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Multi-criteria evaluation of plant resource for livestock farming systems under Tropics

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Why we need a multi-criteria evaluation ?

- The context of agricultural production is changing
 - **Competition for resources**
 - Less land for agriculture (7,95 ha/ha in 1900 to 1,60/ha in 2050, FAO) with a competition between crops and livestock
 - Water (fresh water is scarce, only 2,5% of all water resources; production of livestock feed : 1 M³ water for 0,5 to 5 kg feed)
 - **Climate change** (Thornton, 2009)
 - Contribution of agriculture to GES : 18%
 - **Reduction of biodiversity** (Feed = Maize + soybean)
 - **Socio-cultural modifier** (livestock welfare...)

Why we need a multi-criteria evaluation ?

- **News challenges for agriculture**
 - Contribute to **GES reduction**
 - Reduce use of fossil Energy (Fertilizers, Pesticides, Transportation, tillage..)
 - Increase carbon sequestration in soil and biomass
 - **Save water**
 - Contribute to **energy production**
 - **Develop biodiversity**
 - Increase **productivity** by way of **Agro-ecology** concepts

Why we need a multi-criteria evaluation?

- Adapt plant criteria evaluation to new challenges for agriculture
 - *“Environmentally sustainable production of food, feed and fuel from natural resources in the tropics” (Reg Preston, 2009)*
 - *“Energy-Smart” food for people and climate (FAO, 2011)*

What is multi-criteria evaluation of plant ?



- An on going concept
- An evaluation of plant which take into account :
 - the multiplicity of plant functions
 - its impact on the land and farm
- An evaluation which allows to predict livestock responses to consumption
 - Livestock performances
 - Livestock health and welfare
 - Emission of certain compounds in the environment



What is the most appropriate scale to achieve the multi-criteria ?



- A major question : *“How to manage potentials contradictions between the levels of organization of territories ?”*:

The best feed is not necessarily the one with the lowest negative environmental impacts

What is the most appropriate scale to achieve the multi-criteria ?



- The plant
 - Too small to take into account the interactions ?
- The animal
 - operational level / farmers ?
- The farm operational level / farmer ?
- The territory (land)
 - Too large to take into account the variability of the factors related to farmer management ?

Multi-criteria Evaluation

Animal scale

Feed and industrial products

Meat

Milk

Leather

Wool

Energy

Labor

Effluents



Releases to environment

gas (CH_4 , CO_2)

Urine (N)

Feces (N, Energy)

Multi-criteria Evaluation

Animal Scale



- The classical approach :
Balance between “Nutrients requirements and nutrient inputs” of livestock to achieve the production potential
- The **multiple responses approach** (Sauvant, 2009) should be based integration of representative parameters of Animal performance
 - Animal performance
 - Feed efficiency
 - Quality of products
 - Environmental impact
 - Animal Health and welfare
 - ?

Multi-criteria Evaluation Animal Scale

This new concept can be applied in practice if multiple responses of the animals to the diets or feeding practices are known and modeled.

As a consequence we need :

- **identification of criteria** that are to be optimized;
- **modeling the marginal responses** of each criteria to the diets and the dietary practices
- Knowledge about **relationships among the responses** to each determinant:
 - to know the possibilities of compromise between antagonistic responses.
 - the weights between criteria according to the importance accorded to them, even economical weights.
 - Definition of tools to achieve these optimizations
- **Interactions between feeds**

Multi-criteria Evaluation

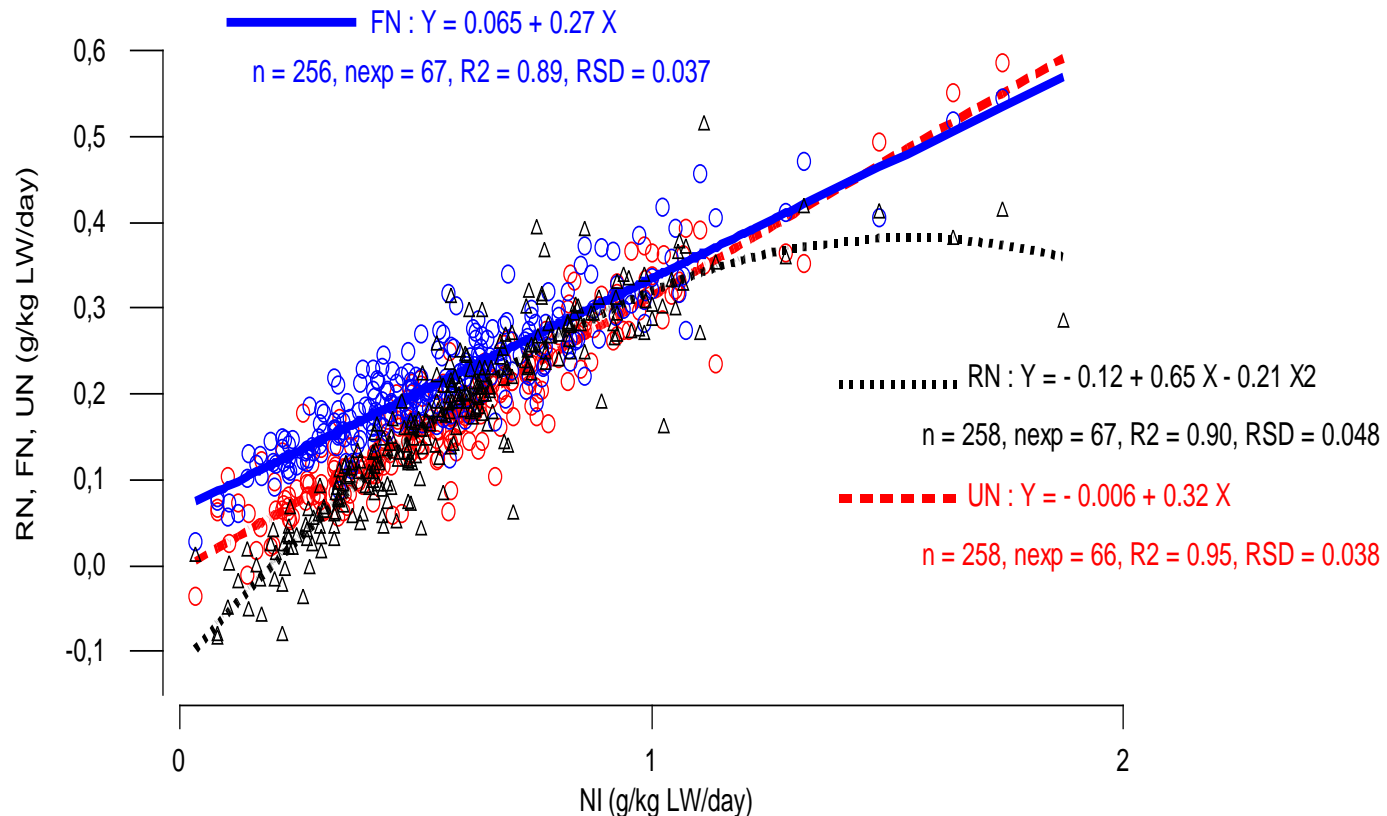
Animal scale

Antagonistic responses:

	Feed components			
	Fiber	Starch	Nitrogen	Tannins
Animal performance	-	+	+	-
CH4 emission	-	+	?	+
Animal health and welfare	+	-	+	+/-
Fecal and urine emission			-	

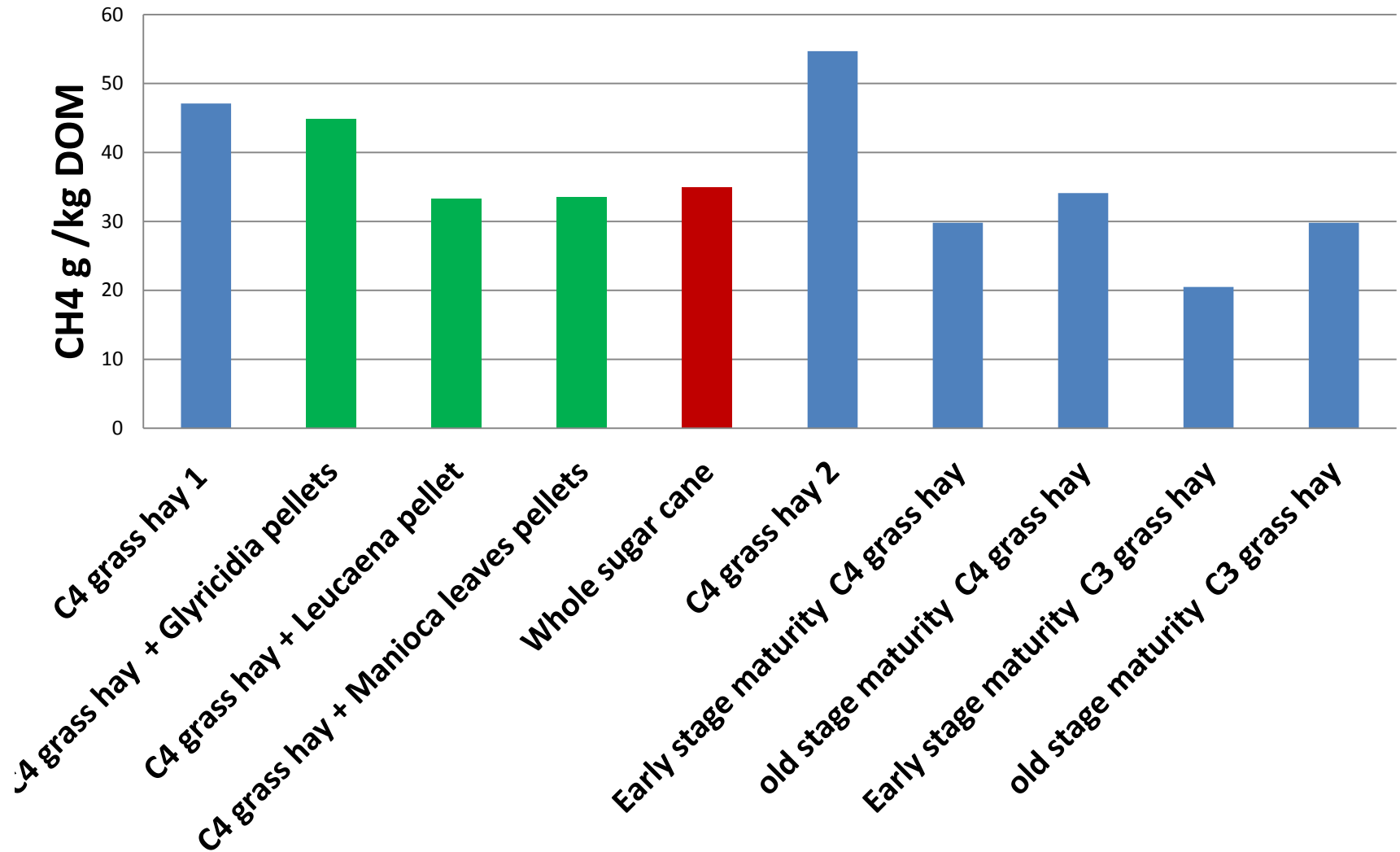
Relations between N intake (g / kg LW / day) and urinary N, fecal N and N retained (g / kg LW / J)

(Salah et al, 2013)



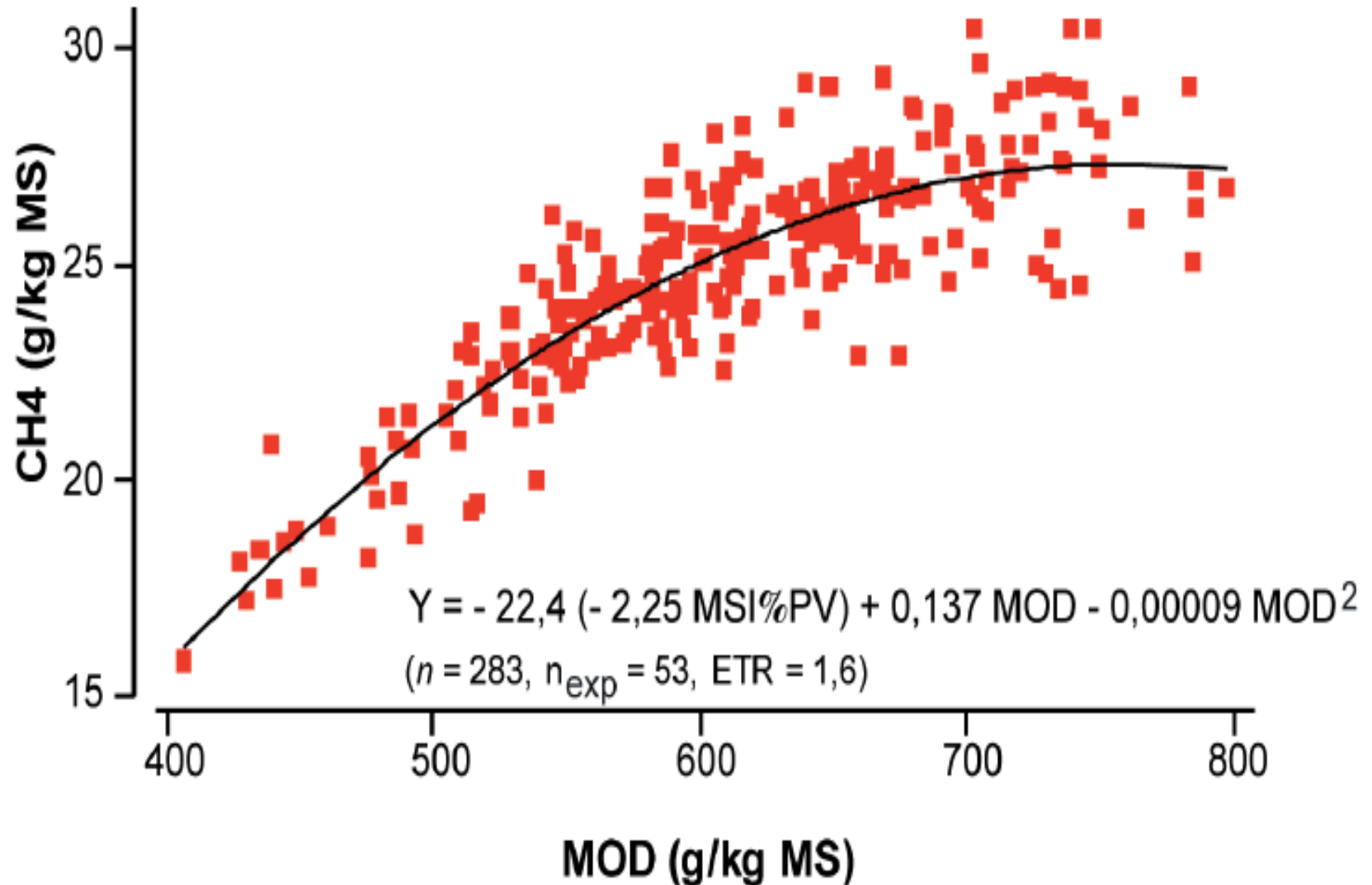
Diet effect on methane emission of rams in tropical area

(Archimède et al 2013, unpublished results)



Feed and GES production

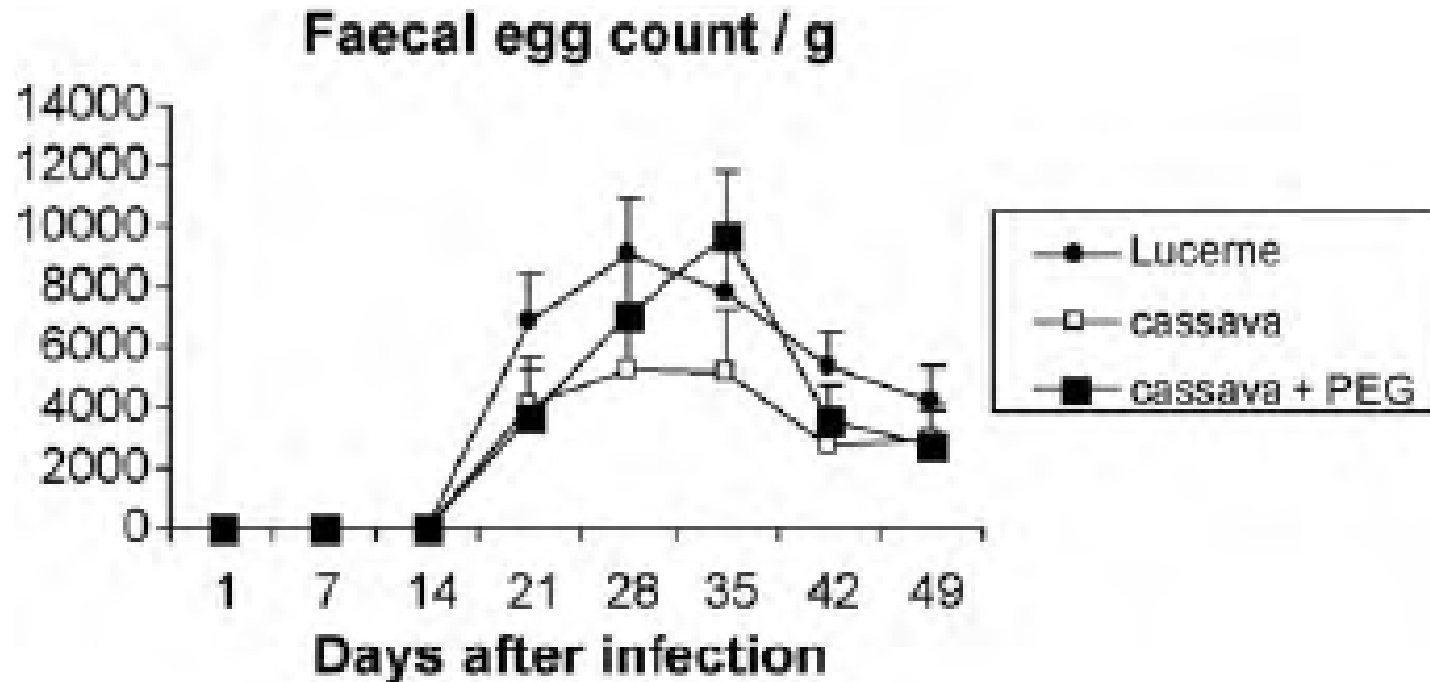
(Sauvant et al, 2010)



Multi-criteria evaluation of the plant

Animal Level

Effect of tannins on resistance of small ruminants against gastro-intestinal strongles (Marie-Magdeleine et al, 2010)



Multi-criteria evaluation of the plant Animal Level

We need to improve our knowledge on plant bioactives



Available online at www.sciencedirect.com



Phytochemistry 69 (2008) 299–322

PHYTOCHEMISTRY

www.elsevier.com/locate/phytochem

Review

Plant bioactives for ruminant health and productivity

Simone Rochfort ^{a,*}, Anthony J Parker ^b, Frank R. Dunshea ^c

Multi-criteria evaluation of the plant Animal scale

Perspectives

- Identification of predictors of multiple response (performance and quality of products, welfare and health, environmental impact)
- New design for in vivo experiments (laws response) to study simultaneously multiple responses of animals to a large typology of feeds and diets
- Identification of indicators, predictors, tools to predict
- Tools :
 - Identification of tools to predict biological responses
 - Quantitative analysis of databases (meta-analyzes)
 - Modeling multiple responses of animals

Limits of the animal scale:

- overestimate the feeding function and "adjustment" for other functions

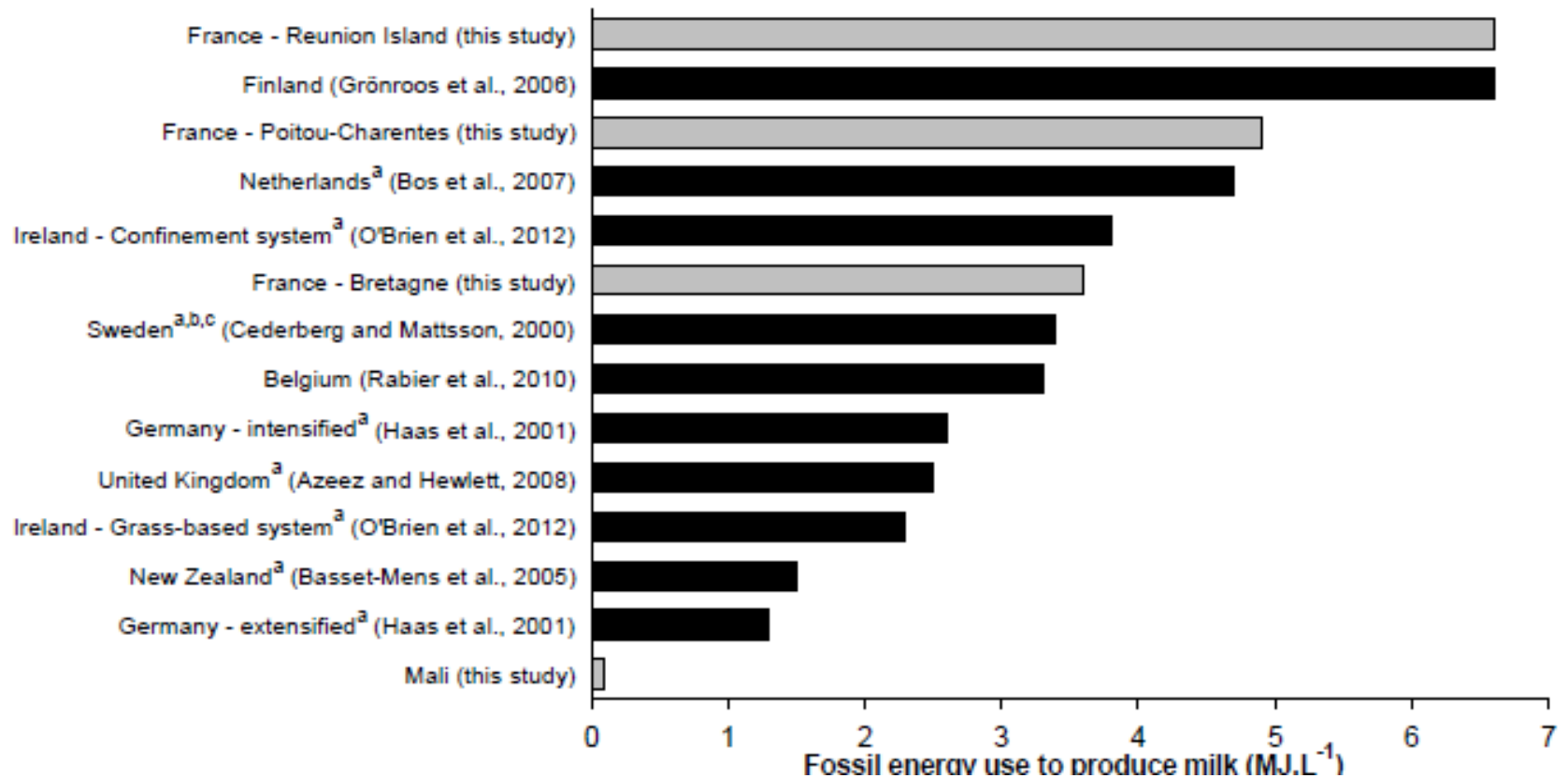
Multi-criteria evaluation of the Plant Farm scale



- Limits of the animal scale:
 - Mainly a feed approach
 - Other functions for plants
- Others functions and criteria
 - Agronomic productivity
 - Energy production
 - Carbone sequestration
 - Soil fertility
 - Recycling of some livestock emission
- Energy cost of feed
- Status of Co-products

Energy cost of milk prodction

(Vigne 2012)



Protein yields of several crops

(Archimède et al, 2011)

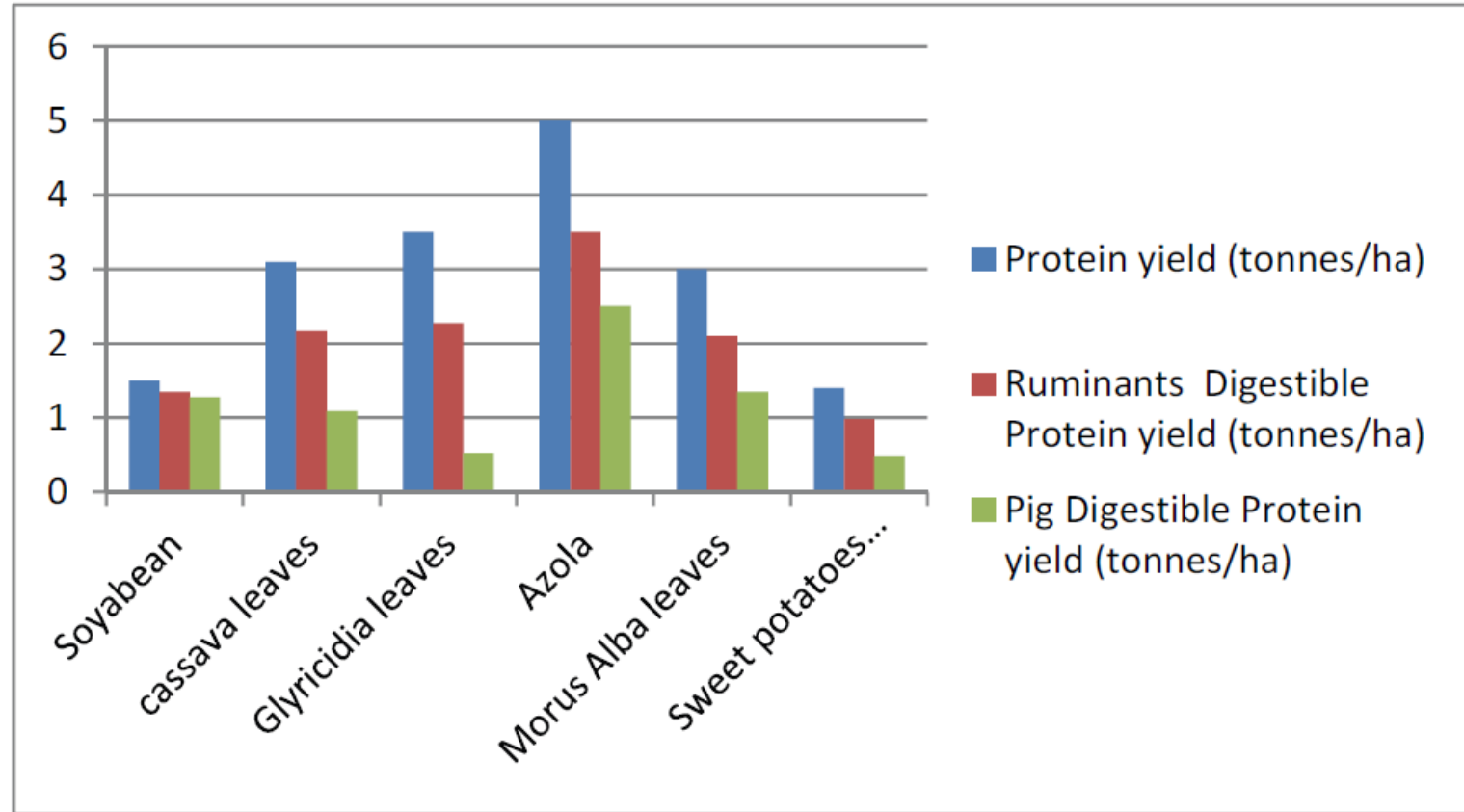


Fig. 1. Comparative protein yields in some typical crops from grown tropical latitudes.



Multi-criteria evaluation of the Plant Farm scale

Carbone sequestration in tropical
grassland :

- 0 à 150 kg C/ha/Year in arid warm area (Lal, 2004)
- 100 à 1000 kg C/ha/year in tropic humid area (Lal, 2004)
- 42 à 45 T C/ha /year on east Africa savanna (Batjes, 2001)



A photograph of a small, calm pond in a rural setting. The pond is surrounded by dense green vegetation, including tall grasses and banana trees. In the foreground, there is a large pile of dry straw or mulch. The water in the pond is still, reflecting the surrounding greenery. The overall scene suggests a natural or semi-natural environment, possibly a farm or a conservation area.

Leaves are left on the soil
Fixing 100 kg N-ha

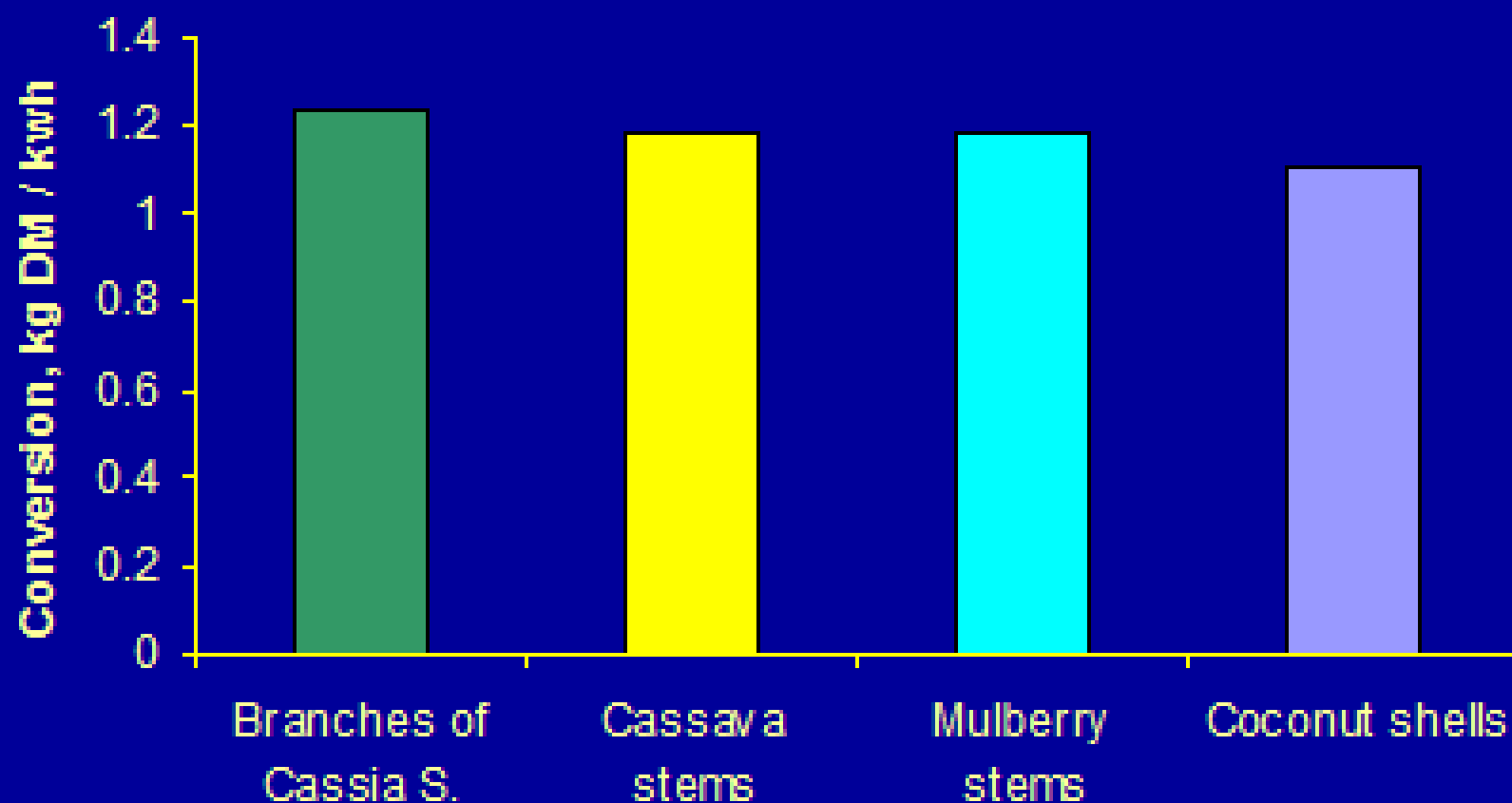
Multi-criteria evaluation of the Plant Farm scale

Shrubs evaluation



- Fractioning
 - Feed fraction
 - woody fraction
- Relatively low productivity for Feed fraction compared with a C4 grassland
- Others function
 - Energy production
 - Carbone sequestration
 - Soil fertility

Conversion of fibrous biomass to electricity in Cambodia



Source: Mich Phalla and Preston 2005

Multi-criteria Evaluation

Farm Scale

Define pertinent indicators at the farm scale complementary to those identified for the animal scale

- Efficiency of land use / animal performance
- Energy cost of feed
- energy independence
- Carbone balance / compensation relatively to CH₄ and N₂O emission
- Nutrients recycling

New tools

- Environmental analysis : Life Carbon Analysis method
- Experimental design for farm scale study

Conclusions

- How to link animal and farm scale approaches ?
- How to take into account of seasonality of resource availability ?
- Multi-criteria evaluation is a complex process but that requires the production of simple tools for research and decision support at the farm
- The multi-criteria give different values to resources (local value)