Increases in body weight per unit body condition score in Katahdin ewes under tropical Tabasco, México

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List of Abreviations

Abreviation	Term
BW	Body weight
BCS	Body condition score
MSE	Mean square error
RSD	Residual standard deviation
R^2	Coefficient of determination
SD	Standard deviation
CIOS	Centro de Integración Ovina del Sureste
SAS	Statistical Analysis System

Increases in body weight per unit body condition score in Katahdin ewes under tropical Tabasco, México

Abstract

The objective of this study was to determine the relationship between body weight (BW) and body condition score (BCS) in non-pregnant, non-lactating Katahdin ewes under tropical conditions. Body weight and BCS were measured in 110 Katahdin ewes aged 2.5 years with mean BW of 43.18 ±6.73 kg and mean BCS of 2.38 ±0.82. Relationships were analyzed using correlation and linear regression. Body weight and BCS showed a strong positive correlation ($r = 0.90$; $P < 0.001$). The linear regression equation was $BW = 25.66\ (\pm 0.84) + 7.34\ (\pm 0.33) \times BCS$ ($R^2 = 0.81$, MSE = 8.39, RSD = 2.89, n = 110). These results indicate that 7.34 ±0.33 kg of BW are required for each unit change in BCS in Katahdin ewes managed under humid tropical conditions.

Keywords: Body reserves; Nutritional management; Regression analysis; Body composition.

Study contribution

The information presented here may have implications for the implementation of supplementation strategies to increase body condition score (BCS) in female sheep of Katahdin intended for reproductive programs. It is important to determine the BW/BCS ratio in Katahdin, because different breeds of sheep are associated with varying levels of body energy reserves, primarily fat and muscle. Therefore, it is essential to determine the changes in fat and muscle amounts in female sheep for each unit change in BCS (BW/BCS). This could help estimate the amount of metabolizable and net energy required for these increases in Katahdin ewes under tropical conditions.

Introduction

The body condition score (BCS) is a subjective evaluation of fat and muscle coverage over the lumbar region, commonly used to support nutritional and management decisions in sheep flocks.[1-4] Compared with body weight (BW), BCS is a faster and simpler indicator of an animal's nutritional status and body reserves, as BW does not reflect fat distribution or the degree of fatness.[5, 6] Consequently, BCS has become an essential tool for designing feeding strategies, improving flock productivity, and monitoring the nutritional, health, and reproductive status of ewes.[3, 5, 7]

Understanding the relationship between BW/BCS helps identify factors that affect this association in sheep.[6] These include age at first lambing, parity, physiological stage, mature BW, body size, and litter size. Additionally, gastrointestinal tract fill can alter the amount of weight change per unit of BCS among breeds.[3, 5, 6] Genetic factors also influence this relationship; therefore, further research is required to clarify the genetic and physiological mechanisms that control body fat mobilization and deposition across breeds. Such knowledge could contribute to improving animal robustness and guiding genetic selection programs focused on the BW/BCS relationship.[6, 7, 8]

Despite its importance, information on this relationship in hair sheep raised under tropical production systems is still limited.[5, 6] In Mexico, Pelibuey and

Blackbelly breeds have traditionally served as maternal lines, while the Katahdin breed has been recently introduced to enhance productivity. Consequently, data on the BW/BCS relationship in Katahdin ewes under tropical conditions remain scarce.[5, 9] Therefore, the present study aimed to determine the relationship between BW/BCS in non-pregnant, non-lactating Katahdin ewes managed under tropical conditions.

Materials and methods

The study was conducted at the Centro de Integración Ovina del Sureste (CIOS; 17° 50'N, 92°23'W; 10 m above sea level), located in R/a Alvarado Santa Irene 2nd section, municipality of Centro, Tabasco, Mexico. The region has a humid tropical climate with temperatures ranging from 15 to 44 °C (average 26 °C). Body weight and BCS were recorded in 110 multiparous non-pregnant, non-lactating Katahdin ewes mean age 2.5 years (range 2–3 years). Mean BW was 43.18 ±6.73 kg. The animals were treated according to the guidelines and regulations for ethical animal experimentation of the Department of Agricultural Sciences of the Univesidad Juárez Autónoma de Tabasco (protocol ID UJAT-CIEI-2023-084).

Ewes were weighed without fasting at 8:00 a.m. before feeding, using a portable platform scale as described by Mendoza-Domínguez *et al*.[6] These ewes were fed a whole grain diet formulated with 34 % cereals and 66 % roughage to meet maintenance requirements (12 MJ/kg dry matter metabolizable energy and 10 % crude protein.[10] The BCS was assessed using the method proposed by Russel *et al*.[2] where 1 = very lean and 5 = very fat. Animals were intentionally selected to cover a wide range of BW and BCS, reflecting the natural heterogeneity of Katahdin ewes managed under tropical grazing systems. Age, body size, and nutritional status varied among individuals.

Ewes with a BCS of 1 represented adults that had experienced notable weight loss at the end of the dry season and the preceding lactation period, thus defining the lower limit of the BCS range observed under field conditions. Most observations were concentrated between BCS 2 and 3.5, while extreme scores (1 and 4.5) were less frequent but retained adequate representation for statistical analysis (**Figure 1**). Relationships between BW and BCS were estimated by correlation coefficients using SAS PROC CORR.(11) and by regression models using SAS PROC REG.(12) of the SAS statistical package version 9.4.

Results

The mean (±SD), maximum, and minimum values for BW and BCS are presented in **Table 1**. The study included ewes with BCS values ranging from 1 to 4.5; however, most observations were between 2 and 3.5, typical of non-pregnant, non-lactating ewes under moderate nutritional conditions. BW increased consistently with BCS. The correlation between BW and BCS was strong ($r = 0.90$; $P < 0.001$; **Figure 1**), and the regression model ($R^2 = 0.81$) indicated that each one-point increase in BCS corresponded to an average gain of 7.34 kg in BW (**Figure 2**).

Table 1. Statistics for body weight and body score in non-pregnant and non-lactating Katahdin ewes

Variables	N	Mean ±SD	Minimum	Maximum
BW	110	43.18 ±6.73	29.01	65.23
BCS	110	2.38 ±0.83	1	4.5

BW: Body weight; BCS: Body condition score; SD: Standard deviation.

Data were obtained from the Centro de Integración Ovina del Sureste, Tabasco, Mexico, 2023.

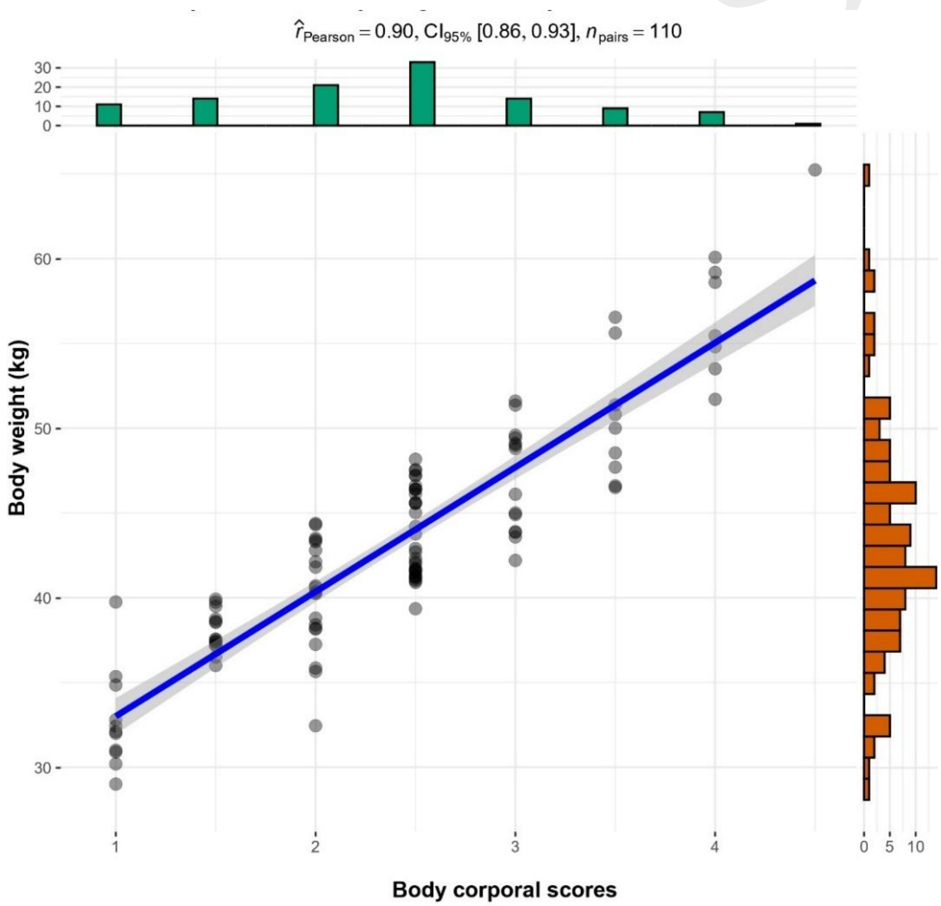

Figure 1. Relationship between body condition and live weight in non-pregnant, non-lactating Katahdin ewes, Tabasco, Mexico, 2023. Scatter plot showing the Pearson correlation coefficient value and its corresponding 95 % confidence interval.

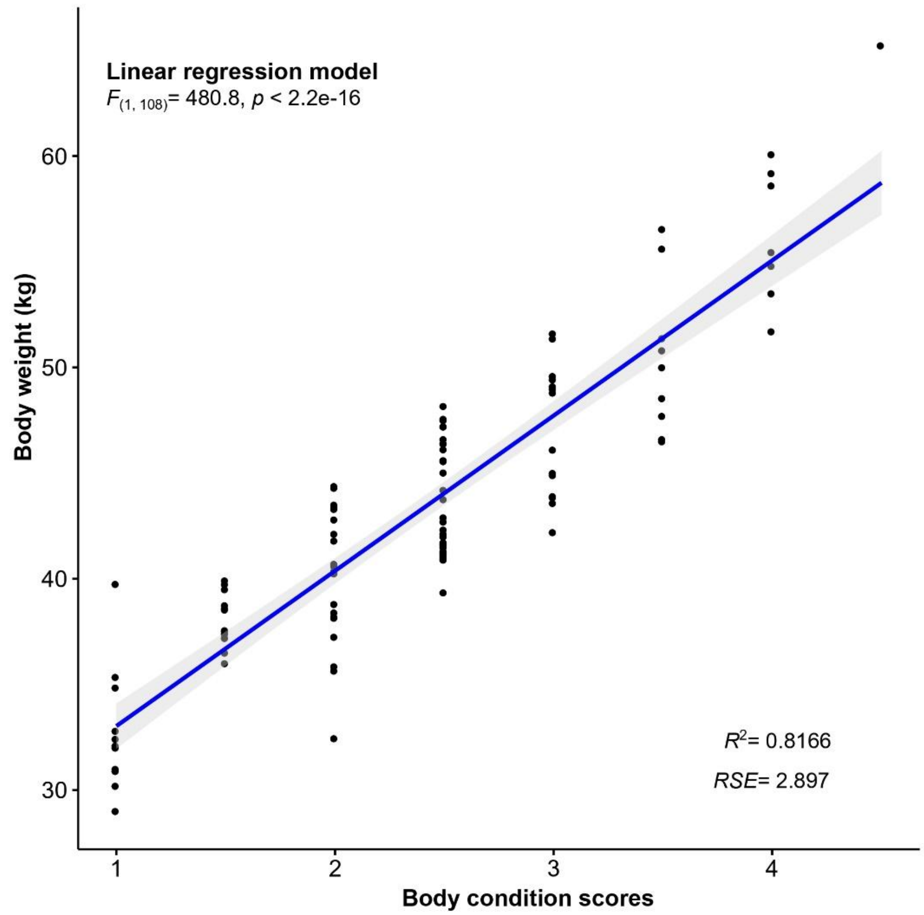

Figure 2. Linear regression model for body weight prediction from body condition score in non-pregnant, non-lactating Katahdin ewes, Tabasco, Mexico, 2023. The equation BW = 25.66 (±0.84) + 7.34 (±0.33) × BCS (R^2 = 0.81, mean square error (MSE) = 8.39, residual standard deviation (RSD) = 2.89 and n = 110).

Discussion

This study evaluated the relationship between BW and BCS in non-pregnant, non-lactating Katahdin ewes. Information on this relationship is limited for the main hair sheep breeds used in tropical production systems in Mexico. To our knowledge, this is the first report describing the BW/BCS relationship in Katahdin ewes under tropical conditions. Previous studies have shown that BCS and BW are statistically, and often linearly, related in ewes.[4, 12, 13] In this study, each unit change in BCS corresponded to 7.34 ±0.33 kg of BW, a value slightly higher than that reported by Chay-Canul *et al*.[5] for Pelibuey ewes (5.84 kg BW/BCS) and by Montes de Oca de la Cruz *et al*.[14] for the same breed (6.90 kg). Similar results were later confirmed by Mendoza-Domínguez *et al*.[6]

Few studies have quantified BW/BCS ratios in hair sheep. In contrast, higher ratios have been reported in wool breeds, such as 16 kg in New Zealand Romney ewes.[3] or values ranging from 4.16 to 9.79 kg across genotypes.[15] The ratio observed here (7.34 kg BW/BCS) was lower than the 10.6 kg reported by Russell *et al*.[2] in Scottish Blackface ewes. The wide variation in BW and BCS reflected the natural heterogeneity of Katahdin ewes managed under tropical grazing, where age, body size, and nutritional history differ among individuals. Although this increased within-group variability, it enabled a broader characterization of the BW/BCS relationship. The association remained highly significant ($P < 0.001$), indicating that variability did not distort the overall trend.

Ewes with a BCS of one represented animals in poor nutritional condition at the end of the dry season, while most observations were within BCS values of 2–3.5, typical of non-pregnant, non-lactating ewes with moderate nutrition. Overall, BW increased predictably with BCS, supporting its use as a practical indicator of body reserves when BW data are unavailable. The variability observed here agrees with differences reported across breeds and production systems. The broad range of BW/BCS ratios described in the literature likely reflects differences in breed, gastrointestinal content, physiological status, age, body size, conformation, mature weight, fat distribution, diet, and parity.[3, 5, 14–16] According to CSIRO,[17] the BW/BCS ratio represents about 13 % of mature BW. Considering an average mature maximum observed BW of 65.23 kg for Katahdin ewes,[18] the ratio obtained here (7.34 kg BW/BCS) corresponds to roughly 12 % of mature BW, consistent with previous estimates.[17]

These results have practical implications for nutritional management. Estimating the BW/BCS ratio allows quantification of body reserves, mainly fat and muscle, associated with each unit change in BCS, supporting more precise supplementation strategies in reproductive programs. Understanding the energy cost of improving BCS also facilitates estimation of metabolizable and net energy requirements for tissue gain. According to CSIRO,[17] increasing BW by a kilogram in non-pregnant, non-lactating ewes requires about 23 MJ of net energy (NE), equivalent to 53.5 MJ of metabolizable energy (ME), assuming an efficiency of 0.43.

The positive BW/BCS relationship observed in Katahdin ewes agrees with previous reports. However, as noted by Semakula *et al*.,[12] this correlation may be relatively weak when analyzed through simple linear regression, as changes in BW do not always correspond to proportional changes in body reserves. These authors also observed that predictive accuracy declines as the interval between measurements increases due to dynamic physiological effects. Later studies by Semakula *et al*.[4, 13] improved prediction accuracy using additional variables and machine learning algorithms, though they confirmed that estimating BCS solely from BW remains limited.

Overall, the present results confirm that BW alone is not a reliable indicator of body reserves, as the BW/BCS relationship varies with breed, production system, and physiological status. Direct BCS assessment therefore remains essential for accurately evaluating the nutritional and metabolic condition of ewes, particularly under tropical production systems. Future research should aim to refine the predictive accuracy of BCS as an indicator of BW and body composition in maternal hair sheep breeds, particularly by quantifying body energy reserves (fat, muscle, and protein) and developing non-invasive (*in vivo*) methods to monitor tissue mobilization and deposition throughout the production cycle. However, the present study was limited by the sample size and by focusing solely on non-pregnant, non-lactating Katahdin ewes. Therefore, further studies including a larger and more diverse population are needed to validate and strengthen these predictive relationships.

Conclusions

A strong correlation was found between BW and body condition score (BCS) in non-pregnant, non-lactating Katahdin sheep. This association also indicates that a change in BCS requires a change in BW of 7.34 ±0.33 kg.

Data availability

All relevant data are within the paper and its supporting information files.

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Conflicts of interest

The authors have no conflict of interest regarding this publication.

Author contributions

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