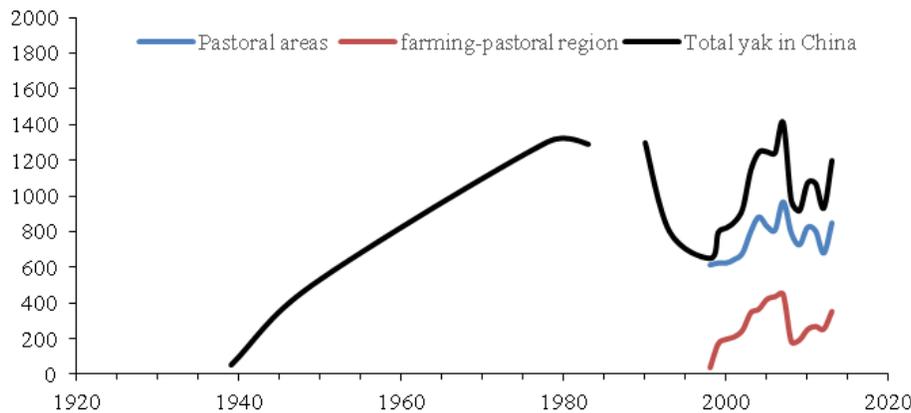


Figure 2: Yak's total population in China (10⁴).

Limitation temperature of yak distribution

The temperature of yak distribution line ranges from -16.5 to 28°C, respectively. When the ambient temperature arrived 13°C, the yak's respiratory rate increased by 23 times per minute; when the ambient temperature continues to arrived at 16°C, yak's body temperature and skin temperature increased from 0.3 to 3.2°C, respectively, and increased 5.4 times per minute in pulse, maladjustment appearing. When the temperature increased above 20°C, the yak had no activities, just standing by the water or in shade. Maladjustment with an annual average temperature exceeding 5°C and an average temperature of July exceeding 13°C is not fit for survival (Qin, 2016).

Yaks population in China

By the end of 2014, China had about 12 million yaks, accounting for more than 1/9 of the total number of Chinese cattle at the time, ranking after cattle and buffaloes.

The following information about the Chinese yak population and its share of the total number of cattle in China is based on the Chinese Yearbook of Livestock and Husbandry (1999 to 2015). **Figure 2** shows that the population of yaks in China has been on the increase since 1998.

The yaks' population greatly decreased in 2008 to 2009 in both pasturing and semi-pasturing areas as snow disaster in 2008. In addition, the experience of wild yaks in the past 50 to 60 years is also synchronous of a microcosm and other wildlife in the Qinghai-Tibetan Plateau (Feng, 1991; Long, 2008).

DISCUSSION

After nearly three decades of protection, hunting of wild yaks has basically been brought under control. Yaks play a special role in the cyclic of plant resources in alpine grassland and in maintaining the balance of the alpine grassland ecosystems. Most of the yaks are distributed

above the forest belt line (De, 2014; NandaKafle, 2017). Yaks sustain themselves and multiply offspring, relying on alpine meadow limitation forage resources, maximum absorption and provide local resident in extreme environment with high-energy milk, meat and carrying-energy, etc. On the other hand, the local people and yak breeding is an important pillar of the livestock husbandry economy in the alpine grassland. However, in recent years, the rapid restoration in the number of yaks and the rapid development in local economy have resulted in the overload of livestock carrying capacity of the limited distribution grassland (Zhang, 2016). Therefore, to make the yak population, the ratio of resource maximum circulation in extreme environmental red-line is achieved by the best matching (Rothschild, 2001).

ACKNOWLEDGEMENT

The authors are grateful to CYX, SY, WL, LC and CKS's for financial assistance rendered in the course of the research.

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