

Results of Study Demonstrating the Links Between the Specificity of Yak Down Growth and Habitat

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Abstract - The effects of altitude above sea level, the main climatic variables and their interconnections, and the dynamics of the growth changes of yak down and its properties were examined in this study. This is significant for the creation of a brand for products made of yak down. Using ARCGIS mapping software, the main yak habitats in Mongolia can be divided into four key regions: Core, central, middle and remote. The core region - Tariat soum in Arkhangai aimag - is 2000 m above sea level. A total of 77.7 percent of yaks in Mongolia are found 2000 m above sea level. The correlation coefficients between yak down per 1cm² and air temperature in two areas - above and below sea level (for lower than 2000 m altitude r_{-2000} ; for higher than 2000 m altitude r_{2000}) - were the same: $orr_{-2000}=r_{2000}=0.98$. However, according to a mathematical expression with a single peaked curve or an upper peak parabolic equation, yak down yields per square centimeter of skin increase as temperature decreases. Although the correlation observed between yak down per square centimeter of skin and differences in monthly temperatures in both areas was the same, yak down yields per square centimeter at altitudes less than 2000 m above sea level were less than 22.48 percent of those at altitudes more than 2000 m above sea level.

Keywords – Core, central, middle and remote region of yak distribution, yields per square centimeter, correlation coefficient, parabolic equation.

I. INTRODUCTION

It has been reported that the biological features of yaks are the result of the ecological impact on the anatomical-morphological, physiological and biochemical specificities of their bodies, cells, tissues and organs, which have adapted to the extreme natural and climatic conditions of their habitat, the high mountainous regions of Central Asia [1], [19], [2].

Cai Li [8-10], Yao Yubi, Li Yuqing [15], Chen Zhihua [11], Blaxter, KL, [7] and Shagdarsuren, O [2] cited habitat air temperature as one of the ecological factors having the biggest impact on the body growth and size of animals, including yaks.

Yao Yubi and Li Yuqing, [15] developed a mathematical model for meat production based on the relationship with air temperature using multiple regression: $Y = 2.452 + 7.166T_7 + 1.726 R_2$ (T_7 is the average air temperature in July; R_2 is relative humidity in February).

Long, thick hair and tails, more down fibres, sweat and oil glands, and soft, thick skins provided yaks with unique cold resistance. Because their thermal regulation ability through body-surface heat loss is weak, yaks have a lower level of thermal regulation in hot conditions and hence are not resistant to the heat [1].

Ouyang Xi and Wang Qianfei [20] found that yaks' coats were comprised of three types of hair fibre: Coarse, mid-type and down fibres, which significantly differ in terms of external appearance, internal structure and technical characteristics [13], [1], [18].

Xue Jiying and Yu Zhengfeng [16] found that the waterproof properties of yaks' coats were instrumental in enabling them to survive in very cold and wet conditions. Khishigjargal, Ts [18] measured the impact of the geographical location of yak habitats on the depth of yak fibre crimp using a dispersion analysis technique and found the relationship to be 70 percent.

A database containing information on technical parameters (such as composition, length and diameter), resources and geographical location was established.

Bat-Erdene, T [1] and Doyoddorj, D [5] said "yak down has seasonal character; the fibres of the belly and tail are gradually shed and replaced with new ones, ensuring the thermal balance of the body during the cold season".

II. MATERIALS AND METHODS

Based on data on yak population numbers and distribution, the study was undertaken in Ikh Tamir, Erdenebulgan and Tsetserleg soums in Arkhangai aimag at altitudes up to 2000m above sea level, and in Tariat and Undur-Ulaan soums in Arkhangai aimag and Tosontsengel and Ikh-Uul soums in Zavkhan aimag at altitudes higher than 2000m above sea level representing the high mountainous areas of the Khangai range.

Location and above sea level altitudes of yak distribution

For primary data, the location of the 98 herder families involved in the study, including seasonal pastures, soum or bag and distances between herder families, were determined through the use of GPS equipment. A map showing yak distribution was developed using data gathered via the Landsat ETM satellite. The above sea level altitudes of the yak locations were also estimated via an Aster DEM digital elevation model.

Air temperature of yak locations

Analysis was undertaken using data from local meteorological stations in the aimags and soums involved in the study.

Growth of yak hair fiber

The density of yak down was measured via observation and counting under laboratory conditions.

III. RESULTS AND CONCLUSIONS

A. Above sea level altitude of yak locations

In order to determine where yak populations breed and become acclimatized, the locations of yak herder families and the elevations of pastures used for yak grazing throughout the seasons were identified and estimated using information gathered from herders and data from ARCGIS GPS measurements, Aster DEM (digital elevation model) and satellite Landsat ETM (the results are listed in Table I). The study's statistical data has a more than 95 percent rate of probability ($P < 0.05$).

Table I shows that yak herder families move to relatively lower areas during summer and to relatively higher areas or mountain ridges in winter due to their livelihood needs and the availability of pasture. If the details are estimated in accordance with the seasons, the movements in spring range between 2063 m and 2104 m in altitude, or an average of 2084 m; in summer that figure is 1929 m and 1975 m, or an average of 1952 m; in autumn 2062 m and 2112 m, or an average of 2087 m; and in winter between 2281 m and 2341 m, or an average of 2311 m.

Table 1. Statistical data on the altitudes of the locations for raising yaks

Seasons	Winter	Spring	Summer	Autumn	Annual average
Average of altitude above sea level, m	2311±30	2084±21	1952±23	2087±25	2109±23

B. Distribution and location of yaks

The distribution zone and central distribution point for yaks in the high mountainous region of the Khangai range

were determined using ARCGIS software, with the results summarized in Figure 1.

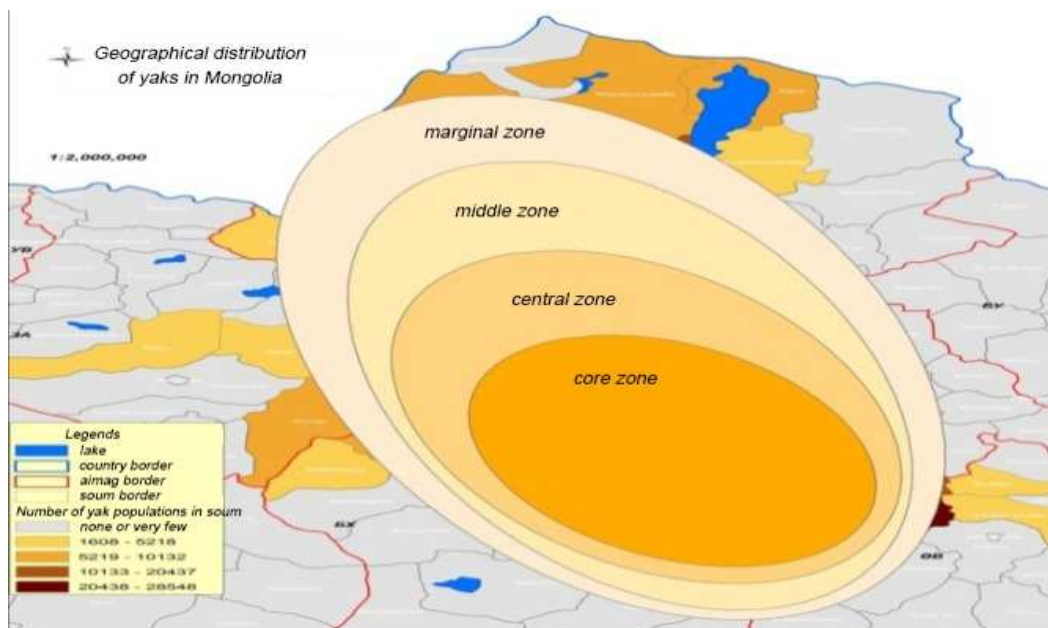


Fig. 1. Zones of yak distribution

According to the calculations derived from the ARCGIS software, yak distribution can be divided into four zones: Core, central, middle and marginal. The core zone includes the high mountainous regions of Arkhangai, Bayankhongor and Uvurkhagai aimags, with Tariat soum the location of the central distribution point.

C. Relationship between yak distribution and sea level

Yak distribution and population numbers, depending on the altitude of acclimatized areas, are shown in Figure 2. It shows that 22.3 percent of all yak populations in the selected aimags and soums are at elevations ranging from

1800 m to 2000 m above sea level, while the remaining 77.7 percent are at elevations higher than 2000 m above sea level. The most suitable elevation for raising yaks was determined through the use of ARCGIS software and is shown in Figure 3. The altitudes of the locations of yak populations can be divided into two categories: Lower than 2000 m above sea level and higher than 2000 m above sea level. Meteorological data from Tsetserleg soum in Arkhangai aimag (1600 m) from the past decade was selected, along with meteorological data from the past decade from Tariat soum in Arkhangai aimag (2052 m), which is summarized in the table.

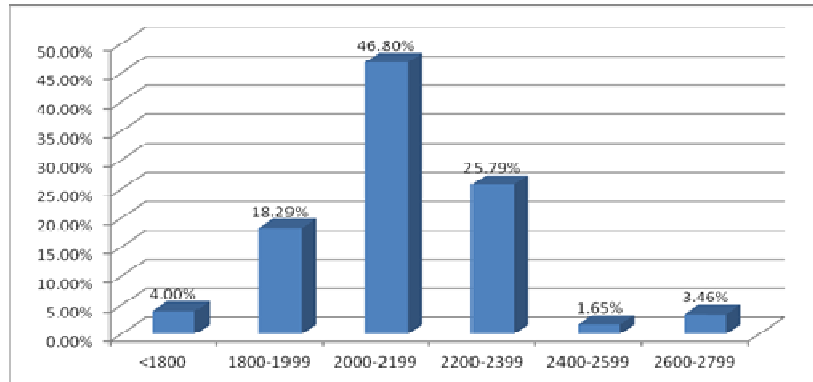


Fig. 2. The relationship between yak distribution and above sea level elevation

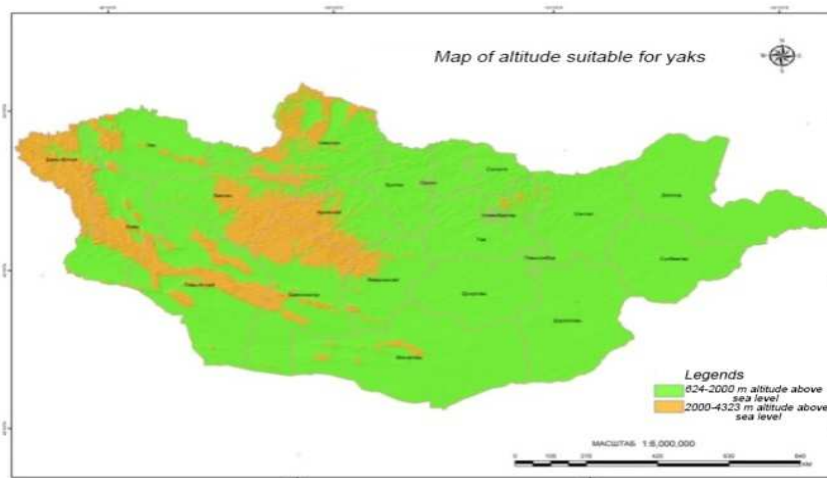


Fig. 3. Total distribution of yak locations

D. Relationship between the altitude of yak locations and air temperature

Monthly dynamics and differences in average air temperatures for the two soums selected for the study are shown in Table 2.

Table 2. Average air temperature

Observation point	Months											
	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX
Tsetserleg	1.8	-4.8	-13.5	-18.6	-17.9	-9.2	-2.2	9.3	15.6	17.4	13.9	10.9
Tariat	-0.7	-9.1	-18.2	-23.3	-22.3	-13.5	-5.8	5.6	13.4	14.6	11.1	8.1
Differences	1.1	-4.2	-4.7	-4.7	-4.4	-4.3	-3.6	3.7	2.2	2.8	2.8	2.8

According to the multi-year averages of the soums' meteorological stations, the average air temperature in the area of Tariat soum, which is more than 2000m above sea level, was -0.7C in October, while it was 1.8 C in October for Tsetserleg soum, which is situated at a lower altitude. This data reveals that warm and cold periods differ in the two soums; in other words, the higher the altitude above sea level, the earlier the cold or later the warm.

Therefore, both correlation and regression analyses (Figure 4) on the relationship between the air temperature processes observed in the two meteorological stations had a correlation coefficient r_{xy} of 0.99, or almost 1.0, and hence there is a very strong positive correlation. A principally linear correlation ($y=1.0608x-3.5803$, $R^2=0.99$) reveals there are no differences between the dynamics of air temperatures in these areas, although there are

significantly stable differences between monthly air temperatures.

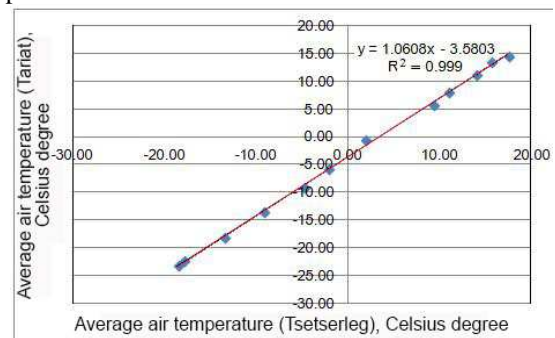


Fig. 4. The relationship between air temperatures in both soums

E. Effect of air temperature in yak locations on the growth of down

The density of yak hair fiber was estimated via simple observation when average air temperatures rapidly dropped from 8.1 °C in September to -0.7 °C in October in areas higher than 2000 m, and from 10.9 °C in September to 1.8 °C in October in areas below 2000 m. The results can be seen in Figure 5 photos, which show the yak hair line in areas below 2000m becoming almost invisible with the appearance of dense, with a further increase in density visible at higher altitudes.



Fig. 5. Yak hair-line patterns

“(a)”- yak down (fine fibre)

“(b)”- coarse fibre

This change is the result of the growth of yak down (soft, fine fibres) between coarse fibres (thick) and occurs earlier in colder areas than in areas of relatively lower elevation.

Thus, in order to study the effect of the seasons throughout a year and the dynamics of air temperature on the growth of yak down, the number of the down per square centimeter of skin was measured and estimated through mathematical modeling.

The study aimed to determine the following variables for the soums involved from September, or from when the cold weather began, through to January of the following year, which is the coldest period annually:

The relationship between changes in the number of yak down per square centimeter and the cold period in two areas - above and below sea level (for lower than 2000 m altitude and for higher than 2000 m).

The presence of a relationship between the number of yak down per square centimeter and differences in monthly air temperatures in two areas - above and below sea level (for lower than 2000 m altitude and for higher than 2000 m).

Relationship between changes in the number of yak down per square centimeter (density) and the cold period in two areas - above and below sea level

Mathematical calculations based on the data obtained through correlation and regression analyses (Figure 6) demonstrated that the number of yak down per square centimeter on yaks located in areas up to 2000m above sea level was more than 2000 at a temperature of 15°C; the lower the air temperature, the greater the number of down, reaching 5000 when air temperature dropped to -15°C. Despite the principles of growth, the patterns were similar: the number of down fibres per square centimeter was more than 4000 at temperatures above 10°C, rising to more than 7000 at -10°C and becoming stable.

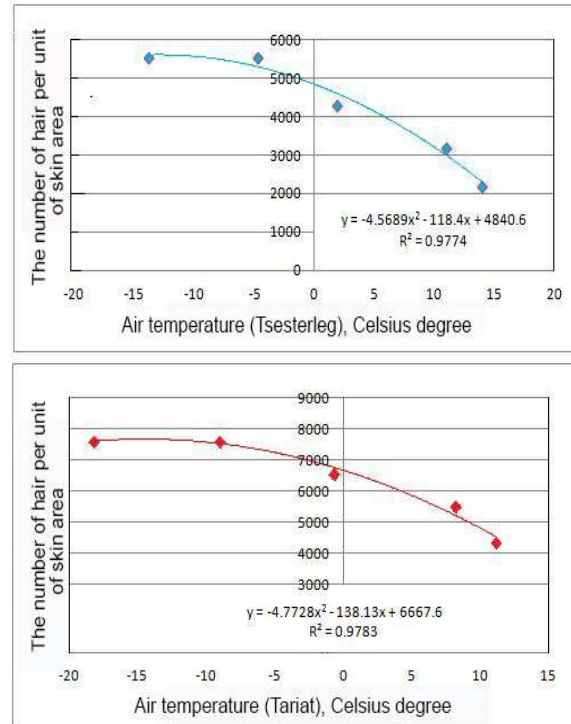


Fig. 6. The relationships between the number of down per unit of area and air temperatures

In Figure 6, the correlation coefficients between the number of yak down per square centimeter of skin and air temperatures in both soums (below 2000 m r_{-2000} ; above 2000 m r_{+2000}) were the same, or

$r_{-2000}=r_{+2000}=0.98$; in other words, there is strong positive correlation. Mathematical modeling of the common principle of this relationship is expressed by the following two parabolic equations, and correlations are $R^2_{-2000}=R^2_{+2000}=0.98$:

For below 2000 m above sea level
 $y=-4.57x^2-118.40x+4840.60$ “Fig. 6(a)”

For above 2000 m above sea level
 $y=-4.77x^2-138.13x+6667.60$ “Fig. 6(b)”

Specifically, there is a regression expressed with a single peaked curve between the number of yak down per square centimeter and air temperature.

In this instance, the expression of the principle of a relationship between the number of yak down per square centimeter of skin and the cold period with a single peaked curve or upper peaked parabolic equation demonstrated that the number of yak down increased when it became cold, reached a maximum value, and then dropped to a lower value.

If the temperature corresponding to the maximum value after an increase in the number of yak down is determined by mathematical modeling, 5606.7 are found at -13.0°C in areas below 2000 m and 7666.9 at -13.0°C in areas above 2000m. However, if $R^2_{-2000}=R^2_{+2000}=0.98$ or they are similarly close to the value of 1 in both areas, the principle is stable for both each year.

Because there is no difference between warm and cold periods and changes, the effect of differences in cold temperatures observed during cold seasons in both areas

(the aforementioned temperatures -3°C to -4.7°C) on the growth of fine fibres (down) were investigated. The relationship between monthly air temperature differences at the two observation locations and yak down per square centimeter was determined through correlation and regression analyses

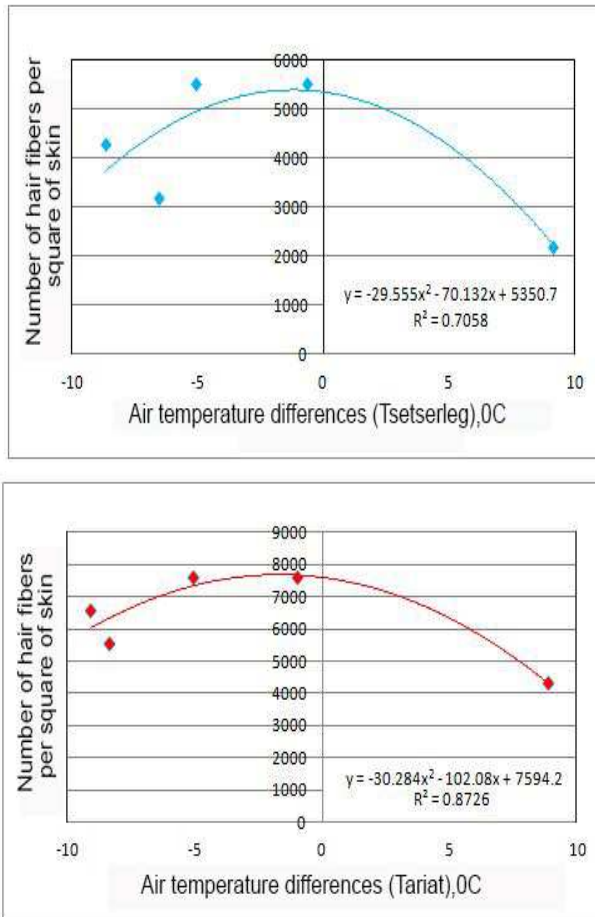


Fig. 7. The principle of the relationship between down per square centimeter of skin and monthly temperature differences

The relationship between down per square centimeter of skin and monthly temperature differences is expressed in the following two parabolic equations, differing only in the numerical value of the previous coefficient, $R^2_{-2000}=0.71$, $R^2_{+2000}=0.87$:

For below 2000 m above sea level
 $y = -29.55x^2 - 70.132x + 5350.7$ "Fig. 7(a)"
 For above 2000m above sea level
 $y = -30.248x^2 - 102.08x + 7594.2$ "Fig. 7(b)"

From the results of the correlation and regression analyses, it can be inferred that the number of down per square centimeter of skin increases in cold periods and reaches a maximum value at certain temperatures.

Calculations of temperature differences corresponding to the maximum value in numbers of down using both equations demonstrated that the number reached 5953 at -0.5°C in areas lower than 2000 m above sea level and 7680 at -1.7°C in areas higher than 2000 m. Although the general principle is the same, the number of yak down per

square centimeter in areas lower than 2000m was 22.48 percent less than in higher areas.

CONCLUSIONS

Using ARCGIS mapping software, the distribution of the yak populations can be divided into four zones: core, central, middle and marginal. The central distribution point is Tariat soum at more than 2000m above sea level.

22.3 percent of the yaks surveyed were raised in areas lower than 2000m above sea level and 77.7 percent in the areas higher than 2000m.

The coefficient of the air temperature process relationship r_{xy} is equal to 0.99, or almost 1.0 in other words, there is very strong correlation and a linear relationship ($y=1.0608x-3.58.3$; $R^2=0.99$).

A principally this linear correlation reveals there are no differences between the dynamics of air temperatures in these areas

In the two selected areas, the correlation coefficients between the number of down per square centimeter of yak skin are the same at $r_{-2000}=r_{2000}=0.98$. The expression of the principle observed between the number of down per square centimeter and monthly temperature differences, with a single peaked curve or upper peaked parabolic equation, showed that the number of down increased with the onset of the cold period, reached a maximum value at certain temperatures, and then fell.

Despite the general principle observed between down per square centimeter of skin and monthly temperature differences being the same, the number of down per square centimeter in areas below 2000m above sea level was 22.48 percent less than in higher areas. Otherwise yak down yields per square centimeter at altitudes less than 2000m above sea level were less than 22.48 percent of those at altitudes more than 2000m above sea level.

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