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Seasonal heat production and energy balance of grazing yaks on the Qinghai-Tibetan plateau

L.M. Ding[a,*], Y.P. Wang[a], A. Brosh[b], J.Q. Chen[c], M.J. Gibb[d], Z.H. Shang[c], X.S. Guo[a], J.D. Mi[a], J.W. Zhou[c], H.C. Wang[c], Q. Qiu[a], R.J. Long[a,*]

[a] *State Key Laboratory of Grassland Agro-Ecosystem, School of Life Sciences, International Centre for Tibetan Ecosystem Management, Lanzhou University, Lanzhou 730000, China*
[b] *Beef Cattle Section, ARO, Newe Yaar Research Center, P.O. Box 1021, Ramat Yishay 30095, Israel*
[c] *State Key Laboratory of Grassland Agro-Ecosystem, International Centre for Tibetan Ecosystem Management, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou 730000, China*
[d] *Formerly of the Institute of Grassland and Environmental Research, North Wyke, Devon EX20 2SB, UK*

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ABSTRACT

A study was conducted to measure the energy balance of free-ranging yak during the four annual seasons in order to elucidate the factors constraining energy utilization by grazing yak. The heat production (HP, kJ/day) of grazing non-lactating female yaks was calculated as the product of heart rate (HR, beats/min) and the amount of O_2 delivered to the body at every heartbeat (O_2P, μl), and by the constant value of 20.47 kJ/l of O_2 consumed. Heart rates were recorded continuously over 4 days, using modified heart rate monitors. Individual daily fecal output was measured using Cr_2O_3 as an external marker. Daily herbage dry matter (DM) intake was calculated from fecal output and digestibility of the forage determined *in vitro*. The greatest herbage mass was measured in August (496 kg DM/ha), and the least in December and May (208 and 226 kg DM/ha). However, the herbage present in both May and August had higher crude protein contents and lower NDF contents than those sampled in October and December. Daily average HR (beats/min) was greater in summer (August) than during the other three seasons (78 *vs.* 49–52). The greatest O_2P was recorded in May. The highest metabolizable energy intake (MEI) (1120 kJ/kg $BW^{0.75}$ per day) was measured in August when yaks grazed on lush green forage. HP was higher in August than in October and December (715, 548 and 400 kJ/kg $BW^{0.75}$ per day, respectively), but did not differ significantly from that measured in May (640 kJ/kg $BW^{0.75}$ per day). The animals were in positive energy balance only during August (energy retention (ER) = 405 kJ/kg $BW^{0.75}$ per day). Energy balance did not differ between the other seasons: −111 (October), −91 (December) and −13 (May) kJ/kg $BW^{0.75}$ per day, respectively. HP and ER were highly correlated with MEI (R^2 = 0.73 and 0.88, respectively). The formulas calculated through the regression of HP and ER on MEI were used to estimate fasting heat production (FHP = 341 kJ/kg $BW^{0.75}$ per day) and maintenance ME requirements (ME_m, 545 kJ/kg $BW^{0.75}$ per day) of the free grazing yaks. The results showed that free-ranging yaks expended much more energy to resist harsh environmental and sward conditions compared with confined yak or cattle and grazing cattle in low land area.

Abbreviations: HP, heat production; HR, heart rate; DM, dry matter; OM, organic matter; NDF, neutral detergent fiber; O_2P, oxygen pulse; MEI, metabolizable energy intake; BW, body weight; ER, energy retention; FHP, fasting heat production; ME_m, maintenance metabolizable energy requirement; CP, crude protein; DE, digestible energy; VO_2, oxygen consumption; RH, relative humidity; DMI, dry matter intake; BW, body weight.

* Corresponding authors. Tel.: +86 931 8915650; fax: +86 931 8915650.
E-mail addresses: dinglm@lzu.edu.cn (L.M. Ding), longrj@lzu.edu.cn (R.J. Long).

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1. Introduction

The yak is a unique bovine that has survived on the Tibetan plateau for centuries under harsh alpine environmental conditions and under extensive grazing management all the year round. Because of the long period of negligible or zero plant growth each year (7–8 months) and year-round grazing management, the winter dormant period is a harsh period for yaks (Ding et al., 2007). This situation has been exacerbated in recent years because of rangeland degradation, which has reduced the amount and quality of the herbage available, especially in the winter. Deterioration of pasture can affect yak productivity throughout the year because of the expected high energy requirement for maintenance due to severe climatic conditions (long-term extreme cold in winter, and increased temperature in summer), and the requirement to walk long distances in steep terrain to reach their pastures.

Various adaptive features regarding yak energy utilization have been studied and reported, such as high hemoglobin concentrations, a short trachea with a large cross-sectional area, and thick hair with a dense undercoat in winter (Zhang, 1989). So far no studies have been conducted on the energy metabolism of free-range yak. Previous studies of yak energy balance have been based on confined animals (Han et al., 1992a, 1992b, 1993; Hu et al., 1992a, 1992b). A method for measuring heat production (HP) in grazing animals has been presented and evaluated in beef cows by Brosh et al. (1998, 2002, 2004), and (Brosh, 2007). This method was also used in this study of grazing yaks on the Qinghai-Tibetan plateau. A better understanding and quantification of energy balance of yaks grazing on the Qinghai-Tibetan plateau is required for further studies of yak nutrition and developing optimal grazing practices. The present study was designed to assess the energy components of free-ranging yak during the different grazing seasons, and to explain the factors affecting and restricting energy utilization in grazing yak. The hypothesis is that harsh environmental factors and grazing activities play a great role in yak energy expenditure. The objective of present study is to reveal the energy utilization and balance of grazing yaks in different seasons.

2. Materials and methods

2.1. Study site

Measurements were conducted during four periods in 2010 and 2011: August (summer), December (winter), May (spring) and October (autumn). The study area was situated in an alpine rangeland, at Wushaoling (N 37°12.48′ and E 102°51.70′), 50 km north of Tianzhu Tibetan Autonomous County, Gansu Province, northwest China. The pasture was under communal village grazing management and is typical of alpine meadow without any artificial improvement (irrigation or fertilization), being predominantly composed of sedge species (*Carex qinghaiensis* and *Kobresia pygmaea*), which made up >85% of the total vegetation (Ding and Long, 2010) with small seasonal changes of the botanical composition. Grazing management was seasonal rotation system, normally with summer pasture, autumn pasture, winter–spring pasture, where the animals moved in the different pastures throughout the year (Long et al., 1999). The climate is dominated by the southeast monsoon and high atmospheric pressure from Siberia, with severe, long winters and short, cool summers, which is referred to alpine climate in the Köppen climate classification (Wong et al., 2012). The climate becomes colder at high elevations. And with the increase of altitude, the main form of precipitation becomes snow, and the winds increase. The mean annual temperature was −0.1 °C, and mean annual precipitation is 416 mm.

2.2. Animals and management

Twelve 4- to 8-year-old non-lactating yaks were used throughout the experiment selected from a farmer's large yak herd (80 yaks). The experimental yaks were integrated within a larger yak herd and subjected to traditional management, which was carried out on open pastures without fencing. The yak herd was grazing at pasture continually from June to October, except when the lactating yaks were corralled between 0600 and 1030 h for milking, and between 1730 and 2000 h to allow the calves to be separated from the cows. From November to May, the yak herd was corralled at night between about 2000–0700 h from November to April, and 2100–0500 h in May. No supplements were provided for the experimental yaks.

2.3. ME and MEI calculation

Six yaks of the twelve were used as a group in each period to measure daily herbage intake. After collection of fecal samples for determination of background content of Cr_2O_3, each yak was dosed every morning for 10 days with a capsule containing 20 g Cr_2O_3 administered using a dosing gun. During the last three days of dosing period, fecal samples were collected from the individual yaks by following them during the morning from 0800 to 1100 and afternoon from 1400 to 1830. The fresh feces were first air dried in a room avoiding direct sunshine before being dried in a ventilated oven at 60 °C for 72 h, then ground through a 1 mm screen for analyzing DM by drying at 105 °C for 48 h (AOAC, 1990; method 934.01). Chromium was determined by atomic absorption spectrophotometry following the protocol of Costigan and Ellis (1987). Neutral detergent fiber (NDF) content of feces was determined according to the method of Goering et al. (1970) and Van Soest et al. (1991) without adding heat stable amylase and expressed inclusive of residual ash. In addition, forage samples