Final Scientific Report

Cover Page

BARD Project Number: US-3694-05 R

Date of Submission of the Report: June 30, 2009

Project Title: Energy Expenditure for Activity in Free Ranging Ruminants: A Nutritional Frontier

Investigators

Principal Investigator (PI): Arthur L. Goetsch

Co-Principal Investigator (Co-PI): Yoav Aharoni


Institutions

Langston University

Agricultural Research Organization

Agricultural Research Organization

MIGAL-Galilee Technology Center

Agricultural Research Organization

Langston University

Langston University

Keywords: Beef cattle, Goats, Grazing, Activity, Energy, Nutrient requirements

Abbreviations: DM - dry matter, EE - energy expenditure, EE_a - EE for activity, EE_a% - EE_a expressed as a percentage of the metabolizable energy requirement for maintenance, GIS - global information system, GPS - global positioning system, HP - heat production, HR - heart rate, LF = large frame, ME - metabolizable energy, RE - recovered energy, SF = small frame

Budget: IS: $160,000 US: $150,000 Total: $310,000

Signature
Principal Investigator

Signature
Authorizing Official, Principal Institution
Publication Summary

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Postdoctoral Training
Adnan Beker

Cooperation Summary

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Description Cooperation
Dr. Goetsch (US Principal Investigator), Dr. Gipson (US Co-Investigator), and Mr. Kesete Tesfai (US Laboratory Coordinator) received training at the Newe Ya’ar Center early in the project in data management and n-alkane laboratory analyses over a 1-week period. Drs. Goetsch, Gipson, and Sahlu (US Institute Director) made a short visit to the Newe Ya’ar Center in early 2008 when in Israel for other projects to discuss project activities. Likewise, early in 2009 when in Israel for another project, Dr. Goetsch made a short visit to the Newe Ya’ar Center to discuss final project activities and preparation of the final report. Drs. Aharoni (Israel Principal Investigator) and Brosh (Israel Co-Investigator) each made short visits to Langston University to discuss project activities when in the US for annual national meetings of the American Society of Animal Science and the American Dairy Science Association. Dr. Amit Dolev (Israel Co-Investigator) spent a 1-week period at Langston University when in the US for a scientific meeting to provide training in GPS/GIS procedures.

Patent Summary

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ABSTRACT

Heat production (HP) or energy expenditure for activity (EEa) is of fundamental nutritional importance for livestock because it determines the proportion of ingested nutrients available for productive functions. Previous estimates of EEa are unreliable and vary widely with different indirect methodologies. This leads to erroneous nutritional strategies, especially when intake on pasture does not meet nutritional requirements and supplementation is necessary for acceptable production. Therefore, the objective of this project was to measure EEa in different classes of livestock (beef cattle and goats) over a wide range of ecological and management conditions to develop and evaluate simple means of prediction.

In the first study in Israel, small frame (SF) and large frame (LF) cows (268 and 581 kg) were monitored during spring, summer, and autumn. Feed intake by SF cows per unit of metabolic weight was greater (P < 0.001) than that by LF cows in both spring and summer and their apparent selection of higher quality herbage in spring was greater (P < 0.10) than that of LF cows. SF cows grazed more hours per day and walked longer distances than the LF cows during all seasons. The coefficient of specific costs of activities (kJ•kg BW−0.75•d−1) and of locomotion (J•kg BW−0.75•m−1) were smaller for the SF cows. In the second study, cows were monitored in March, May, and September when they grazed relatively large plots, 135 and 78 ha. Energy cost coefficients of standing, grazing, and horizontal locomotion derived were similar to those of the previous study based on data from smaller plots. However, the energy costs of walking idle and of vertical locomotion were greater than those found by Brosh et al. (2006) but similar to those found by Aharoni et al. (2009). In the third study, cows were monitored in February and May in a 78-ha plot with an average slope of 15.5°, whereas average plot slopes of the former studies ranged between 4.3 and 6.9°. Energy cost coefficients of standing, grazing, and walking idle were greater than those calculated in the previous studies. However, the estimated energy costs of locomotion were lower in the steeper plot. A comparison on a similar HP basis, i.e., similar metabolizable energy (ME) intake, shows that the daily energy spent on activities in relation to daily HP increased by 27% as the average plot slope increased from 5.8 and 6.02 to 15.5°. In the fourth study, cows grazing in a woodland habitat were monitored as in previous studies in December, March, and July. Data analysis is in progress.

In the first US experiment, Boer and Spanish does with two kids were used in an experiment beginning in late spring at an average of 24 days after kidding. Two does of each breed resided in eight 0.5-ha grass/forb pastures. Periods of 56, 60, 63, 64, and 73 days in length corresponded to mid-lactation, early post-weaning, the late dry period, early gestation, and mid-gestation. EEa expressed as a percentage of the ME requirement for maintenance plus activity in confinement (EEa%) was not influenced by stocking rate, breed, or period, averaging 49%. Behavioral activities (e.g., time spent grazing, walking, and idle, distance traveled) were not highly related to EEa%, although no-intercept regressions against time spent grazing/eating and grazing/eating plus walking indicated an increase in EEa% of 5.8 and 5.1%/h, respectively. In the second study, animal types were yearling Angora doeling goats, yearling Boer wether goats, yearling Spanish wether goats, and Rambouillet wether sheep slightly more than 2 yr of age. Two animals of each type were randomly allocated to one of four pastures 9.3, 12.3, 4.6, and 1.2 ha in area. The experiment was conducted in the summer with three periods, 30, 26, and 26 days in length. EEa% was affected by an interaction between animal type and period (Angora: 16, 17, and 15; Boer: 60, 67, and 34; Spanish: 46, 62, and 42; sheep: 22, 12, and 22% in periods 1, 2, and 3, respectively (SE = 6.1)). EEa% of goats was predicted with moderate accuracy (R² = 0.40-0.41) and without bias from estimates of 5.8 and 5.1%/h spent grazing/eating and grazing/eating plus walking, respectively, determined in the first experiment; however, these methods were not suitable for sheep. These methods of prediction are simpler and more accurate than currently recommended for goats by the National Research Council.
ACHIEVEMENTS

Significance of Main Scientific Achievements or Innovations
Grazing activity may increase the energy requirements of animals on pasture compared with those of confined animals. Published estimates for cattle, based mostly on measurements of walking costs on a treadmill, combined with estimates of distance walked on pasture have ranged from minor to a 50% increase. The combination of short-interval records of heat production of free-ranging cows with accurate GPS-generated locations and activity records during those intervals enabled reliable estimates of energy costs of cattle activities under field conditions. It can be concluded that two advantages made Baladi cows better adapted to harsh conditions than heavy beef cows: a) better efficiency of intake utilization and b) smaller relative locomotion cost of small stature. Plot size did not directly affect the length of time spent by cows in various activities (i.e., standing, walking idle, grazing, horizontal locomotion, and vertical locomotion). However, cows in larger plots walked for longer periods of time and traveled longer distances in single uninterrupted bouts of locomotion than those in a smaller plot. Consequently, the estimated energy cost coefficients of being in a walking-idle state and of vertical locomotion were greater and more realistic in larger than in smaller plots. Current methods of the National Research Council to predict the activity energy costs for beef cattle are to either 1) assign a subjective percentage of the maintenance energy requirement from 10 to 50% for the ‘best grazing conditions’ to ‘extensive, hilly pastures where animals walk considerable distances to preferred grazing areas and water’ or 2) calculate an absolute amount based on an Australian formula with independent variables of pasture dry matter intake, dry matter digestibility, ruggedness of the terrain, and available forage. The energy costs for specific activities determined in this project will provide a much more accurate means of determining the activity energy cost of cattle.

The amount of energy used for activity by goats can be appreciable, with previous literature estimates of 0 to 100% of the maintenance energy requirement of confined goats. Current means by which this loss in goats is predicted have not been evaluated. The method of projection of the National Research Council is based primarily on time spent grazing/eating plus walking, with small adjustments from distance traveled, forage digestibility, and ruggedness of the terrain. Findings of this project support basing the activity energy cost of goats on time spent grazing/eating or grazing/eating plus walking but indicate that projections should not be adjusted for forage digestibility or distance traveled. The methods of prediction developed from this work are simpler
and more accurate compared with that recommended for goats by the National Research Council. In addition, the methods for predicting the activity energy cost of goats developed were not appropriate when tested with sheep, reflecting need for similar study with different ruminant livestock species.

**Agricultural and/or Economic Impacts of the Research Findings**

In order to achieve highest levels and efficiencies of production by ruminant livestock, it is necessary to know nutrient requirements. Energy requirements are affected by many factors, of which activity is very important. Previous estimates of the amount of energy used for activity have ranged from values similar to those for confined animals to 50% for beef cattle and 100% for goats of the energy requirement for maintenance in confinement. Current methods of predicting the activity energy cost recommended by committees such as the National Research Council are not based on direct estimates and have not been evaluated. The energy costs of activities determined in this project will provide a research-based approach to estimate the amount of energy beef cattle expend in activity when grazing, which presumably will be adopted and recommended by committees such as the National Research Council when beef cattle nutrient requirement literature is reviewed and nutrient requirements are recommended. Similarly, the methods developed in this project predicted the activity energy cost of goats with moderate accuracy and without bias. These methods are simpler and more accurate than that recommended for goats by the National Research Council. With the potential for more widespread and accurate adjustments of the energy needs of beef cattle and goats for activity now possible through this work, more appropriate feeding and nutritional management practices can be imposed to achieve desired levels of production and high efficiency of nutrient utilization.

**Details of Cooperation**

There were a number of exchanges during the project that contributed to achieving project objectives. Dr. Goetsch (Langston University Principal Investigator), Dr. Gipson (Langston University Co-Investigator), and Mr. Kesete Tesfai (Langston University Laboratory Coordinator) received training at the Newe Ya’ar Center early in the project in data management and n-alkane laboratory analyses over a 1-week period. Drs. Goetsch, Gipson, and Sahlu (Langston University Institute Director) made a short visit to the Newe Ya’ar Center in early 2008 when in Israel for other projects to discuss project activities. Likewise, early in 2009 when in Israel for another
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**List of Publications**


