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THE USE OF TOTAL SERUM PROTEINS AND TRIGLYCERIDES FOR MONITORING BODY CONDITION IN THE IBERIAN WILD GOAT (*CAPRA PYRENAICA*)

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Abstract: Body condition in wild ungulates is traditionally evaluated during the necropsy of animals on the basis of the weight of fat stored around or within the vital organs, the weight of the organs themselves, and their derived indices. However, sometimes it is important to evaluate the nutritional status of the animal by means of blood and serum analyses and the interpretation of specific parameters. Only in a very few studies is the nutritional status of the animal obtained by blood biochemistry and, when obtained, compared with the values for body condition obtained by anatomic dissection. In this study, the usefulness of two serum parameters, total serum proteins (TSP) and serum triglycerides (ST), was assessed in the monitoring of the body condition of Iberian wild goats (*Capra pyrenaica*). In addition, their relationship with the kidney fat index (KFI) and its components, kidney mass without fat (KM) and kidney fat (KF) is evaluated. A total of 25 wild goats from the Sierra Nevada National Park (southern Iberian Peninsula) that were shot by hunters were used in this study. The parameter TSP was found to be correlated with KM, and ST was correlated with both KM and KFI. Hence, both TSP and ST can be used for monitoring physical condition in wild and captive Iberian wild goats.

Key words: Body condition, *Capra pyrenaica*, kidney fat index, kidney mass, physiologic status, serum parameters.

BRIEF COMMUNICATION

Zoo and wildlife managers need to be able to monitor the nutritional status and the body condition of captive and wild animals in an integrative fashion.[4] Nutritional status is linked to body condition by the consumption and utilization of nutrients. Nutritional status is often evaluated by comparing actual serum parameters with reference values. For example, in several species of wild ungulates, including camelids (*Lama pacos*,[7] *Lama glama*[11]), cervids (*Alces alces*,[16] *Cervus elaphus*,[35] *Odocoileus virginianus*,[3,29] *Rangifer tarandus*[30]), bovids (*Ovis canadensis*[14]), and suids (*Tayassu tajacu*[10]), studies have confirmed that serum parameters vary according to food availability and seasonality. In addition, parameters have also varied based on population and management factors.

Body condition is linked to nutritional status. When food intake exceeds the cost of biologic activities, the animal can store the surplus energy by increasing the weight of its organs and tissues. The weight, size, and appearance of these reserves are generally considered by wildlife managers to be good means of describing ''body condition.'' Consequently, when the animal enjoys a positive balance between food consumption and the utilization of nutrients (nutritional status), body condition improves.

Monitoring the body condition of wild ungulates has long been used by wildlife managers as a means of assessing physiologic responses to variations in habitat quality and seasonality[17,38]; reproductive status[33,34]; and the management and carrying capacity of a habitat.[13,18,32] Most of the conventional techniques for monitoring body condition parameters described for ungulates consist of weighing organs and their stored fat after death.

Although the correlation between serum and body condition is quite commonly used in domesticated animals,[5,8] only a few studies have been conducted on wild ungulate species, including cervids (*Cervus nippon*,[23] *Odocoileus virginianus*,[12] *Rangi-*

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fer tarandus[24]), and suids (*Sus scrofa*[36]). To date, no such studies have ever been performed on wild Caprinae.

Two of the most usual parameters used to assess nutritional status are the calculation of total serum proteins (TSP) and serum triglycerides (ST).[22,30] These two parameters have been used to assess nutritional status in Alaskan moose (*Alces alces*),[15] white-tailed deer (*Odocoileus virginianus*),[3,12] and reindeer (*Rangifer tarandus*).[30]

On the other hand, kidney mass,[21,28] as well as associated kidney fat (KF)[1,38] and a derived kidney fat index (KFI; KF/KM expressed as a percentage[27]), have been used for over 50 yr to monitor body condition in game ungulates,[20,27] because these parameters are easily measured after death.

In this study, the relationship between two serum parameters (TSP and ST) and three traditional indicators of body condition (KM, KF, and KFI) in the Iberian wild goat *Capra pyrenaica*, an endemic Caprinae from the Iberian Peninsula, will be investigated. The aim of this study was to elucidate the relationship between serum biochemistry and body condition and to evaluate their value in monitoring body reserves in both free and captive Iberian wild goats. Despite the use of blood hematology and biochemistry in assessing the health of this Caprinae species,[25,26] their utility as indicators of body condition in other species of wild goats remains unknown. Nevertheless, the results suggest that the link between serum parameters and body condition is a useful way of monitoring body condition in Iberian wild goats.

MATERIALS AND METHODS

Animals and sampling procedures

A total of 25 Iberian wild goats (14 females and 11 males), ranging in age from 1–10 yr old, that were shot by hunters in the Sierra Nevada (southern Spain), a mountain range that covers 850 km^2 (36°55′ to 37°10′N, 2°56′ to 3°38′ W) and includes several peaks over 3,000 m. Samples were collected throughout the year, 12 in the snowy season (winter and spring) and 13 in the dry season (summer–autumn), during 1995–1998. Animals sampled had no evidence of disease or starvation. The goats were weighed in the field and then eviscerated, and each kidney together with the surrounding fat was removed and stored individually in a plastic bag. In the laboratory, kidneys were dried with paper towels and weighed to the nearest 0.01 g without their attached fat and connective tissue capsule (tunica fibrosa). Finally, the average between the right and left KF and KM was calculated in order to compensate for potential differences between the two organs.[2] The KFI was estimated as KF/KM (%).

About 10 ml of blood was taken from the heart cavities of the sampled animals and transferred into tubes without anticoagulant. Blood was then centrifuged (4,750 *g* for 10 min) within a period of 4–10 hr after collection, and the serum was kept at −20°C for subsequent analysis. Triglycerides (mg/dl) were quantified using an autoanalyzer (BT 2245™, Biotechnica Instruments, Rome, Italy), and total proteins (g/dl) were measured with a biuret reaction using BioSystems™ kits (BioSystems-Atom, Barcelona, Spain). Blood samples and kidneys were kept at 4°C during transportation from the field to the laboratory.

Statistical analysis

Before analyzing the relationship between serum parameters and indicators of body condition, the independence of the relationships STP–KF, STP–KM and STP–KFI, and ST–KF, ST–KM, and ST–KFI, and the factors, sex, and seasons were tested. This analysis was performed by several analyses of covariance, in which the noninteraction between the covariables (KM, KF, and KFI) and factors (sex or seasons) was tested. Then, the relationships between KM, KF, and KFI and the serum parameters (TSP and ST) were analyzed by means of a linear regression and correlation,[39] using SPSS 12.0 software (SPSS Inc., Chicago, Illinois 60606, USA). Because the probability of obtaining significant results increases with repeated tests, the obtained *P*-value was corrected by the sequential Bonferroni step-up procedure.[19] The normality of the data was evaluated by means of a Shapiro-Wilk test in order to use the Pearson correlation coefficient.

RESULTS

All parameters showed normality after a logarithmic transformation ($\log_e$). Both serum parameters were correlated to at least one indicator of body condition (Table 1). The concentration of serum proteins ($\log_e$ TSP) was influenced by KM ($\log_e$ KM), but not by KF ($\log_e$ KF). However, concentrations of ST ($\log_e$ ST) were influenced by the amount of KF ($\log_e$ KF) and their proportion with respect to kidney weight (KFI). Serum triglycerides were independent of KM (Table 1). The relationships between serum parameters and body condition were not affected either by sex ($F = 0.311$, df = 1, $P = 0.582$ for $\log_e$ TSP–$\log_e$ KM; $F = 0.11$, df = 1, $P = 0.616$ for $\log_e$ ST–$\log_e$ KF; $F = 0.102$, df = 1, $P = 0.690$ for $\log_e$ ST–$\log_e$ KFI) or by season ($F = 0.255$, df = 1, $P = 0.618$ for $\log_e$ TSP–$\log_e$ KM; $F = 0.111$, df = 1, $P = 0.616$ for $\log_e$

Table 1. Pearson correlation coefficients between serum parameters (total serum proteins [TSP; g/dl] and serum triglycerides [ST; mg/dl]) and body condition parameters (kidney mass without fat [KM; g]; fat around kidneys [KF; g] and kidney fat index [KFI; KF/KM (%)]) in 25 Iberian wild goats sampled in the Sierra Nevada mountain range (Southern Spain). All parameters were $\log_e$ transformed.

	TSP			ST		
KM	$r = 0.524$	$F_{1,24} = 8.706$	$P < 0.005$[a]	$r = 0.021$	$F_{1,24} = 0.01$	$P = 0.922$
KF	$r = 0.297$	$F_{1,24} = 0.088$	$P = 0.150$	$r = 0.672$	$F_{1,24} = 18.94$	$P < 0.001$[a]
KFI	$r = 0.143$	$F_{1,24} = 0.48$	$P = 0.495$	$r = 0.658$	$F_{1,24} = 17.5531$	$P < 0.001$[a]

[a] Values are still significant after Hochberg Bonferroni correction.

ST–$\log_e$ KF; $F = 0.102$, df = 1, $P = 0.752$ for $\log_e$ ST–$\log_e$ KFI).

DISCUSSION

From these results, it was demonstrated that increments in KM are related to protein levels in the serum, i.e., 27.5% of the total variability in serum proteins can be explained by oscillations in the total kidney mass. This finding is consistent with the works of Brown et al.[6] and Wolkers et al.,[37] who concluded that food abundance is positively related to kidney weight protein anabolism. The correlation between ST and both KF and KFI has been previously reported in a number of Cervidae species.[2,9,31] It should be noted that 42.8% and 43.3% of the variability in the ST can be explained by oscillations in KF and KFI, respectively.

In summary, the two serum parameters analyzed in this study are useful for assessing body condition in captive animals because they avoid the need to kill the animal for sample collection and analysis. The TSP reflects the weight of the kidney and the ST reflects the amount of fat stored around the kidney. It is recommended that these serum parameters be used as indicators of protein and fat reserves when studying live animals, especially when the monitoring of the serum biochemical values is routinely evaluated.

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