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 tool for interpreting decision-making by farmers in a complex domain. This type of approach might be widely applied to make more complete use of qualitative information garnered from local people in the process of participatory rural appraisal.

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 variability 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.

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 animals receiving these types of feeds. The utility of such a mixed model is explored below.

A simple model was constructed using fuzzy logic in which farmers’ rankings of eight of tree fodder found in the Eastern Province of Nepal according to their relative obano and posilo status were used to provide information on their relative abilities to satisfy appetite and promote milk production.

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 autofocus 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 terminology 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, (LV2), 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 \(\min\{\text{PDIN},\text{PDIE}\}\)) 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 satisfied. Milk production was predicted as \(\max(\text{PDIE intake} - \text{PDIE required for maintenance}, 0.5)\).

<table>
<thead>
<tr>
<th>Fuzzy variable</th>
<th>Linguistic values (variables)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obano status</td>
<td>obano, intermediate, chiso</td>
</tr>
<tr>
<td>Posilo status</td>
<td>posilo, intermediate, kam posilo</td>
</tr>
<tr>
<td>Ability to satisfy appetite</td>
<td>acceptable, low</td>
</tr>
<tr>
<td>Level of milk production</td>
<td>high, medium, low</td>
</tr>
</tbody>
</table>
Table 2. Assignments of values for fill units to linguistic values describing obano status.

<table>
<thead>
<tr>
<th>Obano status</th>
<th>Fill unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>very chiso</td>
<td>0.6</td>
</tr>
<tr>
<td>chiso</td>
<td>0.75</td>
</tr>
<tr>
<td>intermediate</td>
<td>1</td>
</tr>
<tr>
<td>obano</td>
<td>1.25</td>
</tr>
<tr>
<td>very obano</td>
<td>1.4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Posilo status</th>
<th>PDIN</th>
<th>PDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>very kam posilo</td>
<td>53</td>
<td>138</td>
</tr>
<tr>
<td>kam posilo</td>
<td>84.5</td>
<td>123</td>
</tr>
<tr>
<td>intermediate</td>
<td>116</td>
<td>108</td>
</tr>
<tr>
<td>posilo</td>
<td>162</td>
<td>121.5</td>
</tr>
<tr>
<td>very posilo</td>
<td>208</td>
<td>135</td>
</tr>
</tbody>
</table>

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.
Results

To explore the utility of the model the objective was postulated that during feed shortages, while farmers may wish to maintain production 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 *chio* 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 *chio* 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 *chio* 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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References


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 the main 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, through 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 of international research institutes who are engaged in agroforestry activities. This paper expands on some of these activities, and considers mechanisms,