Conferencia

Silvopastoral systems: technical, environmental and socio-economic challenges

Sistemas silvopastoriles: retos técnicos, ambientales y socioeconómicos

E.B. Ørskov

Macaulay Institute, Craigiebuckler, ABERDEEN AB 15 8QH, UK
E-mail: b.orskov@macaulay.ac.uk

ABSTRACT

In this article agroforestry is discussed with examples from coconut and oil palm plantations with animal interactions. Reference is also given to regeneration of forests with interaction with complementary crops and crop-animal-soil interactions in general. Feed evaluation systems more adapted to consumption of tree forages must be developed to support silvopastoral systems.

Key words: Crops, silvopastoral systems

RESUMEN

En esta conferencia se discute acerca de la Agroforestería relacionada con las plantaciones de coco y de palma de aceite y sus interacciones con el animal. También se hace referencia a la regeneración de los bosques y sus interacciones con los cultivos complementarios y con el cultivo-animal-suelo, en general. Para sostener los sistemas silvopastoriles se deben desarrollar sistemas de evaluación de alimentos más adaptados al consumo de follajes arbóreos.

Palabras clave: Cultivos, sistemas silvopascícolas

Introduction

I feel a bit like an amateur speaking to experts but I feel strongly that in the search for sustainable systems of livestock production there is often much to be gained from better understanding of the integration of animals with tree culture. In this paper I will discuss some aspects that I have come across in Asia and the many new challenges it opens up and in particular how it is necessary not to be specialistic. A systems approach is essential, i.e. a multi-disciplinary approach involving plant/forest, soil, animal and socio-economic sciences.

I first became involved with the challenge in a joint project with the Coconut Research Institute in Lunawila, Sri Lanka. Large areas of Sri Lanka are covered with coconut, owned by both large companies and small farmers. Coconut plantations will never give full canopy so there are always possibilities for growth of other plants under the coconut plantations. In many instances cattle graze under the coconut trees, and it is often the case that the owners of the coconut trees are not the owners of the cattle. Cattle are owned by small poor farmers and usually the owners of the coconut trees let them graze at no cost. An experiment was set up to graze cattle under the coconut at a high stocking rate and to explore the effects of supplementary feeding.

As shown in table 1 from Pathirana, Mangalika, Liyanage and Ørskov (1996), the animals' age at calving and calving interval were high and milk yield was low when no supplement was provided. Supplementing with rice straw improved the animals' reproductive performance and if they were also given rice bran, perfor-

Table 1. Effect of grazing and supplementation of female cattle grazing under coconut on age at calving, calving interval and milk yield.

	Age at calving (months)	Calving interval (months)	Milk yield (kg/d)
Grazing	57	20	0,87
Grazing + rice straw	47	18	1,53
Grazing + rice straw + rice bran	40	13	2,36
SE	1,9	0,31	0,07

mance was further increased so that the calving interval was reduced to 13 months.

While these results may have been unexpected, the unexpected for me was the effect on the coconut yield (table 2). Grazing alone increased coconut yield by about 15%. No wonder the owners of the coconut trees were quite happy for the small farmers' animals to graze under them!. This was not doubt due to a more rapid turnover of biomass and the effect on soil quality and especially water holding capacity. Bringing nutrients for the cattle from outside the system in the form of supplementary fodder further increased coconut yield probably as a result of the N, P and K etc. contained in the feed. This increase in N, P and K in the coconut leaf when feed from outside was added can be seen in table 3.

The increase in coconut production by the introduction of animals can effectively be seen as an output from the animals but often these types of product are ignored or people are even unaware of their existence. Since then, when I have seen animals grazing under trees or tied to trees I have often asked the question 'what is the effect on production from the trees be it mango, coconut, durian or other fruit or on wood production e.g. teak?. There is seldom an answer. Maybe this is due to my lack of knowledge in this field, but one thing is sure: we need a multidisciplinary approach to the analysis of the system if we are to understand and manage these systems effectively.

Oil palm plantations

The involvement too of socio-economics became very apparent to me recently on a visit to an oil palm plantation in Bengkulu province of Sumatra, Indonesia. The Indonesian company owning the plantations had taken the initiative to give to the workers collecting palm fruit bunches from the plantation to a road passable by trucks, a cattle beast, in this case Bali cattle (Bos Bentang), for pulling a small cart which could hold about 15 to 20 bunches. This increased the capacity of the worker to attend to 15 rather than 10 ha. The feed for the cattle was plants growing under the trees plus leaves and core from the palm fronds which had to be cut down before a palm bundle could be cut off. At night the cattle were also given some palm sludge from the factory. It soon transpired that there was much more food than 1 animal could eat, so each farm worker is allowed to take several animals with him during his working day in the plantation. At the moment an average of 6 animals come with

Table 2. Effect on yield of coconut and soil water holding capacity during 18 months (from Pathirana et al., 1995).

	Nuts/palm/year	Copra/palm/year (kg)	Water holding capacity (mm/m)
No grazing	41,1	11,1	16,9
Grazing	47,9	13,3	18,3
Grazing + rice straw	50,6	14,2	18,9
Grazing + rice straw + rice bran	57,4	16,7	17,6

Table 3. Effect of grazing and supplementation with rice straw and rice bran on soil properties after 6 years.

	Water holding capacity (mm/m)	Content in coconut leaf (%)		
		N	P	K
No grazing	17,01	1,89	0,15	1,21
Grazing	18,23	1,86	0,15	1,18
Grazing + rice straw	19,72	1,92	0,16	1,48
Grazing + rice straw + rice bran	18,98	2,23	0,18	1,76
SE	2,63	0,06	0,01	0,06

each worker in the morning. What is the possible stocking rate under oil palm trees? I was told maybe 2/ha, even with full canopy. If this is so many millions of cattle could be fed under oil palm trees in the world. These could provide a secure living for many families. What would be the effect on oil palm yield? I did not get an answer, but I think it would be positive as the biomass would turn over more rapid as with the coconut trees.

Reforestation with small farmers and complementary crops

In Indonesia where many forests have been illegally cut and sold to Western buyers the government is trying to re-establish the forests with nearby small farmers who are given the right to cultivate and plant complementary crops between the trees when the trees are young; in this case teak and eucalyptus trees until full canopy.

A relevant question: is full canopy necessary for optimal growth and quality of trees? Less than full canopy could give small farmers continuous access to grazing, other complementary plants could be grown and better quality trees. E.g., Leguminous trees and bushes could be grown for animal feed which could capture N and maybe also benefit forest trees. The way silvopastoral systems should be developed, or perhaps more precisely redeveloped, will vary environmentally according to climate, type of trees, type of animals and socioeconomic circumstances. Maximum trees production may not always result in optimal output from the system. Such systems are much more likely to be sustainable than monoculture tree systems and specially animal systems. Chickens and pigs were originally forest animals and not designed for large intensive stall fed and battery fed systems. The trees also will accumulate carbon and therefore contribute to slowing down climate change. The relentless push to monoculture promoted recently by herbicide resistant GM crops cannot be the solution from an environmental and socio-economic point of view.

Problems of monocultures

The negative effect of monoculture was recently demonstrated also in rice production. Herbicides had been recommended for use in the paddy fields in Vietnam. Instead of herbicides, ducks were introduced (Minh, Ly and Ørskov, 2003). They ate the weeds and the insects and even increased the yield of rice. As the young ducks were also fed at night they essentially brought some fertiliser to the paddy in the form of faeces.

Now fish have also been introduced to consume the plankton grown in the paddy fields as a result of the ducks fertilising the paddy. The total income per ha has increased by 50 times. There are so many options to be explored which have many advantages both environmentally and socio-economically and are far superior to the monoculture of crops and specialised animal production.

Feed evaluation relevant to silvopastoral systems

Present feed evaluation systems are based essentially on evaluating cultivated crops for animal production e.g., maize, root crops, grasses, straw and byproducts of plants used for human consumption. For such feed the main limitation

to feed intake generally is the rumen fill so the amount the animal can eat of the feeds can to a large extent be described by the degradation characteristics. This can, for example, be described by the nylon bag technique as reviewed by Ørskov (2000).

The equation established by Ørskov and McDonald (1979) can be used namely:

$p = a + b (1- e^{-ct})$,

where p is degradation at time t and c the rate constant.

The evaluation of roughages here can best be described by the solubility (A), the insoluble but fermentable fraction (B) and the speed of degradation (C). A is determined simply by the water solubility. B is determined by the asymptote (a+b) – A, to give the insoluble but potentially fermentable fraction and C is the rate constant from the equation.

As illustrated by Ørskov, Reid and Kay (1988) and reviewed by Ørskov (2000) this can provide a good prediction of voluntary intake of cultivated roughages. The rumen volume of different breeds of animals will however also influence feed intake. Generally indigenous breeds have a higher rumen volume rather than so-called upgraded animals. While for cultivated roughages the content of anti-nutritive factors is generally zero or very small, this is often not the case where tree leaves form a large part of the diet. These often contain a range of plant secondary compounds. The gas production technique described by Menke and Steingas (1988) and further elaborated on by Makkar, Blümmel and Becker (1995) can be very useful here. For the gas production technique the feed is incubated in rumen fluid and the gas produced measured. This can be described by the same equation developed for the nylon bag technique above. The advantage of the gas production technique is that the phenolic-related anti-nutritive factors can be estimated by measuring the differences in gas production caused by addition of polyethylene glycol (PEG). PEG will react with tannins and eliminate the anti-nutritive properties. A great deal of work has recently been reported using this technique. Kustantinah, Orskov, Lomax, Suhartanto, Somitro, Hartadi and Subaida (2004) compared cassava leaves with and without PEG but found no differences. On the other hand, Osuga, Abdulrazak, Ichinohe and Fujihara (2004) observed with some tree leaves an increase in gas production of more than 100% as a result of adding PEG. PEG can be used in the drinking water of animals browsing on materials high in tannins. Tree leaves vary enormously in digestibility *in vivo* from less than 35% in Sitca spruce in Scotland (Odeyinka S.M, Hector B.L. and Ørskov E.R., unpublished) to more than 80% in Mulberry (Saddul, Jeland, Liang and Halim, 2004), but on the whole insufficient information is available relative to the importance of this topic. There are, however, also other factors affecting palatability in some tree leaves which cannot be detected by the gas production technique and there is still a need for further research into an effective feed evaluation system when tree leaves form a large part of the diet and where there are palatability problems which are poorly understood.

Measurements of interaction of tree forage with other plants

In many instances when tree forages are combined with other feeds which may be cultivated grass or legume species, it is useful to set up systematic studies on the rumen environment. This philosophy has been described in some detail and reviewed by Ørskov (2002). The tree leaves under study can be given at different proportions and the effect on degradation characteristics of a standard cellulosic feed such as a good quality grass can be studied. Such studies are very useful as they can identify whether there are negative or even positive interactions of tree forages on degradation of cellulosic feeds. This approach was for instance reported recently by Toure, Michalet-Doreau, Traore, Friot and Richard (1998) in a study from Senegal where different levels of tree forages from different species of trees were fed to cattle and the optimal levels identified in relation to the degradation rate of peanut hay.

Need for new methods

The need for new approaches has been discussed in detail in an excellent paper by Thorne, Subba, Walker, Thapa, Wood and Sinclair (1999) relating to indigenous knowledge of tree fodder in Nepal. Farmers were asked to rank their perception of nutritive value and palatability of 8 tree fodders and conventional laboratory analysis, i.e. gas production, was carried out and compared with the farmers' ranking. On the whole the corrections were very poor. This is an important finding as there is room for new innovative feed evaluation techniques that can assist farmers whose animals interact positively with silvopastoral systems. Better information here can help to give more confidence to this system and have a huge impact on future agriculture.

References

Kustantinah, M. ; Ørskov, E.R.; Lomax, M.A.; Suhartanto, B.; Somitro, P.W.; Hartadi, H. & Subaida, S. 2004. Effect of drying process of cassava leaves on its degradability. In: 11th AAAP Meeting, Kuala Lumpur. p. 387

Makkar, H.P.S.; Blümmel, M. & Becker, K. 1995. Formation of complexes between polyvinyl pyrrolidones or polyethylene glycols and tannins, and their implications in gas production and tru digestibility in *in vitro* techniques. ***British Journal of Nutrition.*** 73:897

Menke, K.H. & Steingas, H. 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. ***Animal Research and Development.*** 28:7

Minh, T.N.; Ly, L.V. & Ørskov, E.R. 2003. Using local ducks to control insects in paddy field and in duck, fish, rice systems and eliminate use of insecticides. SAREC International meeting. Hue, Vietnam

Ørskov, E.R. 2000. The *in situ* technique for the estimation of forage degradability in the ruminants. Forage evaluation in ruminant nutrition. CABI Publishing, Wallingford, UK: 175-188

Ørskov, E.R. 2002. Trails and Trials in Livestock Research. IFRU Publication, Macaulay Institute, Craigiebuckler, Aberdeen, Scotland

Ørskov, E.R. & McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. ***J. agric. Sci., Camb.*** 92:499

Ørskov, E.R.; Reid, G.W. & Kay, M.R. 1988. Prediction of intake of cattle from degradation characteristics of roughages. Animal Production. 46:29

Osuga, I.M.; Abdulrazak, S.A.; Ichinohe, T. & Fujihara, T. 2004. Chemical composition *in vitro* gas production and tannin bioassag of some browse species form Kenya. In: 11th AAAP Meeting, Kuala Lumpur. p. 361

Pathirana, K.K.; Mangalika, U.L.P.; Liyanage, M. De S. & Ørskov, E.R. 1996. Effect of grazing and supplementation in a coconut plantation on cattle production, coconut yield and soil fertility. ***Outlook on Agriculture.*** 25:187

Saddul, D.; Jeland, Z.A.; Liang, J.B. & Halim, R.A. 2004. Mulberry, a promising forage supplement for ruminants. In: 11th AAAP Meeting, Kuala Lumpur. p. 402

Thorne, P.J.; Subba, D.B.; Walker, D.H.; Thapa, B.; Wood, C.D. & Sinclair, F.L. 1999. The basis of indigenous knowledge of tree fodder quality and its implications for improving the use of tree fodder in developing countries. ***Animal Feed Science and Technology.*** 81:119

Toure, S.F.; Michalet-Doreau, B.; Traore, E.; Friot, D. & Richard, D. 1998. Occurrence of digestive interactions in tree forage-based diets for sheep. ***Animal Feed Science and Technology.*** 74:63