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Using local knowledge of the feeding value of tree fodder predict the outcomes of different supplementation strategies

Farmers in Nepal have previously been credited with a sophisticated understanding of the fodder value of different tree species and how this varies seasonally, much of which is encapsulated in two independent classification systems that they use to distinguish fodders of different utility. These farmer classifications have also been found to correspond to biologically pertinent attributes of fodder such as protein supply and overall dry matter digestibility. Here, a model derived from these correspondences and incorporating fuzzy sets, is used to explore the utility of combining the qualitative knowledge of farmers about a wide range of tree species with quantitative scientific data and understanding. Although a simple example of what may be possible using these methods, the result is a potentially powerful too' for interpreting decision-making by farmers in a complex domain. This type c approach might be widely applied to make more complete use of qualitati information garnered from local people in the process of participatory rural appraisa..

Introduction

Resource-poor farmers in the eastern mid-hills of Nepal have a detailed local knowledge system for describing the nutritive value of tree fodders from a wide range of species that they use as dietary supplements for ruminant livestock, particularly in the dry season when other feeds are scarce. For a number of species, farmers have classified trees into several sub-types with different leaf morphology and feeding value. These subtypes are not currently recognized botanically. In contrast, laboratory assessment of the nutritive value of many of the native species used by farmers has only recently been attempted and is complicated by the presence of antinutritive factors (principally tannins) and sources of intraspecies variability in fodder value (in relation to season and phenotype) that are not well understood scientifically.

Thapa *et al.* (*in press*) found that farmers classified tree fodder according to two different systems known locally in Nepali as *posilopan* and *obanopan* respectively. In the first system, fodders labeled as *posilo* can be literally translated as being 'nutritious' and *kam posilo* fodders to have a low nutritive value. Fodder of a particular species may vary in the degree to which it is considered *posilo* or *kam posilo* depending upon season and the species of animal to which it is fed. *Posilo* fodders are generally considered by farmers to promote milk production and a high butter fat content in lactating animals, rapid live weight gain and animal health and to be palatable and satisfy appetite. Fodder described as *kam posilo* has converse attributes. In the second system, fodders may tend to be *obano* (literally translated as 'dry and warm') or *chiso* (literally 'cold and wet'), and as with *posilopan* the status of tree fodders may vary in the degree to which they are *obano* or *chiso*, according to season. Rusten and Gold (1991) working in western Nepal, took these terms to refer to the consistency of dung produced by animals consuming the tree fodder - an important issue in a system where manure is manually collected and application of composted manure is the primary means of maintaining soil fertility. However, Thapa *et al.* (*in press*) state that farmers also consider *obano* fodder as highly palatable, particularly during cold months, and to be eaten voraciously, often causing constipation if fed in excess and, as with *posilo* fodders, to be associated with high milk and butter fat production and animal health. *Chiso* fodder in contrast is reported to be less palatable and, if fed in cold months, to cause animals to produce watery dung that is difficult to collect.

Farmers have a detailed local knowledge system for describing the nutritive value of tree fodders from a wide range of species

Thorne *et al.* (*in review*) and Walker *et al.* (*in review*) asked a large sample of farmers to rank a range of tree fodders at various times in the season, in terms of their *posilopan* and *obanopan* status and then subjected the same fodder to laboratory assessments of nutritive value (including conventional proximate composition, detergent fibre determinations, measures of the content of anti-nutritive factors and digestibility using a microbial gas production technique which is affected by tannins in much the same way as rumen processes). This revealed, amongst other things, that:

- the two classification systems used by farmers were consistently applied by different farmers and were independent of each other
- there was evidence of a correspondence between *posilopan* status as judged by farmers and protein supply predicted from chemical composition, and
- there was evidence of a correspondence between *obanopan* status as judged by farmers and overall dry matter digestibility predicted from laboratory assessments.

These relationships provide a basis for the development of a mixed model, incorporating qualitative farmer assessment of the nutritive value of a wide range tree fodders for which chemical compositions are not known, that are interpreted in practically useful ways for the farmer, in combination with quantitative data from a more mechanistic description of feed utilisation by nimals receiving these types of feeds. The lity of such a mixed model is explored w.

model

nple model was constructed using fuzzy in which farmers' rankings of eight of tree fodder found in the Eastern of Nepal according to their relative and *posilo* status were used to provide nation on their relative abilities to y appetite and promote milk duction.

Fuzzy logic provides a means of translating qualitative and imprecise linguistic descriptors used by farmers into quantitative terms and has been successfully applied to the development of intelligent knowledge based systems in a number of other complex domains, notably autofocusing systems in cameras (Zadeh, 1992). The basic concept in fuzzy logic is that rather than a data item (for example, a particular fodder, such as *Ficus nemoralis,*) being assigned one particular value of a variable (such as 'intermediate' *posilo* status), a membership function is used to assign a degree of membership of the item, of between 0 (does not belong) and 1 (does belong), to each linguistic value in the set. Each of the linguistic values is then itself a variable taking some value of between 0 and 1 for each data item. Linguistic modifiers or 'hedges' such as 'more or less' or 'very' may also be defined and degrees of membership to them similarly assigned. These allow the range of values covered by the fuzzy sets to be extended where no clear terminolgy is available to define further linguistic variables.

Four fuzzy variables were used to define the *obano* and *posilo* status of the tree fodder, the ability of a particular tree fodder / straw combination to satisfy appetite and the level of milk production achieved by that combination (Table 1; Figure 1).

Membership functions (FV1, FV2) derived from farmers' rankings of the tree fodders were used to assign a degree of membership of particular tree fodders to each of the linguistic variables in the fuzzy variables for *obano* and *posilo* status respectively. The hedge, (LV^2), was used to assign degrees of membership of very *chiso*, very *obano*, very *kam posilo* and very *posilo*. The inverse relationship observed between *obano* status and digestibility (Thorne *et al.*, 1997) allowed fodder in different classes to be assigned to a level of fill units (UEL; as defined by Jarrige (1988) in the 'French' ruminant rationing system to describe the maximum voluntary intake of a feed by a particular class of livestock relative to that of a reference material). These assignments are shown in Table 2.

Similarly, based on the association of *posilo* status with protein supply (Thorne *et al.*, 1997), PDIN (Degradable N-limited microbial N supply) and PDIE (Energy-limited microbial N supply) values (Jarrige, 1988) were assigned to different classes of *posilo* status using the data of Pozy and Dehareng (1996) as shown in Table 3. These values were used in the calculation of PDI (duodenal protein supply) values (as MIN[PDIN,PDIE]) from which a crude prediction of milk yield was obtained. Dietary UEL values were then used to determine a fill ratio (actual dry matter intake / potential dry matter intake) to describe the extent to which appetite would be satisified. Milk production was predicted as MAX[(PDI intake - PDI required for maintenance),0.5].

Table 1. Fuzzy variables used in the model and their linguistic values.

Fuzzy variable	Linguistic values (variables)
Obano status	*obano*, intermediate, *chiso*
Posilo status	*posilo*, intermediate, *kam posilo*
Ability to satisfy appetite	acceptable, low
Level of milk production	high, medium, low

Table 2. Assignments of values for fill units to linguistic values describing obano status.

Obano status	Fill unit
very chiso	0.6
chiso	0.75
intermediate	1
obano	1.25
very obano	1.4

Table 3. Assignments of values for parameters describing N supply with linguistic values describing posilo status.

Posilo status	PDIN	PDIE
very kam posilo	53	138
kam posilo	84.5	123
intermediate	116	108
posilo	162	121.5
very posilo	208	135

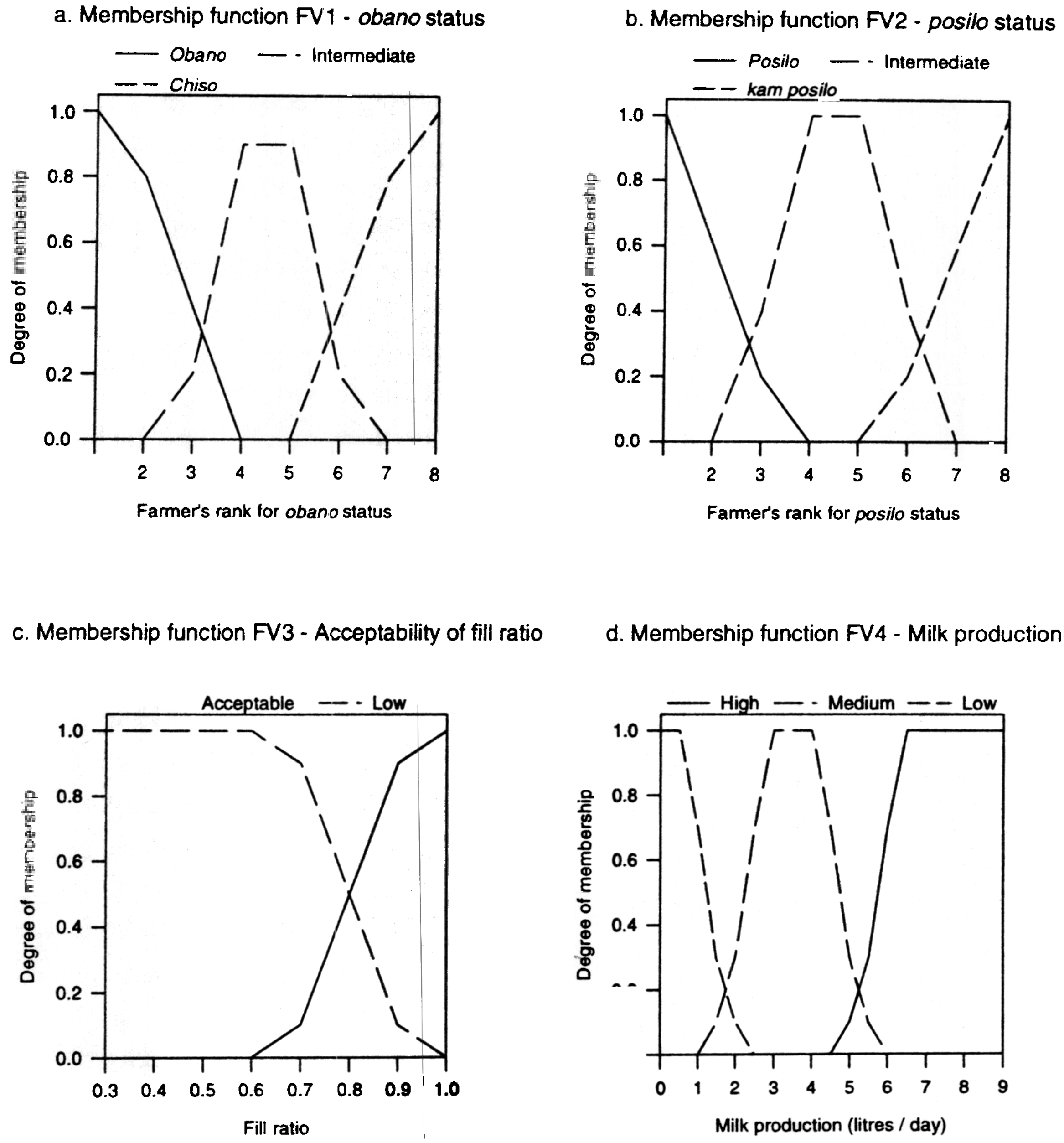

Figure 1. Membership functions

Omitting the contribution of body reserves to milk production in this simplified model was justified on the basis that it would be used in the prediction of trends and not absolute values. The fuzzy sets describing the outcomes of feeding strategies (FV3), that is whether the animal's appetite is satisfied and milk yield (FV4) were derived from the values of fill ratio and milk production using membership functions derived from the French model (Jarrige, 1988). These were then used to define a series of rules to suggest interventions in feeding strategies that would promote milk production whilst maintaining adequate fill ratios.

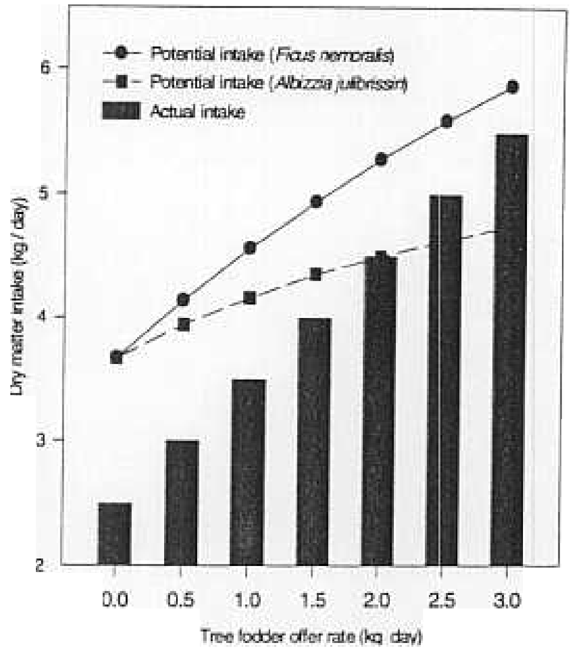

Figure 2. Comparison of actual dry matter intake and intake predicted by model.

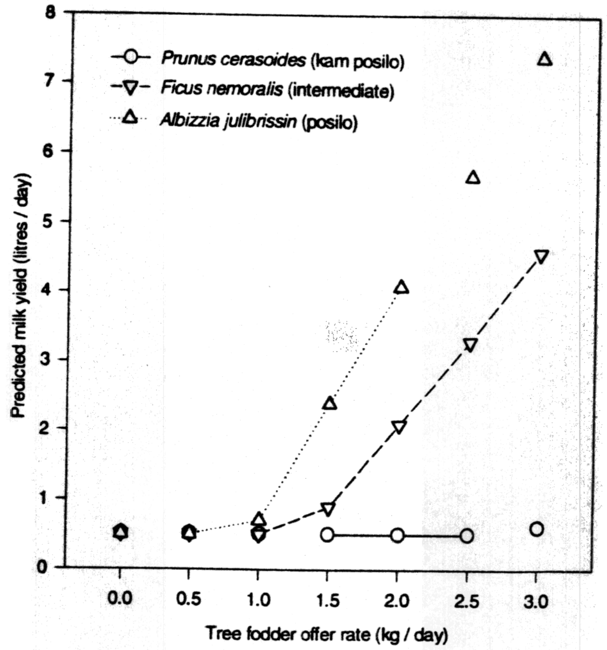

Figure 3. Predicted milk yield with different tree fodder supplements.

Results

To explore the utility of the model the objective was postulated that during feed shortages, while farmers may wish to maintain production at as high a level as possible, under difficult animal management conditions (stall feeding) they have an absolute requirement to ensure that feed intake matches appetite to avoid behavioural problems.

Figure 2 shows the actual and potential dry matter intake of straw/tree fodder mixtures predicted by the model when two different tree fodders are supplemented at various daily amounts. *Ficus nemoralis* was considered by farmers as a *chiso* fodder with an intermediate *posilo* status, while *Albizia julibrissin* was considered both highly *obano* and *posilo* by farmers. It can be seen that at low levels of basal fodder availability, the use of an *obano* fodder could be expected to satisfy the animals appetite at a lower level of supplementation than a *chiso* fodder. This may be important to farmers if feed is in short supply because what is available can be made to last longer without incurring behavioural problems.

Figure 3 shows the predicted milk yield for different levels of supplementation with three tree fodders that are contrasting in their *posilo* status. The lines represent feasible production levels, the points are predictions of production levels but where they are not joined by a line either exceed the appetite limits of the animal for the particular basal : supplement combination or the fill ratio is low and therefore likely to lead to behavioural problems. Here, the need to understand an interaction between *obano* and *posilo* attributes in planning feeding strategies is apparent. If, in contrast to the situation postulated in discussing Figure 2 above, the tree fodder supplement is in relatively plentiful supply, a fodder with intermediate *posilo* status, like *F. nemoralis*, that is also *chiso* and, therefore, has a high potential intake may lead to higher milk production than a highly *posilo* fodder like *A. julibrissin* that is also *obano* and, therefore, reduces feed intake.

Conclusion

This simple exercise demonstrates a potential utility in combining local qualitative knowledge with quantitative data and scientific understanding. The key point is that the model did not require any feed composition data once a general appreciation of what farmers mean when they classify fodder as *obano* and *posilo* had been established, which was achieved using evaluation of a few contrasting species for which both laboratory and farmer assessments were available. The model is thus a powerful tool since laboratory data are time consuming and expensive to collect and farmers already know how *posilo* and *obano* status vary amongst and within species. Furthermore, factors that would complicate a more conventional use of laboratory assessments, such as the need to interpret results in the light of farmers production objectives and the presence of seasonal variation, are implicitly catered for in the farmers' assessments.

Rural development projects have in recent years increasingly worked with qualitative information as it is perceived by rural people, frequently garnered using various PRA (participatory rural appraisal) techniques. There appears to be a potential for developing mixed models along the lines demonstrated here to make fuller use of what information and insight is gained, at considerable cost, in the appraisal process.

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Agroforestry in British overseas aid programmes

Around 70% of the UK Forestry Research Programme is related to agroforestry, largely through the selection and breeding of multi-purpose trees, improvement of nursery and outplanting techniques, understanding the nature of tree-crop competition, synthesis of local knowledge, and dissemination of research results. Most agroforestry research is ultimately directed towards 'resource-poor farmers' but it must be interpreted through national and international research institutes, extension agencies, and through a panoply of development projects. Research results should be disseminated to increase the extension agent's understanding of *why* and *where* agroforestry should provide a net benefit for the farmer, rather than blindly promulgating 'best-bet' formulas. Mechanisms to improve the two-way flow of information are suggested.

Introduction

The UK Department for International Development's (DFID) main forestry objective is 'to assist in the sustainable development of forests and trees, *including agroforestry*, to enable developing countries and their people to maximise the sustainable economic and social benefits they enjoy from forests and forest-based industries'. Agroforestry is specifically mentioned in this objective and is a significant part of many of DFID's research, development, training and extension projects. Of the 12 programmes which comprise the DFID Renewable Natural Resources Research Strategy (RNRRS), agroforestry is mainly the responsibility of the Forestry Research Programme. However it is also central to the Systems Programme, and is represented in other programmes such as Plant Sciences and Crop Protection. Many of the developmental projects which DFID co-finances with NGOs, though the Joint Funding Scheme, stress the potential for agroforestry to increase rural livelihoods, whilst protecting the environment. Several bilateral projects also aim to develop and disseminate agroforestry techniques. DFID also provides direct and indirect (e.g. through the 'Holdback Scheme') assistance to a number international research institutes who are engaged in agroforestry activities. This paper expands on some of these activities, and considers mechanisms,