Main conclusions and recommendations

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Main conclusions and recommendations

I – Session 1 – Plant-animal interactions: Implications for animal and landscape management

Plant-animal interactions are critical components of many ecological processes in grazed ecosystems, such as seed dispersal, enhancement and maintaining biodiversity, restoration, invasion of weeds, or community structure. Therefore, the determination of interactions between forage resource characteristics (such as available plants and their forage availability and quality) and animal characteristics (such as kind and class of animal, animal's age, morphology and physiology, and animal's dietary experiences) is of high importance to understand the principles that govern diet and habitat selection, and finally to extract guidelines for the sustainable management of natural resources.

There is evidence that behavioural principles and processes can be translated into practices that provide an array of solutions to the challenges people face in managing to maintain livelihoods and the integrity of landscapes. Behaviour-based management of landscapes offers opportunities to use understanding of: (i) the relationship between palatability and plant biochemistry to rejuvenate landscapes to benefit wild and domestic animals; (ii) the importance of experiences early in life in creating locally adapted animals; and (iii) the value of biochemical complementarities for developing plant mixes for pastures that provide a full range of benefits (nutrition and health for plants, herbivores and people) without the unsustainable costs of fertilizers, herbicides, insecticides, antibiotics and anthelmintics. The challenge is people to realize the power of behaviour to transform systems ecologically, economically, and socially, and to work with others to reconcile differences of opinion about how to manage landscapes.

Grazing on forages high in plant secondary compounds can affect substantially the animals' parasite populations. Condensed tannins, which present in many plants, affect *Trichostrongylides* infections in sheep by reducing nematode egg excretion and worm burdens. However, the condensed tannin consumption has been associated with reduced food intake, digestibility and impaired rumen metabolism. The severity depends on the concentration of condensed tannins and the concentration of other nutrients, such as proteins and carbohydrates in the diet. For example, the supplementation of grazing goats with heather, a medium tannin-containing diet, had beneficial anthelmintic effect without anti-nutritional cost. Therefore, it was suggested that on how different hosts experience the positive and negative effects of plant secondary compounds, and whether they can use them for their own benefit, is an issue that requires further investigation, prior to incorporating such compounds in parasite control schemes.

It was shown that through direct effects on parasite fitness, host nutrition has the potential to impact animal health, affect the epidemiology of the parasitic infection and consequently ease public concerns over environmental contamination. However, developments of non-chemical parasite control strategies would require a multidisciplinary approach and close collaboration among a range of specialists, including nutritionists, parasitologists, geneticists and veterinarians.

Animals' sheds affect the habitat use because livestock tend to spend more time grazing near than away from them. Close to sheds animals open up dense shrublands by browsing, thus favouring short vegetation (mainly herbaceous) and creating a heterogeneous landscape with a high variety of habitats resistant to wildfires.

Tannic phenols confirmedly play a role in modulating faecal nitrogen excretion. Legume-based pastures that differ in agronomic features and chemical composition with particular reference to tannic phenols can result in different levels of nitrogen utilisation efficiency. Grazing a sulla (*Hedysarum coronarium*)-based pasture with a moderate level of tannic phenols increased nitrogen

excretion in faeces. In contrast grazing a burr medic (*Medicago polymorpha*)-based pasture resulted in higher nitrogen intake and excretion in urine and overall in lower nitrogen utilisation efficiency. It was recommended that pastures based on forage legumes containing tannic phenols or with a relatively low protein content are more benign to the environment.

II – Session 2 – Rumen ecology and manipulation to improve small ruminant performance

1. Basic knowledge of rumen microbiota

Rumen microbiology made a significant contribution to the understanding of ruminant nutrition. Further progress in research has been limited by the incomplete analysis of rumen microbiota (bacteria, protozoa, fungi). Most of bacteria are at present unknown due to the difficulty in isolation and cultivation. Only 10-50% of all rumen bacteria are cultivable, while the rest have been totally ignored until now. Recent advances in molecular biology techniques allow analysis of these bacteria without cultivation, thereby identifying many functional but uncultured bacteria. Some results obtained with these techniques have been presented here. There is no doubt that more and more information will be available on rumen microbiota on the next future.

2. Manipulation of rumen microbial ecosystem

The challenge is to produce efficiently high quality and safe animal products with minimal environmental impact. There are alternative sources in plants that will allow us to achieve this. The question is how to progress to achieve this? Currently *in vitro* methods are used for screening. How do these relate to *in vivo* effects?

Because of the ban of antibiotic feed additives in Europe, there is a need for more "natural" additives to control rumen digestion and fermentation. Probiotics and enzymes if obtained from generally recognized as safe (GRAS) microbes could reach this objective without major criticism. Although plant extracts are commonly accepted as safe products because they are naturally-occurring, it must be remembered that secondary metabolites are part of defence mechanism used by plants against pathogens, herbivores, insects, etc. Toxicity and toxic doses for animals are unknown for most of them. Little is known on their transfer into edible animal products and their possible toxicity for consumers. Owing to the strong odoriferous properties of extracts, their transfer could alter organoleptic quality of animal products.

The content of active compounds in plant extracts must be known and must not vary with batches or with time. Nothing was done on lipids used as additives to control rumen fermentations. Here is probably one of the best ways to manipulate both the rumen fermentations and fatty acid composition of animal products.

3. *In vitro* systems

Nothing new has been developed regarding the *in vitro* systems during the last two decades. Conditions of incubation will influence the results on digestion and fermentation: diet of animal donors, sampling of rumen content (time after feed intake of donors, anaerobiosis, etc.), adaptation or not of animal donors to the ingredient or additive to be tested, etc. Transfer of optimal dose of an additive from *in vitro* to *in vivo* is very difficult. Microbial population differs between systems and with time for a system.

4. Mycotoxins

This is a new concern with animal production, including ruminant production, especially in countries harboring aflatoxins. GAP and GMP associated with protective agents are the best way to limit the

deleterious effects of mycotoxins. A great effort must be done on teaching of mycotoxins in universities, education and training of farmers to limit the presence of mycotoxins in the food chain. A major issue for animal feedstuffs: they are ubiquitous. Difficult to obtain a representative sample. Currently there is no universal test for all mycotoxins present in foodstuffs. Mass spectroscopy appears to be a promising technique but currently very expensive. Impact of animal production on environment through a better control of rumen microbiota. Enteric methane and gases from animal manure (CH_4 + N_2O) have to be reduced to limit the global warming effect whereas animal production must increase to feed people on the world. Here is a big challenge for the next decades. Pollution of water resources by N and P is another challenge due to intensification and concentration of animal production.

5. Improvement of low-digestible forages

Treatments applied on low-value forages must be cheap, simple, and safe to be easily done at the farm level. Well balanced diets is another way (but limited in efficacy) to improve the nutritional value of low digestible forages.

III – Session 3 – Targeted feeding to improve performances of sheep and goats at different physiological stages

Interesting studies on the interaction reproduction nutrition were presented in this seminar. It is clear that an appropriate feeding of ewes over only few days within the mating period would be enough to increase the ovulate rate, thus the reproductive performance. These findings would encourage farmers to adopt the focussed feeding technique since it can alleviate feeding cost and reduces labours. Briefly talks and posters presented in the third session of this seminar revealed that qualitative, quantitative and chronological manipulation of feeding is a promising way to improve livestock performances. The main conclusions that merit consideration are summarised below:

(i) Long term and short term target feeding improve productive and reproductive performances of sheep.

(ii) Synchronisation of nutrients supply is the issue of targeted feeding.

(iii) Benefits from target feeding depend on the quality and quantity of nutrients supplied (e.g. macro, micronutrients and plant secondary metabolites).

(iv) The response of the animal to target feeding would depend on the interaction genotype × nutrition × gene expression.

(v) Feeding behaviour of the lamb could be programmed since the pregnancy period of its mother. One of the presented papers showed that weaned lambs perform better on saltbush if their mothers grazed better saltbush while pregnant.

(vi) The effect of target feeding should be evaluated by using known parameters like ovulation rate, sperm production and colostrum. Therefore, there is no need to use sophisticated and complicated parameters.

(vii) There is a bridge gap between fundamental research models for human health improvement and practical farming systems (developing countries).

The discussion among participants led to the following recommendations:

(i) Longer term studies (past neonatal) on the interaction reproduction-nutrition are needed.

(ii) We should use targets to drive decisions about the many permutations relating to quality and quantity of nutrients.

(iii) Foetal programming for milk production is a promising technique that should be investigated.

(iv) Focused grazing management is another option to adapt animals to field conditions and to manipulate landscape.

(v) Further studies should be scheduled to investigate breed differences and gene expression (epigenetic) for producing milk and meat.

(vi) There is a need to develop a specific network programme characterising systems for developing countries putting in place interventions based on recent findings in areas of foetal programming and targeted feeding.

IV – Round Table 1 – Strategies that use plant secondary compounds to improve the efficiency and profitability of small ruminant agriculture

Sufficient evidence exists highlighting the beneficial effects of plant secondary metabolites (PSM), in particular of tannins and saponins, for increasing animal productivity and health and animal product quality. Moreover, feeding of low levels of tannins might also enhance manure quality and reduce methane production, benefiting the environment. However, there is a need to better determine levels, using chemical/bio/assays for achieving these beneficial effects.

Tropical and Mediterranean regions have large plant biodiversity with high levels and activity of PSMs. The countries in these regions would benefit immensely from identifying plants and plant products having bioactivity moieties which could be used as alternative to antibiotics, bio promoters and antiparasitic drugs. Some examples have been provided during the session.

Levels and quality of PSM is not only a function of genetic make-up of the plant but also of environment, in which it is grown. This leads to variations in activities. There is a need to reduce batch-to-batch variations. An approach to achieve this could be characterisation of active moieties and to use bioassays-driven approaches to achieve product of consistent quality.

Future researches should also be directed towards better understanding of nutrient-PSM interactions and PSM-PSM interactions. Examples were presented to illustrate the importance of this field of research where different sequences of ingestion of PSM and nutrients were shown to have different biological effects.

PSMs impact microbial ecology in the rumen and could get converted to a lesser or more active moieties. Research is required to understand the fate of PSM in the gastrointestinal tract (GIT) and effects on rumen microbes and organs.

Similarly, evidence exist indicating effects of PSM on nematodes of the GIT. Research is required to better understand their mode of action on the different worm stages and species and to define which factors govern the balance between the anthelmintic efficacy and the potential negative effects. Whether sheep or goats are parasitised or not, a better understanding of the interactions between animal behaviour-PSM is required, in order to develop strategies to integrate PSM rich plants for enhancing livestock production and health in farm conditions.

Caution has to be exercised to extrapolate results from *in vitro* tools to *in vivo* studies although the interest of the formers to screen potential plant candidates remain valid. These methods can also be of interest to validate the bioactivity of plants, whose PSMs differ from tannins and saponins and which has been traditionally exploited so far intensively.

The possible adaptation of bacteria, protozoa and nematodes to PSMs has been evoked. How to beat these adaptative processes represent a field for future research to favour the sustainable use of PSMs in animal production.

V – Round Table 2 – Quality products of sheep and goats for human nutrition and health

Synthetic *c*9, *t*11 CLA is incorporated in plasma lipids in a dose response manner. Formation and incorporation of CLA metabolites are well correlated to *c*9, *t*11 CLA intake. In the range of 1-4 g/d *c*9, *t*11 CLA was able to decrease LDL significantly. Pattern of plasma UFAs CLA metabolism and TAGs shows seasonal variations. Intake of about 50 g/d of the CLA-enriched cheeses tested was able to supply the equivalent of 0.3-0.8 g/d of *c*9, *t*11 CLA with a contribution from conversion (~18%) of VA to CLA. Intake of about 50 g/d of the CLA-enriched cheese was able to significantly modify plasma fatty acid profile, modifying the ω-3 ω-9/ω-6.