Joint FAO/IAEA Division
of Nuclear Techniques in Food and Agriculture

A coordinated research project (CRP) on

"Quantification of intake and diet selection of ruminants grazing heterogeneous pasture using compound specific stable isotopes"

Summary of the CRP

Optimization of the utilisation of grassland/ranch-land by livestock growers would benefit many millions of farmers in the World since 40.5 percent of the terrestrial area excluding Greenland and Antarctica Grasslands are covered by grasslands, which are important as feed source for livestock.

The project aims to develop a practical method to predict pasture intake of ruminants grazing heterogeneous pastures and rangeland using stable isotopes to provide tools for better grassland management that enhance animal productivity and reduces impact on environment due to overgrazing, and to allow the design of effective feed supplementation strategies at farm level to optimize animal production.

In the CRP are planned three major laboratory activities: (a) the analysis of concentrations and stable carbon isotope composition (delta13C values vs. VPDB - Vienna Pee Dee Belemnite) of n-alkanes in the plant and faecal samples to predict dry matter (DM) intake and its plant proportions; (b) the use of conventional chemical analysis of plants to determine their nutritional value; and (c) the development of the near infrared reflectance spectroscopy (NIRS) predictive equations of DM intake and the plant profile of that intake to facilitate the design of diets and supplements required to cover the nutritional needs of animals to optimise their productivity. The combination of the three technologies applied to plant and faecal samples obtained in a common research protocol used by all participating countries will allow reaching the scientific objectives of the CRP.

The project will run for five years and will involve 7 Research Contract (RC) holders from developing countries, three technical contracts and four Agreement holders from laboratories engaged in the use of stable isotopes and advanced techniques for measuring nutritional feed value of plants. CRP proposal must reach the Research Contracts Administration Section (NACA.Research-Contracts-Administration-Section@iaea.org) at or before 15 April 2016 end of business, additional contact details are referred to the end of this document.

1. Background

Grasslands are among the largest ecosystems in the world, estimated to cover 52.5 million square km, 40.5 percent of the terrestrial area excluding Greenland and Antarctica Grasslands. These are important as feed source for livestock. Many millions of livestock farmers, ranchers and pastoralists across the World depend on grasslands for their livelihoods. Optimization of the utilisation of grassland/ranch-land by livestock grower would therefore have direct impact on the animal productivity, protection of environment and thus sustainable food security.

Although the FAO/IAEA Sub-programme on Animal Production and Health in collaboration with Members States have generated important useful data the nutritional value of a wide selection of conventional, non-traditional, and unconventional animal feeds, including shrub and tree foliage, agricultural and industrial by-products, etc., tools and methodologies for the estimation of intake by grazing/browsing animals are not enough to support Member States for optimal utilisation of grasslands and ranch-land. Conventional technologies for objectively estimating intakes of total dry matters (DM) and of grass/browse species by animals are limited by lack of accuracy. This is because techniques used to estimate intakes in stall feeding systems have not been effective in free-range animals. Farmers and livestock extension workers need to know accurately the quantity and quality of nutrients consumed by animal to enable them determine the amount and type of supplements required by the animals to optimise their yields.

Several stable isotopes techniques have definite benefits over the conventional techniques, and in this case, stable isotope techniques using carbon-13 can accurately estimate animals' intakes at free-ranging. It is known that individual plant species have their own alkane composition and carbon-13 content in those alkanes. Based on this, by combining different n-alkanes profiles with natural carbon-13 concentration data can facilitate determining feed intake in cattle under grazing/grassland browsing conditions.

Once the dry matter intake is known, scientists can use the near infrared reflectance spectroscopy (NIRS) to develop prediction equations of total pasture DM intake, as well as its proportion of individual pasture species, which can be directly used at farm level for managing the grassland and for determining suitable feed supplements.

2. Overall Objective

To develop a practical method to predict pasture intake of ruminants grazing heterogeneous pastures/rangeland using stable isotopes to allow farm level design of effective feed supplementation strategies to optimize animal production.

3. Specific Objectives

- To quantify intake and diet selection of cattle grazing heterogeneous pasture/rangeland using compound specific stable isotopes of long chain n-alkanes
- To create practical near infrared reflectance spectroscopy (NIRS) based prediction equations of total pasture dry matter (DM) intake, as well as its proportion of individual pasture species, based upon analysis of individual animal faecal composite samples
- To evaluate impacts on animal performance and efficiency of potential feed supplementation strategies using existing animal metabolic models based upon predicted pasture DM intakes
- To strengthen research capacity among animal scientists in developing countries
- To networking among animal scientists from developed and developing countries

4. Expected Research Outputs

- A uniform dataset of n-alkanes concentrations and their stable carbon isotope composition of common pasture grass, legume and browse species, which are consumed by cattle and measured in many world ecosystems
- An improved prediction of intake and diet selection/composition of cattle consuming mixtures of plant species in pastures/rangelands
- Practical NIRS based prediction equations of intake and diet composition of cattle consuming multi-species pasture grasses, legumes and browses
- Recommendations for future research and development using stable isotope compositions of lipids in pasture/rangeland grasses, legumes and browses
- Publications and dissemination of results
- Regional and international collaborative linkages

5. Expected Research Outcomes

- Wider application of stable isotope based tools in animal nutrition research and its findings applied in the animal production systems
- Protocols to predict intake, and its plant species composition, of cattle consuming mixtures of plant species in pastures/rangelands, and dissemination to Member States (MS)
- Improved understanding of cattle diet selection on pasture/rangelands, resulting in enhanced pasture/rangeland sustainability and resilience
- Improved feed supplementation strategies of cattle on pasture/rangelands resulting in increased cattle productivity/farming efficiency, and farmers' livelihoods
- An important "added value" of the CRP will be the new dataset of concentrations and carbon isotope composition of epicuticular wax n-alkanes of plants/grasses covering a broad range of environments and climatic settings that will have wide interests and many applications in agriculture, plant science, ecology and environmental research.

6. Action Plans and Activities

The CRP contract will last five years and individual RC holders will receive €9,000.- per year to cover costs of local expenses involving minor equipment, conventional feed analysis and preparation and shipment of forage/feed and faeces samples. Every year a satisfactory progress report will be required before releasing the money for the next year budget.

Up to seven research contracts (RC) will be awarded to MS, who will be submitting appropriate research proposals. Institutions willing to participate in the CRP must be engaged in programmes of national importance in cattle nutrition, have access to basic laboratory facilities for studies of cattle nutrition and be recipients of collateral financial supports from national, bilateral or international sources.

Four research agreements (RA) will be awarded to institutes that have expertise in specific areas of importance to the CRP. Up to three technical contracts could be awarded for analysis of concentrations and stable carbon isotope composition ($\delta^{13}C$ values vs. VPDB) of n-alkanes in the plant and faecal samples and development of the NIRS predictive equations of DM intake and the plant profile of that intake. Selection of participating institutes will consider the importance of the country and facilities to work on cattle nutrition and feeding experiments.

The first RCM will be held by the end of 2016/early 2017 after the award of contracts. All CRP participants and an FAO representative from the animal production group will be invited to attend the meeting. RC holders will present an outline of the general conditions of pasture/rangeland situations, including cattle types, climatic conditions, pasture/rangeland plant species in their eco-zone, and conditions of their research capability. The RCM will focus on evaluating and agreeing on the details of standardized work plans and protocols for the next 24 months, and on general activities for the whole CRP.

The cattle research facility must have at least four separate pens, one pen for each animal, each pen has a water source and contains five (to be finalized at the first RCM) separate feed troughs for feeding of the plants and capability to weigh feeds offered to the cattle and feeds not consumed. Measurements of feed and intake of cattle can be completed in one group of eight animals or two groups of four animals. The cattle will need to be 12 – 48 months of age, non-lactating and non-pregnant, and not have been suckled for at least 2 months prior to the start of the experiment. Cattle can be mixtures of females and males (intact or not) at all sites. The animal research facility must also have the capability to dose fluid n-alkanes via oesophageal tube to the rumen, or feed small quantities with full consumption. The cattle research facility must have the ability to collect drop or grab samples of faeces.

Each RC holder must have access to a pasture/rangeland representative of local conditions. Each RC holder must have the ability to identify, cut and transport sufficient quantities of the main five range/pasture plants on their pasture/rangeland sites. Pasture/rangeland sites with less than 5 plants available are not eligible for the study. The nutrition laboratory facility must have capability to weigh and dry plant samples, grind and store samples under refrigeration (at 4°C). The team must be capable of collecting and reporting data on farm, animals and weather related parameters

The project should be time-framed in a way that by the end of Year 1, each RC holder will complete collection of data on farm, animals and climatic conditions and animal production systems. By the end of Year 2 will be initiated conventional feed analyses and completed the animal feeding studies involving preparation, storing and packaging of feed and faecal samples for shipping. Feeding experiments will be done during both wet and dry seasons at approximate six month intervals. By the end of Year 3, individual RC holders will ship sub-samples of all plants and faecal samples to the identified technical contract holders for analysis of concentrations and carbon isotope composition of n-alkanes. Each RC holder will complete assay of sub-samples of all plant and faecal samples for moisture, ash, N, NDF, ADF, lignin and EE. The technical contract holders will complete analysis of concentrations and carbon isotope composition of n-alkane.

The second RCM will be held in late 2018 or early 2019 to review the results in relation to animal experimentations, concentrations and carbon-13 values of n-alkanes of Experiment 1 (that would cover one of the seasons) and individual RC holders will update on the status of Experiment 2 (that would cover the remaining season). A workshop will be organised as a part of the second RCM to develop capacity of each RC holder in how to use the carbon- 13/ n alkane to predict DM intake, and its plant proportions. By the end of Year 4 will be developed the overall NIRS prediction equation for all sites and will be tested. Year 5 will be dedicated to the conduction of four week grazing project that will evaluate the impact of a grazing strategy on weight and body condition score gain as predicted based upon the NIRS model predicted DM intake on cattle performance as evaluated by a metabolic model.

Final RCM will be held in late 2020/early 2021 to review the results from the CRP, and to make recommendations for future directions, strategies, and activities related to use of carbon -13 based research techniques to cattle nutrition, and its outcomes relative to improving cattle productivity and efficiency in developing countries. Final reports will be peer reviewed, edited, and prepared for publication as an Agency TECDOC or for external publication.

How to join the CRP?

Please submit your Proposal for Research Contract or Agreement directly to the IAEA's Research Contracts Administration Section, using the form templates (http://cra.iaea.org/cra/forms.html) on the CRA web site (preferably via email): For further details please feel free to contact project officers (Mohammed Shamsuddin, M.Shamsuddin@iaea.org or Mario Garcia Podesta, M.Garcia-Podesta@iaea.org).

Deadline for submission of the CRP proposal

15 April 2016 end of business is the **deadline** for submission of the CRP proposal to the Research Contracts Administration Section, contact details referred to above.