Proceedings:

2006 Mealani Forage Field Day

Hawaii Grown Beef: From Pasture to Market

October 7, 2006

Mark S. Thorne and Linda J. Cox, Editors

College of Tropical Agriculture
and Human Resources
University of Hawai'i at Mānoa

Mealani Forage Field Day 2006

Hawaii Grown Beef: From Pasture to Market

Mealani Forage Field Day is an annual educational outreach program that provides information on forage based livestock production to Hawaii's livestock industry. The program has three primary goals that focus on creating a livestock industry in the state that is ecologically, economically, and socially sustainable: 1). To provide technology and information on development of sustainable forage production systems to Hawaii's livestock industry (ecological sustaina-bility); 2) To provide information on opportunities and incentives for market development of forage based livestock products (economic sustainability); 3) To provide information to producers, processors, retailers, and the consumer about the benefits of forage based animal production systems; healthy foods, healthy economy, healthy environment (socially sustainable).

Hawaii has the potential to produce high quality forage-finished beef on a year-round basis; something that is not necessarily possible in most mainland beef producing areas. This represents a tremendous opportunity for Hawaii's ranchers as demand for forage-finished beef products increase nationally. However, there are significant gaps in the industry infrastructure (stocker and finishing operations, available pasture land, etc.) that continue to limit the potential to market local beef products. In addition there is a great need for federal, state and local government focus on providing assistance and support (land, tax incentives, enterprise zones, water issues, etc) of the industry. Research and technology development (slaughter and processing facilities, packaging technologies, sustainable forage systems) are also crucial to assure Hawaii's beef industry has the right tools to successfully compete in a global market and to become leaders in the production of quality beef products. Other critical issues that affect the well being of the beef industry in the state include transportation costs, import and export laws, designation of critical forage species as noxious weeds, weed infestations, water and land availability need also be addressed.

The content of this year's Field Day Program will present attendee's with a variety of topics that address issues and needs that affect the Hawaii Beef Industry from the pasture to the market. Mr. Steve Keville, the National Meat Coordinator for Whole Food Markets, Inc. is the keynote Speaker. Mr. Keville will provide an over view of Whole Food Markets' philosophy on purchasing and marketing natural meat products as well as challenges that they face in acquiring the necessary volume of high quality meat products. Later in the program, a panel local slaughter and market experts will provide an over view of issues they face and will discuss solutions to those issues with the audience.

Providing a forum for ranchers, vendors, and educators to network and display products, research, and knowledge is an important function for the field day program. This year we have set aside a large part of the program for this. We hope that this portion of the program will provide opportunities for the development of good partnerships among all participants.

The forage field program strives to provide producers with information on new tools and technology. This year Dr. Linda Cox will provide information on evaluation market options using a new CTAHR program currently being finalized for release. Extension agent, Mike DuPonte will give a presentation on using ultrasound technology to evaluate beef production traits in the beef herd. In the afternoon, participants will have an opportunity to discuss pasture management issues with Dr. Mark Thorne, observe the Kx2 Leucaena grazing trials, and see a range drill seeding demonstration.

It is hoped that this year's program will help the Hawaii beef industry sustain a strong, healthy, and vibrant industry into the future.

Mark S. Thorne and **Linda J. Cox**
Co-Editors

Acknowledgments

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Mealani Forage Field Day 2006
Hawaii Grown Beef: From Pasture to Market

Location: Mealani Research Station, Kamuela, Hawaii

Date: October 7, 2006

Time: 7:00 am – 4:30 pm

Schedule:

7:00 – 8:00 am	Registration
8:00 – 8:10 am	**Welcome and Introductions** – Wayne Nishijima, Associate Dean of Extension, University of Hawaii - CTAHR
8:10 – 9:30 am	**Market Options and Strategies: The Future of Hawaiian Grown Beef.** Whole Foods Market Inc. Steve Keville (tentative)
9:30 – 11:00 am	**Facilitated Introductions and Networking:** Vendors, Researchers, and Organization Representatives.
11:00 – 11:30 am	**Evaluating Market Options With A Ranch Production Cost Analysis.** Dr. Linda Cox, Agricultural Extension Specialist, University of Hawaii - CTAHR
11:30 – 12:00 pm	**Evaluating Beef Production Traits Using Ultra-Sound Technology.** Mike DuPonte, Agricultural Extension Agent, University of Hawaii - CTAHR
12:00 – 1:00 pm	**Lunch Break**
1:00 – 2:30 pm	**Slaughtering and Marketing Beef in Hawaii: An Industry's View** **Industry Representatives:** Jill Andrade, J.J. Andrade Meats Dave DeLuz, Big Island Beef Alex Franco, Maui Cattle Company
2:30 – 4:00 pm	**Field Tour and Demonstrations:** Pasture Walk – Estimating forage production; Kx2 Leucaena Trials; Corn Silage; and Range Drill Seeding Demonstration
4:15 – 4:30 pm	Closing Remarks

Mealani Forage Field Day 2006
Hawaii Grown Beef: From Pasture to Market

Poster Submissions

Welcome Address

Wayne Nishijima
Associate Dean/Associate Director for Cooperative Extension, CTAHR

On behalf of the College of Tropical Agriculture and Human Resources, University of Hawai‘i, I wish to welcome you to the 2006 Mealani Forage Field Day. I hope (and expect) all of you to go away from here with at least one or two pieces of new and useful information that you can take home. I hope that the information presented today will help you improve your ranch or related operations, or if you are a government agency, service or support business you will be able to use this new knowledge to help our cattle industry become more successful and profitable. I'd like to give you a short update on the College and upcoming events:

We are on track with our capital improvement projects. Construction should begin in early 2007 for the construction of a new Extension Building on Moloka‘i in Hoolehua and also for the construction of a new research facility and renovation of a building at the Komohana Research and Extension Center in Hilo. Governor Lingle released the planning funds on July 5, 2006 for the College's Agribusiness Incubator Facility proposed for Waialua on Oahu on land being donated by Dole Foods. The Agribusiness Incubator Program helps new and established agriculture-based companies on a one on one basis to “get to the next level”.

The Ag 2006 Conference will be held on October 26 at the Hilton Hawaiian Village and will be preceded by the Hawai‘i Farm Bureau Federation Annual Convention on October 24-25. A series of 2-day Organic Farming training workshops started on Oahu on September 7-8, and Moloka‘i on September 28-29. Sessions are scheduled for Mau‘i in November, Kona in December, and Kaua‘i in January 2007.

As a result of a Hawai‘i Produce Workshop which CTAHR organized in April 2007, the Hawai‘i Food Industry Association wants to hold a similar workshop focusing on locally produced beef. Representatives of the supermarket chains indicated they want to buy local but often are not able to get what they want in the quantities they need. The objective of this proposed workshop would be to acquaint the food industry personnel with the producers and educate food industry personnel on basic information on the Hawaii cattle industry such as what's available and where, quantity, quality, benefits, and other issues except for specific pricing discussions to prevent any potential accusations of price fixing.

We are in the final stages of selection of the Hawai‘i County Administrator and began the selection process for the County Administrators for Kaua‘i and Oahu Counties.

It's hard to believe that it was only 4 years ago in 2002, that I stood here as the Hawaii County Administrator outlining the changes we planned (some of which we had already started) to the focus of what we do here at Mealani. It was a major decision but we felt we didn't have a choice because we felt that we were not doing enough to help the cattle industry here in Hawaii. Although we still have a long way to go, the CTAHR Beef Initiative team, led by County Extension Agent Glen Fukumoto, has made significant progress. You will be hearing updates today.

Thanks to Dave DeLuz, the Paauilo processing plant is back in operation and cooperating with other processors. Our industry here is too small and we need to cooperate with each other. For that I commend and thank you. This processing plant is important for the local cattle industry and a vital component to the viability of the local, forage fed cattle industry. Commercial beef production for local sales in 2006 has been averaging about 15 to 20% higher than in 2005. Commercial slaughter for March 2006, was 1000 head as compared to the 800 head in March 2005. In this context, I am anxious to hear what Steve Keville from Whole Foods has to say about Hawaiian Grown Beef and the possibilities. Best wishes for a successful Forage Field Day.

Evaluating Market Options With A Ranch Production Cost Analysis

Linda J. Cox
College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa

Since 1986, Hawaii's market share of the local beef market has decreased from about 30 percent to less than 10 percent. Hawaii cannot compete in the production of grain-finished beef from the U.S. Mainland because of the high cost of inputs here. Currently, about three quarters of all cattle marketed in Hawaii are finished and marketed in North America. Shipping feeders has been the preferred option for larger producers because the local price was not competitive with the price on the Mainland. Smaller producers have been generally more willing to accept the local price and have had more flexibility when it came to forage finishing cattle. Transportation costs and other challenges associated with shipping live animals may make exporting a less attractive marketing option in the future (Cox and Bredhoff, 2003).

At the same time, consumer preferences for natural or forage-finished beef are causing demand for these types of beef to increase, which is likely to increase the price for cattle that yield such beef (Cox and Shehata, 2003). The dynamic nature of the beef market makes it difficult for producers to analyze all the information needed to make marketing decisions. Therefore, Beef-XL was designed so that producers can enter the costs associated with various marketing options and quickly calculate the cost of each option.

Figure 1 outlines the potential marketing options for Hawaii beef cattle that are examined in Beef-XL. These options include: Hawaii: Sell at weaning, Hawaii: Background weaned cattle on forage, Hawaii: Independent retained ownership through feedlot finish, Hawaii: Independent retained ownership through forage finish, Mainland: Background weaned calves on forage, Mainland: Independent retained ownership through feedlot finish, Mainland: Independent retained ownership through forage finish, Mainland: Market alliance.

According to Cox and Bredhoff, only one feedlot exists in Hawaii, which limits the market for stockers here. However, cattle moving to the mainland may be sold as feed cattle, since these markets are more developed. While some options in Beef-XL, such as using a feedlot finishing in Hawaii, may be limited, they are still included because they may become more viable in the future. Beef-XL is a tool that allows the producer to compare the cost of each option in order to make a decision.

Mainland market alliances are an option for local producers. Although some alliances involve seed stock or cow-calf/production, the majority include the entire production/marketing channel up to and including the retail and/or food service level. If a market alliance involves moving cattle into a marketing channel that includes the retail level, the producer will give up independent control and abide by the decisions made by the alliance. This allows the alliance to act as one producer in order to obtain a consistent supply of a quality product. By bringing producers together to act as one, market alliances give producers more power in the market place. Cattle producers usually deal with one buyer who buys from many sellers. When the sellers join together, they control a larger volume of cattle and do not compete with each other on the selling price (Cox et al.).

Before joining an alliance, producers should be aware that alliance organizations and programs might differ. Producers should choose an alternative that complements their own objectives and production systems. At the same time, producers must understand that for the market alliance to be effective, all members must be committed to the program.

Beef-XL is set up as a spreadsheet program so that it can do all the calculations for you. You will need to be familiar with the basic concepts of Excel or a similar spreadsheet program in order to use it. The first thing you should be aware of is the difference between a *worksheet* and a *workbook*: A worksheet consists of cells that are organized into columns and rows. It is the primary document that you use in Excel to store and work with data. A workbook is used to store worksheets.

Beef-XL is organized to complement Calf-XL. If you can enter data from Calf-XL, Beef-XL identifies the location of the information on Calf-XL so that you can transfer it to Beef-XL. Beef-XL contains a total of 11 worksheets, with eight that require the user to enter information.

The first worksheet includes a Disclaimer to inform everyone that the Cooperative Extension Service is not responsible for the accuracy of the information you enter. It does not require you to enter information.

The next eight worksheet are infoSum worksheets that require you to enter information.

The worksheet *InfoSum, Pg.01* is designed to collect your ranch's livestock sales information, which you can find in Calf-XL and the information to determine the returns form selling at weaning in Hawaii.

The worksheet *InfoSum, Pg.02* is designed to collect the information needed to determine the returns from backgrounding your weaned calves on forage before selling them.

The worksheet *InfoSum, Pg. 03* is designed to collect the information needed to determine the returns if you retain independent ownership of your weaned calves through feedlot finishing before selling them.

The worksheet *InfoSum, Pg. 04* is designed to collect the information needed to determine the returns if you retain independent ownership of your weaned calves through forage finishing.

The worksheet *InfoSum, Pg.05* is designed to collect the information needed to determine the returns from shipping your weaned calves to the U.S. Mainland and backgrounding them on forage.

The worksheet *InfoSum, Pg. 06* is designed to collect the information needed to determine the returns if you ship your weaned calves to the U.S. Mainland and retain independent ownership of your weaned calves through feedlot finishing before selling them.

The worksheet *InfoSum, Pg. 07* is designed to collect the information needed to determine the returns if you ship your weaned calves to the U.S. Mainland and retain independent ownership of your weaned calves through forage finishing before selling them.

The worksheet *InfoSum, Pg. 08* is designed to collect the information needed to determine the returns if you ship your weaned calves to the U.S. Mainland and enter into a market alliance before selling them.

The remaining two worksheets are:
Worksheet 10. *BXL Report* and Worksheet 11. *BXL Summary*.

Both of these worksheets present a comparison of the eight marketing options being considered by Beef-XL. BXL Report provides three summary tables for each option including: Gross receipts, Net Return and Break-even Price for each option. In addition, for those options that involve independent retained ownership and backgrounding or finishing, a fourth table that summarizes costs and returns per pound of gain is included. BXL summary is a chart that displays the net returns for each option side-by-side.

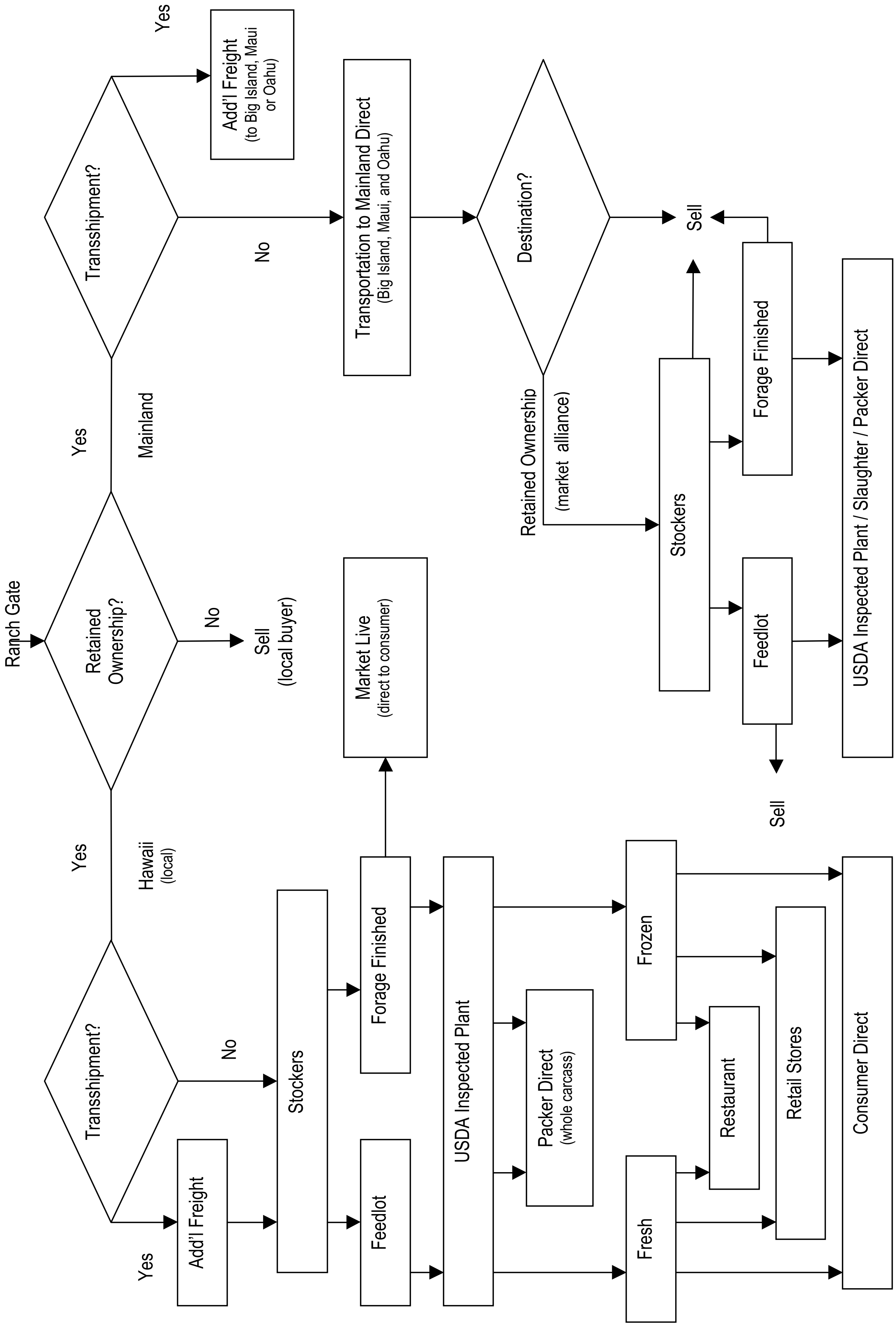
Currently, Beef-XL is being field tested and a user's guide is being written. This process will be finished in a few months. Then, the guide and Beef-XL will be available on CTAHR's website.

References

Cox, Linda J., Quincy A. Edwards, Mark Thorne, Glen Fukumoto and Lincon Ching. 2006. *Commerial Cow-Calf Decisions: Calculating the Cost of Production for a Cow-Calf Operation*. College of Tropical Agriculture and Human Resource, Livestock Management No. 12, Honolulu, Hawaii, 21 pp

Cox, Linda J. and Sabry Shehata. 2003.*The Market for Hawaii-Grown Natural and Organic Beef*. College of Tropical Agriculture and Human Resource, Livestock Management No. 9, Honolulu, Hawaii, 4 pp.

Cox, Linda J. and Soot Bredhoff. 2003. *The Hawaii Beef Industry: Situation and Outlook Update*. College of Tropical Agriculture and Human Resource, Livestock Management No. 8, Honolulu, Hawaii, 11 pp.



Hawaii Beef Cattle Marketing Flowchart

Application of Ultrasound Technology in Beef Cattle Carcass Research and Management: Frequently Asked Questions

Michael W. DuPonte[1] and Marla L. Fergerstrom[2]
[1]Department of Human Nutrition, Food and Animal Sciences, [2]Mealani Research Station

Hawai'i's beef industry has experienced significant changes over the past decade due to consumer demands on the market and food safety regulations. Providing the consumer with a leaner product in less than 20 months is increasingly the focus for all segments of the industry. Cattle ranchers are now implementing new management procedures to upgrade genetic programs with intensive use of artificial insemination and emphasizing selection by expected progeny differences (EPDs), embryo transplanting of superior animals, DNA mapping of key growth genes, and ultrasound technology (UT).

The use of ultrasound for predicting fat and muscle content in live cattle has been around since the early 1950s (Wild 1950). Today, UT is routinely used by the beef industry for

- evaluating seed stock (Wilson 1992)
- identifying dates to slaughter cattle (Houghton and Turlington 1992)
- predicting quality, palatability, and cut-ability in carcasses (Hamlin et al. 1995)
- sorting feeder cattle into uniform groups for specialty markets (Williams and Trenkle 1997).

UT measurement of carcass traits in live cattle, when combined with good production records, can serve as a powerful tool in beef cattle breeding programs. The purpose of this publication is to answer some frequently asked questions about ultrasound technology.

What is ultrasound technology?

Ultrasound is the use of high-frequency sound waves, on the order of 20 kilohertz (Khz), or above what is perceived by the human ear. These sound waves produce vibration-reflection images of tissues such as muscle, fat, and internal organs in live animals using specialized, "piezoelectric" crystals housed in an ultrasound transducer or wand. The reflected images are then converted to electrical current and appear as gray-shadowed pictures on a viewing screen (monitor).

Is UT the same technology used for human pregnancy?

Yes, in fact all live-animal ultrasound technology used by veterinarians was adapted from human medicine.

Is UT safe?

Yes. For over a decade, UT has been accepted by cattle breed associations as being of diagnostic value. UT is a safe, humane, non-invasive, non-destructive, painless technique that can be readily used on live animals.

How much does an ultrasound machine cost?

Because most ultrasound use is in human medicine, the machines could be prohibitively expensive for small-scale livestock producers. A typical machine with software can cost from $15,000 to $35,000.

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How can a small-scale producer afford a UT machine with it being so expensive?

Small-scale producers usually do not purchase a machine. A certified, trained technician usually purchases a machine and starts up a for-hire service within a district. A scanning session usually costs between $10 and $25 per animal, depending on the number of animals scanned and the distance traveled by the technician.

What part of the animal is scanned for carcass data?

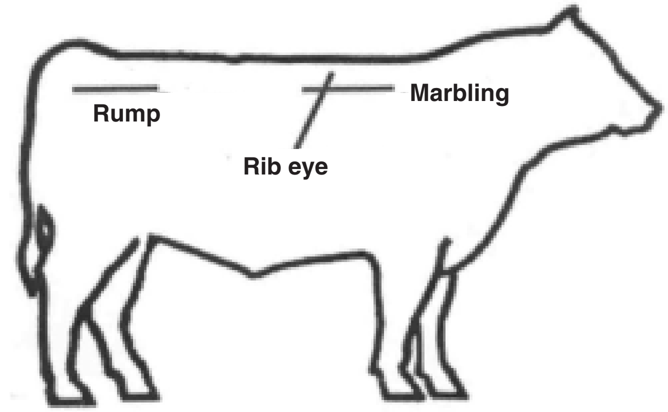
Animals are scanned in three different areas on the right side of the body. Ultrasound images are taken of the rib eye area (REA), the 12th to 13th rib-fat thickness and intramuscular (marbling) fat (IMF) area, and the rump fat (RF) area (see illustration). The technician routinely takes two scans for REA, four scans for IMF, and two scans for RF, and submits the images to a centralized ultrasound processing laboratory (CUP) for interpretation. Pictures received from the field must be of superior quality, complete with accurate animal identification, and include contemporary grouping records. Failure to abide by these guidelines results in rejected images, and thus the data will not be used in calibrating genetic expected progeny differences.

How accurate is UT?

UT is very accurate. Certified technicians have been trained to measure and interpret within 0.6–0.7 square inches of actual rib eye area, 0.04–0.05 inches of actual rump fat area, and 0.8–0.9% of intramuscular fat area.

How do technicians become certified?

To become a certified UT technician, one needs to attend a basic, sanctioned ultrasound training session. Once completed, the technician then needs to become comfortable with the equipment (usually scanning 300 animals from at least six to ten different herds). The technician then enrolls in an intensive four-day certification program to demonstrate proficiency using UT in both scanning and interpretation. All applicants must pass each section according to the Ultrasound Guidelines Council (UGC) standards. Standards are rigorous, and only 60 percent of participants become certified. Technician certification is usually renewed every other year.



Scan positions for ultrasound images

What is UGC?

The Ultrasound Guidelines Council is an organization that was formed by the U.S. Beef Breeds Council to be responsible for developing, maintaining, and governing testing protocols and standards for beef cattle ultrasound technician certification. Committee members are usually breed organization representatives, university personnel involved with UT research, and representatives of industry companies and technician organizations that support the beef cattle industry through ultrasound service programs.

What is a CUP?

A Centralized Ultrasound Processing (CUP) Laboratory is an independent business that processes images sent by certified technicians. To prevent biases on pictures sent, certified technicians do not interpret their own images. CUP requirements assimilate UGC standard protocols for all image collection, assure accuracy in the interpretation of ultrasound scanned pictures sent, and provide cross-checks on problem images submitted. Data collected by the CUP is then used by breed associations to develop genetic EPD calculations.

At what age would I have my animals scanned with UT?

The recommended use of UT is on yearling bulls and replacement heifers. Depending on your breed association, the proper animal scanning age range should fall between 320 to 440 days, and yearling weights are adjusted to 365 days of age.

Are there any special animal preparations needed prior to scanning animals?

Collection of individual animal weights should be done within seven days prior to or after scanning. Animals should not have access to overnight feed or water prior to being weighed in. Once a herd has enrolled, all animals in a contemporary group must be scanned with ultrasound within a three-day period.

Is there any special equipment I will need so that animals can be UT-scanned?

The basic necessities are a weight scale and a covered squeeze chute to protect animals, equipment, and the technician from rainy conditions while scanning. Electrical power maybe needed for the ultrasound equipment and also a pair of hair shears for clipping animals with long, dirty, or matted coats.

Are there any specific records I will need to get started using UT?

Any kind of recordkeeping on the animals is helpful. Birth weights and yearling weights are useful in determining growth rate and for comparing it with UT carcass data.

What are the advantages of UT over traditional beef quality grading?

UT has the ability to quickly amass large amounts of data on live yearling offspring for use in carcass trait genetic evaluations. With UT, producers are now able to evaluate a sire's carcass merit transmitting ability without waiting two to three years for the results from slaughtering offspring, which could be quite expensive. This information can be used as a management tool in selection and replacement of breeding stock for the improvement of the genetics of the herd. Producers also can sort live cattle into different management categories, leading to uniformity of product destined for specialized markets.

Literature cited

Wilson D.E. 1992. Application of ultrasound for genetic improvement. J. Anim. Sci. 70:973–983.

Hamlin, K.E., R.D. Green , L.V. Cundiff, T.L. Wheeler, and M.E. Dikeman. 1995. Realtime ultrasonic measurement of fat thickness and longissimus muscle area. II. Relationship between realtime ultrasound measures and carcass retail yield. J. Anim. Sci. 73:1725.

Houghton, P.L., and L.M. Turlington. 1992. Application of ultrasound for feeding and finishing animals: A review. J. Anim. Sci. 70:930.

Williams, R.E., and A. Trenkle. 1997. Sorting feedlot steers using ultrasound estimates of backfat at the 12^{th} and 13^{th} rib prior to the finishing phase. J. Anim. Sci. 75 (Suppl. 1):55.

Wild, J.J. 1950. The use of ultrasonic pulses for measurement of biological tissues and the detection of tissue density changes. Surgery 27:183

Slaughter and Market Issues at the Andrade Slaughterhouse, Honokaa, HI

Jill J. Mattos[1] and Mark S. Thorne[2]
[1]Owner/Operator, J.J. Andrade Slaughterhouse, Honokaa, Hawaii.
[2]College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa

Introduction

The following text was compiled from discussion with Mrs. Jill Mattos, owner and operator of the J.J. Andrade Slaughterhouse in Honokaa, Hawaii. During the discussion she identified many issues that affect her business and the industry as a whole. In addition, Mrs. Mattos provided perspectives on possible solutions to many of the issues. She also noted that there are many "untapped" opportunities in the industry.

Major Issues

Labor Force

One of the principle concerns for the slaughter industry in the state, and one that Mrs. Mattos must deal with regularly, is the lack of an adequate, trained, labor force. There are no vocational education courses in meat cutting, packing, or slaughterhouse operations and management in Hawaii. This means that all slaughter facilities and packers in Hawaii must train their employees on the job. Without training, new employees cannot start at adequate wage levels and so do not typically stay in the job long enough to move up with subsequent training. This results in a continual cycle of hiring and training which reduces the overall efficiency of the operation.

A solution that Mrs. Mattos believes is critical to the continued success of the slaughter industry in Hawaii is the development of a vocational education program in Meat processing. This program would be developed by the University of Hawaii at Manoa and taught at the various Community Colleges. Courses should include meat cutting, handling, packing, slaughterhouse operations, and management.

Mrs. Mattos also pointed out that the number of available workers in the labor force is greatly reduced in Hawaii primarily because of the lack of affordable housing. Workers interested in a trade within the meat processing industry in Hawaii cannot afford housing. Consequently, they typically look for positions on the mainland. For the slaughter industry too remain successful in Hawaii, affordable housing options have to be developed here.

Another labor issue includes a discrepancy, or limitation in the number of categories defined for slaughter faculties under **Workman's Compensation** rules. Currently there are only three categories; clerical, driver, and butcher. Workman's compensation assessments for butchers are higher ($17/hour per $100 in wages) than the other categories ($6/hour per $100 in wages). However, there are other, less dangerous positions in the slaughter facility; such as wrappers. Unfortunately, these positions are assessed at the high rate for butcher instead of at the lower level. The inclusion of more designations would greatly reduce the operating costs of the slaughter facilities in the state.

Cattle

Another important concern, and one central to the success of the slaughter industry in the state, is the lack of adequate supply of high quality cattle for slaughter. There is an increase in demand for local beef products, but when the gap between supply and consumer demand is made up in animals with poor carcass traits it negatively affects the industry.

The solution to these shortfalls in quality beef carcasses is for more ranchers to keep animals here for slaughter. This would involve many of the small ranches adopting programs to grow and finish beef animals on forages.

Rendering

Currently there are no rendering facilities in the islands. This presents a major limitation to the slaughter facilities and raises their operation costs dramatically over those of similar facilities on the mainland. The development of the rendering facility at the Hawaii Beef Producer's facility is an important improvement and should go a long way to reducing the over all cost of slaughter.

Cost of Utilities

Utility costs at Andrade Slaughterhouse continue to rise at an alarming rate. While these rising utility costs are driven by the utility company's cost of producing the energy, wholesale/retail meat prices, are driven by the consumer's willingness to buy the products. Thus, utility costs rise independent of the ability of any business or individual to pay. In Hawaii, these costs are rising faster than any increases in the price consumer's are willing to pay for wholesale/retail meat products. Consequently, profit margins are rapidly shrinking for the slaughter and packing industry in the state.

Opportunities

Although there are many challenges to the slaughter and marketing of beef in Hawaii, Mrs. Mattos pointed out that there are many untapped opportunities. The industry need's to focus on advertising on the forage finish potential in Hawaii. In addition, Mrs. Mattos indicated that it is vital that the College of Tropical Agriculture and Human Resources conduct research and provide extension outreach materials on forage finishing cattle in Hawaii. By doing, this more ranchers will have the kind of information they need to make the decision to begin raising beef animals for local slaughter.

Today's Hawaii Beef Industry

Robert A. Sporleder and David DeLuz
Hawaii Beef Producers, Inc

Hawaii's beef industry is on the verge of a "Paradigm Shift" in production and marketing of their cattle. If we can provide the model that will produce Premium Beef Products, we then can command premium prices for that product at the market place.

Most of the livestock produced in the state are exported as 400 to 500 weight calves. These are being shipped to the mainland and are either sold to mainland producers or fed to finish on a retained ownership basis.

For the past decade or more, marketing cattle through the mainland was our most viable option and it will remain an option in the future, but the continuing profitability of this practice in the long-term is questionable. We certainly will be at the mercy of not only mainland commodity prices but also the ever-increasing prices for fuel and transportation.

We all know that importing enough high-energy feedstuffs into the State to finish our cattle is not economically viable. However, we do have options before us. To determine the most viable options, we need to look at the end market place. What is the fastest growing market in the beef industry today, what types of products are most limited in supply and which command premium prices at the end market place.

Our research indicates that while "All Natural Grass Finished Beef Products" has a very small production supply it commands the highest prices. These types of products are what more and more health conscious consumers are demanding. This market demand is projected to continue to increase over 10-fold in the next decade. The only reason market expansion is not growing at a faster rate, is that it is difficult for these products to be produced on the mainland at any sizeable quantity.

It appears that the new proposed USDA labeling regulations for products labeled, as "Grass Finished" will not allow cattle to be fed in a feedlot to finish them. They will have to be on grass for at least 99% of their life. Finding an ideal location on the mainland to produce this type of product is very difficult because of environmental conditions. The cattle country of the upper high plains and Midwest are too cold; the lower areas are too hot and are susceptible to droughts and poor growing conditions.

This puts Hawaii in a unique position. We have the potential to produce the "Grass Finished Beef" that is in demand, year around. Our natural resources provide us with almost all we need to produce premium grass finished beef products that are healthy and command premium prices in the market place. These resources include an abundance of fertile volcanic soils, ample rainfall fall and sunshine, and a year-round temperate climate. Thus, Hawaii has one of the best places in the world to produce this type of product.

Obstacles and Issues Of Infrastructure Rebuilding That Need To Be Addressed

We do however have some obstacles to overcome before we can fully implement this "paradigm shift" in production and marketing. Over the last decade, while the infrastructure for the shipment of cattle was being developed, most of our infrastructure required for growing, finishing, slaughter, and processing, along with the marketing of our beef products, has deteriorated severely.

Over the last year, several of our more prominent ranchers and businessmen began the process of rebuilding the infrastructure that will be needed to develop a complete "Vertically Integrated Beef Industry" here in the state.

Sales and Marketing

A sales and marketing team have been retained and they are progressing towards a full scale marketing program to not just sell Hawaii Grass Fed Beef as a discount item, but to create a demand for our product as being the "Premium Grass Finished Product in the nation". As such it is expected that our beef will command top prices in the end markets. Hawaii after all is the best location in the country to produce "All Natural Grass Finished Beef". We need however, to ensure market buyers that we can supply the quantity and quality of product that they require.

Processing Plant
They have started renovation on the Hawaii Beef Producers, Paauilo processing plant. When complete it will be able to kill and process enough cattle every week that will entice the larger high-end marketing contracts. Unfortunately, as we are all painfully aware, the cost for utilities continues to increase faster than we can upgrade this plant with more efficient equipment. We will have to develop alternatives sources of energy to be able to process cost effectively. We will also have to provide extensive training to keep an experienced labor force fully staffed so we can process sufficient numbers to meet expected market demands.

Drop Credits
This plant will ensure the processing capacity required by the marketplace, but the ranchers will continue to be at a disadvantage of not being able to receive a drop credit for the edible offal that is commonplace in the mainland. This State's processing plants need to find a viable market for these products, so producers can be paid the drop credits that normally come with the kidneys, heart, liver and other such items; like the mainland producers. However, we need a high quantity of animals to develop the proper markets for these products. While increasing weekly slaughter numbers is one means to meet the needed volume to develop the markets for these products, consolidation of operations or pooling these products together with other plants are important options that should be considered also.

Rendering
The rebuilding of the rendering facilities can eliminate the cost of disposing offal in our landfill, which will help reduce processing costs. When this is completed, in 2007, the Paauilo facility will be able to convert offal to tallow and meat & bone meal. This in theory should help the bottom line for the plant. The savings should be able to be passed along to the producers. However, we cannot readily utilize the products from the rendering plant because of state regulations prohibiting their use for feeds or for fertilizing our pastures. We cannot afford to ship these products to the mainland because the freight costs are equal to the product price they will bring once delivered. We will need additional investments in facilities and equipment that will produce products like Bio-diesel, methane gas for fuel and fertilizers that will pass the State's criteria. Through converting these basic rendered products to value added products, we can provide a ready local market for the products rendered and reduce the energy cost required to run the facility.

Labor Issues
Another obstacle at our meat processing plant is the lack of qualified labor. Our state does not have an educational program to teach people to become butchers. This affects not only the slaughter and processing plants but also the retail supermarkets. Most of new employees have to undergo extensive training before becoming efficient on the processing line. Some of the qualified people that would like to work find it very difficult to find affordable housing close to the plant. Thus the industry needs to address the training and our housing issues in order find and keep sufficient numbers of qualified employees.

Stocker Operations and Backgrounding
Since most of our calves are being shipped to the mainland at 400 – 500 weights, the infrastructure and the personnel required for backgrounding no longer exists at most ranches. Several of our ranchers are in the process of rebuilding their paddocks to implement intensive rotational grazing programs. These programs are required to keep our supply chain at constant levels. A consistent supply of high quality young calves, are needed for the finishing program. If we are going to supply the high-end, health conscious consumer market, these cattle have to be grown, without being fed antibiotics or hormone implants. In order to capture these high-end markets, the industry needs to form alliances and partnerships, along with developing a profitable retained ownership program, to provide enough animals that are produced under the strict "Natural Beef" guidelines.

Finishing Programs
Although consistency of supply is a major concern of the retail marketplace, consistent quality is the major focus of the consumer. High-end consumers, not only want the product on the shelf every time they go to buy it, they want every piece of meat they purchase to have the health benefits their counting on. They also demand that each cut will cook and taste the same way it did last time they purchased it.

Several ranchers are now working together to develop a grass-finish program that will produce young finished cattle with consistent flavor, cooking ability, and health benefits of an "All Natural, Grass Finished Beef" product. This requires a strict regime in the finishing program. Every animal destined for this "Premium Product", must have comparable genetics and their diet must be the same every day. This can be difficult to achieve in an animal on a grass diet. This is due to the fact that as the season of year changes, the nutritional values of the forages change. Additionally, every location contains different grasses with varying nutritional values. To overcome these nutritional differences, one of the largest mainland producers of "grass fed beef", finishes their cattle in feedlots with a ration of almond hulls, rice brand and alfalfa. Although this might not fit our idea of grass fed, it does produce a consistent product that consumers want. If we are to produce a consistent product that will compete with some of the other large producers, we must implement a set of strict guidelines for finishing these cattle. We have started the development of custom formulated range supplements, so every animal has access to a nutritionally balanced diet, everyday, under all conditions. To accomplish this we need to build a full scale feed manufacturing company that is capable of producing enough custom formulated range supplements locally that will balance the nutritional deficiencies in our forages.

Land Availability

Our available acreage for grazing is dwindling every year because of development and environmental set-aside programs for wildlife. We need to work hard to keep our important Agricultural lands in production and develop conservation programs where cattle, wildlife, and other organisms can co-exist on these lands. As we assign more of our grazing lands for backgrounding and finishing programs, we will have to continue to find new efficient ways to produce even more high quality cattle on less acreage. We also will need to develop new creative ways to find additional dual use lands to produce sufficient numbers to fulfill end market contracts.

Retained Ownership
Feeding Alliances and Partnerships

To overcome some of the hurdles we have started forming alliances with individual ranches and feeding on retained ownership basis. However, we have a long way to go to be able to provide enough animals every week of the same quality to entice some of these larger high-end markets. We will be working on individual programs with other ranchers that will provide the economic incentive necessary to keep their calves here and place them in a grass-finishing program. Once we can guarantee a specific volume of high quality product that builds the necessary market demand, we then can then begin to demand a premium price at the market.

Conclusion

With sufficient numbers of these cattle to consistently produce this type of premium product, the "Paradigm Shift" in product quality will initiate the "Paradigm Shift in Prices", which will benefit all phases of production, from the Cow/Calf producer to the end retailer. This will allow everyone in the entire industry to make a reasonable profit for their efforts and place Hawaii as the leader in production of: "All Natural Grass Finish Beef"

The Markets for Hawaii Beef: Challenges and Opportunities

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Hawaii cattle now go to one of two markets, the local market or the U.S. Mainland market. Each one has a unique set of challenges and opportunities. This paper provides a brief overview of each one in order to help Hawaii cattle producers understand what they are facing as they make their marketing decisions.

U.S. Mainland Market

Shipping weaned calves to the U.S. mainland is difficult since it involves moving live animals on a boat. First, the shipping is costly, with prices increasing 45 percent since 1999. Given rising energy costs, this situation is not likely to change.

Secondly, Matson would rather not ship cattle, but is forced to do so by the State PUC. Therefore, cattle have a low priority for scheduling and Hawaii's ports do not have sufficient quantity and quality to handle cattle from staging until time of shipment. The airflow and lack of space for the staging areas are of concern. The off island cattle may remain at Sand Island in cowtainers for as long as two days before being shipped to the mainland. At the same time, the off island schedule is constantly changing, making planning ahead difficult. The government regulations dealing with shipping are also a challenge.

Shipping also puts the cattle into a stressful situation. This stress is a constant concern of animal rights organizations. At the same time, the weight loss that occurs during shipping is costly.

Once the cattle reach the mainland, it is costly to move them from the port. In fact, trucking costs have doubled in recent years. Feed yards tend to give preference to their own cattle over contracted cattle, which may result in increased costs and lower revenues. The cattle moving into Mainland markets becomes a commodity and receives a commodity price, which means that Hawaii cattle compete with all other cattle on the market. At the same time, most of the value added to the animals is added outside of Hawaii. Therefore, 55 percent of the money spent by local producers is going to support businesses on the mainland and is not going to support Hawaii's economy.

Hawaii Beef Market

Shipping calves remains the preferred option for most producers because the local price they receive is not competitive compared with the Mainland price. However, some producer groups and individual producers have developed management protocols that have allowed them to successfully capture a share of the local market at a price that is competitive with the Mainland price. The producers have developed a "branded" product that can be sold at a price that is higher than the price received locally for commodity beef. Many challenges had to be overcome in order for these producers to obtain a consistent supply of high-quality cattle in order to establish a "branded" product.

Significant investment costs and risks are incurred in order to establish a "brand" in the local market. In order to obtain a consistent supply of high quality beef, a vertically integrated company must be built that maintains a strictly enforced quality control program. Production inputs such as labor, feed, and processing/storage/slaughter and waste management are a challenge in Hawaii. All of these inputs are costly and finding economical options is difficult. In addition government regulations, from traceability and slaughter to waste management, are increasingly restrictive and increase costs.

Backgrounding and finishing the cattle presents some unique challenges in Hawaii. Forage-finishing cattle may not produce a consistent supply during the year, which make it difficult for the market to absorb them. Forage-finishing also requires 24-30 months of pasture space that could be used to support a cow-calf unit that may return a higher profit. The weather may limit the producers' ability to grow forage and require a feed reserve for drought years. Feedlot finishing is challenging because the State has only one feedlot because feed is so costly that most feedlots have not proved to be economical.

The following outline details the issues that need to be addressed in order to establish a “branded” product for the local market.

I. The concept

II. Targeted market
Understand costs associated with getting a consistent product to market

III. Set protocol

IV. Know your resources (People, Land quality, Water, Cattle, Location, Fencing and Handling facilities)
- -Control
- -Supply
  - -Quality
  - -Availability
  - -Competition
  - -Feed Conditions
    - -Have a plan to deal with dry conditions or drought
    - -Supplement

V. Facilities and infrastructure
- -Control
- -Supply
  - -Labor
    - -Experienced management
    - -Dedicated employees
      - -Training
      - -Motivation
- -Slaughter
- -Processing
- -Packaging
- -Storage
  - -Delivery
  - -Waste

VI. Commitment to stay the course

Rate of Dry Matter and Insoluble Macromineral Release of Tropical Pasture During *In Situ* Digestion Trials in Cattle.

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Introduction

In most tropical areas of the world, and especially in undeveloped countries, the primary source of nutrition for cattle and other ruminants is pasture and other forages. In these areas it is simply not economically practical to provide any large degree of supplementation to the animals. A similar situation can be found in Hawaii, where although it is well-developed, because of its geographical isolation the importation and delivery of supplements to the animals is often considered impractical.

This is in contrast to more well-developed, temperate regions of the world where supplements can either be produced locally or imported at lower cost. This inability to supplement is compounded by the fact that tropical grasses are higher in fiber and lower in protein and other nutrients than temperate grasses, and what nutrients are present are often less available to the animal than in temperate grasses. It has been well-documented that animals on tropical grasses underperforming those animals on temperate grasses (Minson and McLeod, 1970; Stobbs, 1971; Kaiser and O'Neill, 1975).

In other warm-climate areas, mineral deficiencies have been blamed for poor production of beef cattle (McDowell, 1985). Likewise, there are extensive records in the literature documenting deficiencies, as well as toxicities, of minerals in both soils and plants (McDowell, 1985; 1997). Because of this, it is important to be aware of the mineral status of the animals. However, often, only soil and/or plant levels of minerals are assessed in making a decision on whether or not supplementation is required, and the level of a mineral in the soil or plant does not necessarily mean that those minerals are available to the animal at the same level. Additionally, mineral supplements are often expensive and could lead to excess excretion and/or poor utilization by the animal. Therefore, unnecessary supplementation can have a dramatic impact on both economic returns and environmental sustainability, in addition to leading to toxicities. Therefore, to both ensure adequate supplementation and eliminate unnecessary supplementation, it is necessary to know the levels of minerals present in the forages being grazed and the bioavailability to the animal.

Previous *in situ* trials demonstrate that there are differences in rate and extent of mineral release in the rumen between forages (Emanuele and Staples, 1990; Emanuele, et al, 1991). Therefore, it is dangerous to draw general conclusions from limited studies and it becomes necessary to determine the rate and extent to which minerals are released from each individual forage in question.

It is also of interest how the rate of overall dry matter disappearance tracks with the rate of macromineral release in the rumen. It may be the case that dry matter disappearance is much more rapid and complete than mineral release.

The primary objective of this research was to determine the proportion or levels of minerals actually released in the rumen, and are therefore available to the animal for productive purposes, and to compare the release of minerals with the digestion of dry matter in the rumen.

Materials and methods

Forage and digesta residue samples from previous *in situ* rumen digestion studies were analyzed for macromineral (Ca, P, Mg, K, Na, and S) levels.

Animals

Fistulated steers from the Mealani Research Station on the Big Island of Hawaii were used for these studies. All trials to assess the various grasses used either 2 or 3 steers and most of the studies were conducted at the Waialee Livestock Research Farm on Oahu.

Grasses

Six grasses were analyzed in this study, including kikuyu grass (*Pennisetum clandestinum*), fresh and hay, California grass (*Brachiaria mutica*) hay, guinea grass (*Panicum maximum*) hay, green panic grass (*Panicum maximum* var. *trichoglume*) hay, napier grass (*Pennisetum purpureum*), and pangola grass (*Digitaria eriantha)*, fresh and hay.

Incubation procedure

Enough sample of each feed to provide for 10-15 g of dry matter was inserted into a nylon bag. Each feed was run in duplicate per steer. The duplicate bags were clamper together then inserted into the steer and tied to a 1 kg stainless steel weight. The bags were incubated for 0, 4, 8, 12, 24, 36, 48, 72, and 96 hours in the rumen. Only the 0, 12, 24, 48, and 96 h samples were assayed for mineral content. Bags were rinsed several times with warm water and frozen upon removal from the rumen.

Results

Dry matter disappearance

Figure 1 shows the rate of dry matter disappearance of the feeds for which data was available. All the feeds displayed similar patterns of dry matter disappearance. With the exception of fresh kikuyu grass, 65% of the potentially digestible dry matter (pDDM) was digested with 36 h of incubation and by 72 h of incubation at least 85% of pDDM was digested, for all feeds. Of particular note is the napier grass; all of the pDDM was digested with 72 h of incubation.

Mineral Release

The pattern of mineral release of the different grasses is shown in Figure 2.

Calcium

There is little difference in the pattern of calcium release of the feeds. After 12 hours, there was little calcium release, and, most cases, a small amount of calcium appears to have been sorbed (percent recoveries range from 88% in pangola hay to 130% in napier grass). From this point there is a steady decrease in calcium recoveries until 96 hours (percent recoveries range from 16% in pangola hay to 49% in napier grass)

Phosphorus

There is an obvious difference in the patterns of phosphorous release in the test feeds. Napier grass and california grass hay sorbed phosphorous (96 h recoveries of 132 and 165%, respectively), while guinea grass hay exhibited very little phosphorous release (97% recovery after 96 hours). The other feeds exhibited varying levels of phosphorous release (96 h recoveries ranged from 15% in pangola grass hay to 45% for green panic hay), with the majority of the phosphorous released by these feeds being released within 12 h.

Magnesium

Magnesium, like calcium, showed little difference in the pattern of release between feeds. None of the feeds demonstrated any sorption of magnesium, and, after 96 hours, magnesium recovery ranged from 8% in pangola grass hay to 42% in california grass hay.

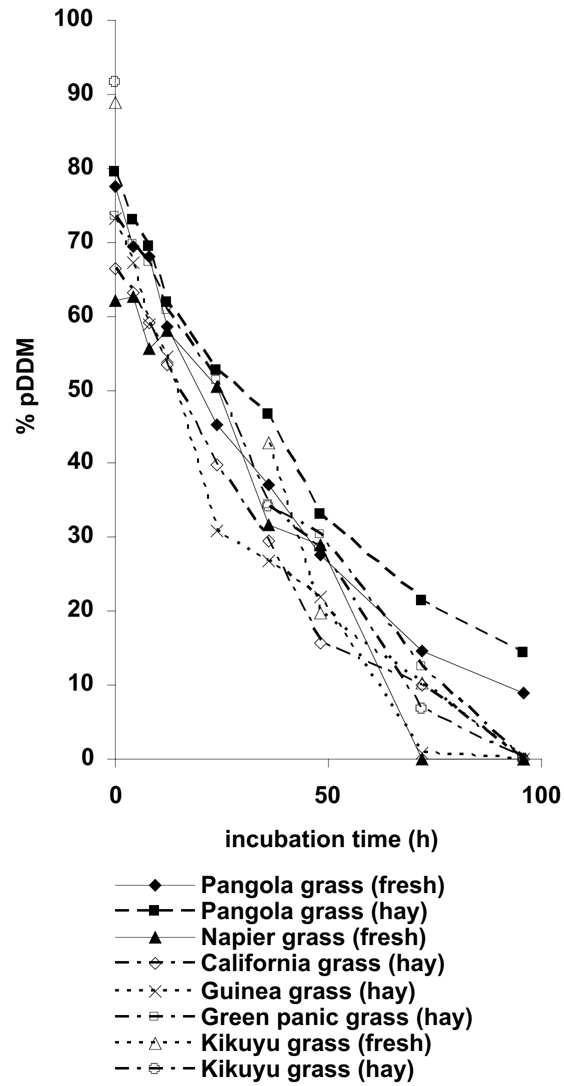

Figure 1. Dry matter disappearance of selected feeds.

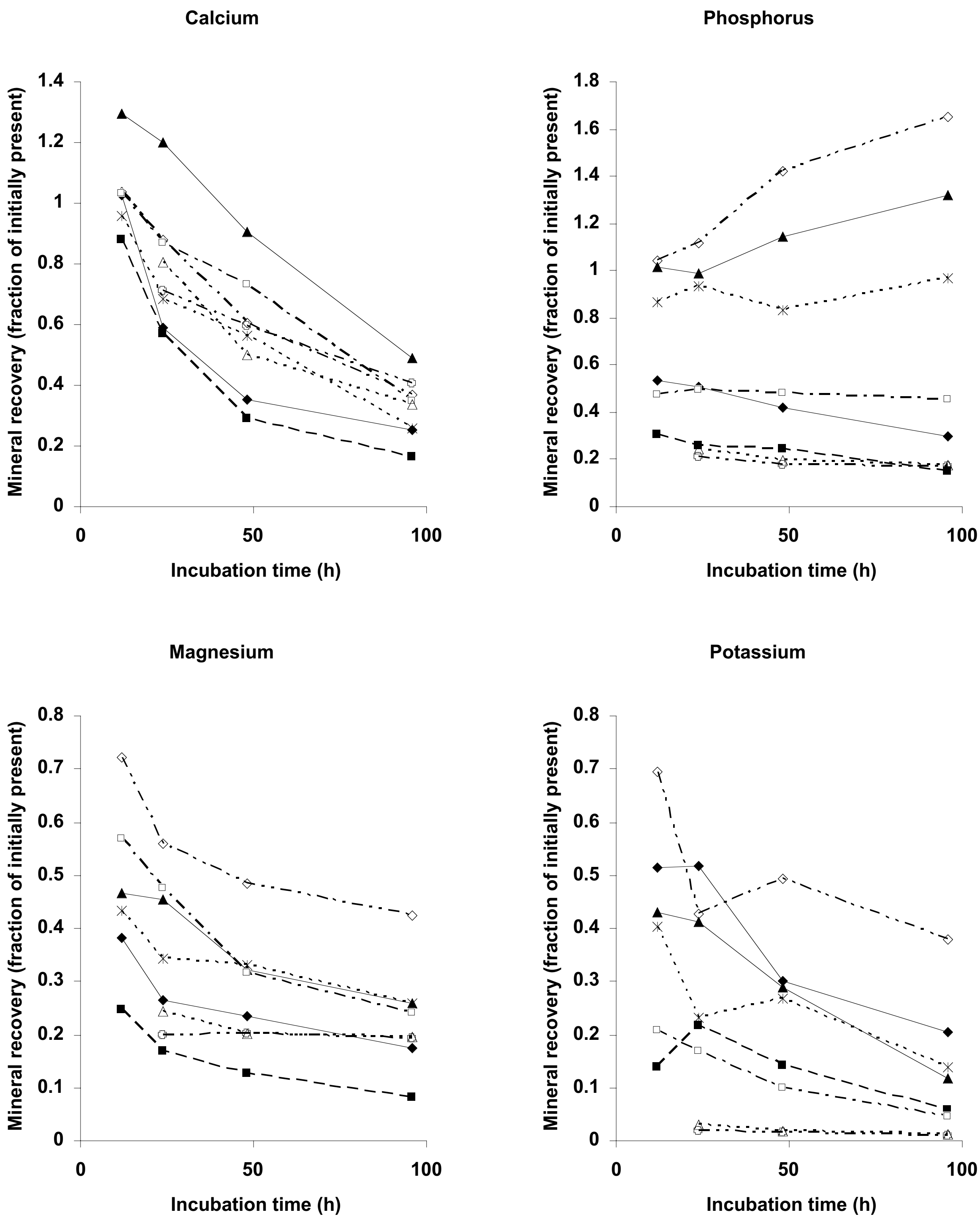

Figure 2. Mineral recovery after ruminal incubation as a percent of initial insoluble mineral in sample at 0, 12, 24, 48, and 96 h.

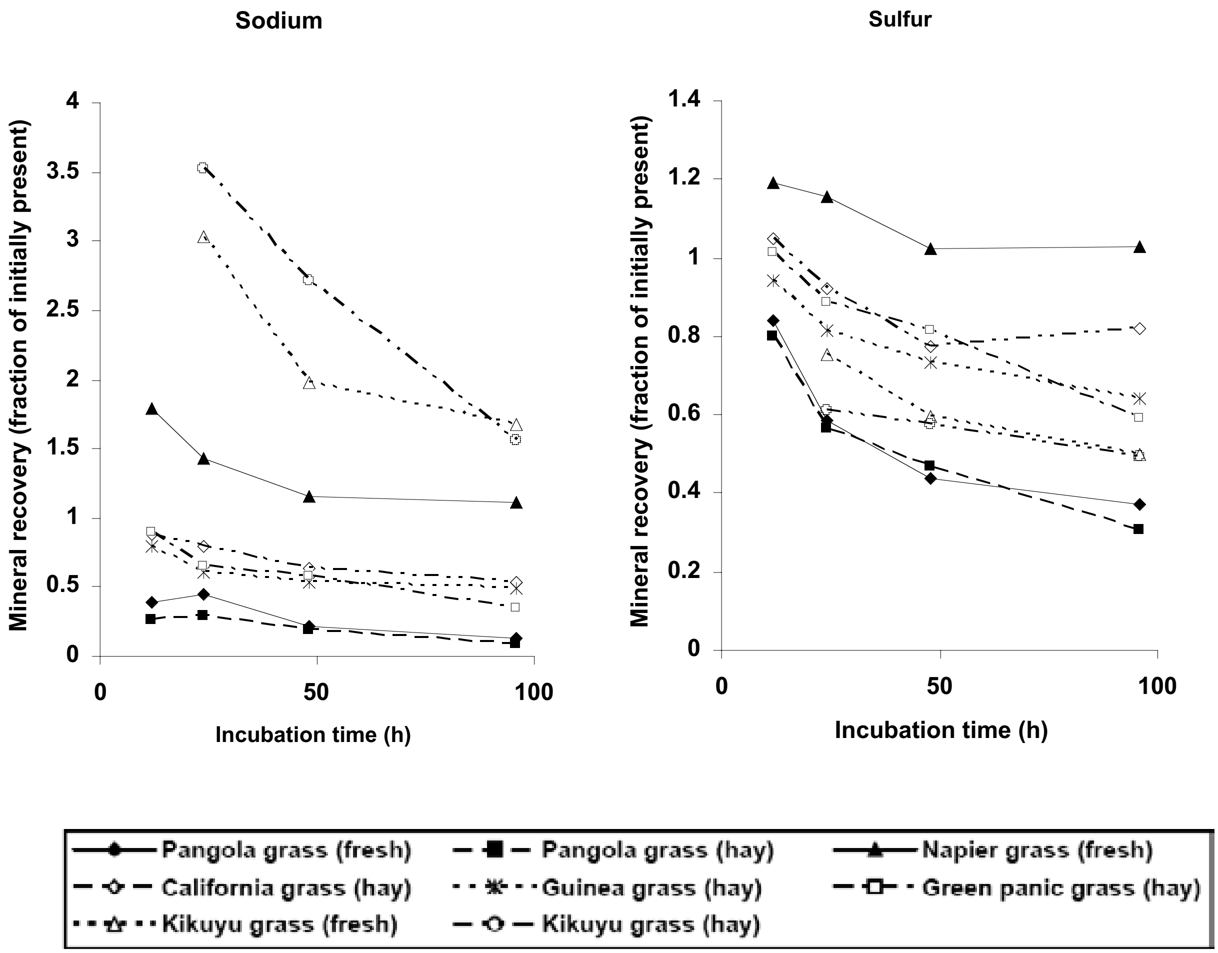

Figure 2. CONT.

Potassium

There is more variation over time and within feed in the release of potassium from the test feeds than there is among the other macrominerals. Pangola grass 23 to 27%, respectively). Overall, however, hay sorbed some potassium from 12 to 24 h (an increase of 14 to 22%), while california hay and guinea hay sorbed potassium from 24 to 48 h (43 to 49% and after 96 h all the feeds had released most of the insoluble potassium present at the beginning of the incubation (96 hour recoveries range from 1% in kikuyu hay to 48% in california grass hay). Of particular note is the rapidity with which kikuyu released its potassium; at 36 hours recovery was only 2 and 3%, for hay and fresh grass, respectively.

Sodium

Kikuyu grass (both hay and fresh) and napier grass sorbed large quantities of sodium. Fresh kikuyu and kikuyu hay in particular had 36 h recoveries of 303 and 352%, respectively, while napier grass had a 12 h recovery of 179%. All three of these grasses released sodium from that point on, resulting in 96 h recoveries of 168, 156, and 111% for fresh kikuyu, kikuyu hay and napier grass, respectively. The other five feeds released sodium readily and evenly across the incubation, resulting in 96 h recoveries ranging from 8% in pangola hay to 54% in california grass hay.

Sulfur

Napier grass sorbed sulfur as well (12 h recovery of 119%) but released to near initial levels at 96 h (recovery of 102%). California grass hay and green panic hay also initially sorbed some sulfur (12 h recoveries of 105 and 102%, respectively), but released sulfur from there. The other feeds released sulfur to varying degrees, with 96 h recoveries ranging from 30% for pangola hay to 82% for california grass hay.

Discussion

The data presented here make it evident that different feeds vary widely in their ability to sorb/release the various minerals assayed. Furthermore, within an individual feed, different minerals are released differently.

Dry matter was digested much more thoroughly than were many minerals, particularly calcium, sodium, and, in some feeds, sulfur and phosphorous. On the other hand, potassium was digested more thoroughly than dry matter in most cases, while magnesium was digested to about the same extent as dry matter.

Calcium was sorbed in the early stages of the incubation by some of the grasses, although in relatively small quantities. Ibrahim, et al. (1998) also found that calcium was sorbed by certain feeds that are low in calcium. They found that guinea grass and rice bran had calcium recoveries of 315 and 455%, respectively, after rinsing in water.

Phosphorous was sorbed by napier grass and california grass, as well. Of the grasses that had a net release of phosphorous after 96 h, only four of the grasses released greater than 70% of the initially insoluble phosphorous.

In the same study, Ibrahim, et al, (1998) found that, in grasses, 55-78% of the magnesium was released during ruminal incubation. The data obtained in this study ranged from 58-96%, and are roughly in line with the data obtained by the above authors.

Potassium was released to a similar extent as magnesium. Half of the feeds released more then 70% of potassium after 48 h. However, within 96 h, only california grass hay released less than 80% of the total insoluble potassium.

Sodium was not as thoroughly released as other minerals and there was a large amount of sorption by napier grass and kikuyu grass (both fresh and hay). Only pangola grass (both fresh and hay) released more than 80% of the insoluble sodium, and of the remaining grasses, only guinea grass hay released more than 50%.

Sulfur was sorbed by napier grass and small quantities early in the incubation by kikuyu and green panic hay. The remaining grasses released 18-70% of the insoluble sulfur after 96 h of incubation.

There does not appear to be a discernible pattern of mineral release among the feeds and minerals tested, and, therefore, it may be necessary to test a given grass and/or method of processing individually in order to accurately determine the extent to which a given mineral will be released.

Incomplete washing of samples may have lead to bacterial contamination of the samples assayed via retention on particulate matter in the rumen. There is also the matter of elemental flux in steers during rumination. Because these were live animals, the recycling of mineral elements via the saliva could not be controlled.

The data presented here are not the entire picture as far as mineral availability to livestock is concerned. This paper concerns itself only with the insoluble portion of the minerals, and, in most feeds, the largest part of the minerals are immediately soluble in the rumen. Also, this paper does not consider the impact of abomasal digestion on mineral release and further investigation will be necessary to determine the complete picture of mineral availability of tropical grasses.

Works cited

Emanuele, S.M. and C.R. Staples. 1990. Ruminal release of minerals from six forage species. Journal of Animal Science 68:2052-2060.

Emanuele, S.M., C.R. Staples, and C.J. Wilcox. 1991. Extent and site of mineral release from six forage species incubated in mobile dacron bags. Journal of Animal Science 69:801-810.

Ibrahim, M.N.M, G. Zemmelink, and S. Tamminga. 1998. Release of mineral elements from tropical feeds during degradation in the rumen. Asian-Australasian Journal of Animal Science 11:530-537.

Kaiser, A.G. and G.H. O'Neill. 1975. Rearing dairy beef calves by multiple suckling. 2. Effects on liveweight gain of calves. Australian Journal of Experimental Agriculture and Animal Husbandry 15:314-320.

McDowell, L.R. 1985. Nutrition of grazing animals in warm climates. Academic Press, Orlando, FL.

McDowell, L.R. 1997. Minerals for grazing ruminants in tropical regions. 3rd ed. Univ. of Florida Coop. Ext Serv. Bull., Gainesville, FL

Minson, D.J., and M.N. Macleod. 1970. The digestibility of temperate and tropical grasses. Proceedings of the 11th International Grassland Congress, Surfers Paradise, Australia, 719-22.

Stobbs, T.H. 1971. Quality of pasture and forage crops for dairy production in the tropical regions of Australia. 1. Review of the literature. Tropical Grasslands 5:159-70.

Biological Risk Management

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Biological risk management is the overall process of awareness education regarding the risk of infectious diseases entering or spreading through an animal facility. It also involves evaluating and managing those risks. BRM is designed to help livestock producers understand the need for disease control, not only for foreign animal disease threats but domestic diseases as well. Biological risk management provides the tools to minimize the risk.

BRM recognizes that diseases cannot be eliminated, but that the risk can be managed through effective control measures. As animal caretakers, it is our duty to be knowledgeable of the animal and its environment to minimize the risk of disease. For nearly all diseases there is a relationship between dose exposure and severity of disease. For diseases that are always present (endemic), reducing the dose of infectious agent the animal is exposed to can positively affect the farm's economic impact and help justify the cost of implementing BRM. Many different solutions exist and because all cattle facilities are different, there is not a one-size-fits-all answer.

Agriculture is an enormous economic industry. Biological risk management is important in order to minimize the animal health and economic consequences to the nation and agriculture industry should there be an infectious disease outbreak.

It has been stated that one in six jobs in America is related to agriculture in some manner. It is understandable then why our economy is heavily dependent on the agriculture sector and within it, the animal production industry. The agriculture industry affects every man, woman, and child in America in some way. Even though all Americans do not work directly in agriculture, we are all affected by the industry in some way, such as buying products from the supermarket.

Beef production is the single largest segment of the agricultural industry, accounting for 1.4 million jobs and $188.4 billion dollars of direct and indirect economic activity. Moreover, beef cattle are produced in all 50 states, and thus have an impact on all state and local economies. The dairy industry also has a significant contribution to the economic impact of agriculture. 2002 estimates 900,000 jobs created $29 billion in household earnings with an overall economic output of $140 billion. In Hawaii, there are over 800 ranches with gross sales of over $30 million dollars annually.

One of the cattle industry's main focus areas is a safe food source, which comes from healthy animals. In the dairy industry, milk supplies 73% of the calcium in the U.S. food supply. Using the NAHMS 2001 total milk production of 165 billion pounds of milk, this would translate into a total of 19.8 billion gallons of milk which could be converted into 16.5 billion pounds of cheese, 7.8 billion pounds of butter, or 13.8 billion gallons of ice cream! Instituting biological risk management plans in cattle facilities can help mitigate the economic consequences that could be inflicted by endemic diseases on the farm as well as a new or a foreign animal disease.

It is essential that we realize the impact of agriculture on every person and do everything we can to keep animals healthy and provide an income conducive to a lifestyle in livestock production. Protecting animals from disease through proper hygiene of people and equipment has a direct effect on the agricultural industry. Disease control and working to institute biological risk management plans can help mitigate the economic consequences of a disease outbreak.

Why is this important now?

Animal agriculture has changed a lot in the past few decades. This presents opportunities to implement BRM plans. Each year the Census of Agriculture reports fewer farms, yet strong growth in the number of animals that remain on some of those farms. This intensity in animal production and species specialization has allowed livestock farmers to efficiently provide food for America and the world. Changes in production animal management present opportunities and challenges that were not part of raising animals only a few decades ago. With new and re-emerging diseases, susceptible animal populations could be located in a fairly small geographic area so that a single cattle disease could have devastating economic effects. The way we raise and interact with animals has drastically changed; so too must our concept of how to prevent disease introduction to continue to ensure the animal's well-being and a safe food source.

Beef cattle production is a very diverse and segmented industry. Most producers have small operations, particularly on the cow-calf side. Approximately 80% of cow-calf operations own less than 50 head. This often limits the ability to devote significant resources to facilities and management improvement. Feedlots are much larger operations, and as a whole, the feedlot segment is moving toward consolidation. Additionally, feedlots tend to be concentrated in specific geographic areas. Changes in beef cattle management present opportunities and challenges that BRM can help address.

In the last 25 years, some serious animal and human diseases have emerged or re-emerged. Starting at the bottom in 1982, *E. coli* O157:H7 and Lyme Disease (*Borrelia burgdorferi*) first appeared. Next came the emergence of HIV in the United States in 1983; The first case of Bovine Spongiform Encephalopathy (BSE) was identified in the United Kingdom in 1986; Cat Scratch Fever (*Bartonella henselae*) was recognized in 1992; Hantavirus (Sin Nombre virus) was recognized in the four corners region of the U.S. in 1993. In 1996, variant Creutzfeldt-Jakob Disease (vCJD) appeared in humans in the U.K. Nipah virus emerged in swine and humans in Malaysia in 1998, and West Nile Virus appeared in the United States one year later. In 2003, SARS appeared in humans in Asia and Canada, Monkeypox was transmitted from prairie dogs to humans in the Midwestern U.S and the first case of BSE appeared in the U.S. In 2004, highly pathogenic avian influenza (H5N1) started in East Asia and spread west causing disease and death in poultry, wild birds and humans. The outbreak continued into 2005 and 2006. By preparing for infectious disease outbreaks through awareness, proper planning and control measures, the impact from these new diseases can be greatly reduced.

Increased globalization through travel and commerce has a significant impact on everyday life. We are able to travel anywhere in the world in less time than it takes for a disease to incubate and appear in animals. This increases the importance of biological risk management for everyone.

The increasing global nature of travel and the importation of animals increases the risk of a disease entering the U.S. and disrupting our economy and livelihood. A foreign animal disease, either carried within a food product or on the traveler's person could serve to introduce disease to U.S. animals. Often when we travel abroad, we do not wash our clothes prior to returning to the U.S., so we may be a risk factor for introducing diseases. Additionally, the importation of live cattle and animal products requires strict regulation to minimize the threat of disease introduction. Many infectious diseases can be carried by asymptomatic animals, and others may remain viable in animal products for periods of time. Finally, the waste or garbage generated on international flights or sea voyages could carry a livestock disease from a foreign country. The USDA APHIS Plant Protection and Quarantine (PPQ) and DHS Customs and Border Patrol (CBP) are responsible for monitoring garbage unloading from the various vessels and airplanes that arrive at approved U.S. ports. All regulated garbage must be placed in sealed, leak proof containers and transported to an APHIS approved facility for incineration to ash, sterilization, or grinding and discharged into an approved sewage system to minimize the spread of disease.

On any given day, over 1.4 million people and over 38,000 animals enter the United States; 500 million people annually (330 million of which are non-citizens). Approximately 730 million people travel on commercial aircraft each year and 11.2 million trucks and 2.2 million rail cars cross into our country annually. Also, 7,500 ships from foreign countries make 51,000 calls in U.S. ports annually. Each of these modes of transportation poses a risk to introducing a foreign animal disease either within a food product carried by a traveler, the garbage generated during travel from products originating in a country with a FAD, or the traveler harboring a disease that could be spread to U.S. animals.

Components of BRM

The concept of biological risk management involves multiple components. Before a sound, applicable program for an operation can be established, it is important to first understand what the producer's perception of risk really is. After risk perception is understood, risk assessment, based on the routes of disease transmission, can begin. Once the risks are identified, risk management can begin. To be successful, the BRM plan must be communicated to all involved.

Risk means different things to different people. It is imperative to first identify what those involved with the operation think about the real and potential risks of infectious and zoonotic diseases. The public often relies heavily on previous experience, the media, and their environment. What risks are deemed acceptable or tolerable also varies between individuals.

Risk assessments can change over time depending on the situation at hand. It is important to remember that living systems are variable and predicting illness or disease can be a complex series of conditional events. Disease predictions are not as simple as yes or no, but the various risks that predispose to disease development often are. Cattle's vulnerability to disease is influenced by cleanliness, stress, nutrition, and other management factors; these are all aspects that can be managed.

The approach that was taken in the development of these biological risk management tools was to look at diseases based on their route of transmission to the animal, or human in the case of zoonotic diseases. An advantage of minimizing risk by examining routes of transmission is that it will also help protect against new or unanticipated infectious diseases. While disease agents and the infections they produce vary, they all have one thing in common: the animal must be exposed to them to develop disease. Once it is understood that different diseases can be acquired orally and others are breathed in via aerosol transmission, it is easier to gain control over them. This classification system is effective and easy to understand without requiring knowledge about a wide range of diseases. From a management standpoint, it may be easier to identify risk areas, such as fomites, and then design protocols to minimize exposure.

Disease agents can be spread from animal to animal, or animal to human, through a variety of transmission routes. For the purposes of the biological risk management materials, 5 main routes were identified: aerosol, direct contact, fomite, oral and rector-borne. The sixth route, zoonotic, can be spread from animals to humans through one of the 5 previously listed routes. Many infectious agents can be transmitted by more than one route of infection.

Aerosol transmission occurs when disease agents contained in droplets are passed through the air from one animal to another, or animal to human. Most pathogenic agents do not survive for extended periods of time within the aerosol droplets, and as a result, close proximity of infected and susceptible animals is required for disease transmission.

Transmission by *direct contact* requires the presence of an agent or organism in the environment or within an infected animal. A susceptible animal becomes exposed when the agent directly touches open wounds, mucous membranes, or the skin through blood, saliva, nose to nose contact, rubbing or biting. It is important to note that depending on the disease agent, it is possible for direct contact transmission to occur between animals of different species as well as to humans. For the purposes of the BRM information, reproductive transmission will encompass those diseases spread through venereal and in-utero routes. Venereal transmission (breeding), a type of direct contact, is the spread of pathogenic agents from animal to animal through breeding. In-utero (dam to offspring) transmission, another type of direct contact, is the spread of pathogenic agents from dam to offspring during gestation.

A *fomite* is an inanimate object that can carry disease agents from one susceptible animal to another. Examples of fomites include contaminated brushes, clippers, needles, balling guns clothing, milking units, teat dip cups, feed or water buckets, and shovels.

Pathogenic agents can also be transmitted to animals or humans *orally* through consumption of contaminated feed, water or licking/chewing on contaminated environmental objects. Feed and water contaminated with feces, urine or saliva are frequently the cause of oral transmission of disease agents. However, feed and water can be contaminated with other infectious agents as well such as ruminant protein in ruminant feed.

Vector-borne transmission occurs when an insect acquires a pathogen from one animal and transmits it to another. Fleas, ticks, and mosquitoes are common biological vectors of disease, and flies and cockroaches are a common mechanical vector.

Many disease agents can survive for extended periods of time in soil or other organic material like bedding, old feed, etc. Animals or humans can then acquire the disease agent from the environment through inhalation or aerosolization, oral consumption, direct contact, or via fomites as discussed in previous slides. Therefore, *environmental contamination* should not be ignored but recognize the routes it uses to get into the animal can be controlled.

It is important to remember that disease transmission can occur without animals exhibiting obvious signs of disease. That is why awareness of the various routes of transmission becomes so essential when assessing and developing a strategy to minimize the risk of disease for a facility or operation.

Management plan

Once a facility or operation has been evaluated, the challenges to implementing a successful BRM plan can be identified. Only then can a tailored management plan be proposed and implemented. When first working on change, prioritize those items that are relatively easy to implement, inexpensive, yet yield rewards. There is no common formula for what that entails, and rewards will be different for everyone. Simply reducing exposure could be beneficial.

Just like the risk assessment is a living document, the management plan should be modeled to reflect immediate challenges, short and long-term goals. The full BRM assessment program available on-line includes a number of possible implementation strategies for each of the areas for improvement identified. Just as the question set is not 100% comprehensive, these are possible solutions, realizing many more exist. Everyone should remain open to suggestion and realize that recommendations can vary between individuals for the same facility, based on the reviewer's experience and knowledge.

There are many general prevention steps that every farm could implement that would help prevent against a variety of diseases that are transmitted in various ways. Things such as knowing what is in the area of your farm perimeter- farms, neighboring livestock, wildlife; individual animal identification, animal health protocols, recognizing and dealing with sick and dead animals, isolation/quarantine, supply handling, and neonatal management.

General prevention methods

Limit contact with animals that may present a disease risk by coordinating with your neighbors to avoid fence line contact between herds. Prevent cats and dogs from roaming between farms. By maintaining fences (repairing/replacing posts, tightening wires), you minimize the risk of animals escaping, or other animals entering, and mixing with other livestock or wildlife species, which increases their risk of disease exposure. You should establish biosecurity protocols for delivery vehicles and personnel to follow on your farm. Gates are installed as a barrier to human entry and should be locked to prevent animal contact and subsequent disease exposure.

If more than one person works on an operation, individual animal identification is imperative for proper communication of health status, treatment needs, antibiotic withdrawal/residue prevention status, and location on farm. Individual animal identification is imperative to proper record keeping (vaccinations, treatments, pregnancy status) which is an integral part of managing animals and minimizing disease risk on farm. Keeping treatment records is an integral part of minimizing disease risk on farm because protocols can be tracked over time with your veterinarian and used to determine whether things are working in various disease situations.

To monitor health status, it is imperative to keep health records on every animal. There are many computer programs out there that can simplify this for producers. Producers should work with their veterinarian to investigate those animals that present with unusual symptoms or are unresponsive to treatment, especially neurologic cases, downers and those that die suddenly.

By establishing and educating all employees on what to look for regarding sick animals and having a reporting system so that those in charge can make treatment decisions or the veterinarian can be contacted, serious diseases can be identified early on and minimize the risk of disease spread. It is important to clean any equipment, boots or clothing that is used between groups of animals with differing health status. Animals that are not going to recover can serve as a reservoir for many disease organisms and should be euthanized humanely and in a timely manner. Dead animals can also serve as a reservoir for many disease organisms and should be promptly removed from the operation. Dead animals need to be rendered, composted or buried in a timely manner so predators, wild birds, etc do not spread disease. By having a veterinarian necropsy animals that die of undetermined causes, a diagnosis may be obtained by sending samples into a diagnostic laboratory. Unusual diseases may not present in a manner you are used to, so involving a veterinarian may help identify a potentially infectious disease before it becomes widespread on your facility.

Cattle that are identified as ill should be removed from the rest of the herd immediately and placed in an isolation area where ventilation, feed/water, and other equipment are not shared and direct contact with other animals does not occur in order to minimize the risk of disease spread. Newly introduced animals, including show cattle/calves that have been away from the farm, may be carrying diseases that your home herd is not immune to, so quarantine them for a period of time.

Time spent in isolation and quarantine varies depending on the risk so this should be determined together with your herd veterinarian. Before taking animals out of isolation or quarantine, it is a good risk management plan to test them for key diseases (determined together with your herd veterinarian) and make sure they are not carrying diseases that could be introduced into the home herd.

Sunlight can deactivate vaccines resulting in inadequate protection; it can also reduce effective treatment by rendering antibiotics ineffective. When using these in your animals, make sure you read the label and store them properly. Vaccines and medicines that need to be refrigerated are susceptible to changes in temperature and may not be effective if they get too warm (greater than 46 degrees Fahrenheit) or too cold/frozen (less than 36 degrees Fahrenheit); monitoring your refrigerator at least monthly can help ensure the products are adequately stored. Work with your veterinarian to teach proper handling procedures to all people who routinely deal with vaccines and medicine and restrict access to only trained personnel.

The cornerstone of the biological risk management plan is effective communication of risk with all those involved. A good plan, poorly communicated will benefit no one. A program must be understood and supported by everyone in order to be effectively implemented. The success of the plan lies in how it can be carried out, who is responsible for making changes happen and incorporation into daily activities.

Additional information

Additional information is available on specific disease risks and transmission, economic analysis and management plan development. Contact the author for additional information.

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Effects of Aeration and Sewage Biosolids on Improved Kikuyugrass Pasture Productivity and Nutrient Composition

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Introduction

Kikuyugrass has been estimated to account for about 85% of the pasture production in Hawaii and is common in tropical highland and subtropical environments throughout the world (Hanna et al., 2004). There are no data available for responses of improved kikuyugrass (*Pennisetum clandestinum* Hochst. *ex* Chiov.) pastures to aeration and sewage biosolids application. Miles (1997) found that productive kikuyugrass pastures that had received 300 ± 50 kg N ha^{-1} yr^{-1} for over 5 yr continued to require similar annual N inputs in order to maintain productivity as there was little residual effect. The six-month study of Fukumoto and Yamasaki (2003) on an Andisol soil in Hawaii indicated that kikuyugrass production would be reduced by about 50% if N fertilization was discontinued after 30+ yr of urea applications (~250 kg N ha^{-1} yr^{-1}).

Production declines in old kikuyugrass swards have also been attributed to soil compaction and a phenomenon referred to as mat- or root-bound (Theron et al., 1958; Morrison, 1966). It is common for a 2- to 4-cm thick compacted layer to form near the surface of fine-textured pasture soils (Vicente-Chandler and Silva, 1960; Greenwood and McKenzie, 2001). Aeration of kikuyugrass pasture surface soil with a rotovator that penetrated to a depth of 5 cm and destroyed the mat was of little benefit in kikuyu grass pasture renovation in Kenya (Morrison, 1966). However, the work of Theron et al. (1958) in South Africa suggests that deeper disturbance of the topsoil for aeration could be beneficial.

Urea is the main N fertilizer used on established pastures because it is relatively inexpensive but it is often inefficient in terms of N recovery even when applied in several split applications over the growing season (Prasertsak et al., 2001; Mathews et al., 2004). It is important to investigate alternative slower-release N sources that would have the added benefit of requiring less frequent applications and hence lower application cost in manpower, equipment, and fuel (Muchovej and Rechcigl, 1997, 1998). However, data are not available in Hawaii to address this suggestion.

Specific objective of this 2-yr study was to determine if well-fertilized (N-P-K) pastures would respond to aeration or Milorganite® (biosolid/ sewage sludge) application (at equal N levels) with improved yield and/or changes in nutrient and macro-/micro-mineral composition.

Materials and Methods

This 2-yr study was conducted during 2001-2003 in 0.2 ha portions of a 1.2 ha^{-1} kikuyugrass pastures that had been established in 1964 on a Maile silt loam soil (hydrous, ferrihydritic, isothermic Acrudoxic Hydrudands) at the University of Hawaii’s Mealani Experiment Station (elevation = 900 m) located in Waimea (20^{o}01'N), Island of Hawaii. These intensively managed kikuyugrass pastures historically had received 250 ± 100 kg N ha^{-1} yr^{-1} as urea and periodic applications of P as treble superphosphate (Mathews et al., 2001). Selected chemical characteristics of the soils (0- to- 15-cm depth) taken from these improved pasture paddocks are shown in Table 1.

The trial consisted of four treatments arranged in a completely randomized design with four replications. Each treatment plot was 4.6 by 3.1 m with a 1 m border between plots. Treatments were: 1) N alone [60 kg N ha^{-1} at study initiation and after every other defoliation (every 12 wk) for a total of 300 kg N ha^{-1} yr^{-1}]; 2) N (same as Trt 1) + aeration; 3) an annual 300 kg N ha^{-1} yr^{-1} sewage biosolid application (B-A1N) applied each Spring, and 4) a single 600 kg N ha^{-1} sewage biosolid application at study initiation (B-S2N). An anaerobically digested, heat-dried, granulated sewage biosolid marketed as Milorganite® (Milwaukee Sewage Commission, Milwaukee, WI - see Table 2) was selected for this experiment because it is fairly representative of a low heavy metal type of product that could be produced in Hawaii (Hue and Ranjith, 1994).

The experiment commenced on 3 April 2001 following pasture defoliation with a sickle bar mower to a stubble height of 5 cm. The monthly temperature variation and rainfall distribution during the study period is presented in Figures 1 and 2.

The aerated treatment received two parallel aeration passes at initiation of the study with an AerWay® spiked tine aerator (Model AW118, Holland Equipment Ltd., Norwich, ON, Canada) that was mounted on the three-point-hitch of a 55-HP tractor. An additional 225 kg of weight was added to the aerator per the manufacturer's suggestion. The 20-cm tines arranged in a spiral pattern around the shaft penetrated to a soil depth of 10-12 cm and created 2-cm wide slits that were about 10 cm in length at the soil surface.

Forage Sampling, Chemical Analysis, and Defoliation by Mob Grazing

Every 6 wk a 1 m by 1.54 m strip of forage was collected from each plot by clipping to a stubble height of 5 cm immediately prior to defoliation by grazing. Mixed breed mature cows (*Bos* spp., 250 head ha^{-1}) were allowed to mob graze (Mislevy et al., 1981) the paddock containing the experimental plots and consume the forage down to a 5-cm stubble height within a 1-d period. Any clumps of forage not grazed by the cattle were clipped and discarded outside the plots.

The harvested forage was weighed fresh and a 1 kg subsample used for DM determination and subsequent chemical analysis. Samples were dried for 1 wk at 55^{o}C using a mechanical convection oven and DM production calculated. The dried samples were then ground to pass a 1 mm stainless steel screen using a Wiley Mill (Arthur H. Thomas Company, Philadelphia, PA). A LECO CNS 2000 combustion analyzer was used to measure N and tissue concentrations of P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, and B were determined by inductively coupled plasma emission spectroscopy (ICPES) following digestion in nitric acid and hydrogen peroxide as outlined by Jones and Case (1990). Concentrations of Al, Cd, Ni, and Pb were also determined by ICPES.

Forage N uptake was estimated as the product of forage DM production and N concentration.

Statistical Analyses

Data were analyzed by using Proc GLM of the Statistical Analysis System (SAS Inst., 1999) using the appropriate models for a completely randomized block design with treatment replication within each block (Hinkelmann and Kempthorne, 1994). Year was considered a sub-plot. Treatment by sampling date interactions and comparisons of responses among sampling dates within a year were determined using repeated measures analysis of variance procedures and associated contrasts (Hinkelmann and Kempthorne, 1994). Treatment mean comparisons were made by Fisher's F-test protected LSD test at the 0.05 level of significance unless otherwise noted.

Results and Discussion

There were treatment ($P < 0.001$), treatment by year interaction ($P < 0.001$), and treatment by defoliation date interaction ($P < 0.06$) effects for kikuyugrass DM production, N concentration, and N uptake. Over the two-year study period B-S2N produced more ($P < 0.05$) total forage (mean = 37.55 Mg ha^{-1}) than B-A1N (mean = 31.96 Mg ha^{-1}) which in turn produced more ($P < 0.10$) forage than N + aeration (28.10 Mg ha^{-1}) and ($P < 0.05$) N alone (mean = 26.36 Mg ha^{-1}). There were dramatic DM production responses to B-A1N and B-S2N compared to the N and N + aeration treatments for the first two defoliation dates in 2001-2002 (Figure 3). Responses were inconsistent the remainder of the first year, particularly for the B-A1N treatment. Cumulative DM production for B-A1N and B-S2N in 2001-2002 was 1.5 ± 0.1 and 2.0 ± 0.1 fold greater than the N and N + aeration treatments which did not differ. Considering the large first-year responses to the biosolid treatments in the present study, the possibility of a stimulatory (priming) effect of biosolid application on the mineralization of extra soil organic N for plant growth should be further explored with high organic C soils such as the Maile soil (Sastre et al., 1996; Stevenson and Cole, 1999).

During 2002-2003 DM production responses in the present study were inconsistent and cumulative DM production did not differ among treatments (Figure 4). With the exception of the first defoliation date (8 July) of 2002-2003, the lack of greater response to the second application of biosolids for B-A1N may have been due to leaching and denitrification of readily mineralized N (Mathews et al., 2004). This could have resulted from the moderately heavy July rainfall (220 mm, Fig. 2) coupled with existing high moisture soil conditions due to the unusually heavy rainfall near the end of the first year (Jan.- March 2001-2002) (Fig. 2). In contrast rainfall was light (< 80 mm mo^{-1}) for the first four months (April-July) following biosolid application during 2001-2002.

In general, the kikuyugrass N concentration and N uptake data mirrored the DM production response except that the responses to B-S2N persisted through most of 2001-2002 (Figures 5 and 7). The cumulative N uptake for B-A1N and B-S2N during 2001-2002 was 1.6 ± 0.1 and 2.5 ± 0.2 fold greater than the N and N + aeration treatments which did not differ. About 52 ± 1% of the 2001-2002 cumulative N uptake for B-A1N and B-S2N was obtained from the first three defoliations. Sartain et al. (2004) found that 33% of the applied N was released during the first 12 wk with only an additional 7% of the applied N being released during the last 14 wk of incubation. The observations of these investigators coupled with the observations in the present study indicate that after an initial period of rapid N release, subsequent N release from heat-dried biosolids is slow.

Mean annual N concentration and cumulative N uptake did not differ among treatments in 2002-2003 (Figures 6 and 8). Over the two year study period, however, B-S2N had a greater ($P < 0.05$) total N uptake (mean = 1185 kg ha^{-1}) than B-A1N (mean = 932 kg ha^{-1}) which in turn had a greater ($P < 0.05$) total N uptake than the N + aeration (761 kg ha^{-1}) and N alone (mean = 722 kg ha^{-1}) treatments. These increases paralleled the cumulative DM yields for the 2 years (Figure 9).

Specific affects of these treatments on forage macro- and micro-mineral composition for this study were previously presented and discussed by Mathews and Carpenter (2007), but mean macro- and micro-mineral concentrations across the four treatments for the various months of harvest are presented in Figures 10 and 11. There were also no treatment effects ($P > 0.47$) for Ni (mean = 0.67 mg kg^{-1}; SE = 0.07), Pb (mean = 0.16 mg kg^{-1}; SE = 0.02), or Cd (mean = 0.05 mg kg^{-1}; SE = 0.01). The lack of heavy metal effects was expected considering the low concentrations in the biosolid (Epstein, 2003). Furthermore, Hydrudand soils strongly sorb heavy metals with their considerable concentrations of amorphous minerals and organic C (Hue et al., 1988).

There were no treatment effects ($P > 0.15$) for soil pH (mean = 5.0); exchangeable Ca (mean = 1930 mg kg^{-1}; SE = 99), Mg (mean = 547 mg kg^{-1}; SE = 44), and K (mean = 351 mg kg^{-1}; SE = 56); or extractable NO_3-N (mean = 22 mg kg^{-1}; SE = 4) and NH_4-N (mean = 15 mg kg^{-1}; SE = 1) at the 0- to 15-cm depth. The only soil nutrient response that occurred at the 0- to 15-cm depth was for P_{MT}. Both B-A1N (mean = 117 mg kg^{-1}) and B-S2N (mean = 107 mg kg^{-1}) had greater ($P < 0.05$; SE = 7) P_{MT} concentrations compared to the N (mean = 72 mg kg^{-1}) and N + aeration (mean = 73 mg kg^{-1}) treatments. The biosolid treatments resulted in the application of 205 kg P ha^{-1} and excess of P delivered to soils is an inherent consequence of sewage biosolids applied at agronomic N rates (Epstein, 2003). Phosphorus buildup in pasture soils is primarily an environmental concern for soils with a limited capacity to sorb P because of the increased possibility that runoff losses could contribute to eutrophication of surface waters (Mathews et al., 2005). This is not a major concern for the Maile soil (Mathews et al., 2005).

Conclusions and Implications

Daily mean temperatures were similar for both years 1 & 2, rainfall differed significantly between years. Year 2 had less rainfall and poorer DM yields. Macro- and micro-mineral content of forages varied with both types of fertilizer and month of harvest (season). Calcium (Ca), potassium (K), sodium (Na), iron (Fe), and zinc (Zn) varied the most. The levels of heavy metals in the Kikuyu grass forage samples were not altered.

Aeration did not significantly affect productivity of the improved kikuyugrass pastures and the slight increase in yields reported may not be enough to justify the cost of aeration. The pasture soil with a high P_{MT} concentration indicated that a heat-dried biosolid was more effective than N applied as urea in terms of cumulative forage production and N uptake during the first year.

Both milorganite treatments increased yields significantly during year 1 but during year 2, when there was less rainfall, there were no differences. However, a single 2N application of biosolids applied in the first year showed a residual effect in the following year for forage production and N uptake that was equivalent to 300 kg N ha^{-1} applied as urea in five split applications. During the first year B-S2N produced greater cumulative forage yield than B-A1N, which in turn produced more than the N + aeration and N alone treatments. In the first year total annual N uptake mirrored forage DM production, but over half the annual N uptake for the biosolid treatments occurred during the first three harvest periods (defoliations).

Moderately heavy rainfall in the second month after the year 2 biosolid application may have reduced response to the B-A1N treatment through N leaching and denitrification losses from the rapidly released N pool. These results suggest that after an initial period of rapid N release, subsequent N release was slow for the biosolid studied. Based on these studies, use of spiked tine aeration equipment on kikuyugrass pastures on Hawaiian Andisols can not be recommended, and the potential of sewage biosolids as a slow release N source should be further investigated. The influence of heavy rainfall on N losses from freshly applied biosolids is of particular interest. Hawaii should seriously consider converting sewage sludge to a valuable biosolid fertilizer.

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References

Epstein, E. 2003. Land application of sewage sludge and biosolids. Lewis Publishers, Boca Raton, FL.

Fukumoto, G., and M. Yamasaki. 2003. Evaluation of fertilizer formulations on pasture yield. Univ. of Hawaii CTAHR, Honolulu, HI and Kona Coop. Ext. Serv. Office, Kealekekua, HI.

Greenwood, K.L., and B.M. McKenzie. 2001. Grazing effects on soil physical properties and the consequences for pastures: a review. Aust. J. Exp. Agric. 41:1231-1250.

Hanna, W.W., C.J. Chaparro, B.W. Mathews, J.C. Burns, L.E. Sollenberger, and J.R. Carpenter. 2004. Perennial *Pennisetums* p. 503-535. *In* L.E. Moser et al. (ed.) Warm season (C_4) grasses. Agron. Monogr. 45. ASA, CSSA, SSSA, Madison WI.

Hinkelmann K., and O. Kempthorne. 1994. Design and analysis of experiments: Volume I. Introduction to experimental design. Wiley-Interscience, New York.

Hue, N.V., and S.A. Ranjith. 1994. Sewage sludges in Hawaii: chemical composition and reactions with soils and plants. Water, Air, and Soil Pollution 72:265-283.

Hue, N.V., J.A. Silva, and R. Arifin. 1988. Sewage sludge-soil interactions as measured by plant and soil chemical composition. J. Environ. Qual. 17:384-390.

Humphreys, V.T., J.R. Carpenter, B.W. Mathews, and B.A. Buckley. 2005. The effects of temperature, rainfall, month of harvest and pasture management on the mineral composition of kikuyu grass (*Pennisetum clandestinum*). p. 46-53. *In* M.S. Thorne and L.J. Cox (ed.) Proceedings 2005 Mealani Forage Field Day - Improved Livestock and Forage Production Through Sustainable Management Practices. Mealani Res. Stn., Kamuela, HI. 17 Sept. 2005. Univ. of Hawai‘i Coop. Ext. Serv. CTAHR Proc. P-09/05.

Jones, J.B., and V.W. Case. 1990. Sampling, handling, and analyzing plant tissue samples.

p. 389-427. In R.L. Westerman (ed.) Soil testing and plant analysis. 3rd ed. SSSA, Madison, WI.

Mathews, B.W., and J.R. Carpenter. 2007. Fertilization, aeration, and sewage biosolid effects on kikuyugrass pasture productivity. Soil Crop Sci. Soc. of Fla. Proc. 66: (In Press)

Mathews, B.W., J.R. Carpenter, L.E. Sollenberger, and K.D. Hisashima. 2001. Macronutrient, soil organic carbon, and earthworm distribution in subtropical pastures on an Andisol with and without long-term fertilization. Commun. Soil Sci. Plant Anal. 32:209-230.

Mathews, B.W., J.R. Carpenter, L.E. Sollenberger, and S. Tsang. 2005. Phosphorus in Hawaiian kikuyugrass pastures and potential phosphorus release to water. J. Environ. Qual. 34:1214-1223.

Mathews, B.W., S.C. Miyasaka, and J.P. Tritschler. 2004. Mineral nutrition of C_4 forage grasses. p. 217-265. *In* L.E. Moser et al. (ed.) Warm season (C_4) grasses. Agron. Monogr. 45. ASA, CSSA, SSSA, Madison WI.

Miles, N. 1997. Responses of productive and unproductive kikuyu pastures to top-dressed nitrogen and phosphorus fertiliser. Afr. J. Range Forage Sci. 14:1-6.

Mislevy, P., G.O. Mott, and F.G. Martin. 1981. Screening perennial forages by mob-grazing technique. p. 516-519. *In* J.A. Smith and V.W. Hays (ed.) Proc. XIV Int. Grassl. Congr., Lexington, KY. 15-24 June 1981. Westview Press, Boulder, CO.

Morrison, J. 1966. The effects of nitrogen, phosphorus, and cultivation on the productivity of kikuyu grass at high altitudes in Kenya. E. Afr. Agric. For. J. 31:291-297.

Muchovej, R.M., and J.E. Rechcigl. 1997. Agronomic uses of pelletized biosolids in Florida. Final report prepared for Bio Gro Systems, Inc., Annapolis, MD., Univ. of Florida IFAS, SW Florida Res. Ed. Ctr., Immokalee.

Muchovej, R.M., and J.E. Rechcigl. 1998. Nitrogen recovery by bahiagrass from pelletized biosolids. p. 341-347. *In* S. Brown et al. (ed.) Beneficial co-utilization of agricultural, municipal and industrial by-products. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Prasertsak, P., J.R. Freney, O.T. Denmead, P.G. Saffigna, and B.G. Prove. 2001. Significance of gaseous nitrogen loss from a tropical dairy pasture fertilised with urea. Aust. J. Exp. Agric. 41:625-632.

SAS Institute. 1999. SAS/STAT user's guide. Version 8. SAS Inst., Cary, NC.

Sastre, I., M.A. Vicente, and M.C. Lobo. 1996. Influence of the application of sewage sludges on soil microbial activity. Bioresource Tech. 57:19-23.

Stevenson, F.J., and M.A. Cole. 1999. Cycles of soil: Carbon, nitrogen, phosphorus, sulfur, micronutrients. 2nd ed. John Wiley & Sons, Inc., New York.

Tamimi, Y.N. 1972. Responses of kikuyu and pangola grasses to nitrogen, phosphorus, and potassium: II. Effect of high rates. p. 85-92. *In* Proc. 7th Ann. Mealani Beef Cattle Field Day, Mealani Exp. Stn., Kamuela, HI. 18 Sept. 1971. Misc. Pub. 81. Univ. Of Hawaii Coop. Ext. Serv., Honolulu.

Tamimi, Y.N., C.M. Campbell, D.T. Matsuyama, and E.B.Ho-a. 1981. Resource assessment of range land along elevation transects on Mauna Kea and Kohala mountains. p. 15-25. *In* Proc. 16th Mealani Beef Cattle Field Day, Mealani Exp. Stn., Kamuela, HI. 24 Oct. 1981.Res. Ext Ser. 011. HITAHR-CTAHR, Univ. of Hawaii, Honolulu.

Theron, F.P., J.M. Gosnell, and A.D. Venter. 1958. Renovating degenerate kikuyu pastures. Farming in South Africa 34:25-31.

Vicente-Chandler, J., and S. Silva. 1960. Effects of nitrogen fertilization and grass species on soil physical condition in some tropical pastures. J. Agric. Univ. Puerto Rico 44:77-86.

Table 1. Selected chemical characteristics of the improved pasture soils (0- to- 15-cm depth).

pH	5.2
modified-Truog extract. P, (mg kg^{-1})	68
Ca^{2+}, (mg kg^{-1})	2018
Mg^{2+}, (mg kg^{-1})	576
K^{+}, (mg kg^{-1})	408
Na^{+}, (mg kg^{-1})	21
Al^{3+}, (mg kg^{-1})	31
$Fe_{OX,}$ (g kg^{-1})	116.9
OC, (g kg^{-1})	169.9

Figure 1. Mean monthly maximum & minimum temperatures (^{o}C) for year 1 and year 2 of study.

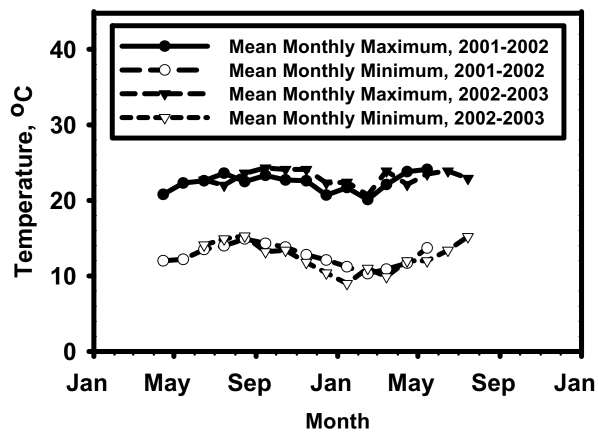


Table 2. The pH and elemental concentration of the anaerobically digested, heat-dried granulated sewage biosolid - Milorganite® (Waters Agric. Labs, Camilla, GA).

pH	5.9	Na, g/kg	2.6
Total solids, g/kg	970	Fe, g/kg	52.6
C, g/kg	340.5	Al, g/kg	10.2
N, g/kg	62.2	Zn, mg/kg	530
C/N (ratio)	5.5	Mn, mg/kg	390
NH_4-N, g/kg	1.0	Cu, mg/kg	250
P, g/kg	21.4	B, mg/kg	40
K, g/kg	7.5	Mo, mg/kg	20
Ca, g/kg	19.5	Ni, mg/kg	30
Mg, g/kg	5.9	Pb, mg/kg	90
S, g/kg	8.5	Cd, mg/kg	10

Figure 2. Mean monthly rainfall (mm) for year 1 and year 2 of Study.

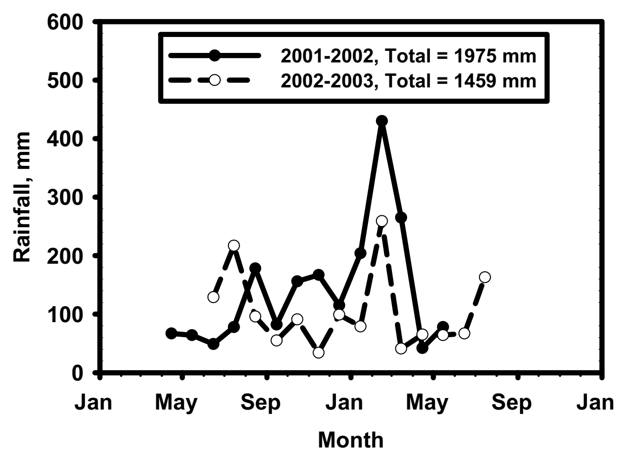


Figure 3. Dry matter production (Mg/ha) during year 1 (2001-2002) of study.

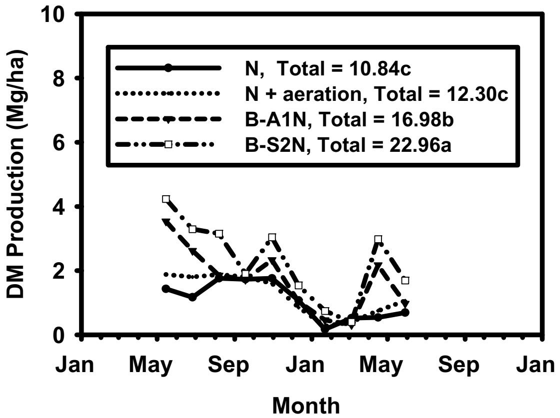


Figure 4. Dry matter production (Mg/ha) during Year 2 (2002-2003) of study.

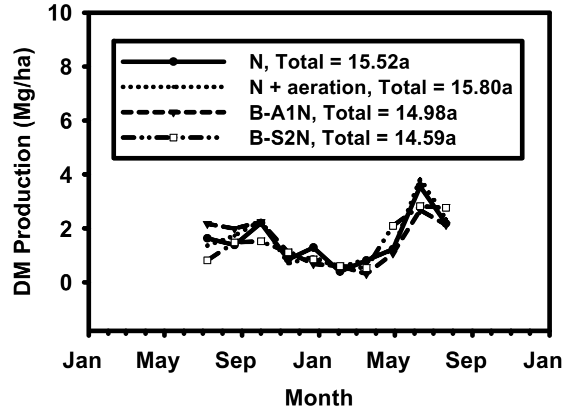


Figure 5. Nitrogen (N) concentration (g/kg) of forage during year 1 (2001-2002) of study.

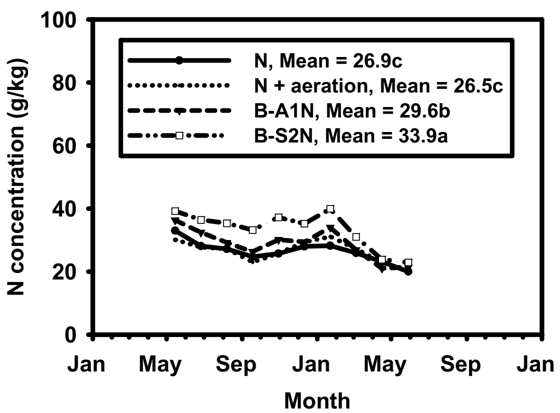


Figure 6. Nitrogen (N) concentration (g/kg) of forage during year 2 (2002-2003) of study.

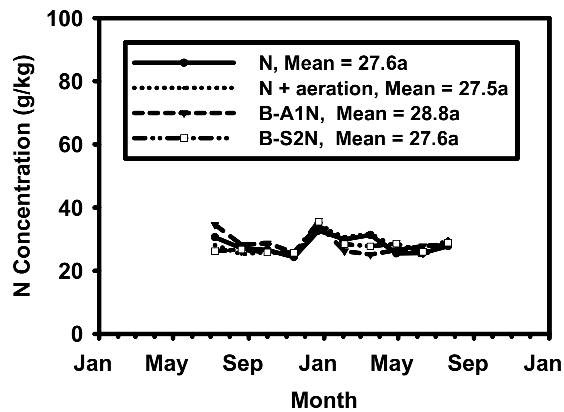


Figure 7. Nitrogen (N) uptake (kg/ha) by Kikuyu grass forage during year 1 (2001-2002) of study.

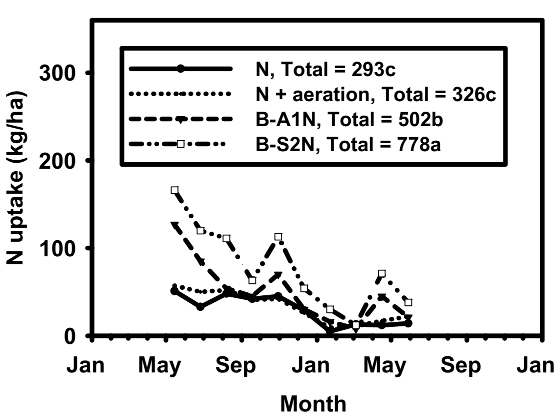


Figure 8. Nitrogen (N) uptake (kg/ha) by Kikuyu grass forage during year 2 (2002-2003) of study.

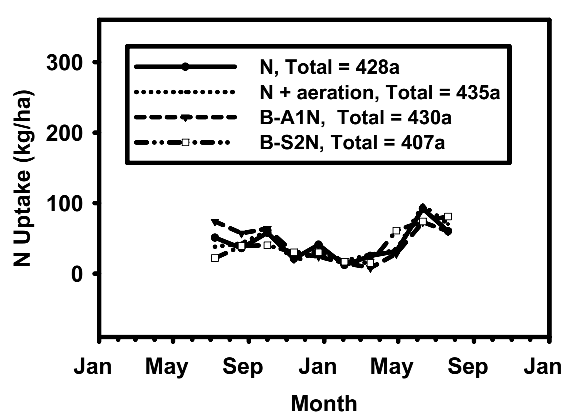


Figure 9. Average yield for years 1 & 2

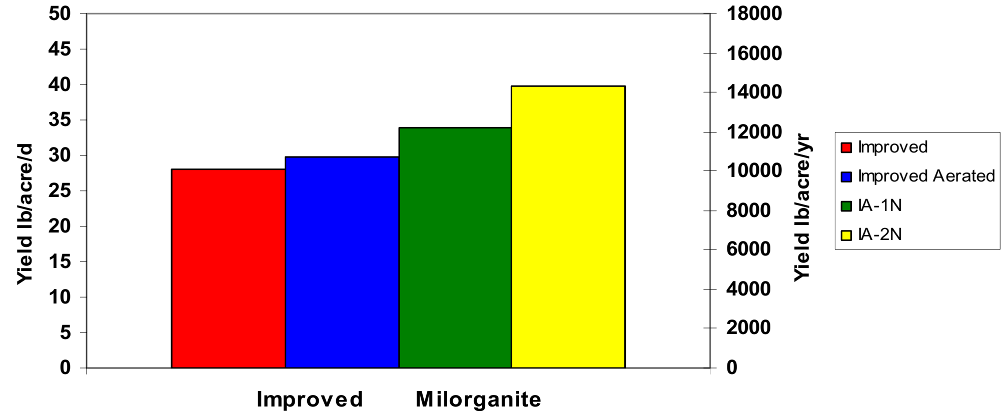


Figure 10. Average forage macromineral concentration (%) for years 1 and 2 (DMB)

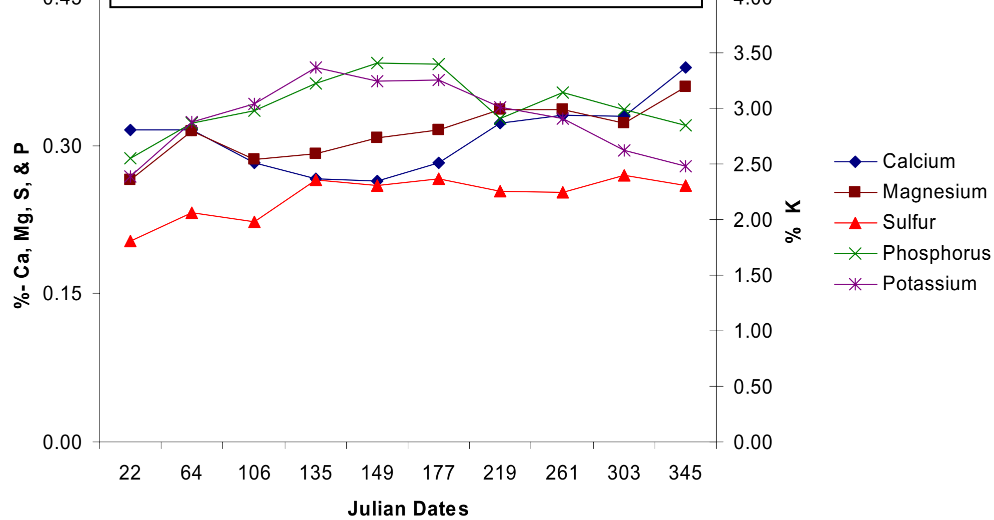
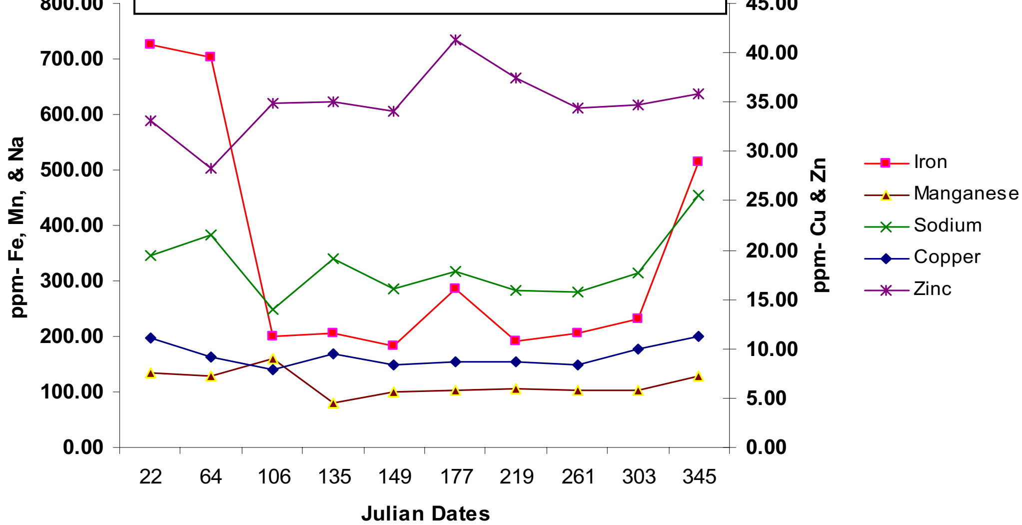


Figure 11. Average forage micromineral concentration (ppm) for years 1 and 2 (DMB)



Evaluation of Protein Banking in a Tropical Pastoral System

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Background

Tropical grasses are very high biomass-yielding plants; however, they generally are low in total available and digestible nutrients for ruminant livestock. Specific nutrient characteristics can be improved by incorporating forage legumes into the pastoral system. With suitable soil conditions, legumes can take up atmospheric nitrogen through a symbiotic relationship with rhizobium bacteria. This amazing ability makes legumes a valuable source of protein for ruminants, advancing the nitrogen mineral cycle of the pastures. However, as with many herbaceous legumes, regrowth and recovery cycles are slower than with the faster growing grasses, which tend to compete with and limit the establishment of the legume sward.

The use of tree legumes in pastoral systems is not a new idea in Hawaii. These legumes function similarly to the herbaceous forms but have a higher mineral cycling capacity due to deep tap roots and greater root mass. In addition, with a deep tap-root system, the tree legumes are more drought tolerant than the shallow rooted forms. *Leucaena leucocephala*, also known as haole koa, is a tropical leguminous forage tree from Central America, and was once very prevalent in low elevation pastures in Hawaii. Plant populations have been markedly reduced due to the damaging effects of a leaf-feeding psyllid insect. Leucaena is adapted to wide environmental regimes, from arid regions on the coast to higher elevations with moderate rainfall levels. Germplasm improvements by Dr. James Brewbaker of CTAHR, University of Hawaii at Manoa, led to many improved selections. Kx2 was selected for this protein banking evaluation for its psyllid resistance and adaptability to higher elevations (Figure 1).

A protein bank is a row or several rows of tree legumes planted in a controlled and managed region of the pasture, such as a fence-line or separate enclosure used in the grazing management scheme. The bank provides a concentrated planting where livestock can pulse-graze to "withdraw" the high quality protein resource and other cycled minerals.

Figure 1. Photograph (taken in late August) shows 60-day regrowth of a 1-year old planting of the Kx2 variety in Kihei, Maui. The last rainfall (0.82") received in this area was in January of the same year. The surrounding buffelgrass shows severe bleaching due to extremely dry conditions and intense solar radiation.

Protein Banking Evaluation at Mealani

The objectives of the protein banking field trial at the Mealani Research Station is to (1) evaluate the establishment period and grazing pressure of the Kx2 in a protein banking system, (2) collect data on the yield, chemical composition of the forage and its contribution to the pastoral mineral cycle, and (3) compare animal performance between the leucaena supplemented and non-supplemented pastures.

An average of 1000 plants per 3-acre paddock was transplanted in April 2005. The seedlings were spaced 1 foot apart within the row with 6 feet between rows. Two rows were established in each of the four paddocks along one side of the fence-line. Due to uprooting of the transplants by feral pigs, three of the four paddocks were re-established in the spring of 2006. An electrified tape perimeter was secured to prevent feral pig intrusion into the plots.

Figure 2. Leucaena (Kx2 variety) seedling ready to be planted into a two-row protein bank in a paddock at the Mealani Research Station.

Figure 3. Overview of the leucaena protein bank planted in a paddock at the Mealani Research Station.

The Kx2 plants in the undamaged plot (Paddock 19) was protected from grazing and allowed to harden in the plot enclosure. At approximately 9 months after transplanting, the stem diameter averaged 1 inch (range 0.5 to 1.25 inches) with plant height ranging from 4 to 6 feet; calves and cows were allocated portions of the protein bank for the first grazing in January 2006. The bank was divided into three equal sections and allocated to steer and heifer calves and the cow herd. After grazing by the calves, the plant stems were cut back to approximately knee-height. The section grazed by the cow herd was not manually height-adjusted but was allowed to recover from the grazing pressure height established by the cows. The cows did a good job of moderating the pruning height to approximately knee-high.

Immediately after grazing, the plot was evaluated for plant damage. Larger diameter stems were observed to be more damaged (split crotch, debarking, and total breakage of stem at ground level) than smaller diameter stems. The smaller stems seem to be more flexible and less brittle than the larger stems, suggesting that an earlier first-grazing may be required to reduce damage due to grazing and trampling.

After the initial winter grazing, regrowth interval (based on regrowth height of 4.5 feet or 1.5 meter) ranged from 3.0 months. Thus, with the current pasture grazing rotation of 45-days, it would take two grazing cycles before the bank can be grazed (defer grazing for one cycle, graze one cycle). We will continue to observe season differences in re-growth and recovery periods.

Initial recovery of the plants has been very good, although a small percentage of plants died back and should be replaced.

In the spring of 2007, the heifer development phase is planned to evaluate animal performance differences between the 12 acres of leuceana-supplemented paddocks compared to paddocks not supplemented with leuceana.

Figure 4. Established leucaena protein bank in a paddock at the Mealani Research Station.

Table 1. Leucaena dry matter yield and chemical composition.

	% as sampled	% dry matter basis						
	DM	Ash	CP	EE	NDF	ADF	Lignin	Cellulose
Average	35.33	4.34	16.46	1.53	56.84	43.55	26.15	17.16
Minimum	31.55	3.60	13.66	0.86	50.96	35.47	21.63	13.37
Maximum	39.77	5.03	22.31	2.13	67.93	53.80	30.74	22.94

n = 9
Regrowth days: average 145, range 74 to 246
Average height: 5.4 feet (1.8 meters)

Table 2. Leucaena mineral yield.

	%					ppm				
	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B
Average	0.13	1.26	0.83	0.24	0.04	369.44	30.00	15.44	9.33	27.56
Minimum	0.10	1.01	0.62	0.21	0.01	221.00	27.00	13.00	6.00	21.00
Maximum	0.16	1.61	1.10	0.29	0.17	619.00	38.00	17.00	13.00	34.00

Using the Flexible Retort Pouch to Add Value to Agricultural Products

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Hawaii's diverse agricultural production sector is the basis of its growing food-processing industries, which provide a variety of unique products to both residents and visitors. In 2000 the food-processing sector contributed $1.07 billion to Hawaii's economy, in addition to the $1.94 billion that came from agricultural product sales (source: Hawaii Agricultural Statistics Service). Hawaii's food processing industries include pineapple processing, sugar processing, canned vegetables and fruits, confectionary products, salted and roasted nuts and roasted coffee, meat products, milk products, grain and bakery products, and beverage products. Many agricultural industries, such as the beef industry (Cox and Bredhoff 2003), are interested in adding value to their products with processing.

Food packaging options

Hawaii's geographic isolation presents a challenge to exporters interested in competing in the global market and makes improvements in product shelf life and stability a top priority for food processors. Canning, one of the most common packaging methods to preserve food products, requires a large capital investment in facilities for production, transportation, and storage. Because the materials needed to fabricate cans must be imported, rising fuel costs combined with the weight of can metal has made canning increasingly less cost-effective in Hawaii.

Consumers increasingly demand food products that have high-quality taste, appearance, and nutrition and, preferably, require minimal preparation time. For quality reasons, consumers often prefer frozen products to canned. This trend is especially important to the beef industry, because many beef cuts require extensive cooking time, as well as considerable processing expertise to maximize palatability. The inability of the beef industry or any other agricultural industry to adapt to consumer preferences could result in a loss of market share.

While high-value products such as coffee and macadamia nuts have been marketed in vacuum-packed pouches for many years, products that require cooking still have limited shelf life, even if vacuum packed. Cox and Bredhoff (2003) reported that retailers and wholesalers want beef products that have longer shelf life. At the same time, cattle producers face a challenge in selling the less desirable cuts and look to processing as way to standardize the quality of these cuts. Processed beef products desired by Hawaii residents and visitors include local-style beef stew, beef jerkey, beef *lau lau*, and *pipi kaula*, and these products offer potential for using and adding value to the less saleable cuts. If a better method can be found to preserve these products, overseas markets could become more accessible, because consumption would not be limited to people currently in Hawaii. Marketing processed products would also eliminate the challenges faced by a fresh beef product, such as bans resulting from outbreaks of BSE (bovine spongiform encephalopathy).

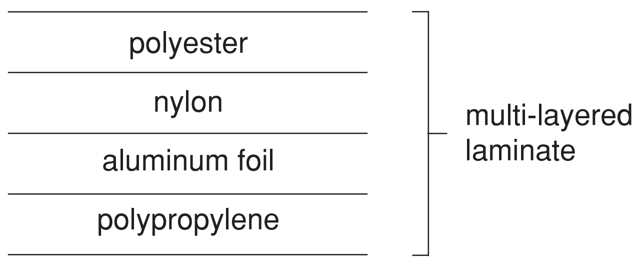
One solution that offers promise is a new packaging technology, the retort pouch, a flexible, laminated package that can withstand thermal processing temperatures and combines the advantages of both metal cans and plastic packages (Fig. 1). In the 1950s, the U.S. Army developed the pouch to replace heavy metal cans with lightweight, easy-to-pack, shelf-stable food containers for packaging combat rations. In 1965, the first com-

Figure 1. Examples of commercial retort-pouched products.

mercial retort pouches were produced in Italy. Research on the development of large-scale facilities continued through the late 1970s to produce "Meal Ready-to-Eat" (MRE) units for the U.S. military. In Japan, retort pouch technology has been widely accepted, and a variety of pouched products, ranging from sukiyaki to soup, is available.

Most retort pouches are constructed with a four-ply laminate consisting of a polyester outside layer, a nylon second layer, an aluminum foil third layer, and a polypropylene inner layer (Fig. 2). The melting point of polypropylene polymers is around 138°C (280°F), which is higher than the commercialized sterilization temperature of 121°C (250˚F). The aluminum foil can be laminated with either the matte or the shiny side exposed to view. Some pouch material contains polyvinylidene chloride (PVDC, or SARAN®), ethylene vinyl alcohol (EVOH), or nylon instead of aluminum foil as a middle layer. The components of the laminate are held together with adhesives, which are usually modified polyolefilms such as ethylene vinyl acetate (EVA). Each component performs a specific function that is critical to the shelf stability and container integrity. In some cases a clear layer, to permit viewing of the product, replaces the foil layer, by using SARAN® (PVDC), EVOH, or nylon. While these plastics are good barriers to oxygen molecules, they are not complete barriers, and therefore the shelf life of the non-foil container is reduced substantially.

Figure 2. Cross-section of a retort pouch.



Advantages of the retort pouch

Retort pouches have several advantages over cans (Table 1). Flexible pouches are more economical to ship and dispose of than rigid cans. The retort pouch–packed product needs significantly less heat than cans to achieve commercial sterility, with cooking time and energy costs reduced by half. Heat penetrates the food much more quickly when it only has to reach the inside of a half-inch-thick mass rather than the much thicker mass in a round can. Unlike canned foods, the pouched foods will not be overcooked and softened into mush, ensuring better texture and taste. Retort pouches of low-acid, solid foods have attained commercial acceptance, and as the

Table 1. Advantages of retort pouches vs. metal cans.

Features of retort-pouch packing	*Benefits*
Reduced cooking time	Better taste, nutritional value; faster turn-around time
Complete product evacuation	Improved product yield and consumer value
Reduced bulk and weight	Lower transportation and storage costs
Environmentally friendly	Less waste and fossil fuel consumption
Package differentiation and larger shelf display	Increased sales
Package durability	Eliminate cuts and promotes employee safety
Rotogravure printing	More attractive graphics on packaging
Package durability	No dented cans

technology is more widely used and accepted, other heat-sterilized foods are expected to appear in pouches, resulting in a new, expanding segment within the packaged foods industry.

Seafood companies in the USA are packaging canned mackerel and tuna in retort pouches. They have concluded that the process time for retort pouches is significantly reduced, while product quality remains high. Smoked seafood that is vacuum packed in retort pouches does not require refrigeration and appears fresh and moist. Stability is accomplished by a heat process (above 230°F) under pressure, which destroys *Clostridium botulinum*, other illness-causing bacteria, and spoilage bacteria. Recently, Star-Kist offered food-service packages, followed by retail sizes, of tuna in a retort pouch, which has been a successful conversion from canned products.

Jack Link's "Fully Cooked Ground Beef" uses an aseptically sealed laminate pouch that keeps 10.6 ounces of 90-percent-lean ground beef "shelf-stable" for up to 18 months without refrigerating. The package is heat-sealed and the meat is fully drained, with no preservatives added, in "Mexican Style," "Lightly Seasoned," and "Italian Style" preparations. Currently, consumers eat about 75 percent of ground beef as an ingredient in "quick-fix" meals, giving this package a huge potential market. Smithfield's Esskay and Knauss Foods also both introduced creamed chipped beef in a stand-up, retorted pouch.

Ohmic heating of retort pouches

Retort systems require hot water or a steam-water mixture to cook the food, which is not particularly energy efficient. The author (S. Jun) and Dr. Sastry at Ohio State University have developed a pouch with conducting strips to warm food to about 80°C and heat it to more than 121°C, hot enough for sterilizing. This makes a military-ration MRE pouch (Fig. 3) that does not require the chemical reaction, the hydration reaction of anhydride, for heating. Instead, these new pouches each have two tabs, like tiny ears, containing electrical contacts that are attached to a small heating unit, which generates pulsed electric power with various frequencies.

The electricity flows through the tabs, the electrodes, and finally through the product. The electric current flowing through the electrodes generates an electrical field that excites food molecules, causing them to vibrate and heat up. This is called ohmic or joule heating, just as an electric heater element heats up when current is passed through it.

The process results in fresher-tasting food with improved texture because it heats evenly from the inside out. The ohmic heating technique sterilizes a food product by holding it for a set time at 121°C after a "come-up time" (CUT), the length of time required for the product to reach 121°C (Fig. 4). The optimized CUT and holding time can vary depending on the food properties, targeted microbes, and packaging materials. Deter-

Figure 3. Flexible retort pouch with foil electrodes.

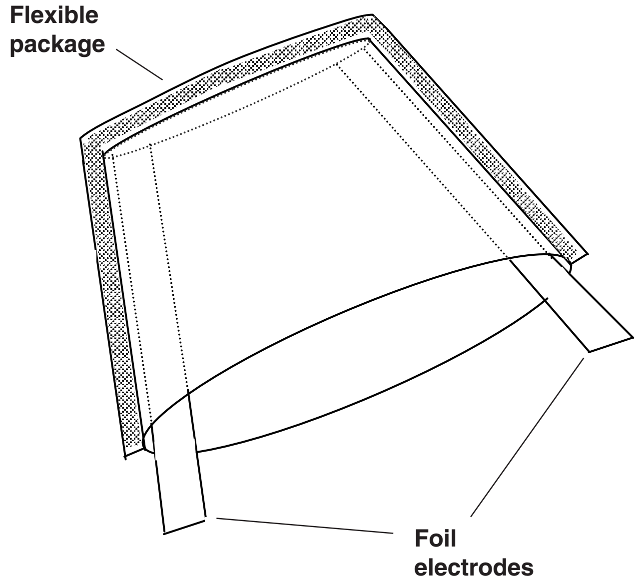


Figure 4. Heating pattern of the ohmic treatment.

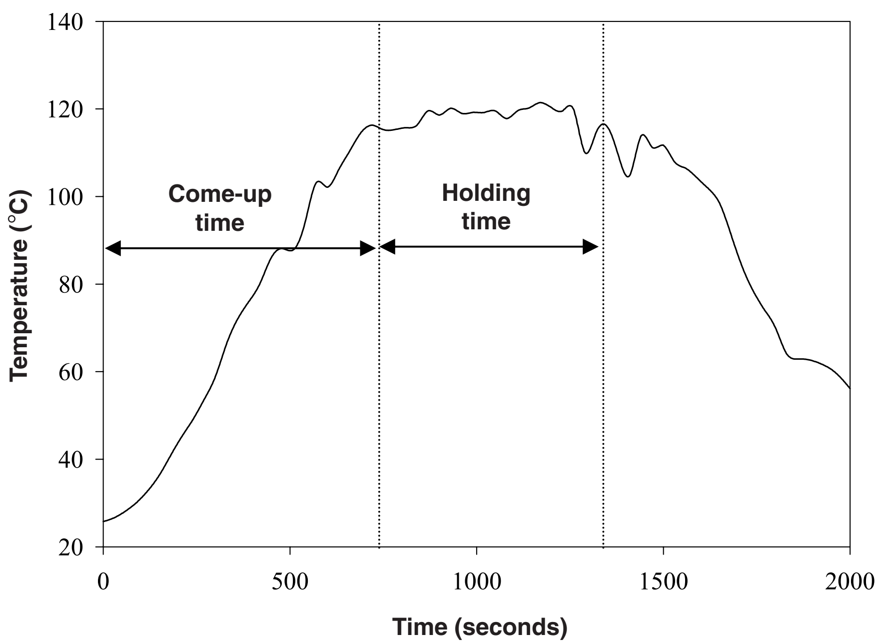
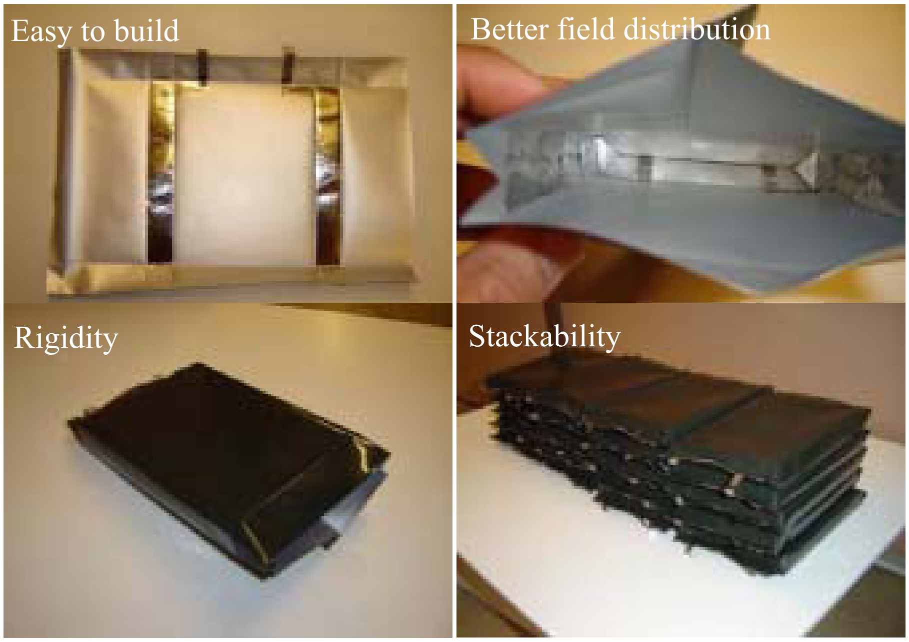


Figure 5. A new design of an ohmic retort pouch.



mining the optimal CUT and holding time for the specific product in question will require research.

The combination of plastic-foil packaging sponsored by NASA was intended to heat up space foods in packaging and reuse the packages to store or sterilize biowaste during long-duration space missions. Thus the pouches are likely to save space and weight on space flights, a critical consideration when the cost of boosting anything into orbit is about $10,000 a pound. The ohmic retort pouch holds promise as a way to cook packaged foods at the household level and at the mass-production level.

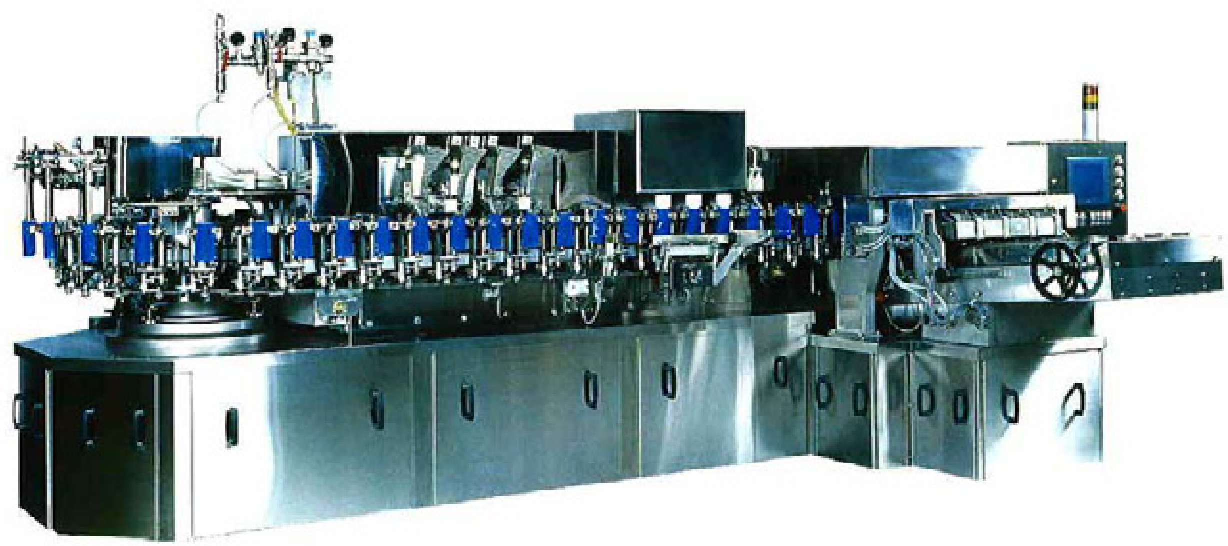
Looking to the future

Retort pouched products generally retail at a higher price than products in metal cans, and consumers appear to be willing to pay for the convenience and improved flavor and texture. Recently, non-foil retort pouches suitable for heating in a microwave oven have been developed, and the ohmic heating technique also has a potential for developing a heat-and-eat package. Figure 5 shows a newer design of ohmic retort pouch that heats more evenly and stacks more efficiently.

While the initial investment in pouching equipment is relatively expensive, pouch packaging technology is expected to be less costly in the long run than high-speed canning lines. For example, the Toyo Jidoki filling machine (Fig. 6) brings new levels of speed and versatility to food-packaging applications that require daily cleaning-in-place (CIP). This system is ergonomically designed to maximize its productivity to open, fill, and seal 250 pre-made retort pouches per minute, continuously. The actual cost of this stand-alone system is estimated at $0.9–1.3M, depending upon the specifications. What happens to the product before and after it goes into the pouch, such as premixing and labeling, along with whether liquids and solids are put into the pouch separately or together, affects the system requirements. The projected annual savings in a meat patty packaging operation, for instance, is estimated at $145,500. This means that the system will pay for itself in cost savings in about eight months.

While food processors are unlikely to remove a functioning can line to replace it with retort packaging, they

Figure 6. A high-speed retort pouch filler-sealer (Model TL-AX1, Toyo Jidoki Co.)



might be reluctant to put in new canning equipment or to replace one that has past its useful life. Machinery costs have declined as the consumer's desire for convenience increased. When compared with the expected benefits—i.e., a rapid return on investment—the initial capital investment could prove to be feasible.

The use of retort pouches for processed products holds potential for Hawaii's beef products and other foods that require cooking to ensure a long shelf life. Hawaii's consumers, including residents and visitors, will enjoy "ready-to-eat" convenience products quality-ensured by retort pouches. Some retort pouches that already have appeared in Hawaii markets, such as the TastyBite® line of "Cuisine of India" preparations, should be an inspiration to Hawaii's food processing enterprises. Given the cost of pouching equipment, however, industry coordination will be needed to provide economics of scale to ensure the feasibility and reduce the risk of adopting this technology. Agricultural producers will need to work cooperatively to maximize an investment in a pouching facility and to identify issues, such as food safety regulations, that need to be addressed during the adoption process.

References

Cox, Linda J., and Soot Bredhoff. 2003. The Hawaii beef industry: Situation and outlook update. University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources, publication LM-8, 11 p.

Jun, Soojin, and Sudhir Sastry. 2005. Modeling and optimizing of pulsed ohmic heating of foods inside the flexible package. Journal of Food Process Engineering 28: 417–436.

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Foraging Behavior and Grazing Management Planning

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Introduction

A successful grazing management plan requires a sound understanding of the effect the grazing animal exerts on the range or pasture ecosystem. The grazing animal exerts pressure on the range or pasture ecosystem through consumption and physical damage of the plants, by their digestive processes, and by their movements across the landscape. Separation of this total influence into individual factors increases understanding of the grazing impacts and promotes informed grazing management decisions (Heady and Child 1994). Managers who learn to manipulate these grazing factors are typically the most successful at maintaining forage and animal production goals (Figure 1).

The goals and objectives of a successful range or pasture management plan are achieved only through two distinct methods of manipulation of the vegetative community. The first means by which managers can affect change in a range or pasture system involves altering the grazing factors (Fig. 1). The second includes the application of seeds, fertilizers, or other improvements directly to the vegetation and soil complex (Heady and Child 1994). While these practices can be an important and effective tool for land managers, they are usually costly. For this reason it is usually reserved for drastically disturbed range and pasture lands where recovery from degradation would be too slow otherwise.

Four Grazing Factors. A grazing animal selects for certain plants or plant parts and consumes them to a particular degree or intensity. This grazing event occurs at a specific season in the growth of the plant and may be repeated. Each of these four factors; selectivity, intensity, frequency (repeated grazing), and season, influences the growth and reproduction of the grazed plants differently (Heady and Child 1994). Inherently then, plant communities are influenced differently. Thus, through management, animals can be used to influence the vegetation of range and pasture systems by manipulating their impact on these four grazing factors (Fig.1).

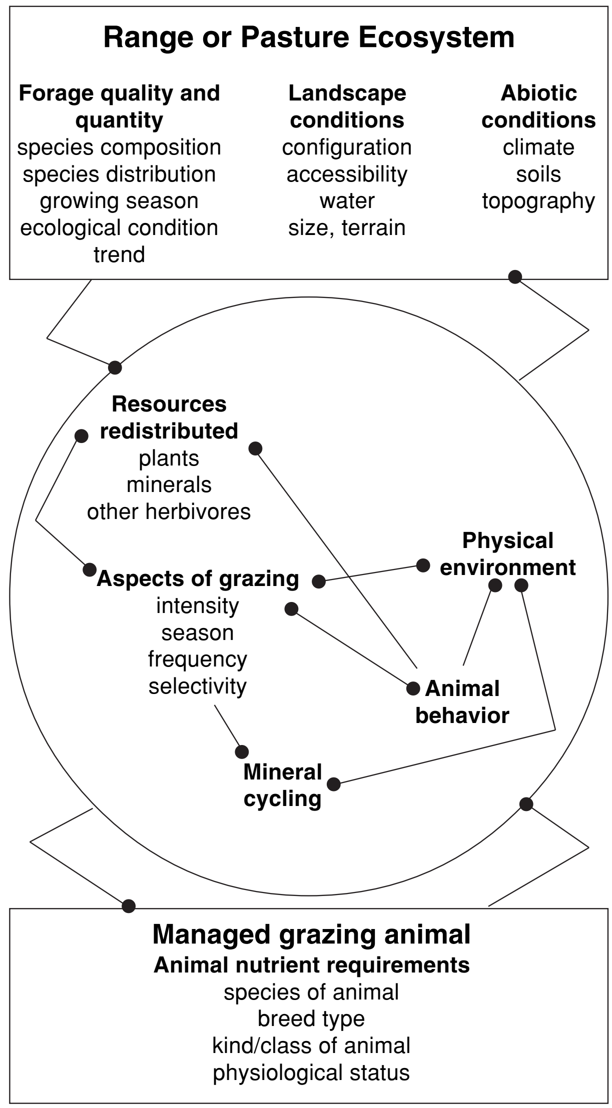

Figure1. A conceptual representation of the relationship between the land, animals and vegetation (Adapted from Heady and Child 1994).

It is important to understand, however, that one grazing factor does not occur without the others. Grazing animals exert the different grazing impacts at the same time. For example, a cow tramples plants while grazing forages to a definite degree or intensity during aspecific season (or period of growth for the plant). Thus, the grazing process and the resulting plant response is a dynamic interaction dependent on the composition of the plant community and the species of animal (determines animal behavior).

Successful managers generally have an understanding of the dynamics of the interaction between the grazing animal and the plant community. While the response of the plant community to grazing is an important factor in the development of a grazing management plan, it is not the focus of this paper. Instead the purpose of this paper is to provide an overview of the factors that influences foraging behavior and to show how it needs to be considered in the development of a successful grazing management plan.

Foraging behavior

Different kinds (species) and classes of grazing animals utilize range and pasture systems differently. Specifically, the foraging behavior of a given kind or class of animal determines how it moves across the landscape, and selects for different forages. In the process of grazing, an animal progresses through levels of instinctive responses and behaviors that lead to the consumption of a plant (Stuth 1991). These instinctive responses and behaviors are driven by sensory cues and the physiological needs of the animal. These vary across the landscape and through time.

Factors that influence foraging behavior can be divided into two categories: Factors that affect spatial choice, and factors that affect forage species choice. Spatial choice is a function of landscape features, plant community characteristics and grazing patch attributes.

Landscape Features. Foraging behavior at the landscape level is primarily a function of physical and thermal features of the range or pasture system that influences animal distribution and movement (Table 1). The array of certain features across the landscape influence how the grazing animal will utilize the range or pasture system as they seek to meet physiological needs. Physiological needs of grazing animals that determine distribution and movement across the landscape include, in order of importance to the animal:

1. thirst
2. heat/cold (thermal balance),
3. hunger
4. orientation and predator avoidance
5. rest

Table 1. Characteristics of the landscape that affect the distribution, movement, and diet selection of grazing animals (from Stuth 1991).

Attribute	Components
Boundaries	Fences, home range, migration routes
Distribution of Plant Communities	Range sites, soils, aspect, elevation, structure, species composition
Accessibility	Slope, gullies, streams, shrub density, rockiness, roads, trails, fence lines, cut openings
Distribution of Important Features	Location of water, shade, loafing and bedding sites, and other convergent and divergent points in a landscape

The grazing animal must maintain their water balance or die. Thus thirst is the most influential physiological need determining animal movement and distribution across the landscape. Large ungulates are "central place foragers" (Stuth 1991). That is, they have a home range that is centered around water. Cattle and sheep generally do not graze beyond 1 mile from water. Distance between water points greater than 2 miles reduces grazing capacity by 50% (Holechek 1989). When calculating stocking rates in large pastures, managers must consider not only the spatial distribution of the herd in relation to all the water points, but also the frequency of drought. Stocking rates will need to be reduced accordingly.

Maintaining a thermal neutral balance is a major physiological requirement for grazing animals and often takes precedence over alleviating hunger, especially when experiencing temperature extremes. Landscape features that provide relief from temperature extremes include trees for shade and riparian areas or gulches that provide protection from the wind. Animal thriftiness often suffers in areas where relief from temperature extremes is not available.

The final three physiological needs of the grazing animal are interrelated and include mitigation of hunger (maintaining energy balance), orientation and predator avoidance, and rest. After grazing for some time most ungulates move to loafing or bedding areas to ruminate and digest food. This will be in an area where the animal feels safe from predators or other threats. Animals generally graze moving first from their water and shelter areas outward. The distance traveled by the animal while grazing is a function of their digestive (gut) capacity, potential harvest rate of forages encountered, grazing velocity, and level of hunger. These grazing patterns often produce rings of diminishing levels of utilization as distance from the water or bed ground increases.

Plant Community Characteristics. A plant community is typically defined by their structural configuration, spatial arrangement, and composition of plant species. Plant communities can be further divided into patches of more uniform groupings of species. The distribution of these patches influence the foraging behavior of the grazing animal within the plant community. Selection of a particular plant community by a grazing animal is largely a function of the site attributes that determine the animal's ability to harvest nutrients (Table 2).

Typically plant communities can be divided into four categories (Stuth 1991): Grazing preferred, grazing avoided, terrain constrained or directed use, and high-impact grazing sites. The bulk of the grazing animals forage is derived from grazing preferred sites. Thus, preferred sites have high occupancy to area ratios and high utilization to forage mass ratios. Typically grazing preferred sites have a greater density of high quality forage species. This often results in slower grazing velocities and greater residence time relative to other grazing areas available to the animal. For these reasons, grazing preferred sites can easily become overgrazed when management actions are not timely.

Grazing avoided areas generally have low forage value, generally because of the species composition, or they are inaccessible to the animal. Terrain constrained or directed use sites generally have high occupancy time but low utilization levels despite often abundant forage (Stuth 1991). Typically these sites result from herd concentration in pasture corners, or against gullies, hills, or roads. Finally, high-impact grazing sites have low residence times relative to the area but have high utilization levels. High-impact grazing sites develop along directional grazing paths such as along trails to and from water or shelter areas.

Table 2. Attributes at the plant community and patch level which influence the animal's selection of forage sites (from Stuth 1991).

Attribute	Function
Soil moisture-holding capacity	Forage supply and stability
Species composition	Affects suitability/stability of the site to meet general nutritional needs
Plant frequency	Affects the probability that the animal will encounter a desirable plant species and number of dietary decisions the animal makes
Abundance	Affects the supply of nutrients
Structure	Affects accessibility of forages species
Continuity	Affects animal movement velocity
Size	Affects amount of search area available
Aspect	Affects the thermal characteristics of the site
Orientation in the landscape	Affects the frequency of exposure to grazing (position relative to other areas that meet animals needs)

Foraging behavior and grazing management

Understanding the foraging behavior principles and the four grazing factors outlined above livestock managers can develop sound grazing management programs. The prime focus of a grazing management plan is to properly distribute the grazing impact across the pasture. By doing this, managers increase the quantity and quality of the forage available to the grazing animal and allow adequate recovery time for the forages between grazing events.

Poor grazing distribution within the pasture has been and continues to be a major problem confronting the livestock manager (Holechek et al. 1989). On most range and pasture systems, improvement will occur without reducing livestock numbers if practices that provide more uniform grazing are implemented. Determination of the appropriate practices to implement takes a thorough appreciation for the interaction between an animals foraging behavior and factors that contribute to poor grazing distribution. Factors that lead to poor grazing distribution include: distance to water, rugged topography, diverse vegetation, wrong type of livestock, pests, and weather (Holechek et al. 1989).

Improving Animal Distribution. Several factors can be used to improve livestock distribution in Hawaii including 1) changing and/or increasing the number of water points; 2) increasing the number and/or changing salt, mineral, and supplemental feed stations; 3) fencing; 4) changing kind, class or breed of grazing animal; 5) changing grazing system; 6) range improvements; 7) construction of artificial features to provide shade and/or protection from the wind.

Water. Poor distribution of water within the pasture is the primary cause of poor livestock distribution in most grazing systems (Holechek et al. 1989). Grazing utilization tends to be highest nearest water points and decreases as distance from water increases. The result is zones of over utilization nearest water points and zones of under-utilized pasture farthest away from the water point. Typically, the amount of under-utilized zones in a pasture is greater than the over-utilized zones.

Recommendations on distances between watering points are dependent on terrain, type of animal, and breed of livestock (Holechek et al. 1989). Generally, though distances to water should not exceed:

- 0.5 mile Rough country
- 1 mile Rolling, hilly country
- 2 miles Flat country

A common rule of thumb is no more than 50 cattle or 300 sheep per water point (Holechek 1989).

Often the development of additional watering points will improve livestock distribution and productivity. Development of new water points can be accomplished by drilling wells, installing pumping units, constructing storage tanks and drinking troughs or construction of catchments reservoirs and piping water to new locations. Each manager will need to determine what type of water development is most economically feasible to be constructed. Managers should carefully select the location, number, and distribution of new and existing water points within their pastures in order to improve animal distribution.

Salt, Mineral, and Supplemental Feed Stations. Careful placement of salt, mineral, and other supplements can be a great tool to obtain the desired distribution of grazing animals and can increase grazing capacity by as much as 20% (Holechek et al. 1989). Livestock usually go from water to grazing and then to salt. Thus, it is not necessary or desirable to place salt near watering points. In fact, strategically placing salt in grazing avoided areas is one means to entice livestock to use these areas. Desirable areas for salt grounds include ridges, knolls, benches, and gentle slopes away from water.

Fencing. Fencing is typically used to divide large range units into smaller units. The livestock manager needs to carefully consider the location, size, and shape of the grazing units as well as the direction of livestock rotation in planning fence placement (Holechek et al. 1989). Fences serve to 1) control the movements of livestock; 2) regulate use among forage types or protect choice grazing areas for special use; and 3) separate range or pasture units for special management.

Uniform grazing is difficult when several vegetation types (or range sites) occur in the same grazing unit. Separating large grazing units into several smaller units that are more or less similar greatly increases the uniformity of grazing. Utilization of less palatable forage species can be greatly increased by increasing the density of livestock on each unit for short periods.

Kind, Class, or Breed of Grazing Animal. Livestock typically fall into one of three groups based on their preferences for different forage types. These groups include grazers (cattle and horses) whose diet is dominated by grasses, browsers (goats) who graze primarily on forbs and shrubs, an intermediate feeders (sheep) who exhibit no particular preferences between grasses, forbs, or shrubs. Understanding these grazing preferences can help managers match the type of livestock to their range or pasture system. Moreover, multi-species grazing systems can be an effective management tool to control undesirable vegetation. For example goats can be used to reduce cover of undesirable shrubs and encourage better production of grasses for cattle production.

Within a species, different types of animals use the rangeland or pasture system differently. For example yearling cattle will use rugged terrain better, and will range farther away from water than cows with calves. Likewise some breeds of cattle will make better use of rough terrain than other breeds and still others are more suited to dry country than others. Selection of proper breed and type of cattle for your operation, therefore, can be an important decision.

Grazing Systems. There are many different types of grazing systems and a full discussion on all the variations is beyond the scope of this paper. Thus, discussion here is limited to a brief description of the different systems typically used and conditions where they are most effective.

Factors that need to be carefully considered, when selecting a grazing system include climate, topography, vegetation, kind or class of livestock to be grazed, wildlife needs, watershed protection, labor requirements, and fence and water development costs. Each type of grazing system carries with it a different set of costs for development and maintenance. Likewise each system requires a different level of labor input. Finally, there is no one system that is best in all situations.

Continuous Grazing (continuous stocking, or set stock) – A continuous grazing system is one in which the pasture is continually stocked with livestock. It is widely speculated that this type of grazing program results in overgrazing of desirable grasses, but this is not supported in the research (Holechek et al. 1989). The advantage of continuous grazing over other systems is also part of the problem. Under good management, continuous grazing allows the animals to select the most nutritious diet over the greatest period of time. Thus, their production relative to animals in other systems may be higher. However, this selectivity is typically problematic and often results in areas of overgrazing (preferred use areas). These are in areas where forage, water, and cover are in close proximity.

Deferred-rotation. This system involves using multiple pastures (usually two, but sometimes more) that are periodically deferred (ungrazed for a particular season of year) from grazing on a rotational basis. The period between deferments for a given pasture varies depending on the total number of pastures in the system. This system provides a better opportunity for preferred plants and areas to maintain vigor than does continuous grazing.

Rest-rotation. This system incorporates a 12 month rest period for one pasture while the remaining pastures absorb the grazing pressure. However, the benefits from the year long rest on one pasture may be lost to the extra use that occurs on the grazed pastures. Pastures are alternately rested in successive years.

High Intensity – Low Frequency (HILF). This system of rotation grazing typically involves three or more pastures, with grazing periods longer than two weeks and periods of nonuse extending beyond 60 days (Holechek 1989). An important feature of this grazing system is that it forces the livestock to use all of the available forages in the pasture more uniformly. This reduces the competition between palatable and less palatable forage species and prevents undesirable shifts in species composition. The extended periods of nonuse are intended to offset the heavy use levels that occur during grazing.

Animal performance under HILF grazing is reduced compared to animals on continuous grazing programs because their average diet is of lower quality. However, under the right conditions HILF can result in a higher carrying capacity; perhaps offsetting the loss in average animal performance. The HILF grazing system works best in flat, humid rangelands such as in the tropical and subtropical ranges in Hawaii where recovery from grazing is rapid. It is not a suitable grazing system for rugged, arid rangelands such as found on the leeward side of Hawaii and Maui.

Short-duration (SD, SD – high intensity, cell grazing). Short duration grazing systems typically involve multiple pastures arranged in a wagon-wheel with water and livestock handling facilities located in the center of the wheel. However, SD grazing can be applied without the use of the wheel arrangement, and more recently is advised because the large impact caused by concentrating animals continuously in the center.

Ideally, the grazing period for each paddock is short (5 days or less) followed by four to six weeks of nonuse. Typically livestock are moved more quickly during active growth periods and during slow growth or dormant periods. The high stock density (numbers of animals per unit area) is thought to: 1) improve water infiltration through animal hoof action; 2) increase mineral cycling; 3) reduce animal selectivity; 4) improve leaf area index; 5) give more even use of the range or pasture system; 6) increase the availability of green forage; and 7) reduce the percentage of ungrazed plants (Holechek 1989).

Like HILF grazing SD grazing works best in flat, humid regions with extended periods of plant growth. It is successfully utilized in Hawaii on windward and low to mid elevation ranges. It is not suitable for aired, rugged ranges on the leeward slopes of the islands.

Range Improvements. Several techniques can be used to improve range or pasture condition including fertilization, prescribed burning, mowing, interseeding with more desirable forage species, and irrigation. Often the additional costs associated with the implementation of one or more range improvement practices is of set by the increased grazing capacity of the range or pasture system. While the primary focus of implementing most range improvement practices is to increase the quality and quantity of forages available in the pasture, another equally important outcome is improved animal distribution.

The use of fertilizers to increase production and achieve a better animal distribution on range and pasture systems is well documented for most temperate systems (see Herbel 1963, Graves and McMurphy 1969, and Wight and Black 1979). In Hawaii, the addition of low rates of lime ($CaCO_2$; 2.5 tons/acre) and nitrogen (70 lbs. available N/acre) are very effective in increasing production of desirable forages on former sugarcane and pineapple lands. Strategic application of soil amendments can be used to draw animals into areas that otherwise receive little or no use.

Prescribed burning is an effective tool used to reduce old growth, burn out weedy species, and improve grazing distribution. The accumulation of litter in excess of 1800 kg/ha can cause a reduction in bacterial activity necessary for sustaining decomposition of organic matter in the soil due to reduced soil temperatures. Although slowed, the breakdown of that litter also ties up nutrients in the system so that they are unavailable for plant growth. Finally, a heavy accumulation of litter slows the cycling of nitrogen within the system. Burn prescriptions can be developed to remove the build up of litter and with proper time for recovery, increase the quality and quantity of forages in areas previously underutilized. While the judicious use of fire has been shown to be effective in many regions of the world, it is not commonly used in Hawaii. However, prescribed burning in Hawaii has a great potential to be an important tool for managers interested in controlling many kinds of invasive species and improving pasture condition.

Mowing is a method commonly used in Hawaii to remove old, poor quality forage in guineagrass pastures. While this method helps managers maintain the quality of these pastures, the cost of equipment, maintenance (parts), fuel, and man hours makes this one of the most expensive range improvement techniques. It is most beneficial where stocking rates are insufficient to keep up with the rapid growth of the forages. However, mowing can also be effectively employed to reduce the cover of undesirable shrubs and weeds.

Where mowing is used, the period between mowing and grazing needs to be long enough that the forages recover vigor. The grazing capacity of a mowed pasture should be based on the amount of new growth available. This will help insure a proper grazing intensity and distribution and provide a more uniform allocation of forage quality and quantity for grazing animals.

Inter-seeding desirable forages into range and pasture areas can be used to increase forage quality, quantity and encourage grazing in areas that receive little or no use. The practice has many of the same costs associated with it as does mowing. However, it generally has a longer life. While the benefit of mowing is short lived and must be repeated frequently, the benefits of inter-seeding can last for several years. The longevity of the seeding and how frequently it needs to be repeated depends on what is seeded. For example, seeding with annual forages must be repeated more frequently than seeding with perennial forages. Additionally, some forages can only persist for a few years under grazing while others may persist for decades. For these reasons the costs and benefits of various forages to be seeded, needs to be carefully evaluated before selection.

Irrigation of forages is not a common practice in Hawaii. Still, where water is available irrigation of range or pasture land can dramatically increase the quantity and quality of forage available for grazing animals. Sources of irrigation water in Hawaii include domestic water supplies, wells, and rainfall catchments. Each of these sources of irrigation water has different costs associated with them. While drawing water from domestic sources may be less expensive in development costs, it is a continual expense. On the other hand, the high initial cost of infrastructure development for wells and catchments is greatly reduced when spread over lifespan of such developments.

Delivery of the water to the range or pasture system can be accomplished in a number of ways. Water can be transmitted from the source to the site of irrigation via pipe or ditches. It can be spread over the land surface via sprinklers, flooding, or by a series of spreader trenches. Obviously there are different costs associated with each system and the manager would need to determine which would work best for their situation.

Constuction of Shelters. Recall that the second most critical element that determines how an animal moves across the landscape is the maintenance of their thermal balance. Thus, while it is not common practice in Hawaii, the construction of shelters to provide livestock with relief from sun and wind will greatly improve their performance. In addition, shelters can be strategically placed in order draw animals into areas that would otherwise receive little or no use. Many areas in Hawaii lack sufficient shelter for livestock. It is in these areas that the construction of shelters will have the greatest benefits relative to the initial costs of construction.

Conclusion

Foraging behavior of livestock is an important consideration in the development of a grazing management plan. The livestock manager that fully appreciates how animals move across the landscape, and what factors influence those movements, will be able to capitalize on those factors to improve grazing use and distribution in their pastures. There are many techniques that a manager can use to influence an animal's forage behavior and achieve better distribution of animals. It is important that the manager carefully consider all the costs and benefits before implementing such practices. In this way a manager will be sure to choose only those practices that will fit their situation and provide the best return on their investment.

Literature cited

Graves, J.E., and W.E. McMurphy. 1969. Burning and fertilization for range improvement in central Oklahoma. J. Range Manage. 22:165-168.

Heady, H.F. and R.D. Child. 1994. Rangeland ecology and management. Westview Press, Boulder, Colorado.

Herbel, C.H. 1963. Fertilizing tobosa on flood plains in the semi-desert grassland. J. Range Manage. 16:133-138.

Holechek, J.L., R.D. Peiper, and C.H. Herbel. 1989. Methods of improving livestock distribution. Pp. 250-263, In: Range management: Principles and practices. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 07632. pp. 501.

Stuth, J.W. 1991. Foraging Behavior. Pp. 65-83 In: Heitschmidt, R.K. and J.W. Stuth. (Eds.), Grazing management: An ecological perspective. Timber press, Portland, Oregon.

Wight, J.R., and A.L. Black. 1979. Range fertilization: Plant response and water use. J. Range Manage. 32:345-348.

Dairy Lagoon Effluent—Use It To Lose It!

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The problem

Imported feeds supply a tremendous amount of nutrients to Hawaii and island nations, but dairy producers are not exporting or using the manure and liquid wastes. This situation created an open nutrient cycle in the milk production system in island environments. Most of these nutrients end up accumulating in lagoons where liquid wastes from dairy production are collected. However, lagoons occasionally overflow leading to the transfer of nutrients and other contaminants in effluent to pollute the land and associated surface, coastal, and even shallow ground waters (Fig. 1).

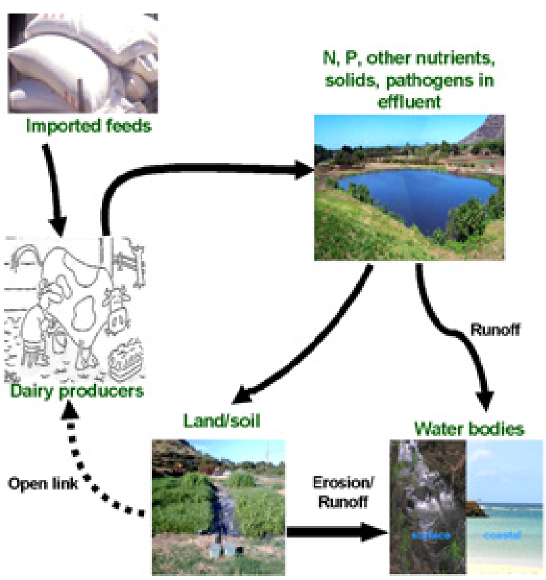

Fig. 1. Environmental problems associated with dairy waste management.

An alternative solution

Scientists at the University of Hawaii, Department of Tropical Plant and Soil Sciences have an alternative—use the water and nutrients in the effluent to nourish highly productive tropical grasses. The approach uses drip irrigation to apply effluent at the root zone so that it is not susceptible to surface runoff and where it can be readily absorbed by plants (Fig. 2). Excessive effluent will move through the filtering soil layers. With this system, an acre can be irrigated with as much as 12000 gal of effluent daily. The forage produced by such grasses can then be fed to dairy cattle, thereby recycling the nutrients, rather than allowing them to accumulate in hazardous effluent lagoons. This win-win solution reduces the risk of environmental pollution and minimizes the cost of imported feeds to the dairy.

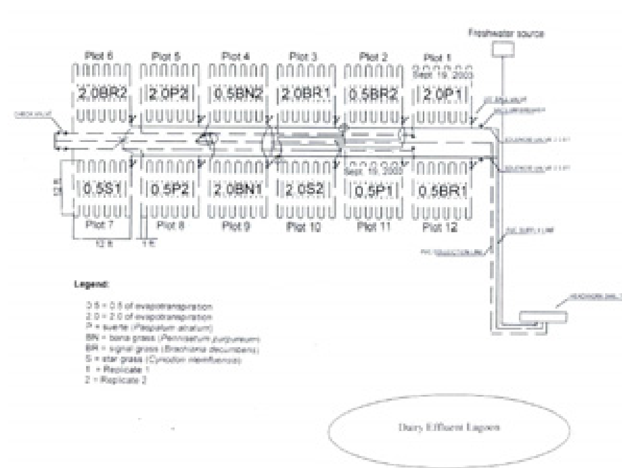

Fig. 2. Lay-out of the drip irrigation system for dairy effluent irrigation.

In Waianae, Hawaii, we planted four tropical grasses—bana (*Pennisetum purpureum*), signal (*Brachiaria decumbens*), star (*Cynodon nlemfuensis*) and suerte (*Paspalum atratum*)—and applied dairy effluent according to the potential evapotranspiration (ET_p) at the site (0.5 ET_p and 2.0 ET_p). The drip irrigation system needs regular maintenance including flushing the drip tubings with fresh water after each irrigation event to minimize cloggings, injecting the tubings with a disinfectant such as Chlorox every three months to minimize build-up of biofilms inside the tubings, checking of pressure gauges, and cleaning the disk filter every week.

When cut at 6-in height every 30 to 42 d, two of the best tropical grasses well known for their high productivity—bana grass and suerte grass—can produce as much as 40000 to 52000 lb/ac/y of dry matter forage (Fig. 3). These yields far exceed the productivity of silage corn and most other feed grain alternatives from temperate countries. An acre of effluent-irrigated land planted to bana grass can support as many as five milking cows (1300-lb with dry matter intake of 2.1 percent of body weight) in a year for a 20 lb/d of four percent fat corrected milk.

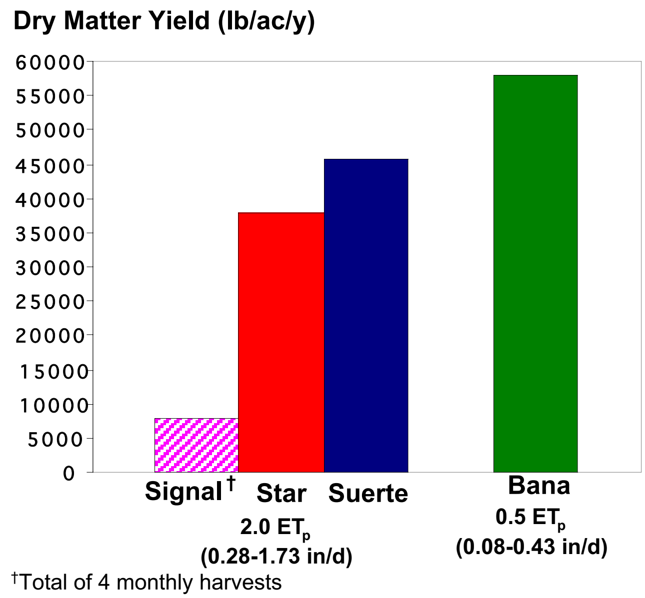

Fig. 3. Dry matter yield of tropical grasses irrigated with dairy effluent, Waianae, Hawaii.

Forage quality is also highly acceptable, with an average of 10 to 13 percent crude protein, 21 to 32 percent dry matter and 52 to 59 percent neutral detergent fiber. Except signal grass, these grasses consume about 500 to 900 lb N/ac/y, 100 to 170 lb P/ac/y, and 700 to 2000 lb K/ac/y. Less or no P supplementation may be needed by the dairy farmer given the average 0.23 to 0.35 percent P in the forage, a level that is sufficient to meet the dietary P requirements of dairy cattle. But potassium uptake of bana grass and magnesium uptake of suerte grass are relatively high and should be given attention when formulating cattle ration to avoid nutritional imbalance in cattle.

Recommendations

Our results suggest that effluent can be applied at a rate twice the potential evapotranspiration, that is, about twice the irrigation rate usually considered sufficient to meet the plant's water needs. Bana grass appears to be the best choice for forage production with effluent irrigation. Effluent application raises the soil alkalinity, thus, application of micronutrients such as iron, zinc, copper and manganese is necessary to sustain grass productivity. As with any other irrigation approaches, one limitation of this system is the limited opportunity to irrigate during the rainy season.