Indigenous and Laboratory Assessment of the Nutritive Value of Tree Fodder.

II: Comparison of Farmer and Laboratory Assessment

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Abstract

Both local and laboratory-based evaluations of tree fodder value in Nepal were previously used to provide consistent means for discriminating fodder value (Thorne *et al*, this volume). In this paper, the possibility that combined use of these two systems provides a more powerful means of making assessments of fodder value than either alone is explored. Compatibility between the two systems is demonstrated in that a clear correspondence between the farmers' *chiso - obano* classification and measures of digestibility and between the *posilo - kam posilo* ranking and measures of protein availability are shown. Complementarity between the two systems in providing enhanced discrimination between species where used in combination is also demonstrated. The effective integration of local and laboratory-based assessment of fodder value requires further research on diet supplementation and the effects of fodders on animal performance but it was shown to be both a realistic and desirable option. It is therefore argued that applied research building on farmer practice may be a more appropriate direction for applied research into fodder assessment than ignoring the local classification and seeking to replace rather than augment it with laboratory-based methods.

Keywords

nutritive value, indigenous knowledge, tree fodder

Introduction

In the farming systems of the middle hills of Nepal, fodder from forests (Panday, 1982) and more recently from trees planted on crop terraces (Carter and Gilmour, 1989) is extremely important as a source of green material, high in protein, to supplement the crop residue based, livestock diets used during the dry season (November - May). In order to facilitate this use, farmers have developed sophisticated classification systems for differentiating tree fodder from different sources on the basis of nutritive value (Thapa *et al*, in press; Rusten and Gold, 1991).

A companion paper (Thorne *et al*, this volume) has described and evaluated the discriminatory powers of farmers' evaluations (based on these classification systems) and laboratory analyses for assessing the nutritive value of tree fodder in the middle hills of Nepal. Both approaches were shown to provide consistent rankings of fodder sources in terms of their nutritive value and appeared to provide information at a similar level of precision. However, they also differed, in some instances, in the detail of their predictions. Farmers indicated that there were differences in the nutritive value of sub-species level variants of some of the fodder tree species tested. Differences between these variants in chemical composition were also observed in some cases. However, the concensus between farmers regarding the relative merits of the sub-species level variants was not particularly firm, nor were they particularly clearly differentiated by combinations of the laboratory methods.

Observations such as these would suggest that the ability to apply the nutritive value assessment paradigms of the farmer and the analytical chemist in parallel might offer a number of potential advantages over the current situation in which the relationships between the two remain unclear. In particular,

- the efficiency and effectiveness of research might be improved by better integration of the existing expertise of farmers;
- nutritive value assessment in fodder improvement programmes and feeding strategies development and even the refinement of laboratory methods might be more effectively targetted on farmers objectives relating to fodder utilisation;
- the effective extension of research results might be enhanced by allowing them to be translated into terms that are more readily understood by farmers.

In order to explore these possibilities further, the comparison of the two systems described in this paper was undertaken. This comparison focused on two principal aspects of the relationship between laboratory methods and farmers' knowledge; the correspondence between them (in order to provide an indication of their compatibility and the extent to which they address the same aspects of nutritive value) and their complementarity (to assess the ability of each to 'add value' to the other). The implications of the correspondence and complementarity between the two systems for the development of integrated approaches to assessing the nutritive value assessment of tree fodder, validated for their ability to predict livestock performance, are also discussed.

Materials and Methods

Data Collection

The creation of the data set used in this study has been described in detail in the companion paper (Thorne *et al*, this volume). The values of a range of analytical variables (Table 1) were determined for samples of eight fodder types at three sampling times. The abbreviations representing these variables that are defined in Table 1 have used throughout this paper. The fodder types included five species, one with two botanically and locally recognised sub-species variants and two with two locally recognised sub-species variants that have not, as yet, been recognised botanically. The eight fodder types were *Ficus nemoralis (SPD); Ficus nemoralis (TPD); Ficus roxburghii (CPN); Ficus roxburghii (KPN); Ficus semicordata var. montana; Ficus semicordata var. semicordata; Prunus cerasoides; Albizia julibrissin* where SPD, TPD, CPN and KPN identify locally defined sub-species variants. At the second sampling time the eight fodder types were ranked by 60 farmers according to two local classifications relating to fodder value, *obano-chiso* and *posilo - kam posilo*, as described by Thapa *et al* (in press) and Rusten and Gold (1991). For the purposes of the analyes described in this paper, it was assumed, because of the high level of replication, that these data were distributed normally. This allowed the creation of an ordinal data set of mean rankings describing the comparative *obano-chiso* and *posilo - kam posilo* status of the eight fodder types.

Comparing Laboratory and Indigenous Assessments of Tree Fodder Nutritive Value

The evaluation, described in this paper, of the correspondence and complementarity between farmers' and laboratory assessments of the nutritive value of the eight fodder types studied focused on four key questions. In relation to correspondance:

> *1. Are farmers' rankings of the eight fodder types significantly correlated with those derived from individual laboratory assessments?* The most direct indication of correspondence between farmer classification and nutritive value assessment would be a direct correlation between the *obano - chiso* or *posilo - kam posilo* classifications applied by farmers and one or more of the analytical variables determined.

2. Are there significant correlations between farmers' rankings of the eight fodder types and the rankings of animal nutritionists based on an informed evaluation of the results of laboratory analysis? Correlations between farmers' rankings of tree fodder according to their *obano - chiso* and *posilo - kam posilo* status with individual analytical variables might not constitute an effective test of correspondence. This is because the former represent an amalgamation of observational data whilst the latter are, effectively, unprocessed data. An appropriate synthesis and interpretation of the laboratory analyses might, therefore, provide an evaluation of nutritive value that is more comparable, with the rankings of farmers. This possibility was addressed by comparing farmers' rankings of the eight fodder types with those of a group of animal nutritionists presented with a summary of the laboratory analyses.

3. Can laboratory analyses be used in combination to predict farmers rankings of the eight fodder types? The preceding test sought correspondence between farmers' rankings and a completely independent evaluation of fodder value by expert nutritionists. A further test was performed that deliberately sought combinations of laboratory tests that might predict farmers' rankings. A series of hypotheses regarding the digestive processes that might determine fodder quality assessed according to the *obano - chiso* and *posilo - kam posilo* systems were formulated. These hypotheses were based on the authors' knowledge of tree fodder use in the feeding systems practised in the middle hills of Nepal (Thorne *et al*, in preparation).

and in order to assess complimentarity:

4. Is the combined use of farmers' classification and laboratory analyses more effective for distinguishing the eight fodder types than either system used alone? The previous questions explored the extent to which the two systems were compatible for estimating nutritive value in equivalent terms. If demonstrated, this compatibility would mean that the two systems might be used in combination in further research and extension efforts. However, it is quite distinct from the hypothesised complementarity, which would be required if such combined be of practical value for enhancing nutritive value capabilities This potential complementarity assessed by comparing the precision of rankings for individual fodder types by farmers and the application of laboratory techniques that correlated with either the *ohano chiso* or *posilo kam posilo* rankings.

Correlations Between Farmers Rankings and Individual Laboratory Analyses

Correlation coefficients (r) of the mean farmer ranking for each of the eight fodder types for *ohano chiso* and *posilo kam posilo* status the results of the 20 laboratory analyses for each of the three sampling times were calculated and their statistical significance assessed.

Correlations Between Farmers and Animal Nutritionists' Rankings

The synthesis of the results of laboratory analyses in order to provide information similar level of organisation to that represented by the farmers rankings achieved by asking number of animal nutritionists summary of the analytical data to rank the eight fodder types the basis of their expected nutritive value. A panel of nutritionists presented with subset of the analytical results for the eight fodder types (coded A H) sampling time (Table 2). The panel told that the different fodder types all examples of fodder that would be used supplement cattle receiving crop-residue based diets. Members then asked, individually, rank the fodder types from to 8, where represented the highest and the lowest nutritive value.

The consistency of the animal nutritionists' rankings assessed by deriving pairwise Spearman rank correlation (r_s) between each pair of the informants. A ranking and standard deviation then calculated for the animal nutritionists rankings. Correlation coefficients

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The principal components of the complete analytical dataset were determined and variables representing each of these presented the panel of nutritionists.

between these mean data and the mean values for *obano - chiso* and *posilo - kam posilo* were determined for each fodder type. Rank correlation coefficients were also obtained between the rank order derived by aggregating the ranks from all farmers and the ranking provided by individual animal nutritionists.

Prediction of Farmers' Classifications from Combinations of Laboratory Analyses

A partial correspondence between the *obano - chiso* classification and digestibility has already been suggested in the companion paper (Thorne *et al.*, this volume). However, no indications of the biological basis of the *posilo - kam posilo* classification were apparent. On the basis of the reported effects of *posilo* as compared to *kam posilo* fodders (see Thapa *et al.*, in press), and the established role of tree fodder in the feeding systems of the middle hills (Thorne *et al*, in preparation) it was proposed that *posilo - kam posilo* might be related to nutritional characteristics of the tree fodders that were not accounted individually by any of the suite of analytical techniques employed by the study.

The major role of the tree fodder in the feeding systems practised by farmers is to supply protein in diets based on low protein crop residues (principally rice straw and maize stover). It was therefore inferred that an indicator of protein supplied to the duodenum might prove to be a reliable indicator of *posilo - kam posilo* status. The analytical profiles of the feeds available suggested that an effective indicator might be derived from a combination of the indicators of dry matter digestibility (NCD or DMD70), crude protein content (CP) and tannin content (NonExt). Therefore, the following protein supply indices (PSIs) were calculated for each sampling time, and correlated with farmers' mean rankings for *posilo - kam posilo* status.

PSI1 = DMD70 x CP

PSI2 = NCD x CP

PSI3 = (DMD70 / mean DMD70) + (CP / mean CP) - (NonExt / Mean NonExt)

PSI4 = (NCD / mean NCD) + (CP / mean CP) - (NonExt / Mean NonExt)

The Combined Use of Farmers' and Laboratory Assessments of Nutritive Value for Distinguishing Tree Fodder Types

The complementarity of farmers' perceptions of the nutritive value of the eight types of tree fodder and the predictions of the laboratory analyses was assessed by simultaneous comparisons of the extent to which each system was able to differentiate according to type. Rank means for the *obano - chiso* and *posilo - kam posilo* status of each fodder type were plotted against the individual or combinations of analytical variables with which they were most highly correlated. Visual assessment of the separation of the means for paired fodder types and their associated standard errors allowed instances of complementarity (i.e where one system appeared to be more effective in distinguishing fodder types than the other) to be identified.

Results

Correlations Between Farmers' Rankings and Individual Laboratory Analyses

Laboratory indicators of digestibility generally increased with increasingly *chiso* samples (ie. declining *obano* status). Correlations were statistically significant ($P<0.05$) for NCD in sampling times 1 and 3, but did not achieve significance in sampling time 2. Correlation with *in vitro* gas production increased as incubation times increased. Correlations achieved statistical significance ($P<0.05$) for CG24, CG52 and CG70 in sampling time 3, other correlations did not achieve significance. Correlations with *in vitro* gas production did not achieve significance ($P>0.05$) in sampling times 1 and 2, and DMD70 did not correlate with *obano-chiso* ranking for any sampling time. The various indicators of fibre content increased with increasing *obano* ranking, ADF and NDF achieving statistical significance ($P<0.05$) in sampling time 1, CF in both sampling times 1 and 2. Other correlations with fibre determinations were not significant. Lignin also increased with increasing *obano* ranking, correlations significant ($P<0.05$) in sampling times 1 and 3. There were no significant correlations between any indicator of tannin content and *obano - chiso* ranking. Other significant correlations were with EE and ADIN in sampling time 1

There were no significant correlations (P<0.05) between laboratory digestibility indicators and the *posilo* ranking of fodders. Low DM was associated with *posilo* fodders, correlations being significant (P<0.05) in sampling times 1 and 2. *Posilo* rankings of fodders were generally related to low fibre, CF was significantly (P<0.05) negatively correlated to *posilo* ranking at times 2 and 3, ADF at time 3. *Posilo* fodders tended to be related to low tannin contents, significant (P<0.05) correlations being found for TP and CT at time 2.

Correlations Between Farmers' and Animal Nutritionists' Rankings

The rankings for the eight fodder types and variability of ranking between those fodder types are shown in Table 3. Pairwise rank correlations between the rankings provided by the animal nutritionists produced a mean correlation of 0.448 with a standard deviation of 0.465. The ranking of the eight fodder types by animal nutritionists was therefore significantly less consistent than the rankings provided by farmers (Thorne *et al.* this volume). The lack of consistency of ranking by animal nutritionists is illustrated in Figure 1. It is interesting to note that, as in the equivalent graphs for farmer rankings presented in Thorne *et al.* (this volume), fodder types with a higher nutritive value appear on balance to be ranked more consistently than those with a lower value.

Calculation of a correlation coefficient between the ordinal mean ranking provided by the animal nutritionists and the ordinal mean ranking provided by farmers revealed a low (and non-significant) correlation between the animal nutritionists' rankings and the *posilo - kam posilo* rankings but a highly significant (P<=0.05) correlation with the *obano - chiso* classification. When comparing the aggregated ranking provided by farmers and the individual rankings provided by animal nutritionists, significant correlations with *obano - chiso* status were observed for more than half of the animal nutritionists that participated in the ranking exercise.

Prediction of Farmers' Classifications from Combinations of Laboratory Analyses

The correlations between *obano - chiso* and *posilo - kam posilo* rankings and the four protein indices for each of the three sampling times are given in Table 4. Correlations were consistently significant between both PSI3 and PSI4 and the *posilo - kam posilo* rank means.

The Combined Use of Farmers' and Laboratory Assessments of Nutritive Value for Distinguishing Tree Fodder Types

Enhanced discriminatory power was observed when *chiso - obano* and neutral cellulase digestibility rankings were combined and when *posilo - kam posilo* and PSI3 rankings were combined. combinations are, therefore, used here as examples of the results. Complementarity plots, for the data relating to sampling time 3, of *obano - chiso* against neutral cellulase digestibility and *posilo posilo* against PSI3 are presented in Figure 3.

Farmers achieved effective discrimination of fodder types using the *obano - chiso* classification system (Figure 2a) for all pairwise comparisons with the exception of that between *Ficus nemoralis* (SPD) and *F. nemoralis* (TPD). However, this pair of tree fodder types was effectively distinguished using NCD. Conversely, NCD was not as effective as the *obano - chiso* system in discriminating the sub - types of *F. semicordata* and the sub - types of *F. roxburghii*. *Albizia julibrissin* and *Prunus cerasoides* were effectively distinguished from each other and from the *Ficus* species by both NCD and *obano - chiso* rankings. A similar range in complementarity between assessments based on PSI3 and the *posilo - kam posilo* classification system was observed (Figure 2b). Again the two sub - types of *F. nemoralis* appeared to be more effectively discriminated by the laboratory methods than by *posilo - kam posilo* rankings, whilst species and sub-types of the other *Ficus* species were more effectively discriminated by the farmer rankings. *A. julibrissin* and *P. cerasoides* were also effectively discriminated by both systems. However, *F. nemoralis* (TPD) and *F. semicordata* var. *montana* did not appear to be effectively discriminated from each other by either system.

Discussion

Correlation between farmers' classifications and individual laboratory analyses

There were clear indications that the *obano - chiso* scale of fodder quality used by farmers was related to digestibility, the more *obano* the fodder the less digestible it was. Fibre and lignin contents were inversely related to *obano - chiso* ranking, probably a reflection of the general inverse relationship between digestibility and these variables. EE is not an important component of the fodders, constituting less than 4% of these fodders so the significant correlation with *obano - chiso* ranking at sampling time 1 may have been coincidental. Nevertheless, the higher EE associated with less *obano* (more *chiso*) fodders is consistent with the overall view that *chiso* fodders are good sources of feed energy. Increasing ADIN with increasing *obano* ranking indicates that feed nitrogen is less digestible in more *obano* feeds, consistent with the decreasing trend in digestibility.

Thapa *et al.* (in press) have reported that *obano* fodders are eaten voraciously by animals, could cause constipation, lead to the production of dry and firm dung, satisfy appetite, and generally improve animal health and improve milk production. *Chiso* fodders, in contrast, are less palatable and could cause diarrhoea during cold months. This is consistent to some extent with the hypothesis that *obano* feeds are of low digestibility, such feeds filling the rumen thus satisfying appetite and, possibly, causing constipation. *Chiso* feeds, although of higher digestibility, also are of lower palatability and have adverse effects on animal health and performance. Higher digestibility of feeds is normally associated with improved animal performance, so this apparent inverse relationship was unexpected. It may have been due to the effects of anti-nutritive factors in *chiso* feeds (discussed below), although there was no evidence from this study to implicate tannins.

Posilo feeds appeared to have the following characteristics, low DM (*i.e.* moist, possibly succulent), low in fibre, low in tannins and potentially rich in digestible protein. *Posilo* ranking did not appear to be linked with *in vitro* dry matter digestibility. Thapa *et al.* (in press) described *posilo* fodders as ones which increase milk and butter fat production, increase weight gains and improved vigour and health. *Posilo* feeds are highly palatable and satisfy appetite. This is consistent with *posilo* describing a highly digestible, palatable nutritious feed, so the lack of correlation between *posilo* characteristics and *in vitro* digestibility was remarkable. The low fibre, low tannin, low DM characteristics identified by laboratory techniques are consistent with the farmers description of *posilo* feeds. The implication that *posilo* fodders are good sources of protein, probably due to the lower tannin content, is noteworthy. Tree fodders are usually fed as supplements to roughages such as rice straw, which are generally deficient in nitrogen. *Posilo* tree fodders would be particularly useful supplements, providing dietary nitrogen to stimulate the microbial population of the rumen and balance the energy supplied by the roughage component of the diet. This is fully consistent with the increases in animal performance and the satisfaction of appetite described by farmers.

Anti-nutritive factors in plants are widely thought to have evolved as defense mechanisms to limit herbivory and disease (reviewed by Kumar and D'Mello, 1995). General inverse relationships have been found between tannins in tree leaves and their palatability, voluntary intake and digestibilities (Kumar and Vaithiyananthan, 1990). The effects of anti-nutritive factors are one possible explanation for the unexpected correlation between high *in vitro* digestibility and the reportedly poor animal performance using *chiso* feeds, and the lack of correlation between high *in vitro* digestibility and highly nutritious *posilo* feeds. More digestible leaves are likely to be more attractive to herbivores and therefore may tend to be better protected by anti-nutritive factors. There is no direct experimental evidence to support this suggestion, nevertheless such a relationship could explain the relationships described above. Tree fodders can contain a wide variety of anti-nutritive factors as well as tannins, which may account for the lack of relationship between tannins and *chiso* characteristics. Farmers identified cold months as times when diarrhoea was a particular problem. This may be due to the weather influencing levels of anti-nutritive factors. Wood *et al.* (1994) found highly variable levels of extractable tannins in Nepalese fodder tree leaves and suggested that they could be linked to weather conditions.

Although the research reported here focused on ranking and evaluation of individual fodder types as the simplest means of comparing farmer and laboratory assessments, this does not reflect farmer practice. It has already been stated that tree fodders are often used as highly nutritious supplements to straw and other agriculture by-products. Additionally, tree fodders are normally mixed to provide a balanced feed. Table 4 gives the most common species with which the 8 fodder types assessed in this study were reported to be mixed with (Subba, unpublished data). The reasons given by farmers for practising this mixing include increasing the palatability of otherwise unpalatable fodders and thereby avoiding waste, adding *chiso* to *obano* fodders to increase diet bulk and mitigating the deleterious effects associated with sole use of *chiso* fodder. So, while the farmers could rank individual fodder samples in terms of the local classifications, the knowledge used in mixing fodders also merits investigation. If the ultimate objective is to improve feeding practice and the management of tree fodder resources, this is clearly of critical interest. Consideration of feed mixes is particularly challenging where laboratory analysis is to play a role. Most analyses are not well suited to dealing with the complex relations that may occur in mixed fodders, although the *in vitro* gas production methods used here may be of particular interest in this regard.

The situation is further complicated because it is known that local classification of fodder value varies according to livestock species being fed and the physiological status of the livestock (eg. lactating and non-lactating) (Thapa *et al.*, in press). Similarly the *obano - chiso* and *posilo - kam posilo* status of leaves is considered to vary with the maturity of the leaf. Finally, variability in fodder value was also reported by farmers (in the questionnaire survey for the collection of ancillary data) in terms of site. For example, there was close to unanimous agreement that fodder from sunny sites was more nutritious than that from shady locations. Similarly southerly aspect was reported to produce more nutritious fodder than northerly. It is also quite likely that soil fertility and adjacent crops and lopping regime are considered by farmers in evaluating the quality of fodder from a particular tree. Hence a range of factors other than those related to animal performance may be integrated into the *obano-chiso* and *posilo-kam posilo* classifications.

Local classification is clearly based on observation of impact on animal performance and handling and observation of the fodders. Farmers are, therefore, able to describe generalised indicators of fodder quality including, for example, leaf texture (softness, coarseness, brittleness), sap content, colour and bitterness. It would be interesting to explore these simple observational tests (that, in being indicators of nutritive value, are more akin to the approaches applied in laboratories) further to see how they might be used in conjunction with the results of analytical assessment in providing enhanced tools for the farmers in fodder selection.

Inspite of the complexities described above, the correlations observed indicate a clear correspondence between farmer classification and sets of the nutritive value assessment techniques applied. They also, thereby, indicate that the *obano - chiso* and *posilo - kam posilo* classifications are at least in part based on a firm (although probably purely empirical) biological foundation.

Correlation between farmers' classifications and animal nutritionists' rankings

The comparative variability of the rankings by nutritionists illustrates that the interpretation of nutritive value assessment methods in the context of unfamiliar tree fodders is challenging. Ranking on a single scale may have been inappropriate, and indeed has presumably been found to be of limited value by Nepalese farmers, hence the development of the two scale system. It is possible that a stronger correlation would have been found with local classification if the nutritionists had been asked to rank samples in terms of both energy supply and protein supply. The significant correlation between animal nutritionist ranking and farmer ranking on *obano - chiso* is not surprising as it was clear from the rankings provided by the animal nutritionists that most had weighted their rankings heavily, if not exclusively, on *in vitro* digestibility derived from the fermentation studies. It is, however, remarkable that the farmers' classifications, unlike the nutritionists, did not appear to necessarily regard fodder with high dry matter digestibilities (*chiso* fodders) as superior to fodders of low digestibility (*obano* fodders) even though farmers were clearly aware of the differences between the fodders.

The possible role of anti-nutritive factors in altering the usual relationship between digestibility and nutritive value has been discussed above. Farmers may also regard *obano* feeds as desirable as they probably facilitate dung collection and help to fill the animals when there is insufficient feed available to otherwise satisfy hunger. Hence *obano* feeds may be desirable due to properties other than those related to conventional nutritive value.

Prediction of farmers' classifications from laboratory analyses

The significant correlations between both PSI3 and PSI4 and the *posilo - kam posilo* rank suggests that the farmers' objectives in preferentially selecting *posilo* tree fodders was to select those fodder species that made the greatest contribution as protein supplements for their protein deficient animals. Furthermore, the approach taken further demonstrates a correspondence between a laboratory based assessment of protein supplied (albeit indirect) and farmer derived assessment of nutritive value, in terms of *posilo - kam posilo* status, and provides further evidence for at least a partial biological basis to farmer ranking.

Combination of farmers' classifications and laboratory analyses to distinguish fodder type

The data presented suggest that there may, indeed, be scope for exploiting significant complementarity between farmers' assessments of the relative feeding values of the types of tree fodder studied and relative assessments derived from laboratory information. Careful use of selected laboratory assessments on fodder types not consistently distinguished by farmers in terms of fodder value and reporting of the results to farmers could enhance the knowledge farmers apply in making routine decisions about feeding regimes. This would probably be significantly more acceptable to the farming community than undertaking a laboratory based nutritive value assessment programme that fails to take into account the existing local classification.

The analysis suggested that, for both the *obano - chiso* and *posilo - kam posilo* status of the two sub - types of *F. nemoralis*, laboratory indicators might be used to augment the discriminatory powers of the farmers' classification systems. Under normal circumstances, there might be little practical utility in being able to discriminate *F. nemoralis* (SPD) more effectively from *F. nemoralis* (TPD). The empirical approaches used by farmers are based on long-term observations of animal performance so the lack of a perceived difference in the quality, according to their criteria, of these two fodder types might suggest that there are no implications for animal performance. However, changing circumstances (*e.g.* the use of different basal feeds) might require changes in approaches to using tree fodder types such as *F. nemoralis.* This could cause the differences identified by the laboratory assessments to express themselves in differences in performance and, thereby, assume a practical significance. Thus, where farmers find it necessary to modify feeding strategies which incorporate these two types of tree fodder, laboratory analyses might be put to effective use in assisting them.

The relatively firm discrimination of the sub-types of *F. semicordata* and sub-types of *F. roxburghii* by the two classification systems reported in the companion paper (Thorne *et al*, this volume) and the lack of effective discrimination of differences between the fodder types by the use of NCD are clearly illustrated in Figure 2. Thus, although NCD correlated well with *obano - chiso* at sampling time 3, it would appear that laboratory-based descriptions of tree fodder quality would need to be more detailed for use in predicting farmers' perceptions of tree fodder nutritive value. However, the development of this kind of approach has obvious potential for supporting farmers in the development of improved feeding systems and strategies relying on the use of tree fodder, such as the better use of feed mixtures, selecting fodder trees of improved nutritive value. The ability for researchers and extension services to rank new species in a way that would be consistent with farmers rankings, and would relate to the quality of species that farmers already have experience of, would greatly assist farmers in selecting fodder types that are most suited to their requirements. Laboratory techniques may also prove valuable in investigating the potential for genetic improvement of indigenous species and selecting superior types.

In summary, the work reported here may have implications of immediate practical relevance. For example, the work reported has only considered eight fodder types out of some 96 used at the study site (Thapa *et al.*, in press). The farmers can provide information on the comparative *obano-chiso* and *posilo - kam posilo* status of most if not all of these. This represents a considerable resource in relation to a range of tree fodders of which few are well known to the scientific community. Pre-screening of local perceptions of fodder value is obviously a sensible thing to do in any research, but the research reported here suggests that considerable confidence might be attached to such pre-screening.

Conclusions

The study described in this paper provides evidence for a firm biological basis to the classification systems used by farmers in Nepal to describe tree fodder quality. Farmers' *obano - chiso* classification of fodder values can partially be explained in terms of the relative digestibility of fodders. The *posilo - kam posilo* classification can be explained to some extent in terms of the available protein within a fodder Demonstration of a biological basis to farmers' classifications that is comparable to the attributes measured in laboratory assessment of fodder value indicates a compatibility between the two approaches.

While the research reported here provides a basis for further investigating approaches to the effective synthesis of local classifications and laboratory-based assessment, further research is clearly required. Comparison of the two systems of classification with the available data set was challenging because neither farmer ranking nor laboratory analyses were evaluated in terms of their correctness in predicting the effects of that fodder on animal performance. This would require *in vivo* trials. Being inherently expensive and demanding, such trials would have been premature before demonstrating the internal consistency, potential compatibility and complementarity of the two systems. The research reported here and in the companion paper has taken internal consistency and correspondence between the two systems as indicators of their predictive ability. Given the evidence that local classification does have some biological basis, *in vivo* trials are clearly the next step in order to further compare the predictive power of local and laboratory-based evaluations in terms of livestock performance. These might include classic measures of animal performance, including growth rate, milk and butter fat yield but should also include other measures of significance, for example manure production, ability to satisfy hunger and maintain body condition across periods of feed shortage. There were also indications that the laboratory methods used may not be adequate for assessing the effects of anti-nutritive factors in tree fodders.

Indigenous knowledge has received considerable attention in the context of research for agricultural development, being espoused as an important but underutilised resource (Warren, 1991b). Additionally, some indigenous knowledge systems have been intensively investigated (Brokensha *et al.*, 1980; Richards, 1985; Warren, 1991a). However, such research has tended to remain discrete from core research in agriculture for development with little or no work aiming at testing the compatibility and complementarity of indigenous and scientific knowledge. The research reported in this and the companion paper illustrate some of the conceptual complexities of doing so but also indicate that results that are ultimately of important practical utility may be forthcoming.

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Table 1 : The analytical variables measured

Variable	Abbreviation
Dry matter content	DM
Crude protein	CP
Ether extract	EE
Total ash	TA
Crude fibre	CF
Acid detergent fibre	ADF
Neutral detergent fibre	NDF
Lignin	-
Acid detergent insoluble nitrogen	ADIN
Neutral detergent insoluble lignin	NDIN
Neutral cellulase digestibility	NCD
Protein precipitation activity	PPA
Total phenols	TP
Condensed tannins	CT
Non extractable condensed tannins	NXCT
In vitro gas production at 12 h	CG12
In vitro gas production at	CG24
In vitro gas production at 52	CG52
In vitro gas production at 70 h	CG70
Dry matter disappearance at 70 h	DMD70

Table 2: *Analytical data (sampling time 3) presented to ruminant nutritionists for ranking of fodder types.*

Variable (g / kg DM unless otherwise stated)	Fodder types A	B	C	D	E	F	G	H
Dry matter	307	457	313	444	416	314	323	324
Crude protein	151	112	141	132	125	261	138	
Acid detergent fibre	406	428	404	324	415	525	396	
Neutral detergent fibre	584	566	570	543	565	753	586	
Lignin	111	125	108	143	116	279	115	125
Acid detergent insoluble nitrogen (g/kg total N)	75	65	77	74	72	126	67	65
Total phenols (g gallic acid eq / kg)	2.0	3.0	2.3	2.7	2.7	1.4	1.7	1.5
Non-extractable tannins (arbitrary units)	287	156	315	624	203	141	472	297
Gas produced from *in vitro* fermentation for 72 hours (ml)	142	102	129	107	101	118	174	187
in vitro DM digestibility (g/kg based on bottle fermentation residues)	443	372	406	404	351	303	540	547

Table 3 : Mean tree fodder ranking by animal nutritionists with standard deviations where 1 is the most nutritive and 8 the least nutritive fodder.

Fodder	**Nutritive value**	
	Mean	Standard deviation
Ficus nemoralis (TPD)	1.71	1.2
Ficus roxburghii (CPN)	3.14	
Ficus nemoralis (SPD)	3.24	2
Ficus roxburghii (KPN)	4.1	
Prunus cerasoides	5.81	1.53
Albizia julibrissin	5.86	2.61
Ficus semicordata var. semicordata	5.9	
Ficus semicordata var. montana	6.24	1.41

Table 4: Correlations of farmers' ranks with protein index scores. Significant correlations shown in bold text.

	P	PI	PI	PI	PI
Sampling time 1					
Posilo-kam posilo					
Protein index 1	-0.40				
Protein index 2	-0.33	0.88			
Protein index 3	**-0.73**	0.07	0.00		
Protein index 4	**-0.69**	-0.00	-0.04		
Sampling time 2					
Posilo-kam posilo					
Protein supply index 1	-0.16				
Protein supply index 2	0.27	0.86			
Protein supply index 3	**-0.78**	0.25	-0.24		
Protein supply index 4	**-0.75**	0.17	-0.30		
Sampling time 3					
Posilo-kam posilo					
Protein supply index 1	-0.54				
Protein supply index 2	-0.49	0.97			
Protein supply index 3	**-0.80**	0.57	0.56		
Protein supply index 4	**-0.75**	0.44	0.46		

The indices used were:

PSI1 = DMD70 x CP

PSI2 = NCD x CP

PSI3 = (DMD70 / mean DMD70) + (CP / mean CP) - (NonExt / Mean NonExt)

PSI4 = (NCD / mean NCD) + (CP / mean CP) - (NonExt / Mean NonExt)

where DMD70 = Dry matter disappearance after 70 h fermentation *in vitro*, NCD = neutral cellulase digestibility (g / kg DM), CP = crude protein (g / kg DM) and NonExt = Non-extractable tannins (arbitrary units).

Table 5 : Fodder types reported as commonly being mixed with the eight fodder types considered in this study.

Fodder type	Commonly mixed species					
Albizia julibrissin	*Dendrocalamus hamiltonii*	*Ficus roxburghii*	*Ficus nemoralis*	*Saurauia nepaulensis*		
Ficus nemoralis (SPD)	*Artocarpus lakucha*	*Bambusa nutans*	*Saurauia nepaulensis*	*Albizia julibrissin*		
Ficus nemoralis (TPD)	*Bambusa nutans*	*Dendrocalamus hamiltonii*				
Ficus roxburghii (CPN)	*Albizia julibrissin*	*Bambusa nutans*	*Ficus nemoralis*	*Ficus roxburghii*	*Litsea polyantha*	*Saurauia nepaulensis*
Ficus roxburghii (KPN)	*Albizia julibrissin*	*Bambusa nutans*	*Saurauia nepaulensis*	*Ficus roxburghii*	*Artocarpus lakucha*	
Ficus semicordata var. montana	*Albizia julibrissin*	*Ficus roxburghii*	*Saurauia nepaulensis*	*Bambusa nutans*		
Ficus semicordata var. semicordata	*Saurauia nepaulensis*	*Ficus roxburghii*	*Ficus nemoralis*			
Prunus cerasoides	*Ficus nemoralis*	*Ficus roxburghii*	*Bambusa nutans*			

Figure 1. The rank position for each of the 8 fodder types provided by each of the 21 animal nutritionists

Figure 2. Complementarity of farmers assessments of tree fodder quality according to *obano - chiso* and *posilo - kam posilo* characteristics with correlated indicators of nutritive value determined in the laboratory

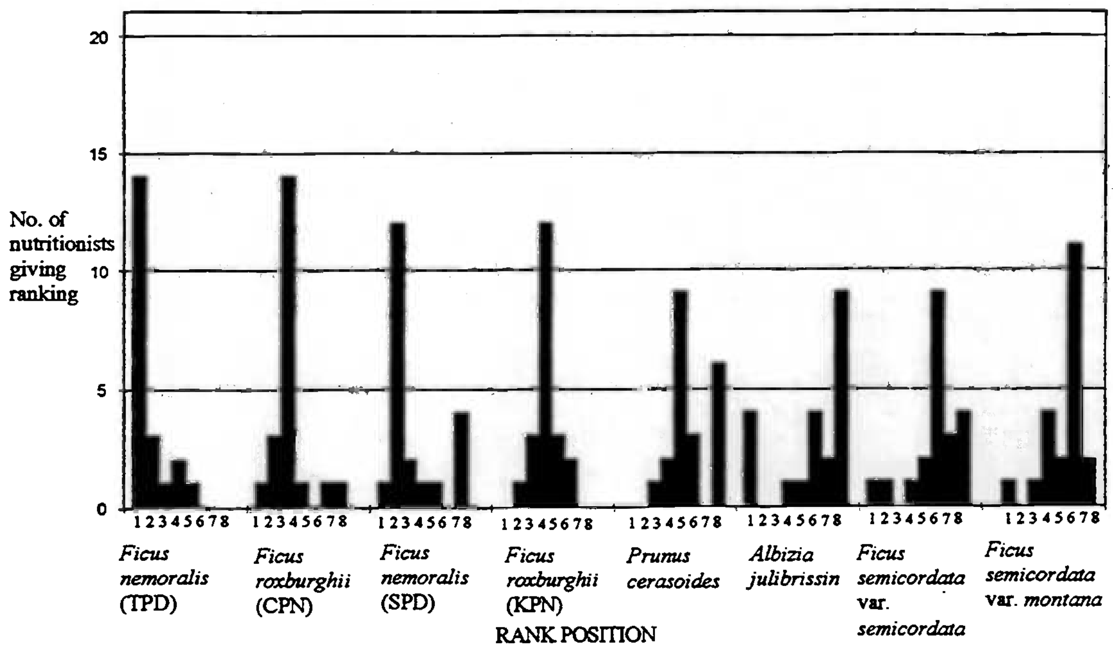
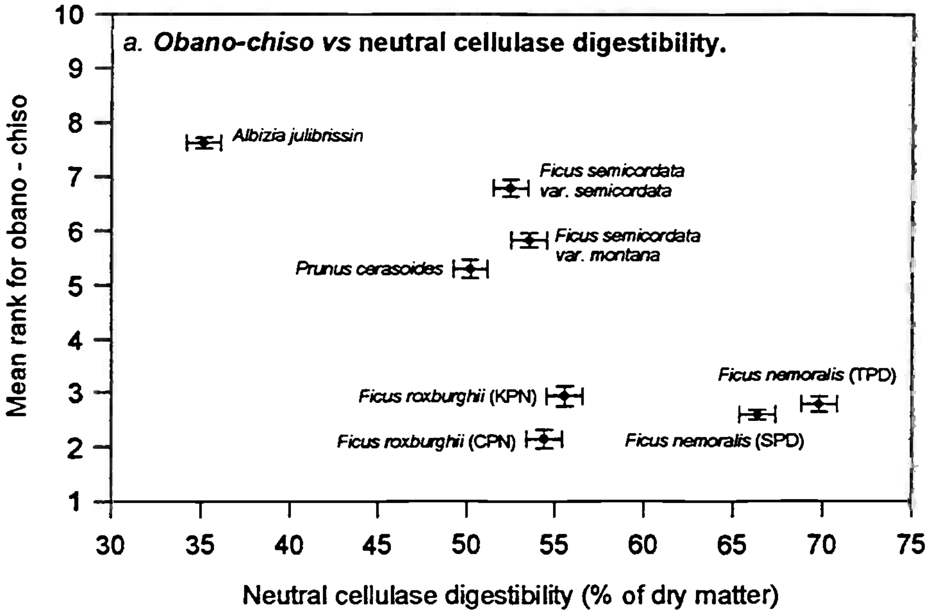


Figure 1: Walker *et al*



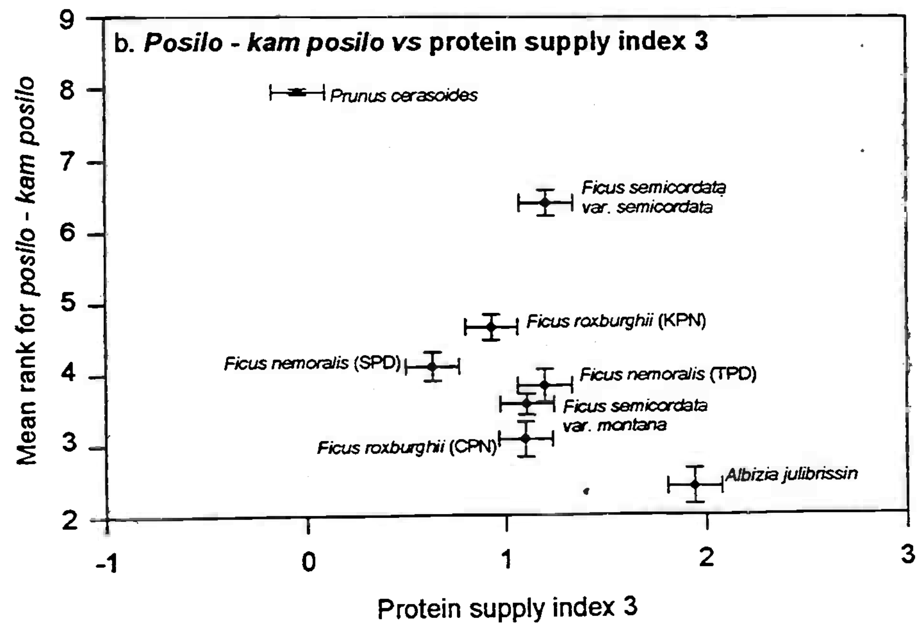


Figure 2: Walker *et al*