GLOBAL LIVESTOCK CRSP

# Infusing Nutritional Profiling Technology in Sub-Saharan Africa for Free-Ranging Livestock

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*A major constraint in determining the relationship between animal performance and the state of pastoral lands in East Africa has been the general lack of nutritional information for free-ranging animals. New technology has been developed that allows the feces of livestock to be scanned with a near infrared reflectance spectrophotometer (NIRS) to predict diet crude protein (CP) and digestible organic matter (DOM). When coupled with the NUTBAL decision support software, which considers diet quality, environmental conditions, forage availability, and feed/metabolic modifiers to predict changes in body weight, this technology package offers resource managers a way to make changes that can improve the herd's overall body condition and mitigate the effects of drought. Five NIRS laboratories were established in Ethiopia (2), Kenya, Tanzania, and Uganda along with trained personnel within the ASARECA AARNET NARS working groups. Validation tests of the NIRS technology indicated that the NIRS system can predict diet CP and DOM within error of standard scientific methodology. The NIRS/NUTBAL system was validated in each of the four countries. Cattle performance of 15 herds representing five breeds and three physiological classes (steers, cows, heifers) was predicted within <3% of body weight, accounting for 93% of variation in the study, and predicting within 5.9 kg of body weight across the population of 105 head. A special solar drier was developed by Egerton University and KARI to ease logistical constraints in pastoral regions. An expanded sub-Saharan African calibration equation was developed for cattle, sheep, and goats based on two Ph.D. dissertations and is currently being combined with calibration sets from the USA, Argentina, Canada, and Australia to form a Global Calibration equation that can be transferred to NIRS labs around the world.*

## Background

NIRS technology is revolutionizing the way analysis is conducted for a wide array of products. The system allows scanning of material (forage, feces, cosmetics, chemicals, tissue, wool, etc.) with monochromic light and measures the differential absorbance, or reflectivity, of chemical bonds in the target substance in the near infrared band (1100-2500 nm) (Roberts et al., 2003). One can predict the concentration or absence of target variables in samples, based on the combination of sophisticated waveform analysis and calibration sets of known chemical compounds of the target substance. Jerry Stuth, the Principal Investigator of the LEWS team, had developed the methodology in earlier years and desired to test the concept in the context of pastoral lands in East Africa. The initial goal was to provide a monitoring tool to complement the early warning system that simultaneously monitors forage conditions. To ensure that the animal monitoring system was viable for East Africa, a series of technology verification experiments were conducted by NARS partners in Uganda, Ethiopia, Kenya, and Tanzania followed by expansion of the equations with East African vegetation resources for cattle, sheep, and goats.

## Methods

Initially, a series of stall-feeding trials were conducted to determine if technology created in the U.S. could predict diet quality from the feces of cattle, sheep, and goats fed mixed rations of native African vegetation. These trials were conducted at ASARECA AARNET research centers in Adami Tulu, Ethiopia (EARO, managed by Abule Ebro), Mbarara, Uganda (NARO, managed by Cyprian Ebong and Steven Byenkya), Kiboko, Kenya (KARI, managed by William Mnene), and Mpwapwa, Tanzania (MLWD, managed by Angello Mwilawa). Concurrently, herds of cattle, sheep, and goats were grazed under normal pastoral conditions at the research centers and the animals' weight and body condition recorded at monthly intervals through one growing and dry season (approximately 6 months). Fecal samples were collected every 14 days, dried, ground, and shipped to Texas A&M University for NIRS scanning. The diet CP and DOM derived from fecal NIRS scans from both the stall-feeding and pastoral grazing trials were predicted with the calibration equation developed for the U.S. Results were put into the NUTBAL metric software, along with animal breed/

sex/age, temperature, humidity, and windspeed. NIRS-predicted CP and DOM values were compared with corresponding wet chemistry values of fed rations. Weights of the animals and predicted weights were contrasted.

After testing the viability of the U.S. system, diet:fecal pairs were gathered from Ethiopia, Niger, and Nigeria by a Ph.D. student (Sarah Ossiya) funded by DANIDA and the Rockefeller Foundation, in collaboration with ILRI animal scientists. Additional sets of stall-fed samples were developed in Ethiopia, Kenya, Tanzania, and Uganda by the ASARECA AARNET NARS network. In addition, a World Bank and Rockefeller Foundation-funded Ph.D. student (Kosi Awuma) was able to work with the LEWS samples and samples collected in Ghana to complete the calibration for sub-Saharan Africa (SSA). These samples were integrated with the sub-tropical samples derived from southern Texas to create a new calibration equation for addressing livestock nutrition in SSA.

Throughout the process of testing and updating the calibration equations, a series of NIRS labs were established. The first, established with ILRI at Debra Zeit in Ethiopia, was a center for training and processing of the samples until the other NIRS labs could be established. Eventually, NIRS laboratories with fully trained staff were established at KARI's research center in Naivasha, Kenya, NARO's research center in Kampala, Uganda, EARO's research center in Holetta, Ethiopia, and the Animal Disease Research Institute in Dar es Salaam, Tanzania. These labs are fully supported by their respective institutions.

## Preliminary Findings

When the original U.S. equation was applied to feces of animals on stall-fed diets, crude protein was predicted with accuracy well within standard laboratory error (Cattle $R^2 = 0.80$ and SEp = 0.95; Goats $R^2 = 0.94$ and SEp = 0.72; Sheep (using cattle equation) $R^2 = 0.87$ and SEp = 0.95). However, it was evident that spectral outliers were emerging for high browse diets and for certain growth conditions, requiring possible expansion of the diet:fecal pairs in the calibration datasets.

A metric version of the NUTBAL PRO nutritional balance analyzer software was created and modified to accommodate night penning of animals, which reduces dry matter intake. The CP and DOM values of the free-ranging animals were input in the NUTBAL PRO software, along with the animal and environmental variables to predict weight change and body condition. When the measured end weights were contrasted with the predicted weights in the 15 cattle herds, 93% of the variation in weight was accounted for with an accuracy of +/- 5.9 kg body weight (Figure 1). For cattle and goats, the monthly weights never differed more than 3% of body weight. However, the sheep predictions varied 5-7% of body weight, indicating a need to create a sheep NIRS equation instead of using the cattle equation. Further inspection of the NUTBAL PRO model indicated a need to improve on the efficiency of gain component that was derived from high performance wool producing sheep. These modifications have subsequently been made to the software.

Overall, the series of studies produced CP and DOM equations that predict values well within conventional laboratory methods. When contrasted to studies in Australia, Hungary, the U.S., and Argentina, most the reported standard errors were within or below those reported in referred journals. The results of the field verification and the resulting laboratory calibration equations are practical, simple, and cost effective. The technology could be a powerful tool in the nutritional management of free-ranging livestock in sub-Saharan Africa. Other fecal NIRS studies are currently underway by LEWS to improve the sheep equation, develop a calibration equation for donkeys, and expand the use of the NIRS technology for pregnancy testing, mineral efficiency assessment, and tick stress.

## Practical Implications

The NIRS/NUTBAL PRO nutritional management system is a rapid way to assess the nutritional status of the free-ranging animal long before the human eye can detect visible changes in body condition. With the network of NIRS labs in place and NARS scientists trained in the use of the NUTBAL PRO system, the capacity to provide nutritional advisories to pastoral communities is in place. Solar driers developed by the LEWS team at Egerton University allow users to inexpensively (<$35 USD) dry feces on-site, where electricity is non-existent, without affecting the predictive capacity of the NIRS system. Fecal samples can be dried in 48 hours on-site, crumbled into a small paper envelope, and placed on a bus, matatu, transport truck, or express taxi for delivery to NIRS labs in each of the countries with minimal recurring costs to the site monitor/advisors.

LEWS has been working on practical methods of reporting the results back to the advisor without relying on phone, land mail, or fax. One system being investigated involves assigning a site and sample code to a text file that is broadcast several times a week via WorldSpace radios. The NIRS labs have internet connections and can send text files to the WorldSpace radio nodes of advisors in the field via containers of

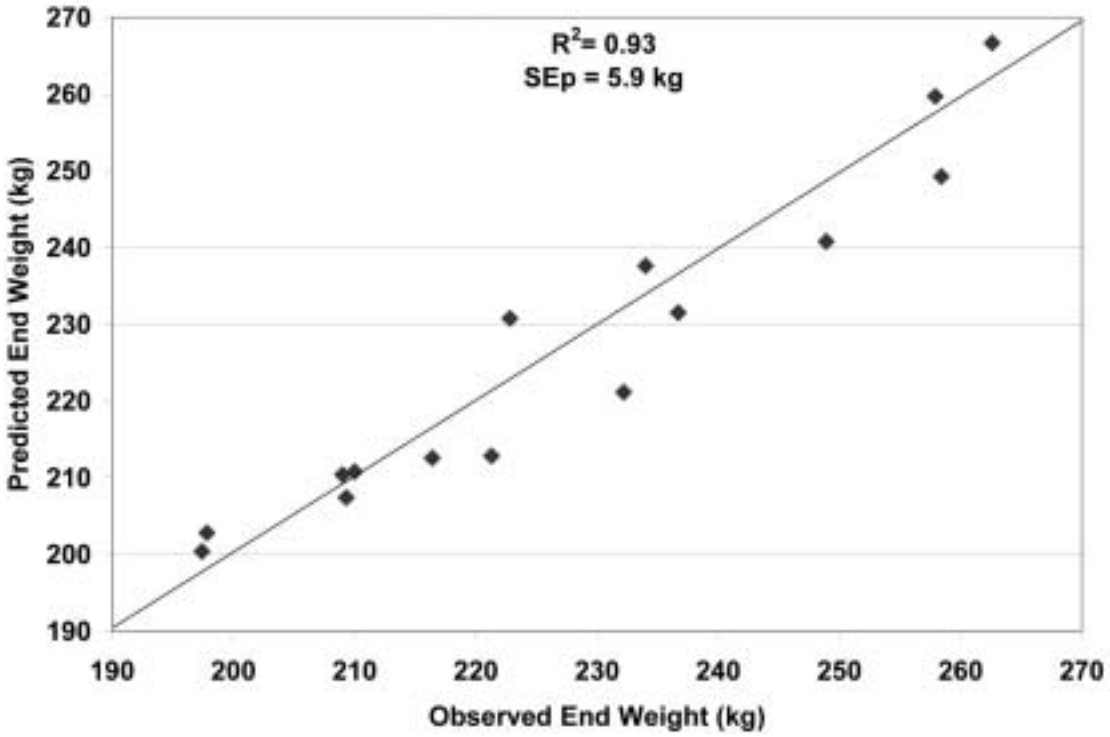


*Figure 1: Relationship between predicted end weights using the NIRS/NUTBAL technology and actual end weights of 15 herds of cattle grazing rangelands in four countries of East Africa.*

LEWS collaborating institutions (Arid Lands Information Network, RANET). This method requires a satellite radio, converter, and cheap laptop, about $800-$1000 USD per node. The other method involves use of SMS text messaging on cell phones, where advisors in areas with cell phone capacity are provided with the phones and code system. The NIRS lab then transmits the SMS text message of sample number, date, CP, and DOM value at a cost of $.01/sample, plus the initial cost of the cell phone. Both techniques require a 2-day training session for the NUTBAL PRO software, and use of the satellite radios or SMS cell phone.

## Further Reading/References

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The GL-CRSP Livestock Early Warning System Project (LEWS) was established in 1998 and conducts research and training in the use of the livestock early warning system, actively monitoring sites in Uganda, Tanzania, Kenya, and Ethiopia. The system detects changes in forage supply and livestock well-being in pastoral regions of East Africa and reports on emerging conditions to both national, international, and community-based early warning and monitoring organizations. The project is led by Dr. Jerry Stuth, Texas A&M Univrsity. Email contact: j-stuth@tamu.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East Africa, Central Asia and Latin America.

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