Contract Report H414300

INCREASING THE CONTRIBUTION THAT GOATS MAKE TO THE LIVELIHOODS OF RESOURCE POOR LIVESTOCK KEEPERS IN THE HIMALAYAN FOREST REGION

Final Technical Report

Undertaken for Natural Resources International Ltd

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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EXECUTIVE SUMMARY

The purpose of this project was to improve resource poor goatkeepers' livelihoods by developing means of increasing the productivity of their goats.

Initially, a participatory rural appraisal was done in three districts of Nepal to determine the contribution goats made to goatkeepers' livelihoods. This was followed by a more detailed six-month longitudinal study in two districts, which confirmed the importance of goats to livelihoods, and established how goats were managed and the incidence of disease and kidding in the flock. Means of increasing the intake of a ubiquitous weed that is generally avoided by goats were investigated. Two studies then followed in one district (in the Nepalese plain). The first investigated strategies to reduce the incidence of disease in goats during the wet season, while the second investigated means of increasing does' productivity. In addition, a survey was conducted of the goat market in Nepal and another investigated the efficacy of different upscaling activities in communicating outputs to farmers. In the light of this last survey, a range of upscaling activities were conducted to communicate the project's outputs to participating and neighbouring farmers and relevant target institutions in both Nepal and internationally. Regular meetings with participating farmers were held, and training courses in goat-keeping run for both participating and neighbouring farmers. Project outputs were also incorporated into the regular training courses given by one of the project collaborators to its large network of farmers throughout Nepal. Project outputs have also been communicated to policy makers in Nepal (through a national workshop held in collaboration with other LPP projects) and to other people and projects working with resource poor goat-keepers in Africa and Asia (through international workshops and conferences).

Goats contribute about 30% of goatkeepers' livelihood. The digestibility of the tree forages that they are fed appears to be increased by wilting, and this certainly increased the voluntary intake of the weed *Eupatorium adenophorum*. Dosing with a broad spectrum anthelmintic at the beginning and end of the wet season increased goat liveweight gain, although the incidence of disease was reduced more by supplementing goats' diets with 100 g/d maize. Supplementing does' diets with 100 g/d maize for two weeks before and six weeks after kidding reduced the kidding interval and increased the number of kids produced by a doe. The difference in the

gross margin of the goat flock that might result from adopting this strategy is equivalent to the value of one month's food supply to the goat-keepers' household and this project output could therefore make a real contribution toward realising the DFID objective of reducing the proportion of people who suffer from hunger in Nepal and similar countries. Since goat-keeping in Nepal is largely done by women, this also helps to enhance the status of women in these communities.

BACKGROUND

Goat-keeping is widespread in Nepal, one of the poorest countries in the world, with approximately 85% of rural households keeping at least one goat (Gurung et al., 1989). There are no cultural restrictions associated with goat-keeping, and as goat meat is the most valued of all the meats, goats fetch a relatively high price when sold. Goats can therefore make a valuable contribution to the livelihoods of very poor households. Goats are kept for raising cash, and for the provision of meat and manure, and these three functions are equally important to goatkeepers (Jha, 1998).

Constraints associated with goat-keeping

There are a number of constraints associated with keeping goats in Nepal, which limits the amount of money that is actually made from goat-keeping enterprises. In common with many developing countries, a major constraint to the management of livestock in Nepal is the shortage of forage. This is particularly acute in the dry season which extends from October to April. Kiff et al. (1999) cited (Pande, 1997) who estimated that there is a 54% deficit in the supply of green forage. It seems likely that the resource poorest farmers (particularly those who are landless) experience an even greater deficit in forage supply. An invasive weed, known locally as 'banmara' grows throughout Nepal. It persists throughout the dry season, growing on roadsides and degraded land, and could potentially be used as a source of forage in the dry season. There are two species of banmara in Nepal. In the low-lying Gangetic plains (the 'Terai'), the plant known as banmara is *Chromolaena odorata*. In the mid hills, it is the plant *Eupatorium adenophorum*. With both species, voluntary intake is low and so the objective of the first phase of the project was to determine whether a simple treatment could be applied to harvested banmara to increase its acceptability by goats.

In addition to the feed shortage in the dry season, disease further reduces the productivity and survivability of the flock. This is particularly an issue in the wet season (Jha et al., 1993; Thakuri et al., 1994a), and studies indicate that helminth infection is one of the commonest diseases affecting goats at this time (Thakuri et al., 1994a; Knox and Steel, 1996; Khakural, 2001). Thakuri et al. (1994a) demonstrated that nematode infection accounted for 76% of helminth infection, with infection by cestodes being relatively minor in comparison. Khakural (2001) estimated that

helminth infection caused losses of productivity of approximately 33% in goat flocks in Nepal. Developing an appropriate means of reducing the losses to the goat flock caused by disease (specifically helminth infection) in the wet season was therefore a second objective of this project.

Consultation with participating farmers in the project also revealed that an additional constraint to goat productivity was doe infertility. Many of the farmers said that they sold their doe if she failed to conceive after two services, and the small number of multiparous does in the project communities suggested that failure to get does to conceive a second time after their first kidding was a frequent occurrence. Developing appropriate means of improving doe fertility and productivity was therefore the third major objective of the project.

Previous findings

Increasing the availability of forage for livestock

For resource poor (and particularly landless) farmers, efforts to ease forage scarcity in the dry season should focus on means of increasing the availability of off farm forage resources. The uptake of technologies to conserve green forage when it is growing abundantly (in the wet season) has been very low. Ensiling is not a feasible technique, as it requires the purchase of relatively expensive materials, and it also requires a high labour input at a time when other farm activities also require high labour inputs (Kilduff et al., 1990). With regard to the supply of tree fodder, the availability of off farm forest resources is variable. Responsibility for the management of village forest areas in Nepal is being handed over by the government to community based Forest User Groups (FUGs). The effect of this on forage availability can be positive or negative. Some FUGs have reduced access to the forest for their members to 'prove' their ability to conserve the forest resource. In other areas, members report improved access to the forest resource (Kiff et al., 1999). For resource poor people, there is a great reliance on having access to the forest to source their fuelwood, timber and forage. Common pasture land is another potential forage resource, but in many areas the need to increase agricultural productivity has led to a greater use of this resource until it has exceeded its regenerative capacity (Kiff et al., 1999).

In areas where forest or pasture land has been degraded, other species have invaded. Banmara (*Chromolaena odorata* in the low-lying plains and *Eupatorium adenophorum* in the mid hills) are two such invasive species. *E. adenophorum* is indigenous to Mexico, but has been introduced to Hawaii, the Philippines, Thailand, New Zealand, Australia, India, Nepal, Sikkim and California (Oelrichs et al., 1995). *C. odorata* is found in western and southern Africa, south and south east Asia and Oceania (McFadyen, 1996). Banmara was first seen in eastern Nepal in the late 1970s, but it has gradually moved westward and is now ubiquitous throughout Nepal (J. Abington, pers. comm.). The high reproductive capacity and light windborne fruits of *E. adenophorum* make it particularly well adapted to colonizing bare or intermittently bare areas (Auld, 1981). This characterises much of the Nepalese landscape during the dry season. It also rapidly colonises an area after fire (Tripathi and Yadav, 1987) and since many Nepalese forest users will use fire to control weed growth, this also encourages the spread of banmara. *C. odorata* is similarly invasive because of its rapid vegetative development and massive production of airborne seeds (Weise and Tchamou, 1999). Once it has colonised an area, it is very successful at competing with other species because of its allelopathic properties. Allelopathic properties have been observed in both *E. adenophorum* (Tripathi et al., 1981; Rai and Tripathi, 1982; Jha and Yadav, 1985; Angiras et al., 1987, 1988, 1989; Narayan et al., 1994; Rajbanshi and Inubushi, 1998) and *C. odorata* (Gieh and Sajise, 1980) . *C. odorata* also shades out competing plants which further helps to establish its dominance (Gieh and Sajise, 1980).

The year-round luxuriant growth of banmara means that it could be used as a feed for livestock. Some work has been done in this area, although relatively little compared with the efforts that have been made to control the spread of the plants. Visitpanich and Falvey (1979) investigated the use of *E. adenophorum* as a basal feed for rabbits, while Gatmaitan (1975) fed *C. odorata* to rabbits, goats and cattle. When using these plant species as a feed, there is the fear that they may be toxic. It has been shown that *E. adenophorum* is toxic to horses (O'Sullivan, 1985), mice (Sani et al., 1992; Oelrichs et al., 1995) and rats (Katoch et al., 2000). The toxin present in *E. adenophorum* has been identified as 9-oxo-10,11-dehydroagerophorone (Oelrichs et al., 1995). However, other species of domestic animals do not appear to be affected by the plant (Sani et al., 1992). When Aryal et al. (1994) fed goats *E. adenophorum*

and concentrates for one year, they found that the liveweight gain of these goats was no different from goats fed other local forages and concentrates. They did observe, however, that the intake of *E. adenophorum* was low compared with the 'local forages', and this was associated with a lower production of meat, and a significant increase in the weight of the liver and kidneys. Neopane et al. (1992) observed no significant differences between three groups of young, female goats fed 0, 33 or 67% *E. adenophorum* in their forage mixture in terms of their growth or reproductive performance over two years. Gurung et al. (1996) also found no adverse effect on the growth and reproductive performance of goats fed forage which consisted of 50% *E. adenophorum*. However, in all these experiments, the voluntary intake of *E. adenophorum* was much lower then that of the 'local' forage. Verma et al. (1987) also observed that the intake of *E. adenophorum* was low compared with grasses, and this resulted in a lower growth rate in calves. There are few reports of toxicity associated with *C. odorata*, but it was reported by Martin and Reyes (1994) that feeding *C. odorata* to goats caused an increase in pulse and respiration rate, as well as a progressive loss of body weight.

Verma et al. (1987) noted that *E. adenophorum* was unpalatable, and attributed this to the presence of secondary plant metabolites such as alkaloids, anthocyanine, flavones, flavenols and glycosides. They tried to overcome this constraint by treating the plant with either alkali (1% NaOH solution) or water. Treating the plant with water did increase its intake, and also the digestibility of protein and fibre. However, the performance of calves fed treated *E. adenophorum* was still only 29% of the growth rate observed in calves fed grass and concentrates. Ansari et al. (1983) observed the presence of isohexacosone, n-hexacosanic acid, β-amyrin, stigmasterol, lupeol, taraxasterol, salvigenin and epifriedelinol in the leaves and shoots of *E. adenophorum*. Ding et al. (1994) also observed the presence of terpenes and phenol ethers in the lipid fraction of the plant. However, its nutritive value was good, with a high crude protein content (182 g/kg DM). Its neutral detergent fibre content (458 g/kg DM) was also reasonable (Neopane et al., 1992). The tannin content of *E. adenophorum* is quite high (29.6 g/kg DM, Neopane et al., 1992) which may reduce both palatability and digestibility. However, it may also confer anthelmintic properties on the plant, which may increase its value as a feed supplement for other species of livestock. The nutritive value of *C. odorata* is also good; the crude protein content of leaves is 258

g/kg DM, while the concentrations of fibre and some anti-nutritional factors are low (neutral detergent fibre 331 g/kg DM, acid detergent lignin 53.1 g/kg DM, total extractable phenolics 37.1, extracted condensed tannins 1.4 g/kg DM; Apori et al., 2000).

Control of helminth infection in goats

Animals develop resistance to helminth parasites, although goats are less resistant to nematode infection than other ruminant species (Etter et al., 2000). However, when nutrition is limiting, the immune response suffers to a greater extent than other functions such as lactation or reproduction (Houdijk et al., 2001). This means that the immune response is sensitive to changes in nutrient supply (Coop and Holmes, 1996), and so improving the nutrition of goats at critical times of the year should increase their resistance to nematode infection. Indeed, it has been observed that when goats' diets were supplemented with protein, their worm burden was reduced (Knox and Steel, 1996; Handayani et al., 1988; Chartier et al., 2000; Etter et al., 2000). Supplementing sheep's diets with legumes also reduced faecal egg count, although it had no effect on lamb mortality or growth rate (Handayani and Gatenby, 1988). Knox and Steel (1996) also observed that if the diet was only supplemented with non-protein nitrogen (in the form of urea), no beneficial effects were observed, and supplementation with true protein was also required.

A more direct approach to reducing losses from nematode infection in the wet season would be the strategic use of anthelmintics, either purchased or prepared from locally available materials. As would be expected, treating infected goats with anthelmintics reduced faecal egg counts (Handayani et al., 1986; Handayani and Gatenby, 1988) and goat mortality (Handayani and Gatenby, 1988). Joshi (1998) recommended that gastrointestinal nematode infection in Nepalese goats be controlled by the strategic dosing of flocks with a proprietary anthelmintic at the beginning and end of the wet season. The cost of such treatment is approximately NRs 20 (£0.16) per goat per annum. Herbal remedies ('krimos powder') that are used in Nepal instead of commercial anthelmintics were found to be ineffective (Thakuri et al., 1994b; Kushuwaha, 2001). However, many tanniniferous forages do appear to have anthelmintic activity, with the tannins having a direct, toxic effect on the nematode (Butter et al., 2001). Tannins are a large family of secondary plant compounds, and

the efficacy of different tanniniferous forages depends primarily on the tannin that they contain, and on the concentration of that tannin in the plant. The tannin needs to be in direct contact with the nematode to be effective, and so lumen dwelling nematodes that consume some digesta (in addition to blood and gut tissue) will be more susceptible to dietary tannins than mucosal dwelling nematodes (Butter et al., 2001). Another potential anthelmintic is a preparation made from the hairs taken from the pod of *Mucuna pruriens*. This has been used successfully in the Karnataka project area of Project R6953 (*Easing seasonal feed scarcity*), and in addition to reduced worm burdens, it was associated with a reduction in the time taken to get does back into kid again (C. Conroy, pers. comm.).

The use of both dietary supplementation and treatment with some form of anthelmintic may have a synergistic effect on the health and productivity of the animal. However, the evidence for this in goats is unclear. When Gurung et al. (1994) supplemented goats with mustard cake, or treated them with anthelmintic, there was an increase in daily liveweight gain compared with untreated controls. However, there was no further increase in growth rate when the goats were treated with both mustard cake and anthelmintic. On the other hand, in an experiment reported by Shrestha et al. (1990), the greatest increase in growth rate was observed when goats received both supplementary feed and anthelmintic. The supplementary feed used in this example was maize grain, which is a high energy but low protein feed compared with mustard cake, which is a source of protein rather than energy. This would suggest that it is energy, not protein, which is the first limiting nutrient.

Dietary strategies to improve fertility

A refinement to the approach of improving general goat nutrition would be to target improved nutrition on the most susceptible goats in the flock. These are likely to be the kids and lactating does. Kid mortality in Nepal is high; 41% of reported deaths in goats were in kids less than three months old (Jha et al., 1993). In Indonesia, it was estimated that the mortality rate of kids was also high (26%, Gatenby, 1988), and in Udaipur resource poor farmers identified kid mortality in the wet season as being the key constraint to goat production (Sharma et al., 2000). The most effective way to improve kid nutrition is to improve the yield and quality of milk produced by their mothers (particularly in cultures such as Nepal where the milk is not used for human

consumption). Improving the nutrition of the doe, particularly in early lactation, will increase her milk yield and quality, and will also reduce the time taken to get her back in kid again. The targeted supplementation of the does' diet in early lactation may therefore help reduce kid mortality, improve the reproductive efficiency of the doe, and help both the kid and the doe to withstand nematode infection in the wet season.

Identification of communities

The original aim of the project was to work in both the middle hills and the Gangetic plain (the 'Terai') of Nepal, so as to widen the ecological diversity and range of farming systems in the study. For the first phase of the project, therefore, communities were identified in both the hills (Kavrepalonchowk and Makawanpur districts) and the Terai (Dhanusha district). Within these districts, communities were selected so as to represent a range of ethnic groups, social diversity, livelihood opportunities and access to local markets. An initial participatory rural appraisal (PRA) was done with twelve communities in these districts, after which it was decided to concentrate on Makawanpur in the hills and Dhanusha in the Terai. A longitudinal study over six months was then done with a total of four in these districts (two communities per district), in the course of which the constraints associated with goat-keeping were identified. In the second phase of the study, the work was focussed on Dhanusha district in the Terai as the political situation in the hills was more unpredictable and there was the risk that field work in this area could not be continued.

PROJECT PURPOSE

The purpose of the project was to develop appropriate strategies for improving the productivity of goats kept by resource-poor farmers in the forest-agriculture production system of Nepal. Three different approaches were taken during the project to achieve this. The first was to ease feed scarcity during the dry season by the development of banmara as a forage resource. The second was to investigate different strategies to reduce the losses from disease during the wet season. The third was to investigate a means of increasing doe productivity by the strategic supplementation of does' diets.

RESEARCH ACTIVITIES: METHODOLOGIES

The constraints that were identified and the strategies that were investigated to alleviate those constraints were decided by the farmers and the 'research team' using a participatory approach throughout the project.

Participatory Rural Appraisal

Community selection and data collection

Twelve communities were selected by a project team of senior staff from New ERA together with a representative from either the Nepal Agricultural Research Council (NARC) or the Nepal Agroforestry Foundation (NAF). New ERA, NARC and NAF were the three Nepal-based collaborators involved in this project. The twelve communities (four from each district) were selected from Dhanusha district (in the Terai), and from Makawanpur and Kavre in the hills, with the aim of surveying a range of communities that would represent social diversity (in terms of ethnic group or caste) and with a variety of livelihoods choices. Two teams were used, one for the Terai and one for the hill sites. Each team was composed of a local facilitator and others who were experienced PRA facilitators. In each community, four exercises were carried out. Firstly, a short community meeting was held to introduce the project and the PRA process. After this, social and resource mapping involving as many people as possible from the community was done, and then a livelihoods strategies matrix was constructed, being done separately by men and women. Objective and activities were scored by each community, and these were analysed to determine their relative importance. Finally, there was a wrap-up session, in which the community was thanked, information from the community was fed back, and the community's willingness to participate in a longer term study was investigated.

Longitudinal study

Selection of communities

The aim of this study was to confirm the findings of the PRA and determine the relative importance of goats in the livelihoods of resource poor goat-keepers in both Makawanpur (hill) and Dhanusha (Terai) districts, and the key constraints associated with goat-keeping. As in the PRA, communities were selected that together would

represent social diversity, a variety of livelihood choices and ecological diversity. Other factors considered included the representation of different ethnic groups and different accessibility to a market. An important definition of community was 'belongingness' and an individual community had to contain at least 20 goat-keeping households. The largest community might be a ward (an administrative unit), while the smallest was a single settlement within a ward. Communities were selected by a project team of senior staff from New ERA together with a representative from either NARC or NAF.

In each district, one community was selected as a focus community based on information from local key informants. Additional communities were then selected randomly within the vicinity of the focus community. Using a map of the district, a line was drawn around the focus representing the total area that was practical for a field team to cover, and this then represented the site for the district. Sources of information such as the Village Development Centre, the Department of Livestock Services (DLS) district office, teachers and DLS subcentres were then used to draw up a list of communities within the designated area with the necessary criteria. From that list, four or five communities were then selected at random. An initial visit was made to the first three communities selected, to check suitability and interest in participating. If a community proved ineligible, then an alternative from the sample was visited. The objectives of community size and diversity in ethnic groups were achieved, but an even distribution of distance from a market was not, although in hindsight this appeared to have been the least important factor.

The communities selected were Ailakh and Okarghaun in Makawanpur and Kemalipur and Jamunibas in Dhanusha. Ailakh was a small (33 households), predominantly Chhettri community, while Okarghaun (85 households) and Kemalipur (70 households) were somewhat larger and Jamunibas (170 households) was the largest of all. Kemalipur and Jamunibas were of mixed ethnicity whereas Okargahaun was predominantly Tamang. Okarghaun was reported to have smaller family sizes and a lower literacy rate than Ailakh, while Kemalipur was reported to have larger family sizes and a lower literacy rate than Jamunibas. The farming systems in the two hill communities and in the two Terai communities appeared to be similar.

Selection of households

In each community, 20 goat-keeping households were selected, with representation from poor and less poor households. A range of criteria for defining poor, medium and rich households had already been described by each community during the PRA, and included land size and quality, ability to grow sufficient food to feed the family, livestock owned, sources of income and education of children. The community members took part in a wealth ranking exercise to select participants for the study. All of the goats owned by each participating household were monitored. This allowed observations to be made of flock dynamics and flock management, which would not have been possible if only part of each flock had been monitored.

A site visit was made to each community by a supervisor from New ERA and one of the PRA team to profile the community and select participating households. At this stage the recording forms were tested with one participating household from each site so that any necessary revision could be made before the start of the study. Six visits were made to each community at monthly intervals starting in March/April 2001. The period covered the end of the dry season (March-May) and the first part of the rainy season. The intention was to cover the period of forage scarcity (end of the dry season) and the time of high goat mortality (beginning of the wet season).

Observations made

Recording was done at monthly intervals using a combination of questionnaires and observation. Observations made included:

- Household and resources
- Contribution of different activities to livelihoods objectives
- Structure of the goat flock
- Goat mortality, sales and reproduction
- Goat feeding and health.

Activities for the first visit

On the first visit, norms and values related to goat-keeping were discussed. This was done by a group interview with representation from each participating household and including both men and women. Each household was then interviewed separately, and at each visit, various recording forms for each household were updated. Individual goat recording forms were set up for each goat in the flock of each participating household. These forms detailed the goat's sex, age category and source (eg. whether it was home-bred or bought). A record for each goat of cases of sickness and treatments, grazing activities and supplementary feeding over the previous week and body condition at the time of the visit was also made. Health and feeding were only recorded for the previous week at each visit in order to be sure of good recall of detail. Each household was also asked to describe its forage collection activities in the week prior to the visit and this information was entered on a household forage recording form. Again, data were only requested for the previous week to improve the accuracy of recall. The project facilitator and the household also completed a household livelihood recording form at each visit. This recorded the contribution of farm and non-farm activities to livelihood objectives in the previous month, and included an estimate of income from each activity. Although the absolute estimates of income might lack precision, it was expected that the relative amounts earned by each household activity would be sufficiently accurate for the purposes of the study. Some activities, such as sales of animals, might occur once or less in a month, while others, such as the sale of vegetables, might occur weekly or twice weekly during the growing season. It was therefore important for these data that information for the whole month was collected rather than just for the week prior to the visit.

On the third visit, a list of household resources (land, crops, livestock, type of house, human resources and major capital items) was also made. This was delayed until the third visit to allow the participating households and the research team time to get to know each other as some of the information requested was potentially sensitive. After the final visit a summary of the results obtained were fed back to the group of participants. A wrap-up session then thanked the participants for their involvement and explained the future progress of the project.

Data analysis

Data were entered into SPSS, checked and then exported to Excel for analysis. Data analysis consisted of summaries, graphs and simple descriptive statistics. The very small number of communities and the purposive selection of the study area in each district meant that each community was treated as a case study and for the most part each community was analysed separately. As there were 20 households and over 400 goats monitored in each community, the sample size was large enough to produce meaningful production and livelihoods parameters. As described before, the monitored households were not selected randomly, but rather they were chosen to provide, as far as possible, a representative sample of wealth among goat-keepers.

Group meetings

Following the PRA and longitudinal survey in Dhanusha and Makawanpur, the project then focussed on Dhanusha district (in the Terai) as the project team were more confident that long term studies could be done here because of a more stable political situation in this area. Two experiments were then conducted in this district, in four different communities. The communities selected were Jamunibas and Kemalipur (as the previous studies had already provided baseline data from these communities and a relationship between the research team and the communities had been established). Two other communities (Baluwa Bhiman and Birendra Bazaar) were also added to the study at this time. These communities were selected as visits to the district had identified them as being poor, with few other livelihood choices, and goat-keeping was already an established part of their livelihoods activities. In each of these four communities, 20 households were selected on the basis of them being motivated to join the study and keeping between three and ten goats each. Some of the less poor households that had been involved in the previous studies were therefore excluded, and the study focussed more on the impact that interventions to improve goat health and productivity might have on the livelihoods of the poorest members of the community.

Two experiments were conducted (one to assess the effectiveness of different strategies to reduce helminth infection in the wet season, and one to increase doe productivity). At the beginning and end of each experiment, meetings were held with

all the participating farmers in each community to discuss the objectives of the experiment, how it might be implemented, and then to obtain feedback from the farmers on their evaluation of the different treatments.

Alleviating feed shortages in the dry season

The aim of this series of experiments was to develop a means of increasing the voluntary intake of banmara, a pernicious weed that grows throughout Nepal and persists throughout the dry season but which is generally avoided by goats when taken out to browse.

Effect of different treatments on the chemical composition of banmara

Samples of the two species of banmara (*C. odorata* in the Terai and *E. adenophorum* in the hills) were collected from Dhanusha and Makawanpur sites in November 2000. Each sample was divided into three, and either left untreated (U), soaked in water for 2 h (S) or spread out and left to dry in the sun for 2 h (W). All samples were then oven dried (60^0C) and ground (1 mm screen). The samples were analysed for crude protein (CP), ether extract (EE), acid detergent fibre (ADF) and neutral detergent fibre (NDF). They were also incubated with buffered rumen fluid for 72 h, and the in vitro organic matter degradability (IVOMD) after this time was estimated.

Effect of different treatments on the short term intake rate of banmara

A range of treatments were screened using the short term intake rate (STIR) technique to assess the effect of treatment on potential dry matter intake. This experiment was conducted at the Nepal Agricultural Research Council's Goat Research station in Bandipur. Eight does (initial liveweight 13.8 kg) were used in this experiment. They were fed a basal diet of (g/kg liveweight, fresh weight basis) khanayo 53, napier 60 and banmara (*E. adenophorum*) 11. They were adapted to this diet for 14 d before commencing the estimation of the short term intake rate of banmara.

Treatments of banmara that were investigated were untreated banmara (UTB), soaking in water for 2 (S2), 16 (S16) or 24 h (S24), wilting for 2 (W2), 6 (W6), 16 (W16), 24 (W24) and 48 h (W48) and hanging untreated banmara in bunches (B) above the goats' heads. Following the adaptation period, the STIR values for each

treatment were estimated. Estimates of STIR were made on Monday, Wednesday and Friday of three consecutive weeks. The protocol used to estimate STIR was to feed, on a testing day, 25% of the day's allocation of feed. After 1 h, all feed was removed from the bowl, and 4 h later a sample (500 g fresh weight) of the test feed was put before the doe. The doe was then closely observed for 5 min, and the time spent actively eating was recorded using a stopwatch. At the end of this 5 min period, all the feed was removed from the bowl and the refusals weighed. After 20 min, the process was repeated with a second test feed. Four banmara treatments were tested with each doe on each testing day. At the end of the testing period, the remaining 75% of the day's allocation of feed was offered.

The STIR value for each feed was calculated using the equation:

$$\text{STIR (g DM/min/kg metabolic body size)} = (W_1\text{-}W_2)/(T\text{x}M^{0.75})$$

where W_1, W_2 are the dry matter weights (g) of offered and refused feed respectively, T is the time (min) spent actively eating and M is the liveweight (kg) of the animal. The predicted dry matter intake of each feed was then calculated using data supplied by Dr D.L. Romney (pers. comm.) in which observations of STIR for a range of different feeds and mixtures were regressed with observed dry matter intakes of the feeds. The equation used was:

$$\text{Predicted dry matter intake (PDMI, g DM/kg liveweight}^{0.75}) = (82.9 \text{ STIR}) + 17.9$$

This was then converted to predicted dry matter intake (g DM/head day) by multiplying PDMI by $M^{0.75}$. The effect of treatment on estimates of STIR and PDMI (g/head day) was estimated using analysis of variance, after taking account of the effect of animal and day.

Effect of treatment on banmara intake

The two most promising treatments identified from the experiment with the STIR technique were then evaluated. This was again done at the Nepal Agricultural Research Council's Goat Research station at Bandipur. These two banmara treatments were compared with untreated banmara in terms of their voluntary intake by goats. A total of 24 goats were used in this experiment. They were housed in

individual pens in a covered house, and fed individually. Clean, fresh water was always available. Following a two week adaptation period, there was a four week experimental period. During this time, the intake of each feed was measured daily for each goat. Liveweight was measured at weekly intervals. The goats were divided into one of six groups, and fed one of the diets indicated in Table 1.

The forage mixture was offered to the goats each morning, after the previous day's refusals had been removed. Each goat also received a commercial concentrate (1% of liveweight on an as fed basis). The dry matter content of feeds and refusals were estimated by oven drying to constant weight at 105^0C. The effect of banmara treatment, the level of inclusion of banmara in the forage mixture, and the interaction between these two main effects, was investigated using analysis of variance. The responses that were investigated were the intake of banmara, total dry matter intake, and liveweight change.

Effect of wilting on forage chemical composition and digestibility

There was some evidence from the in vitro characterisation of banmara that wilting increased the in vitro organic matter degradability of the plant. To determine whether this effect was also observed with other forages typically used by participating farmers in the project, samples (3 kg freshweight) of tree forages commonly used by goat-keepers in Dhanusha district were collected from the Jamunibas area in November 2001. Forages collected were leaves from aule (botanical name not known), sakhuwa (*Shorea robusta*), dudhelahara (botanical name not known), hade (*Zizyphus incurve*), biralli (botanical name not known) and dabdabe (*Garuga pinnata*). Each sample was wilted for 48 hours before subsampling. Half of each sample was then oven dried (100°C) at the laboratories at NARC, Kathmandu while the other half was sun dried for 10 hours. All the samples were then taken to the UK where the sun dried samples were oven dried at 100°C for 24 hours. All samples were then ground through a 1 mm screen. All samples were analysed for ash, crude protein, neutral detergent fibre and acid detergent fibre, and the rumen degradability of their organic matter was estimated in vitro following incubation (72 h) with buffered rumen fluid.

Reducing the incidence of disease in the wet season

Communities

Four communities in Dhanusha district were involved in this study. These were Jamunibas, Kemalipur, Baluwa Bhiman and Birendra Bazaar. Jamunibas and Baluwa Bhiman were relatively close to a road (less than 10 minutes by jeep), while Kemalipur and Birendra Bazaar were relatively distant. Within each village, 20 households were selected that represented both poor (average monthly income <NRs 2000, US$27) and less poor households (average monthly income >NRs 2000, US$27). In each village, households were randomly allocated to one of five treatment groups

Treatments

Five treatments were applied to all adult goats in a household's flock. Each household was treated as a block. The first treatment (ANT) was the administration of anthelmintic (fenbendazole and oxoclozanide) in July and September. The second treatment (NUT) was the inclusion of ground maize in the diet of goats for two months from August to October. The amounts of maize fed were 100 g/d for goats over eight months old, and 50 g/d for goats aged between four and eight months. The third treatment (A+N) involved administering anthelmintic (in the same way as for ANT) and supplementing the diet with ground maize (in the same way as for NUT). The fourth treatment (VIT) involved the supplementation of the diet with a vitamin and mineral supplement while the fifth treatment (TON) involved the application of a digestive tonic. The fifth treatment was taken to be the control, with farmers employing their normal husbandry practices in the management of their goats. The tonic was considered to be a placebo, and included in the experiment to maintain the commitment of farmers in the control group. Goats and households were monitored at fortnightly intervals for four months from July to November. These data were collected by New ERA, with veterinary support being given by the Animal Health Research Division of the Nepal Agricultural Research Council.

All goats were vaccinated against *pestes des petits ruminantes* (PPR), either by His Majesty's Government of Nepal's Department of Livestock Services, or (if this had not been done) by the project. The inputs of maize, anthelmintic, vitamin and mineral

mixture and digestive tonic were provided by the project. It was recognised that these inputs represented a high cost to the farmers, but the objective was to determine whether these inputs had a significant impact on the livelihoods of resource poor livestock keepers, with a view to developing a more strategic use of inputs in future experiments if this experiment was successful.

Household economics

Local facilitators were appointed in each village, and at fortnightly intervals for four months (August- November 2002) they visited each participating household. At the initial visit, the physical, human, natural and social resources of the household were recorded. At subsequent visits, householders were questioned on their sources and size of income since the last visit.

Monitoring goat performance

At the initial visit by the facilitators to each household, the size and composition of the goat flock was described. Each goat was allocated an individual record card, which described the goat (age, sex, breed, parity if a doe, initial live-weight and condition score). During the facilitators' fortnightly visit to each household, these records were updated to note if a doe had kidded, and if the goat had left the flock. The reasons for exits from the flock were noted, and if the goat was sold, the price obtained was also recorded. If a goat entered the flock, a record card was made up for it, which also noted how the goat had entered (through birth, purchase, gift, etc.). At monthly intervals, the goats were weighed and their condition score noted.

Recording the incidence of disease in goats

A veterinary technician (VT) was recruited by the project to monitor the incidence of disease in the goats. When a goat was sick, the VT was called to make a provisional diagnosis and recommend treatment. Both the farmer and the VT took a detailed case history of the goat. These case histories were then compared, and a diagnosis of the goat's disease made by the Animal Health Research Division of the Nepal Agricultural Research Council.

Analysis of results

The effects of community, treatment and community x treatment interaction on a range of parameters were determined using analysis of variance. Parameters that were investigated were total household income, income from goats, incidence of disease and death in the goat herd (per goat at the beginning of the study), live-weight change in the goats (excluding does that kidded during the study) and changes in the asset value of goats during the study. Analysis of variance could not be used to investigate the effect of treatment and community on the sale price of goats because of insufficient data, but descriptive statistics to illustrate the effect of time of sale and treatment on sale price were produced.

Farmer evaluation

At the end of the experiment, each community was visited and asked to report their findings from this experiment. All meetings were facilitated by the same person and attended by representatives of the participating research organizations. Farmers were asked what differences they had observed between households, and within households when compared with previous years. They were also asked which treatment they considered to have been the most beneficial. The results of this analysis were compared with the objective measurements that had been made by linear regression.

Improving doe productivity

The objective of this study was to develop an appropriate means of increasing doe productivity, assessed in terms of the number of weaned kids produced by a doe in a year.

Communities

The same households and communities that were involved in the experiment investigating different strategies to reduce the incidence of disease in the wet season were involved in this experiment.

Treatments

All goats were treated with broad spectrum anthelmintics (fenbendazole and oxoclozanide) in May and September (at the beginning and end of the wet season) and vaccinated against PPR. Other than this, goats were managed according to normal practice throughout the experiment apart from the use of the intervention that was being investigated.

Households were randomly divided into three treatment groups. It was assumed there was no carry-over effect from the previous experiment. The treatments investigated were:

1. DMZ: Does' diets were supplemented with 100 g/d ground maize for two weeks before and six weeks after kidding (n=7 per community).

2. DSE: Does' diets were supplemented with 500 mg selenium and 50 mg Vitamin E for two weeks before and six weeks after kidding (n=7 per community).

3. CON: Does were managed according to normal practice, but finishing goats were supplemented with ground maize (100 g/d) for three weeks before sale (n=6 per community).

Observations made

Individual records of all goats (entries, exits, incidences of disease, reasons for exit and the price obtained (if sold) were maintained by facilitators in each community visiting participating households at fortnightly intervals. Live weight was recorded at monthly intervals, except in the case of pregnant does. In addition, regular records of household income and sources of that income were kept, as were records of the level of household debt. The mean prices obtained from the sale of adult (more than eight months) male and female goats and young (less than eight months) male and female goats were used to calculate the asset value of each goat flock at the beginning and end of the experiment. The effects of treatment, community and interaction between treatment and community on doe productivity, live- weight gain of does and kids

post-partum, income from goat sales and asset value of the goat flocks were estimated by analysis of variance.

Evaluation of the market for goats in Nepal

The objective of this study was to determine how decisions were made by farmers as to when and where to sell goats. The aim was also to determine what factors determined the price obtained from the sale of goats, whether the market was near saturation and what scope there was for expanding goat production by resource poor livestock keepers in the project area. Data were therefore collected by staff in New ERA and the Nepal Agroforestry Foundation from farmers, local traders, butchers and large traders. Focus group discussion was the tool used to collect information from the selected farmers while an interview method was applied to collect data from local traders, butchers and large traders. The questions were asked, probes were made where suitable and the answers were taped as well as noted for report writing.

Farmers

At each of the sites of Jamunibas, Baluwa Bhiman, Kemalipur and Birendra Bazaar, a separate group of farmers were selected randomly for the focus group discussion. Seven women and five men at Jamunibas, five women and seven men at Baluwa Bhiman, eight women and four men at Birendra Bazaar, and seven women and four men at Kemalipur were involved in the focus group discussion.

Farmers were asked who they sold goats to, what proportion of sales went to each destination and whether this changed in different months. They were also asked how the prices for goats were determined, and whether farmers, individual traders or the local market used different criteria. They were then asked if there was any seasonality in the use of goats for home consumption, and how they decided which goats to sell live, which ones were to be slaughtered for sale, and which ones were to be used for home consumption. Finally, they were asked if there was ever a local shortage of supply of goats for slaughter, and whether they thought there would be a market for more goats if they were to be produced locally.

Traders

Seven local traders and five larger traders were interviewed at the local market. The contact details of the local traders had been provided by the farmers. They were all asked who they bought goats from, who they sold to and what proportion of goat sales went to each destination. They were asked what the seasonal pattern was for demand in goats, and whether this changed much from year to year. They were also asked how they determined the prices for goats and what problems they experienced in their work. They were then asked whether they would be likely to buy more goats were they to be available, and what an increased supply of goats might do to the goat price. They were also asked whether this would depend on whether the goats were of a local or 'exotic' breed.

Butchers

Five butchers were interviewed in this survey. Four of them were from Janakpur (the nearest large town to the project area) and one was from Sakhuwa (near the local weekly market). They were asked the same questions as the traders, although their sales would be of meat rather than live goats.

Evaluation of the most appropriate methods for disseminating knowledge to farmers

The objective of this part of the study was to determine which extension methodologies were considered the most effective by extension agencies and by farmers' groups to inform the project's decision in its choice of upscaling strategy.

A survey was therefore conducted by the Nepal Agroforestry Foundation using a structured questionnaire. Key persons and extension agents working in 24 different institutions were interviewed. The criteria for selection of institutions was to ensure representation of government bodies, research institutes, international non-governmental organisations (INGO), non-governmental organisations (NGO) and farmers' groups. The validity and reliability of the set questionnaire was pre-tested both in English and Nepali with extension professionals, relevant stakeholders, partner collaborators, government officers and NGO. Their comments were used in the revision of the questionnaire before it was used in practice. A second

questionnaire was administered to farmers' groups. These were groups that had been associated with projects managed by the institutions involved in this project. The farmers' questionnaire was also piloted before use with this project's participating farmers. Descriptive statistics were used to analyse the data.

Upscaling activities

A range of upscaling activities was undertaken during the project to communicate the project's outputs to different audiences. The target audience determined the particular upscaling technique that was used, and examples of different institutions involved in the particular uptake pathways are presented below.

Pathway	*Target institutions*
Government	Department of Livestock Services
National Agricultural Research System	Nepal Agricultural Research Council, ICIMOD
National and international NGOs	PLAN
Local NGOs working in project locations (both R7632 and R8109)	MADE Nepal, Nepal Agroforestry Foundation
International donors	DFID-Nepal
Donor-funded projects	APPSP (DFID), Helvetas Rural Access Programme (DFID)
Community	Participating farmers. Neighbours. Communities involved in R8109

Having identified these different pathways, and the appropriate target institutions involved in each pathway, a series of evolving activities were conducted to communicate the emerging messages from the project. The project was also involved

in initiatives from other projects, which spread the information further, and included international audiences.

Stakeholder meetings

Stakeholder meetings, which included all participating farmers, research collaborators and often members of DLS staff, were held twice a year throughout the project. At these meetings, information about the experiment being conducted was shared, and farmers' experiences of different treatments were described and evaluated.

Training courses on goat husbandry

A training course on goat husbandry was held in each village involved in the project, to which all participating farmers were invited. These courses were run by the Nepal Agroforestry Foundation, with input from the Nepal Agricultural Research Council, and covered aspects such as housing, basic husbandry and nutrition and the diagnosis and treatment of common ailments. The project's outputs were also communicated to all farmers as part of this course.

Participation in workshop to national staff

In June 2004 a workshop/conference was held in Kathmandu to which delegates from the Third Livestock Development Programme (Nepal), Heifer Nepal, SSMP, Hill Agricultural Research Programme (Nepal), MADE Nepal and the Nepal Government's Department of Livestock Services contributed. Two papers were produced for this workshop, which described the technical outputs from the project, and also described the socio-economic background of the project's participants.

Participation in international workshops and meetings

The project participated in and presented papers at international workshops held in Tanzania, Kenya and Uganda under the auspices of Livestock Production Programme project R7798. Papers were also presented at the British Society of Animal Science's Annual Meetings in 2002 and 2005. A paper was also presented at an International Conference organised by the British Society of Animal Science, the American Society of Animal Science and the Mexican Society of Animal Production and held in Mexico in 2002.

RESULTS FROM RESEARCH ACTIVITIES

Participatory Rural Appraisal (PRA)

Results from the PRA identified the meeting of household expenses as being the most important livelihood objective. This was followed by the acquisition of protein and fertiliser, the payment of loans and contribution to savings, paying for social activities, the purchase of tools and animals and construction. Livelihood activities that contributed to these objectives were identified as wage labour and the sale of alcohol, other jobs off farm, agriculture, the keeping of goats, keeping of other livestock and the cultivation of cash crops.

The contribution that these various activities made to these objectives were scored from 0 to 4 (0 being an activity that did not contribute in any way to that objective). The contribution that goat-keeping made to the different livelihoods objectives is summarised in Table 2. Goats are an important contributor to livelihoods objectives, particularly the most important one of meeting household expenses.

Longitudinal study

Household composition and resources

The composition of the households in the monitored samples is described in Table 3 and Figure 1. In each community, ten households in the sample (in each community) were classed as 'poor' and ten as 'less poor'. During the study, four households dropped out; in Jamunibas one on the fourth visit and one on the fifth visit, in Okhargaun one on the fifth visit and in Ailakh one on the sixth visit.

Household sizes ranged from two to 15, but the majority were five or six people. Females were less likely than males to have attended school or received some kind of formal education. Ailakh had the largest percentage of study participants who had received education, whereas Jamunibas had the smallest proportion. Age composition was very similar in all the study communities, with around 50% aged 20 years or less and around 70% aged 30 years or less.

The resources belonging to households are summarised in Table 4. In all communities the mean land area farmed by poor households was smaller than for less

poor households. Although all communities were land constrained, this problem appeared to be more acute in the Terai communities of Jamunibas and Kemalipur compared with the hill communities of Ailakh and Okhargaun. In Jamunibas nine households had no land at all for cropping or vegetable growing and in Kemalipur one household was without land. Quality of land is another determinant of wealth (as identified during the PRA), and assessment of land quality includes access to a kitchen garden area and access to irrigation. In Jamunibas only two households had kitchen garden land. In the other communities, at least half had kitchen gardens. Only one household out of 80 had irrigation in the kitchen garden. Of the remainder, 72% (28) of the poor and 28% (15) of the less poor households had no kitchen garden at all. 53% (21) of the poor families and 95% (38) of the less poor families had irrigated crop land, while 23% (9) of the poor families and 3% (1) of the less poor had no arable land.

All of the families owned livestock. It was a condition of the study that each family must keep goats (but other studies have indicated that goat keeping in rural Nepal is widespread (Gurung et al., 1989). Many households also owned poultry and large ruminants. Even households with very small amounts of land owned cattle or buffalo; in one case six large ruminant animals were kept on 0.15 ha. Poor families owned fewer large ruminant animals (mean 2.3) than less poor families (mean 3.8) and only one of the ten families without land owned a large ruminant animal. In Ailakh, Okhargaun and Jamunibas poor families owned fewer goats than less poor households but in Jamunibas this pattern of goat keeping was the other way round.

Households classified as poor tended to own slightly fewer farm and household implements than those classified as less poor. Many families had no large farm implements (plough, bullock cart, sprayer, bull) and no household owned a tractor or thresher. Only four households owned more than one implement. Over half the households owned a radio, television or bicycle but no household owned a motorcycle or other major item of household equipment.

Contribution of goats to household income

Goats were important to livelihoods, although in slightly different ways in the two sites. In terms of income contribution, a different picture emerged in the two districts.

In the Dhanusha communities (Jamunibas and Kemalipur), goats contributed up to 50% of monthly income. In Kemalipur they contributed more in the dry season (from March to about mid May), while in Jamunibas they made a greater contribution in the early wet season (June and July). It later emerged that this was because of a high incidence of disease in this community, with many sick goats being sold, which would ideally have been kept until nearer the major Dashain festival when goat prices are higher. Farm activities in total generated between 5 and 80% of income, contributing a greater proportion of household income in the wet season. Jamunibas households were more reliant on off-farm income while Kemalipur had a wider range of agricultural activities. In the two Makawanpur communities, vegetables were particularly important income generators in the wet season, contributing 80 to 95% of income in the early wet season. In the dry season, vegetables provided no income and their contribution was replaced by non-farm income and to a lesser extent income from goats. Goats appeared to be less important in the Makawanpur communities than the Dhanusha communities, contributing in Makawanpur a maximum of 30% of monthly income. Ailakh, which was nearer to the market, relied more on vegetables while Okhargaun, which was further from the road relied less on vegetables and more on goats.

Income levels per household per month in the Dhanusha communities varied from zero to approximately NRs 40 000 (£380), excluding one unusually high non-farm earning. Over the six month period, the total income earned by each household ranged from NRs 500 (ca £5) to NRs 47 000 (ca £450, excluding the same outlier, where the household made over NRs 250 000, ca £2500 but mostly from one non-farm transaction). This provided an average income per person per day ranging from about £0.01 to £0.50. In the Makawanpur communities, income levels per household per month ranged from zero to approximately NRs 60 000 (ca £570). Over the six month period, the total income earned by each household ranged from NRs 5100 (ca £50) to NRs 136 500 (ca £1300). This provided an average income per person per day ranging from about £0.05 to £1.25.

Although patterns of income generation varied, it was evident that diversity of activities was important to ensure income throughout the year. Goats made some contribution in most months and appeared to fulfil the role of cash generator in times

of crisis, as suggested during the PRA. The end of the dry season was a difficult time for families to feed themselves from agriculture, either directly or from sales of crop products. Goats are potentially available for sale all year round, and in the absence of a strong milk market they are a more consistent source of cash than cows or buffalo. Off farm income is also a very important source, but goats as a source of income are more under the control of the family than off-farm labouring work.

Contribution of income from goats to different livelihoods activities

The contribution that different livelihoods activities made to particular livelihoods objectives is summarised in Table 5. Off-farm income and income from the sale of vegetables were the key sources of income for the purchase of health, education, food and daily household expenses in Makawanpur. In this district, off-farm income was also the main source of finance for social events while income from the sale of vegetables was the main activity used for loan repayments. The income from goats contributed about 7% towards all these activities, but was slightly more important (13%) for social events. In contrast, off-farm income was the single most important livelihood activity with regard to all livelihood objectives in Dhanusha, except for the food purchases when income from poultry became the main source of finance. Income from goats contributed between 12-14% to all livelihood objectives except the purchase of food, when a zero contribution was determined.

Goats made little if any contribution to food consumption in the households during the study period, and seemed to be viewed as a source of cash rather than as a source of meat. This may alter to some extent during major festivals when most goat meat is consumed. However, their contribution to manure production was recognised. It was estimated that 57% of manure production came from goats in Dhanusha, and 54% in Makawanpur. This illustrates that goats do make an indirect (and therefore difficult to quantify) contribution to food production, and also to income from the sale of food produced on the farm.

Flock structure, productivity and health

In agreement with the findings of Gurung et al. (1989), flock sizes of individual households are small, ranging from 1 to 16 animals but with a mean of 5.1 goats.

Land holding of individual households did not seem to affect flock size. The proportion of adult does in the flock ranged from 20 to 60%, but with a mean of 41%.

Exits from the flock in the different communities are summarised in Table 6. The longitudinal study lasted for six months and included the wet season but excluded the main festival period of Dashain and Tihar when goat prices are at a peak. The high exit rate at this time, particularly in the Terai communities and especially in Jamunibas therefore represent a huge opportunity cost to the goat-keepers, particularly when the reasons for sale (which are also presented in Table 6) are taken into account. In Jamunibas in particular, most goat sales seemed to be forced, in that the goats were sold because they were sick and not as a result of strategic planning. Selling sick goats at a time of low goat prices will clearly greatly reduce the income that could potentially be made from keeping goats. There was evidence that the flocks in Jamunibas were affected by an outbreak of PPR, and this serves to indicate the vulnerability of the farmers' livelihoods, and their need to maintain a range of livelihoods activities to provide some security against devastating losses such as this.

The entry rates to the flocks were similar to the exit rates in this six month period (49, 32, 43 and 23% for Kemalipur, Jamunibas, Ailakh and Okhargaun respectively). Most of these entries were as a result of births (58 to 100%). The remainder were purchased, except for a small proportion that was exchanged, found, gifted or shared. Kemalipur was different from the other communities in that its birth rate was much lower (28%), and the remaining entries were split almost equally between purchases and other types of entry. Most goats that were purchased or received as gifts were either adult does (30%) or weaned males (28%).

There were many incidences of disease in the flocks during the study period, which concurs with the observation made during the PRA that disease in the wet season was a major constraint. Morbidity rates in the six month period of the study were 59, 121, 66 and 82% for Kemalipur, Jamunibas, Ailakh and Okhargaun respectively. Farmers rarely reported a named disease that affected their goats, but the symptoms were reported. By far the commonest symptoms reported were a general malaise followed by diarrhoea. The exception to this was Kemalipur, where scabies was the commonest ailment affecting the goats. 59% of the cases reported received treatment of some kind. Generally, treatment was carried out by the goat-keeper (55% of

cases), but other sources were animal health workers (15%), traditional healers (14%) or using medicine provided by a livestock owners' group (14%). The treatments administered are presented in Table 7. Anthelmintic was the most common medicine used and was given for diarrhoea, swollen stomach, general malaise and other symptoms such as swollen head, thinness and in one case an eye problem. Medicine of an unspecified type was also popular. 'Traditional healing' was applied to 24 cases, and several others were treated with home remedies. In total, NRs 2735 (ca £25) was spent on medicines for goats during the six month period. This probably underestimates the total amount that was spent on treating sick goats as home remedies that used materials found in the household or farm, or in kind payments made to traditional healers were not included in the estimate of costs.

Feeding

Many of the goats were taken out to graze at some point during the day, while the rest were entirely stall fed. In Jamunibas, about 70% of the flock were grazed throughout the study period. In other communities, the figure was closer to 50% in the dry season, and declined to around 30% during the wet season. In Ailakh, no goats were grazed in June and July. In Kemalipur and Jamunibas the mean time spent grazing by each goat in a week did not vary much during the study period. In Jamunibas it ranged from 3.7 to 4.5 h while in Kemalipur it ranged from 2.7 to 4.3 h. In Okhargaun it was more variable, ranging from 3.9 h in May to 1.3 h in July. In Ailakh it ranged from 1.4 to 2 h in the dry season, no goats were grazed in June and July and then the mean rose to 7 h in August although few goats were grazing at that time. A summary was made of those who took goats out to graze. Out of 848 records, 49% were of children and 34% were of adult women. Adult women were more likely to take the animals into the forest while children were more likely to supervise them grazing within the farm.

Supplementary feeding was more common in the hill communities of Ailakh and Okhargaun than in the Terai communities of Kemalipur and Jamunibas. Adult males were the most likely to be fed some kind of supplement, either grown on the farm or purchased. As Table 8 indicates, adult males were fed on 90% of possible occasions and were the most likely to be fed in any community. Weaned males, adult females and weaned females were fed less often (78, 75 and 68% respectively) and suckling

animals were the least frequent of all (41%). There was variation between communities. In Okhargaun suckling animals were fed more often than in other communities. Adult and weaned females in Kemalipur were fed less often than those in other communities, and adult males less often in Jamunibas than in other communities.

Adult males and females were equally likely to be fed purchased feed, being fed on 25 and 24% respectively of all possible opportunities. The exception was Kemalipur where purchased feed was given to adult males (20%) and weaned males (17%) and hardly at all to other animals. Younger animals were fed less often, on about 15% of possible opportunities. Expenditure on purchased feed was low, averaging NRs 12 (£0.11) in a week for an adult female, NRs 15 (£0.14) for a male, NRs 8-9 (ca £0.08) for a weaned animal and NRs 6 (£0.05) for a suckling animal. The mean expenditure per family per week was between NRs 6 and 21 (£0.05-0.19). There was no clear seasonal trend in feed purchases. Feeding was done by women and girls of the family 89% of the time, with little variation between communities.

Increasing the availability of forage in the dry season

Effect of treatment on the chemical composition and in vitro degradability of banmara

These results are summarised in Tables 9 and 10. Soaking or wilting had little effect on the chemical composition of banmara, but the ADF/NDF proportion was reduced. Soaking reduced the proportion by 0.060 and 0.024 for *E. adenophorum* and *C. odorata* respectively. The effect of wilting was even greater; 0.102 and 0.130 for *E. adenophorum* and *C. odorata* respectively. This would suggest that soaking to some extent, and wilting to a greater extent would increase the digestibility of these plants. There was a significant ($P<0.001$) interaction between the effect of species and treatment on the organic matter degradability of banmara. While soaking greatly increased the degradability of *C. odorata* it had less effect on *E. adenophorum*. However, as was indicated by the chemical analysis, wilting was effective at increasing the digestibility of both species.

Effect of treatment on the short tem intake rate of banmara by goats

These results are summarised in Table 11. Soaking banmara (*E. adenophorum*) or tying it in bunches above the goat's head tended to reduce intake. However, wilting banmara for 24 or 48 h significantly ($P<0.001$) increased intake. Wilting banmara for 48 h increased the short term intake rate by a factor of 2.6, and the predicted dry matter intake by a factor of 2.1. On the basis of these results it was decided that the treatments to investigate for the longer term estimation of banmara intake were wilting for 24 and 48 h.

Effect of treatment on the voluntary intake of banmara by goats

These results are summarised in Table 12. There was no interaction between wilting time and the proportion of banmara in the forage mixture. Wilting banmara significantly increased its voluntary dry matter intake by goats, although this was not reflected in a significant difference in the liveweight change of the goats. There was, however, a tendency for wilting to increase the liveweight gain of goats when banmara constituted 75% of the forage mixture. A noticeable effect of wilting was to remove the unpleasant smell of the banmara plant, and this may have been the factor that caused the increase in dry matter intake of banmara. As mentioned before, wilting banmara also increased its in vitro digestibility, and increased digestibility as a result of wilting may also explain the greater voluntary intake of wilted banmara compared with untreated banmara.

The dry matter content of banmara was increased by wilting, being 143, 496 and 720 g DM/kg freshweight for wilting times of 0, 24 and 48 h respectively. The (unwilted) samples of *E. adenophorum* that were collected in November, 2000 had an *in vitro* organic matter digestibility of 0.464. If the metabolisable energy (ME) content is predicted as being 0.0157 x DOMD (digestible organic matter in the dry matter), then an ME content of 7.3 MJ/kg DM may be assumed (this does not distinguish between unwilted and wilted banmara). The ME intake from banmara was therefore 2.4, 4.5 and 4.9 MJ/d for wilt times of 0, 24 and 48 h respectively when banmara was offered as the sole forage. The mean initial liveweight of the goats used in this experiment was 14.2 kg, and so their maintenance requirements would be approximately 4.2 MJ/d (AFRC, 1993). The effect of wilting would therefore be that

sufficient banmara would be consumed to meet the maintenance requirements of these goats. Since the goats used in this experiment were mature does, and they were being fed at or near maintenance, this might explain the lack of significant difference between treatments in liveweight change. It is likely that measurements of liveweight were not sufficiently sensitive to distinguish between the small (but important) differences in energy balance that might have occurred between treatments in this experiment.

Effect of wilting on the chemical composition and in vitro degradability of other forages

These results are summarised in Table 13. For all species of forage, the estimated apparent degradability was very low, ranging from 17 to 44%. Although it is likely that in vivo estimates of overall apparent digestibility would be somewhat higher than this, it is notable that the basal forages in the goats' diets are of relatively low quality. There were significant differences between species in their chemical composition, with aule, biralli and dabdabe having a higher crude protein content (mean 112 g/kg DM compared with 91 g/kg DM for the other species). Aule and sakhuwa had much higher ADF and NDF contents and aule had a higher oil content and ADF/NDF proportion than the other species. Hade and dabdabe had a higher non-fibre carbohydrate content (estimated as the residual organic matter content after crude protein, ether extract and NDF had been subtracted) than the other species. Wilting reduced the ADF content of tree forages ($P<0.05$) and the ADF/NDF proportion ($P<0.05$).

There was a significant ($P=0.005$) interaction between species and treatment in the estimation of in vitro organic matter degradability. Although wilting brought about an increase in organic matter degradability for all species, it was only of the order of 6% for sakhuwa and dabdabe, but 17% for dudhelahara, 19% for biralli and as much as 28% for aule and 30% for hade. A multiple linear regression was done, which found a very good relationship (adjusted $R^2=100\%$) between the increase in apparent in vitro organic matter degradability and the crude protein, NDF and NFC contents together with the ADF/NDF proportion. The regression equation was:

Increase in OMD (%) = 233-0.911 CP – 0.324 NDF + 154 ADF/NDF – 0.291 NFC

where CP, NDF and NFC contents are expressed in terms of g/kg DM and ADF/NDF is expressed as a proportion. All regression coefficients were significant ($P<0.01$) and the regression was significant ($P=0.005$). In instances (which would be rare) when this amount of information on the chemical composition of a tree forage was known, this relationship may help determine what the possible response to wilting might be in terms of increasing the digestibility of the forage to ruminant animals. However, it would appear that the rumen degradability (and presumably overall apparent digestibility) of tree forages may be increased by wilting them for some time before offering them to ruminant livestock.

In Figure 2, the estimated digestible crude protein contents (assuming that crude protein digestibility and organic matter degradability coefficients are the same) and estimated ME contents of the six forages are presented. The farmers' evaluation of the forages is also given. These descriptions are the pooled responses from Jamunibas and Kemalipur communities from individual interviews with each participant made during the longitudinal study. There is no clear relationship between the objective and subjective estimates of feeding quality, and thus no indication of objective measures that could be used as criteria for selecting tree forages for goats. All of the forages apart from sakhuwa were valued because the goats liked them. Their availability (which was a value attributed to aule, dabdabe and sakhuwa) will be a function of their growth habits, and so would not be reflected in estimates of digestible nutrients. Hade, which had a relatively high non-fibrous carbohydrate content (418 g/kg DM compared with 75-386 g/kg DM for the other forages) was valued because it gave 'quick satisfaction' to the goats and this might be a result of a rather higher soluble carbohydrate content in this forage compared with others. Biralli and dudhelahara were the two forages valued for being nutritious, however, although on the basis of estimated digestible protein and ME content, this value ought to be attributed to dabdabe, which it was not. Clearly the evaluation of forages by farmers is based on a complex set of information that has been gathered over many years, and which cannot readily be predicted from a relatively limited analysis of a single set of samples of the forages.

Reducing the incidence of disease in the wet season

Description of households and assets

Many of the households from Kemalipur and Jamunibas that were involved in the longitudinal study were also participants in this study, but baseline data from new households in these villages, as well as for all the participating households in Baluwa Bhiman and Birendra Bazaar were collected at the beginning of the experiment. The households were quite consistent across the four villages. Household size ranged from 0-9 males and 1-6 females, but the mean size of household consisted of three males and three females. All the householders owned their own house, the majority of which (77%) had a tiled roof, while the remainder (23%) had a thatched roof. Landholdings were small, the mean size of landholding being 0.25 ha. This ranged from 0-1.3 ha, with 15% of householders of Jamunibas and Kemalipur and 50% of householders in Baluwa Bhiman and Birendra Bazaar owning no land at all. These landless householders appeared to have no access to land either, as they did not grow any crops at all. Land that was held by householders in this project was not irrigated, and mean food self sufficiency across all households was just five months per year.

All householders kept some livestock. No sheep were kept, and half the households kept no chickens. Of the remaining households, the mean number of chickens kept was seven, with a range from 1-19. One household in Baluwa Bhiman kept one pig, but pigs were not kept by any of the other householders. The numbers of large ruminant animals that were kept by the householders are summarised in Table 14. More households in Kemalipur kept at least one buffalo, more than in any of the other villages, while Birendra Bazaar had more households that kept cattle compared with the other villages. There was one very large herd of cattle (24) in Birendra Bazaar, but otherwise the herd size generally ranged from 1-5 for both cattle and buffalo.

The numbers of goats kept by the householders is summarised in Table 15. Keeping goats was a criterion for household selection, and this may have introduced a bias to the results. Flocks ranged in size from 3-10 goats, although Baluwa Bhiman and Birendra Bazaar tended to have slightly smaller flocks compared with Kemalipur and Jamunibas.

There was no significant difference between villages in terms of the monthly income of households (Table 16), although householders in Birendra Bazaar tended to have higher incomes than other villages. This was also the village with larger numbers of cattle compared with the other villages. There were no significant differences (between villages or between treatments) in the mean monthly income made from the sale of goats. This does not reveal the full picture, however, as many households chose not to sell goats throughout the whole of the study period.

Description of goat flocks

There was no significant difference between villages in either the numbers of goats that a household had or in the structure of the flock. The flock structure is summarised in Table 17. Of the five goats that most households owned, two were less than nine months old, and these young goats were evenly divided between males and females. The rest of the flock was almost entirely made up of adult does; on average each household owned 2.4 adult does and only 0.6 adult bucks. This shortage of bucks was noted by the villagers as a constraint, with many does failing to conceive (and being sold for infertility) because of a shortage of bucks. Most goats were a 'local' breed, although there were some cross-bred with an 'exotic' breed, but there were no pure-bred 'exotics'.

There was a significant difference between treatments in the number of young and adult male goats owned by each household. This was an artefact of the allocation of treatments, as this difference was observed at the beginning of the experiment. The number of young adult goats kept by households was 1.6, 0.6, 0.6, 0.6 and 1.0 (sem 0.21, $P<0.01$) for treatments ANT, NUT, A+N, VIT and TON respectively. The corresponding numbers for adult male goats were 0.8, 0.8, 0.4, 0.4, 0.6 (sem 0.18, $P<0.001$). A total of 66 of the does kidded during the experiment, compared with 242 which did not. The number of does per treatment that kidded was 13, 13, 9, 15 and 16 for treatments ANT, NUT, A+N, VIT and TON respectively.

Effect of treatment on the goats' health and liveweight change

There were no significant interactions between community and treatments on the live-weight change or incidence of disease in goats. The effect of treatment on these

parameters is summarised in Table 18. Supplementing the goats' diet with maize significantly ($P<0.05$) reduced the incidence of disease. Treating the goats with anthelmintic significantly ($P<0.001$) increased their live-weight gain during the experiment, especially if this was accompanied with supplementary feeding of maize. There was no significant difference between treatments in the number of deaths, with a mortality rate (during the experiment) of 12.5 %. There was also no evidence of differences between treatments of enforced sales of goats due to sickness, with only three goats in the entire experiment being sold at a time when they were sick.

There were a total of 38 cases of disease reported during the experiment. The commonest causes of disease were respiratory (29 %) and skin (26 %) disorders. Suspected infection with internal parasites accounted for 11 % of reported cases. One case of internal parasite infection was observed in each of the treatment groups, except those that had been treated with anthelmintic (when no cases were observed), and the VIT group that had two suspected cases of infection.

Effect of treatment on the asset value of the flock

The asset values of the goat flocks were predicted by estimating what the sale price of the goats that remained in the flock would have been had they been sold. This was achieved by relating the sale price of the goats that were sold to their sex, age, live-weight and month of sale using best subsets regression. The best fit that was obtained used sex, age and live-weight as predictors, and the relationship that was observed was ($R^2=0.45$, $P<0.001$, s=574.9):

Sale price (NRs) = 1177 - 496 Sex (1=male, 2=female) + 9.07 Age (months) + 53.6 live weight (kg).

The mean asset values of the goat flocks at the beginning of the experiment are presented in Table 19. Flocks that were treated with A+M tended to have a lower

asset value at the beginning of the experiment, and this affected the relative value of these flocks throughout the experiment. The asset value of the flocks, together with the cumulative income from goat sales throughout the experiment, is also summarised in Table 19.

The changes in the combined asset value and sales income of goat flocks during the experiment are illustrated in Figure 3. In the later months of the experiment, there were no significant differences between treatments, but in the first month the differences were almost significant (P=0.10), with treatment A+M resulting in a greater increase in the asset value compared with the control treatment (TON). All treatments tended to result in a greater increase in asset value compared with the control treatment (TON) throughout the whole experiment.

Farmers' evaluation of the treatments

Not all farmers were clear about what the treatment groups had been or indeed what treatment their own goats had received. They obviously knew if their goats had received maize or were on a combined treatment but they were not all able to tell whether they had received the ANT or the VIT treatments. However, when sitting in their groups, they were vocal in discussing the effects they had noticed in their own goats compared with a normal season.

The observations of the farmers about the different treatments are summarized in Table 20. There were no obvious differences between villages in their evaluation of the different treatments. When asked to rank the different treatments, farmers ranked them (in ascending order of usefulness) TON, VIT, NUT, ANT, A+M.

Relationship between farmers' observations and objective measurements

Based on the farmers' ranking of treatments, the treatments were ascribed the following scores: ANT 4, NUT 3, A+M 5, VIT 2, TON 1. These scores were correlated with the mean change in asset value and sale income in the first month, the mean live-weight change during the experiment, and the mean disease incidence (%)

during the experiment. The correlation coefficients between the treatments' score and these assessments were 0.975, 0.865 and –0.527 for the change in asset value, live-weight change and disease incidence respectively. When the change in asset value and live-weight change were regressed with treatment score, the relationship that was observed was:

$$\text{Score} = -0.772(\pm 0.4769) + 0.00883(\pm 0.00144)A + 0.379(\pm 0.1560)B$$

where A is the change in asset value and income from goat sales in the first month of the experiment (in NRs) and B is the live-weight change (in kg) during the experiment. The regression statistics were R^2=0.987, P=0.013, s=0.252.

Discussion

The administration of anthelmintic and the supplementary feeding of maize brought about observable benefits in the health and condition of the goats. Disease incidence was reduced and live-weight gain was increased during the experiment by the application of these treatments. However, compared with the previous year (when the longitudinal study was carried out), the disease incidence was generally lower anyway. This might have been because all goats were vaccinated against PPR and were, therefore, less vulnerable to opportunistic infections. Although helminth infection is an important cause of disease in goats in the wet season, the results of this experiment would suggest that skin and respiratory problems are, if anything, more prevalent, although they may not cause the debilitation that acute helminth infection can bring about.

Disease incidence in goats was only poorly related to live-weight change (r=-0.175) and the change in the asset value of the flock (r=-0.563). These relationships may be stronger in years when general disease incidence is higher. Live-weight change was strongly related to the change in asset values (r=0.758). The poor relationship between disease incidence and other objective parameters may explain why it was not strongly related to the farmers' ranking of the treatments. The evidence from this experiment suggests that farmers will value interventions that result in increased goat live-weight gain (and an increase in the asset value of the flock).

During the farmers' evaluation, it became clear that an important factor constraining goat production in Nepal is a failure to get does back in kid. This may be because of a shortage of bucks (which results in available bucks being overworked), or because of infertility in the doe, or a combination of the two. The ANT, NUT and A+M treatments were valued because the 'goats became fat'. This helped to increase the price that goats would achieve when they were sold. However, these interventions may also help to reduce the losses of does from the flock (as a doe that fails to conceive twice is sold). Improving the health and nutrition of the doe around the time of kidding may help to increase her chances of conceiving again.

This experiment used a relatively high level of input to help demonstrate the beneficial effects such inputs might have. A more strategic targeting of these resources is required if they are to be widely adopted by resource poor goat keepers in Nepal. The strategic timing of anthelmintic administration has been investigated in Nepal, but needs to be demonstrated to farmers. The strategic use of increased supplementary feeding before a planned sale of a male goat, or before and after kidding in a doe, may help bring about an affordable increase in the contribution that goats can make to the livelihoods of resource poor livestock keepers. To investigate the effects of such strategic supplementation of goats' diets became the objective of the final experiment in this project.

Improving doe productivity

Description of households and assets

The households participating in this study were the same as those involved in the previous study and the description of their households and assets were the same as before. During this study, goat sales constituted about 11 per cent of household income, and in some months as much as 56 per cent. Mean household debt was NRs 8468 (£77), which ranged from NRs 0 to 30286 (£0 to 275), and mean monthly income was NRs 2392 (£22), ranging from NRs 597 to 9143 (£35 to 83).

Effect of treatment on doe and kid performance

No interactions between community and treatment were observed. The effect of treatment on doe productivity and live-weight gain of kids and does is summarised in

Table 21. Does that were supplemented with maize kidded more frequently and produced more kids during the experimental period (one year) than does that received either no supplement or were fed supplementary selenium. Does, and the kids they produced, gained more live weight in the month after kidding if they were supplemented with maize compared with does kept on the other regimes.

Effect of treatment on the value of sales and assets of the goat flock

The effect of treatment on the asset value of the flock, income from goat sales and potential income from the goat flock is summarised in Table 22. There was no significant difference between treatments in the asset value of the flocks at the start or end of the experiment, but the change in asset value was affected by treatment ($P<0.05$) with DMZ being associated with a 10 per cent increase in the value of the flock, whereas CON was associated with a 29 per cent decrease in asset value. This was in part offset by the tendency for sales income from goats to be higher with CON than DMZ, but this effect was not significant ($P>0.05$). The net benefit (change in asset value plus sales income) was affected by treatment ($P=0.053$) with DMZ being associated with a 64 per cent return on mean asset value while CON and DSE were associated with returns of 41 and 35 per cent, respectively. This increased potential income from DMZ compared with CON amounted to NRs 1784 (£16). The cost of treatment, with mean adult doe numbers of 2.8 per household, kidding 0.85 times a year, amounted to NRs 133 (£1) per year or on average NRs 3 per week. This is in line with current expenditure for feeding goats, which was observed during the longitudinal study to be between NRs 6 and 21 per week. The strategic targeting of purchased feed resources to does at times of high feed requirements resulted in a net benefit of NRs 1651 (£15). This is equivalent to 19% of mean household debt and 69% of mean household monthly income.

Farmers' evaluation of the treatments

The farmers' evaluations of the different treatments are presented in Tables 23-25. Farmers' evaluation of DMZ was that it had increased doe fertility, halved the kidding interval and increased the value of the kids produced. In all communities, except Birendra Bazaar that reported a shortage of maize, participating farmers, and some of their neighbours, had adopted this technology, although many fed maize less

frequently than in the experiment and many used cereals other than maize, which were often cooked with water (*khole*). Although there was no evidence that selenium affected doe fertility, the farmers' evaluation was that it had caused previously infertile does to conceive and they were keen to adopt this technology.

Conclusions

There was no objective evidence that selenium was a limiting nutrient in this experiment, but energy clearly was. Supplementing goats' diets with energy (in the form of ground maize) improved doe fertility and increased the potential income of the goat flock. In the previous study, it was observed that maize supplementation also reduced the incidence of disease in the wet season, and there was again a tendency for the potential income from the goat flock to be increased. The supply of dietary energy is clearly a key constraint to goat production by resource poor livestock keepers in this area, but finding an affordable means of overcoming this constraint can be a challenge. Providing supplementary energy (in this case in the form of maize) at key times in the goats' life cycle is probably the best means of maximising returns on such an investment. The strategic use of supplementary maize (or another energy source) in the does' diet at times of peak requirements (late pregnancy and early lactation) is affordable by many of the participating farmers, as it is in line with current expenditure on goat feeding and they have adopted the technology, albeit with some modifications. The effect of this strategic supplementation is a measurable increase in the contribution that the goat flock makes to the livelihood of the household. The level of adoption by one community (Birendra Bazaar) was lower because maize was not available there. Further work needs to be done to identify alternative sources of supplementary energy in these situations, and to communicate the effectiveness of this technology to target institutions working with very poor and landless livestock keepers in Nepal and elsewhere.

Goat market survey

Farmers' perceptions of goat market

Some farmers sell their goats to other farmers, but most goat sales are to local traders (25%) or butchers, larger traders and the local twice weekly market (held in Sakhuwa Bazaar). The farmers of Kemalipur prefer selling goats to local farmers, traders and

butchers rather than the local market because if they take the goat to the market, they have to bear the transportation cost and spend the whole day in the market rather than work on their farms. Goats are sold when cash is needed, but the highest prices are achieved in the periods September to November and January to March because of festivals such as Dashain and Tihar (in the autumn) and Maghe Sankranti and Holi (in the spring). Nepalese people consume more goat meat during these festivals and so there is high demand for goat meat, which increases the price of live goats at these times.

According to a veterinarian in the District Livestock Services Office in Janakpurdham, the Nepal Food Corporation also buys live goats at NRs 85/kg (£0.77/kg) for small male goats weighing below 15 kg and NRs 105/kg (£0.95/kg) for larger male goats above 15 kg during Dashain and Tihar (September to November). In the June to August period, goat prices are low and farmers selling their goats at this time do so because of the need to raise cash because of the expenses of rice cultivation and other household requirements.

Goat liveweight determines the price of the goat. The weight of the goat is estimated by eye (and is done by both farmers and traders). Live goats are typically sold at the rate of NRs 160/kg (£1.45/kg). If the trader is from the same village as the farmer, the price for the goat is NRs 50 or 100 (£0.45 to 0.90) less than the price in the market, because selling to a local trader in the village removes (from the farmer) the cost of transportation and time involved in taking the goat to the market.

If a goat becomes sick, the farmer either has to sell the goat immediately at a low price or slaughter it and sell the meat to villagers. Goats would also be slaughtered in this way if a household needed to raise cash quickly. If the goat is slaughtered in the village to sell, some of the meat will be sold on credit and it then takes a long time to collect the money from the debtors.

Home consumption of goat meat mirrors that of times when there is a high demand for goat meat away from the farm. Home consumption of goat meat therefore mostly occurs during festivals. For Hindus the major festivals are Dashain in September/October and Tihar in October/November, but they will also slaughter goats for the celebration of Maghe Sangkranti in January/February, Falgun Purnima in

February/March and Sawane Sangkranti in July/August. For Muslims, the major festival would be Kurbani and Bakrid in January/February. Male goats are reared for home consumption during festivals.

Before selling a goat, the household head would consult his wife. In some cases when a goat belongs to a particular family member (such as a goat belonging to an unmarried daughter, daughter-in-law etc.) then that family member has to be consulted before the goat can be sold. Both the husband and wife are involved in fixing the price of a goat. Some of the farmers rear goats just for slaughter and home consumption at different festivals but most rear goats to sell live.

Farmers reported that goats produced in the project area (Dhanusha) cannot fulfil market demand for goats at peak times (Dashain and Tihar) and so traders and the Nepal Food Corporation buy goats from either India or the hilly region of Nepal. They therefore concluded that the market was not saturated by local goats and if they were to increase goat production, there would be a market for them. Farmers did want some regulation of the goat market, with guaranteed minimum prices and a 'proper link' between the producers, traders, butchers and consumers.

Small traders' perception of the goat market

Out of seven traders interviewed, three purchased goats directly from farmers, but they did not name any specific village that they used more than any other. The other traders bought goats from local markets. Most of the local traders would buy goats in Sakhuwa market and then sell them to larger traders in the same market. The small traders were generally seasonal in their operation. During the cultivation season they cultivated the land but at slacker times of the year they would get involved in goat trading.

In common with the farmers, the small traders noted that maximum demand for goats was in September to November and January to March because of the Hindu festivals of Dashain, Tihar, Maghe Sankranti and Holi. One small trader in Kemalipur suggested that the demand for goat meat had declined to some extent recently because there had been a large increase in the supply of chicken meat, which was cheaper than goat meat.

The small traders confirmed that a goat's price was determined by weight, which was estimated by eye. All traders who were interviewed accepted this method. The farmer fixes the approximate price of the goat and the trader then bargains with him/her until a price is agreed.

Problems encountered by small traders are that when they have bought a goat (generally at Sakhuwa market) they then need to sell it (generally to a larger trader) on the same day. If they cannot sell the goat on the same day, they have to pay the market tax (NRs 10, £0.09 per goat) for the goat again on the next market day. Small traders sometimes sell goats on credit to an outside larger trader, but if the larger trader does not return to the market, the small trader has to bear a big loss.

Five of the seven small traders interviewed believed that the market was large enough to absorb more goats without reducing prices, but the other two thought it likely that increased goat production would decrease sale prices of goats. All the traders interviewed reported that consumers preferred the meat of local rather than 'exotic' breeds. Local traders cannot buy exotic breeds of goat anyway as they do not have sufficient capital to buy the heavier (and therefore more expensive) 'exotic' goats.

Large traders' perceptions of the goat market

Five larger traders were interviewed in Sakhuwa market. Three reported that they purchased goats from local traders at the local market, whereas two preferred to purchase directly from farmers. Two of the traders generally sold their goats to butchers or hotels, while the other three sold to other large traders.

In contrast to the farmers and small traders, the large traders reported that most goat sales are made in February to June as consumers prefer goat meat to fish or chicken in the hot season. In the wet season of June to August, trade in goats decreases, as farmers and small traders are busy with rice cultivation. They did, however, confirm that demand for goat meat increases at festival times, but also when there are marriage ceremonies. They could see no reason why this pattern should change in the future. The traders confirmed that market demand is not satisfied by local production and goats are imported from Tibet and India (via the Nepal Food Corporation) to meet demand.

All the traders that were interviewed reported that they selected goats on the basis of goat liveweight and health. Goats with a robust long body and a big spine were higher priced than others. Before fixing the price of a goat, therefore, larger traders check the goat's spine. This also helped them estimate the goat's liveweight, which was the main determinant of goat price.

Problems encountered by larger traders are that when they take goats from the Terai to Kathmandu, they have to pay multiple taxes at the borders of different districts and to the police. Larger traders often have to sell goats on credit to an hotel or butcher and it then takes a long time to collect the money. They also reported that having no information on the market demand for goats was a problem, as was the fact that there was no transparency in the determination of goat prices. They suggested that an association of goat traders needed to be established.

The traders reported that demand for local goats was high, and so if the number of local goats produced between August and October increased, the market would be able to absorb it. Three believed that such an increase could happen with no decrease in goat price but the other two traders thought the price might decline. In common with the small traders, the larger traders reported that local goats (from the Terai) were considered tastier than hill goats and exotic breeds of goats.

Butchers' perceptions of the goat market

Three of the five butchers interviewed reported that they bought goats from local traders while the other two reported that they bought their goats from the local market. Although one butcher said that he would like to buy goats directly from the village, he was not able to because of time constraints.

In common with the larger traders, the butchers reported that most goat meat was sold between February and June as consumers prefer goat meat to fish and chicken in the hot season. The butchers noted that at Dashain and Tihar people consumed a lot of goat meat for a week, but they observed that at this time most consumers relied on goats they had reared themselves for home consumption.

Butchers select goats on the basis of weight and health, which also determines the price of the goat (based on a visual estimation). In common with the larger traders,

they noted that consumers seem to prefer local goats to hybrid and 'exotic' goats, and the favourite meat was from the local 'Chanki' breed.

Problems that the butchers encounter include the need to import goats from India (approximately 300 -400 000 per annum) to meet demand for goat meat. Recent legislation (the Livestock Act, 2055 BC and the Livestock Health Act, 2057 BC) has been passed to improve the health status of goat meat, but the implementation of this legislation is not effective. The butchers interviewed reported that there were about 15 butchers slaughtering goats in Janakhpur, but no ante-mortem or post-mortem examinations were carried out, and they also reported that some butchers would sell meat from fallen stock.

Survey of extension methodologies

Observations and recommendations of extension agencies

The extension approaches that have been adopted by the surveyed institutions are summarised in Table 26, together with an assessment (made by the institutions) of the relative effectiveness of these approaches. The commonest approach, which was considered the most effective amongst the contacted organisations, was the group approach. 16 (77%) of the organisations are working with a group approach and say that it is the most effective means of communicating with farmers. Three organisations (14%) described it as effective. For awareness raising, posters and pamphlets were considered most effective by six (29%) organisations and effective by a further seven (33%). However, some believed that posters were more effective than pamphlets for Nepalese resource-poor livestock keepers. Only two organisations (10%) considered the farmers' cooperative approach the most effective, although a further 12 (575) considered it effective.

Based on their experiences, the organisations made recommendations on which extension approaches would be most appropriate to adopt for a livestock project. These recommendations are summarised in Table 27. As might be expected from the observations summarised in Table 26, the farmers' group approach was the most highly recommended method of engaging with farmers and communicating extension messages.

Recommendations of farmers

The approaches that farmers' groups found the most effective are summarised in Table 28. Farmers were in agreement with the institutions that the group approach was the most effective extension methodology to use. However, farmers rated fairs and competitions much higher than did the institutions, but did not appear to value the use of extension media (radio, pamphlets and posters) to anything like the same extent. They were also less convinced of the value of individual contacts compared with the institutions.

OUTPUTS

Summary of messages

The messages that were produced by this project were:

- Goats are an important component of the livelihoods of resource poor farmers in both the hills and Terai of Nepal.
- Wilting forages before feeding them may increase their digestibility and in some cases their voluntary intake by goats.
- Strategic supplementation of does' diets with energy (eg 100 g/d maize) for two months around the time of kidding increases kid growth rate and doe fertility.
- The incidence of disease in the wet season can be reduced by supplementing the goats' diet with energy.
- Dosing goats with anthelmintic at the beginning and end of the dry season also helps control infection by helminths (worms).

Adoption of these strategies could make a significant impact on the productivity of goat flocks and on the contribution goats make to the livelihoods of resource poor goat-keepers. As an illustration, an estimate of the gross margin made by typical flocks in this district of Nepal is presented in Table 29. This is based on the data collected from the longitudinal study, and the two experiments conducted in Dhanusha district. In Table 30, a second gross margin has been calculated, assuming

the adoption of the strategic dietary supplementation of does. The increased margin that might be realised by adoption of this technology (NRs 1278, equivalent to £12) is 57% of mean monthly income of the households participating in this project and could potentially bring about a noticeable improvement in livelihood. This benefit comes at an increased cost of NRs 133 (£1.21), a more than nine fold increased return on initial investment.

Impact of outreach activities

Stakeholder meetings

In addition to the meetings with participating farmers that were held regularly throughout the project, larger meetings were held in January and September 2004 when representatives of local NGO and the Government Department for Livestock Services' office were invited to attend to share the results of experiments conducted during the project. At these meetings, approximately 40 people attended, half of whom were actively involved in either extension work or working with farmers to devise means of improving farmer livelihood, or alternatively were managing people engaged in these activities.

Training courses

A total of 80 goat-keepers received training in goat husbandry and elementary veterinary care of goats. Included in this course were the outputs of the project's experiments. This training course is run frequently by one of the project collaborators (Nepal Agroforestry Foundation) with its network of groups throughout the eastern hills and Terai of Nepal, and the project's findings are now incorporated into it.

National workshop

Approximately 200 participants attended this workshop. Most participants were either policy makers or those engaged in communicating research outputs to farmers, and the benefits of strategic inputs on goat productivity were therefore communicated to these decision makers.

International workshops and conferences

The benefits of the strategies developed by this project would not be confined to Nepal, albeit that the impact on livelihoods will vary with different circumstances (as it does in Nepal). The results from this project were therefore presented at six international conferences and workshops to ensure that the messages coming from the project were communicated to a wider regional and international audience. There were approximately 60 participants at the workshops in Tanzania, Kenya and Uganda, 200 at the conference in Mexico and around 250 delegates attended the two BSAS conferences in York where project findings were presented.

The project has therefore communicated directly with over 1300 people, many of whom are in a position to take the messages from the project to other relevant farmer audiences.

CONTRIBUTION OF OUTPUTS

Impact of project outputs on DFID development goals.

As demonstrated above, the adoption of strategic supplementation of does' diets around the time of kidding could lead to significant increases in flock productivity, with consequent improvements in the livelihoods of the goat-keepers. In the case of Nepal, an increased income of NRs 1278 would be sufficient to buy enough food to feed a typical goat-keeper's household for one month. Such a contribution would make a significant impact on the nutrition of the whole household, and contribute toward meeting the UN Millennium Development Goal of eradicating extreme poverty and hunger by reducing the proportion of people who suffer from hunger. Both protein and energy malnutrition (together with micronutrient deficiencies) is common in poor Nepalese households. Increasing household income is a key means of enabling households to meet their requirements for basic foods.

Goat-keeping is traditionally carried out by women, and as the survey of the goat market carried out in this project indicated, decisions about selling goats are made in consultation between men and women. Developing means of increasing the contribution goats make to household livelihoods increases the importance of goats to

the household economy, and this helps to empower women within both the household and the wider community.

Publications

The list of publications produced by the project is as follows.

Rymer, C., McLeod, A., Jayaswal, M.L., Dhaubhadel, T.S. and Neupane, K.P. (2002). The contribution of goats to the livelihoods of resource poor crop and livestock keepers in Nepal, and the use of banmara as a forage for goats. *In*: Smith, T., Godfrey, S.H., Buttery, P.J. and Owen, E. (Eds) *Helping smallstock keepers enhance their livelihoods: Improving management of smallholder owned sheep and goats by utilising local resources: Proceedings of the Second DFID Livestock Production Programme link Project (R7798) Workshop for Smallstock Keepers. Sokoine University of Agricultureeeee, Morogoro, Tanzania. 8-10 January 2002.* Natural Resources International Ltd, Aylesford, Kent, UK. ISBN: 09539274-4-x. pp 105-110.

Rymer, C. and Givens, D.I. (2002). The effect of wilting or soaking on the nutritive value of two invasive weed species in Nepal. *Proceedings of the British Society of Animal Science 2002*. p. 143.

Rymer, C., McLod, A., Jayaswal, M.L., Neupane, K.P., Dhaubhadel, T.S., Jha, V.C. and Taylor, N.M. (2002). Increasing the contribution that goats can make to the livelihoods of resource poor livestock keepers in Nepal. *In*: Responding to the Increasing Global Demand for Animal Products. An International Conference organised by the British Society of Animal Science, American Society of Animal Science and Mexican Society of Animal Production. 12-15 Nov, 2002, Merida, Mexico. British Society of Animal Science, Penicuik, UK. pp 143-144.

Rymer, C., Jayaswal, M.L., Neupane, K.P., Jha, V.C., Shrestha, S.P., Dhaubhadel, T.S., Taylor, N.M. and McLeod, A. (2003). Strategies to increase the contribution goats make to the liveslihoods of resource poor livestock keepers in Nepal. *In*: Smith, T., Godfrey, S.H., Buttery, P.J. and Owen, E. (Eds). The contribution of small ruminants in alleviating poverty: communicating messages from research: Proceedings of the third DFID Livestock Production Programme

Link Project (R7798) workshop for small ruminant keepers. Izaak Walton Inn, Embu, Kenya, 4-7 Feb 2003. Natural Resources International Ltd, Aylesford, Kent, UK. pp 79-89.

Neupane, K.P. (2003). Verification and confirmation of appropriate extension techniques for resource poor livestock keepers in Nepal. *In*: Smith, T., Godfrey, S.H., Buttery, P.J. and Owen, E. (Eds). The contribution of small ruminants in alleviating poverty: communicating messages from research: Proceedings of the third DFID Livestock Production Programme Link Project (R7798) workshop for small ruminant keepers. Izaak Walton Inn, Embu, Kenya, 4-7 Feb 2003. Natural Resources International Ltd, Aylesford, Kent, UK. pp 90-100.

Rymer, C., Jayaswal, M.L., Neupane, K.P., Shrestha, S.P., Jha, V.N., Dhaubhadel, T.S. and Taylor, N.M. (2004). Strategic supplementation of does to increase the contribution that goats make to the livelihoods of resource poor livestock keepers in Nepal. In: Tulachan, P.M. (Ed). Proceedings of a meeting held in Kathmandu, Nepal, 1-2 June, 2004. *In press*

Lama, N.K., Jayaswal, M.L., Rymer, C., Neupane, K.P., Shrestha, S.P. and Dhaubhadel, T.S. (2005). A socio-economic description of the communities involved in the 'Goat' research project (R7632). In: Tulachan, P.M. (Ed.) Proceedings of a meeting held in Kathmandu, Nepal, 1-2 June, 2004. *In press*

Jayaswal, M.L., Rymer, C., Neupane, K.P., Shrestha, S.P., Lama, N., Jha, V.N. and Neupane, D. (2005). Interventions to increase the contribution that goats make to the livelihoods of landless and land-constrained livestock keepers in the Gangetic plains of Nepal. *In*: Smith, T. and Godfrey, S. (Eds) Proceedings from a workshop held in Masaka, Uganda, Nov 15-19, 2004. *In press*

Rymer, C., Jayaswal, M.L., Neupane, K.P., Shrestha, S.P., Lama, N., Jha, V.N. and Neupane, D. (2005). Effects of the strategic supplementation of does' diets on goat performance and smallstock keeper livelihood in the Gangetic plains of Nepal. Proceedings of the British Society of Animal Science 2005 p. 46.

Internal reports produced by the project include:

McLeod, A., Moktan, P., Jayaswal, M.L. and Acharya, N. (2002). Management of goats and farmer livelihoods in Dhanusha and Makawanpur districts of Nepal.

Neupane, K.P. (2002). Verification and Confirmation of Appropriate Extension Technique for Resource Poor Livestock Keepers (RPLK) in Nepal.

Rymer, C. and McLeod, A. (2003). Farmer evaluation of 2002 trial.

Shrestha, S.P. and Jha, V.N. (2003). Training module on goat raising.

Jha, V.N. (2003). A Training Completion Report: Goat Keeping Training.

Lama, N. (2003). Market Survey Report.

Rymer, C., Jayaswal, M.L., Neupane, K.P., Lama, N. and Neupane, D. (2004). Results from farmers' meetings on 2004 trial.

Other dissemination materials produced by project include:

Aug 2003 Posters produced summarising findings on anthelmintic trial

Aug 2004 Posters produced summarising findings on supplementary feeding of does

Jan and Sept 2004. Presentations at Stakeholder meetings held in Dhanusha, Rauthat and Bara.

Further upscaling and future research required

The value and impact of this project would be greatly enhanced by engaging in a small number of further activities, in association with project R8109. To this end, an extension to this project (joining it with R8109; Livestock for Landless and Refugee Affected People) has been applied for. This would critically examine the uptake of strategies developed in this project by participant farmers, and determine what impact adoption has had on farmer livelihoods, or (in the case of non-adoption) the reasons for not adopting the strategies. In addition, links would be forged with new and existing target institutions, and the role that livestock inputs may play in these institutions' programmes would be explored and encouraged. The lessons that have been learned in doing participatory livestock research with landless and marginalised

groups would also be communicated by suitable means to others working (or planning to work) in this field.

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Table 1. *Diets used in the experiment to estimate the effect of treating banmara on its voluntary intake by goats.*

Diet ID	Banmara treatment	Proportion of plant in forage mixture	
		E. adenophorum (banmara)	*Ficus cunia*
UT75	Untreated	0.75	0.25
UT100	Untreated	1.00	0.00
24/75	24 h wilted	0.75	0.25
24/100	24 h wilted	1.00	0.00
48/75	48 h wilted	0.75	0.25
48/100	48 h wilted	1.00	0.00

Table 2. *The mean score across twelve communities for the contribution that goats make to different livelihoods objectives*

Objective	Mean score (0-4)	Standard deviation
Household expenses	3.5	0.21
Protein and fertiliser	2.1	0.92
Loans and savings	2.2	1.07
Social activities	1.8	0.94
Tool and animal purchase	1.8	0.58
Construction	0.5	0.50
All	2.0	0.21

Table 3. *Composition (size, gender and education) of the households monitored in the longitudinal study.*

Community	Number of households in sample	Mean household size	Households with 2 to 6 people (%)	% sample female	Females educated (%)	Males educated (%)
Kemalipur	20	5.7	90	45	53	77
Jamunibas	20	5.6	80	53	44	64
Ailakh	20	6.5	75	45	74	90
Okhargaun	20	6.6	70	52	65	69
All	80			50	59	76

Table 4. *Resources belonging to households monitored during the longitudinal study.*

	Community			
	Kemalipur	Jamunibas	Ailakh	Okhargaun
Mean land size of poor households (ha)	0.36	0.03	0.39	0.30
Mean land size of less poor households (ha)	0.84	0.41	0.53	0.40
Number of households without land	1	9	0	0
Number of households with kitchen gardens[1]	11	2	14	10
Number of households with irrigated cropland	18	11	19	11
Mean number of large ruminant animals owned by poor/ less poor	3.3/5.8	0.9/2.0	2.8/4.5	2.3/2.8
Mean number of goats owned by poor/ less poor	3.9/6.3	8.1/5.8	4.0/4.7	4.3/6.3
Mean number of farm implements[2] owned by poor/ less poor	0.5/1.0	0.4/0.8	0.4/1.1	0.0/0.2
Mean number of household implements[3] owned by poor/ less poor.	0.8/1.4	0.5/1.4	0.6/1.3	0.5/0.8

[1]Area near house for growing vegetables and fruit**.**
[2]Plough, bullock cart, sprayer, bull.
[3]Bicycle, radio, television.

Table 5. *Contribution of income from different livelihoods activities to different household objectives.*

Objective	Community	Total score	Contribution (%) of income from activities[1]						
			VEG	CER	OAG	C&B	GOAT	POU	OFF
Health, education,	Dhanusha	377	10	3	2	14	14	0	57
Daily household expenses	Makawanpur	407	41	0	3	1	7	0	48
Food purchases	Dhanusha	726	11	3	0	7	0	67	18
	Makawanpur	959	47	0	0	0	7	0	47
Social	Dhanusha	115	13	4	2	12	12	1	56
	Makawanpur	249	29	0	0	1	13	0	57
Loan repayments	Dhanusha	461	10	3	3	7	14	2	62
	Makawanpur	351	68	0	1	0	6	0	25

[1]Livelihoods activities include VEG: sale of vegetables, CER: sale of cereals, OAG: income from other agricultural activities, C&B: income from cattle and buffalo, GOAT: income from goats, POU: income from poultry, OFF: income from off-farm activities.

Table 6. *Exit rates and reasons for goat sales during the six month period of the longitudinal study (March-August).*

Community	Exit rates (%)			Total	Reasons for goat sales (%)			
	Total	Deaths	Sales	number sold	Sickness	Feed shortage	Household expenses	Other
Kemalipur	50.1	12.8	20.6	21	37	0	32	32
Jamunibas	81.3	31.8	42.4	48	81	0	6	13
Ailakh	40.3	3.4	24.6	22	18	27	36	18
Okhargaun	25.0	6.7	11.6	11	36	9	18	36

Table 7. *Treatments applied to different cases of sickness in the goat flock.*

Treatment	Symptoms of disease						
	Diarrhoea	General malaise	Scabies	Swollen stomach	Respiratory problem	Others	Total
Anthelmintic	8	12		5		7	32
Medicine	18	5	3		2	2	30
Traditional healing	6	14		2		2	24
Injection	2		11		1		14
Injection and medicine			1				1
Hemp flour and maize flour.	7						7
Salt water	1	1			4	1	7
Herbs	1	2				3	6
Mud on body				2		4	6
Burning pepper	2	4					4
Feed heated oil							2
Feed lemon water				2			2
DDT powder						1	1
Feed egg					1		1
Feed oil and turmeric						1	1
Heat on stomach		1					1
Vitamins						1	1
Total	45	39	15	11	8	22	140

Table 8. *Percentage of times when different classes of goats were fed supplementary feed during the longitudinal study.*

Community	Class of goat				
	Adult doe	Adult male	Weaned female	Weaned male	Suckling kid
Ailakh	98	98	98	96	57
Okhargaun	97	100	93	83	73
Kemalipur	48	91	24	78	26
Jamunibas	53	60	55	41	22
Total	74	90	67	78	41

Table 9. *Effect of treatment[1] on the chemical composition of banmara (E. adenophorum and C. odorata).*

	Chemical composition, g/kg DM					
	Organic matter	Crude protein	Neutral detergent fibre (NDF)	Acid detergent fibre (ADF)	ADF/NDF	Ether extract
Eupatorium adenophorum						
Untreated	929	111	492	449	0.912	30
Soaked	924	114	485	413	0.852	38
Wilted	926	118	494	400	0.810	34
Chromolaena odorata						
Untreated	979	146	533	506	0.949	28
Soaked	918	161	546	505	0.925	30
Wilted	929	133	525	430	0.819	25

[1]Untreated: Plant was harvested and oven dried; Soaked: Plant was harvested, soaked in water for 2 h and then oven dried; Wilted: Plant was harvested, wilted in the sun for 2 h and then oven dried.

Table 10. *Effect of treatment*[1] *on the in vitro degradability of banmara*

	In vitro degradability of organic matter
Eupatorium adenophorum	
Untreated	0.464
Soaked	0.496
Wilted	0.501
Chromolaena odorata	
Untreated	0.364
Soaked	0.458
Wilted	0.405
SEM	0.0392

[1]Untreated: Plant was harvested and oven dried; Soaked: Plant was harvested, soaked in water for 2 h and then oven dried; Wilted: Plant was harvested, wilted in the sun for 2 h and then oven dried.

Table 11. *Effect of treatment on the short term intake rate and predicted dry matter intake of banmara (Eupatorium adenophorum) by goats.*

Treatment	Short term intake rate (g DM/min $kg^{0.75}$)	Predicted dry matter intake (g/d)
Untreated	0.369	318
Bunches above head	0.189	224
2 h soaking	0.225	239
16 h soaking	0.101	174
24 h soaking	0.258	260
2 h wilting	0.238	248
6 h wilting	0.315	290
16 h wilting	0.220	240
24 h wilting	0.630	465
48 h wilting	0.973	654
SEM	0.0870	45.7
Significance (P)	<0.001	<0.001

Table 12. *Effect of wilting banmara (Eupatorium adenophorum) on voluntary banmara intake by goats*

	Treatment[1]						SEM	Sig.[2]	
	U75	U100	24/75	24/100	48/75	48/100		W	%
Intake (g DM/d)									
Banmara	204	331	528	614	660	677	51.5	***	ns
Total	466	455	796	737	927	803	63.1	***	ns
Intake (g DM/kg liveweight$^{0.75}$ /d)									
Banmara	29	46	72	84	91	91	5.0	***	*
Total	65	63	109	101	127	108	5.0	***	*
Liveweight change (g/d)	3	7	19	-1	16	-13	13.0	ns	ns

[1]U: Untreated banmara; 75: forage mixture (% w/w freshweight) 75 banmara, 25 *Ficus cunia*; 100: banmara offered as sole forage; 24/: banmara wilted for 24 h before feeding; 48/: banmara wilted for 48 h before feeding.

[2]W: effect of wilting time, %: effect of proportion of banmara in the forage mixture.

* P<0.05, ** P<0.01, *** P<0.001. ns not significant.

Table 13. *Effect of wilting tree forages on their chemical composition and in vitro apparent organic matter degradability.*

Species	Treatment	Chemical composition, g/kg DM[1]					ADF/NDF[2]	OMD[3]
(S)	(T)	CP	EE	NDF	ADF	NFC		%
Aule	Fresh	116	63	651	565	75	0.868	24.2
	Wilted	135	62	613	501	96	0.817	30.9
Biralli	Fresh	109	43	530	443	246	0.836	21.3
	Wilted	122	38	544	431	212	0.792	25.4
Dabdabe	Fresh	112	40	351	232	386	0.661	41.2
	Wilted	109	31	355	228	378	0.642	43.9
Dudhelahara	Fresh	99	54	509	360	239	0.707	27.6
	Wilted	96	48	462	326	287	0.706	32.3
Hade	Fresh	81	52	381	288	418	0.756	17.6
	Wilted	94	37	384	263	409	0.685	22.9
Sakhuwa	Fresh	92	24	674	546	169	0.810	17.2
	Wilted	88	26	656	517	192	0.788	18.3
SEM		52.9	17.9	30.8	21.7	42.9	0.0003	2.12
Significance	S	0.017	0.003	0.000	0.000	0.000	0.001	0.000
(P)	T	0.223	0.068	0.235	0.022	0.593	0.02	0.000
	SxT							0.005

[1]CP: Crude protein, EE: ether extract (Method B), NDF: Neutral detergent fibre, ADF: Acid detergent fibre, NFC: Non-fibre carbohydrate.
[2]ADF/NDF: Proportion of NDF that is ADF.
[3]OMD: In vitro apparent organic matter degradability.

Table 14. *Number of large ruminant animals kept by participating householders in the four communities involved in the experiment investigating strategies to reduce the incidence of disease in goats in the wet season.*

Village	Cattle			Buffalo		
	% households with no cattle	Head of cattle kept in households with cattle		% households with no buffalo	Head of buffalo kept in households with buffalo	
		Mean	Range		Mean	Range
Kemalipur	70	6.7	2-10	35	2.4	1-5
Jamunibas	75	3.0	1-5	80	1.5	1-2
Baluwa Bhiman	75	2.0	1-3	65	2.4	2-4
Birendra Bazaar	55	5.2	1-24	65	1.7	1-4

Table 15. *Numbers of goats kept by households participating in the study to investigate strategies to reduce the incidence of disease in goats during the wet season.*

Village	Mean	Range
Kemalipur	5.5	3-10
Jamunibas	5.1	3-10
Baluwa Bhiman	4.8	3-8
Birendra Bazaar	4.3	3-9

Table 16. *Total mean monthly income, and mean monthly income made from the sale of goats by households participating in the study to investigate strategies to reduce the incidence of disease in goats during the wet season.*

Monthly income (NRs)	Village				SEM	Sig.[1]
	Kemalipur	Jamunibas	Baluwa Bhiman	Birendra Bazaar		
Total	1806	2272	1908	3060	1363.3	ns
From goat sales	326	316	372	393	239.0	ns

[1]ns: not significant (P <0.05)

Table 17. *Mean numbers of goats (percentage of flock) kept by households participating in the study to investigate strategies to reduce the incidence of disease in goats during the wet season.*

	Village				SEM	Sig.[1]
	Kemalipur	Jamunibas	Baluwa Bhiman	Birendra Bazaar		
Male goats:						
Kids	0.1(1.6)	0.4(7.7)	0.6(11.8)	0.2(4.3)	0.13	ns
Young	0.8(13.1)	0.6(11.5)	0.9(17.6)	1.3(28.3)	0.19	ns
Adult	1.6(26.2)	0.3(5.8)	0.5(9.8)	0.0(0.0)	0.16	ns
Female goats:						
Kids	0.1(1.6)	0.4(7.7)	0.4(7.8)	0.4(8.7)	0.14	ns
Young	0.7(11.5)	0.8(15.4)	0.6(11.8)	0.6(13.0)	0.19	ns
Adult	2.8(45.9)	2.7(51.9)	2.1(41.2)	2.1(45.7)	0.28	ns

[1]ns: not significant ($P < 0.05$)

Table 18. *Effect of treatment on the incidence of disease and liveweight change in goats during the wet season.*

	Treatment[1]					SEM	Significance[2]
	ANT	NUT	A+N	VIT	TON		
Live-weight change (kg)	5.11	3.21	5.95	4.11	3.06	0.365	***
Disease incidence (%)	13.9	3.9	2.5	24.9	12.0	1.25	*

[1]ANT, treatment with anthelmintic; NUT, supplementation with ground maize; A+N, combination of ANT and NUT; VIT, supplementation with a vitamin/mineral mixture; TON, treatment with a digestive tonic (control treatment).

[2] * = $P<0.05$, *** = $P<0.001$.

Table 19. *Effect of treatment on the asset value of the goat flocks and the income from goat sales in households participating in the study to investigate strategies to reduce the incidence of disease in goats during the wet season.*

Asset value and income from all goat sales (NRs)	Treatment[1]					SEM	Sig.[2]
	ANT	NUT	A+M	VIT	TON		
Experiment start	8178	7282	5840	6840	6894	766.1	ns
After 1 month	8481	7573	6241	7009	6947	800.1	ns
After 2 months	9094	8313	6473	7538	7158	978.8	ns
After 3 months	9468	8547	6607	7669	7381	1041.1	ns
After 4 months	9804	8575	6703	7972	7282	1071.0	ns

[1]ANT, treatment with anthelmintic; NUT, supplementation with ground maize; A+N, combination of ANT and NUT; VIT, supplementation with a vitamin/mineral mixture: TON, treatment with a digestive tonic (control treatment).

[2] ns: not significant ($P < 0.05$).

Table 20. *Summary of the participating farmers' evaluation of the different treatments investigated to reduce the incidence of disease in goats during the wet season.*

Observation	Treatment[1]				
	ANT	NUT	A+M	VIT	TON
Appetite	Increased. Some goats had eaten soil, but this stopped after treatment				Increased
Weight gain	Goats became fat and sold at a good price	Improved body condition and live-weight gain	Very effective at increasing live-weight gain. Improved condition of goats and goats sold for a good price.	Goats gained weight, improved condition, and had glossy coats	Improved body condition and live-weight gain.
Disease incidence	Health was improved, and no worms were seen in the droppings after treatment	Goats were healthy			
Comparison with neighbours				Goats treated with VIT looked better	
General comments		It would be good to feed maize in the future			

[1]ANT, treatment with anthelmintic; NUT, supplementation with ground maize; A+N, combination of ANT and NUT; VIT, supplementation with a vitamin and mineral mixture; TON, treatment with a digestive tonic (control treatment).

Table 21. *Effect of treatments on doe productivity and live-weight gain of kids and does in a study investigating strategies to increase doe productivity.*

	Treatment[1]				
	DMZ	DSE	CON	sem	Significance[2]
Kiddings/doe	0.85	0.72	0.59	0.069	*
Kids/doe	1.6	1.0	1.2	0.17	*
Live-weight gain, kg (difference between the first and second recording of live weight after kidding):					
Kids	1.52	1.15	1.08	0.071	***
Does	2.15	1.35	1.29	0.862	***

[1]DMZ: does supplemented with 100 g/d maize for two weeks before and six weeks after kidding; DSE: does supplemented with 500 mg/d selenium and 50 mg/d Vitamin E for two weeks before and six weeks after kidding; CON: does were managed according to normal practice.

[2]* = $P<0.05$; *** = $P<0.001$.

Table 22. *Effect of treatment on the asset value and sales income from goats in the study investigating strategies to increase doe productivity.*

	Treatment[1]				
	DMZ	DSE	CON	sem	Significance[2]
Asset value at start (NRs)	6637	6964	7483	778.7	ns
Asset value at end (NRs)	7370	6314	5608	845.8	ns
Change in asset value (NRs)	733	-650	-1876	736.9	*
Income from goat sales (NRs)	3720	3003	4545	663.5	ns
Potential income from goat flock, NRs (sum of change in asset value and goat sales)	4453	2352	2669	803.3	0.053

[1]DMZ: does supplemented with 100 g/d maize for two weeks before and six weeks after kidding; DSE: does supplemented with 500 mg/d selenium and 50 mg/d Vitamin E for two weeks before and six weeks after kidding; CON: does were managed according to normal practice.

[2]ns = $P>0.05$; * = $P<0.05$

Table 23. *Farmers' comments on supplementing kidding does with maize*

Village	Comments on treatment	Comments on adoption
Baluwa Bhiman (comments from 5 farmers)	Liked treatment because fertility, kid performance and live-weight gain improved, and milk yield increased.	Continued feeding maize to does; one participant said they weren't doing this regularly but were feeding forage *ad lib*. One participant buys maize to feed her doe. Most are feeding maize (100 g/d) or khole; neighbours are adopting as well. Leftover rice is given to the goats.
Birendra Bazaar (comments from 7 farmers)	All liked the treatment; 2 said this was because kid numbers and live-weight gain increased, 4 said because kidding interval had decreased from 12 to 6 months. Kid price from does fed maize increased (from Rs 600 to Rs 1000).	Most have not adopted because maize was not available. Will feed does maize when it is available. Neighbours (5 of the 7) are positive about treatment, but they have not adopted. Some neighbours do not know because results have not been communicated. Message should be extended.
Kemalipur (6 farmers present, 1 absent because of bereavement)	All liked the treatment because it increased prolificacy and growth, and the number of pregnancies doubled (twice a year instead of once). Five of the 13 farmers in group ate the maize rather than giving it to their goats.	Now feeding maize flour with water, one is feeding maize bran. One is feeding flour mixed with water to make a ball. No longer separating does from khassi. One (landless) farmer is giving leftover rice, forage and grazing. One giving khole and salt water. Majority of neighbours have adopted.
Jamunibas (comments from 5 farmers)	Liked treatment because goats grew well and does became pregnant. Kidding interval 7-8 months. Good kid performance and goat came back on heat quickly.	Adopted, but not as regularly as in the experiment. Does now fed every 2-3 (or 3-4) d, although one was feeding daily. Does fed every 3-4 d get more (about 2 kg). Lack of time, and maybe feeding leftovers that are not available every day prevent daily feeding. Neighbours have adopted as well. Good message for extension.

Table 24. *Farmers' comments on supplementing kidding does with selenium*

Village	Comments on treatment	Comments on adoption
Baluwa Bhiman	Liked treatment because 19 d after kidding, one doe conceived. Goats became fatter and were ready for the buck quickly.	Want to buy this 'medicine' but don't know where it is available. Message should be extended.
Birendra Bazaar	Kid health improved with treatment, and kidding interval decreased. No problems with infertility, and fertility increased with treatment.	Message should be extended.
Kemalipur	Liked treatment because does became strong, robust and fat. Increased fertility.	Shopkeeper does not know (and, therefore, does not stock) selenium.
Jamunibas (5 present)	Liked treatment.	All want to continue feeding selenium but can't get it. Asked local facilitator about it, who said it was very expensive. Neighbours know about treatment. Facilitator's wife took some and gave it to one of her infertile does which then conceived.

Table 25. *Farmers' comments on supplementing finishing goats with maize (the control treatment).*

Village	Comments on treatment	Comments on adoption
Baluwa Bhiman (18 present)	Good; it made the goats healthy. Good because goats were fed the same, small amount each day.	Will adopt (already normal practice) but will revert to feeding irregular amounts of different cereals. Not worth extending, because it is obvious that if you feed goats cereals they will grow and be healthier.
Birendra Bazaar	Beneficial because goats increased live weight. Became active and strong and fattened.	
Kemalipur (3 present)	Liked treatment because goats became strong and healthy. Five of the 13 farmers in group ate the maize rather than giving it to their goats.	
Jamunibas (5 present)	Liked treatment because although goats were already fed, they were not given measured amounts.	Discussed with neighbours, but they have not adopted- all are feeding irregular amounts. Message should be extended.

Table 26. *Summary of extension approaches used by the surveyed extension agencies and the agencies' estimation of their effectiveness.*

Approaches adopted	Number (%) of agencies finding the approach:		
	Very effective	Effective	Ineffective
Committee/group approach	16 (76)	3 (14)	0 (0)
Supervision and follow-up	10 (48)	3 (14)	1 (5)
Group meeting	11 (52)	6 (29)	0 (0)
Group training	11 (52)	6 (29)	0 (0)
Individual contact	8 (38)	5 (24)	0 (0)
Group exposure visits	8 (38)	7 (33)	0 (0)
Poster/pamphlet	6 (29)	7 (33)	0 (0)
Farmers' cooperative approach	2 (10)	12 (57)	1 (5)
Mass awareness	2 (10)	10 (48)	1 (5)
Fair/Exhibition	1 (5)	6 (29)	0 (0)
Radio	1 (5)	6 (29)	1 (5)
Television	0 (0)	4 (19)	1 (5)

Table 27. *Extension approaches recommended by extension organisations*

Extension approach	Number of organisations recommending approach	Percentage of organisation recommending approach
Group approach	16	76
Group meeting	11	52
Individual contact	9	43
Poster and pamphlets	6	29
Supervision & follow-up	6	29
Group training	5	24
Farmers' cooperative approach	4	19
Mass awareness	4	19
Groups exposure visits	4	19
Fair/ exhibitions	4	19

Table 28. *Extension approaches recommended by farmers' groups*

Extension approaches	Number (%) farmers' groups recommending approach	Rank
Group approach	6 (75)	I
Farmers competition	4 (50)	II
Training and visits	3 (38)	III
Passing on gift	3 (38)	III
Village-based farmers' training	3 (38)	III
Supervision & follow-up	2 (25)	IV
Technical advice	2 (25)	IV
Individual contact	1 (13)	V
Farmers visits	1 (13)	V
Farmers meeting	1 (13)	V
Extension media	1 (13)	V

Table 29. *Estimated gross margin from goat flocks managed conventionally in the Dhanusha district of Nepal.*

Numbers per year	Type of goat			
	Buck	Buck kid	Doe	Doe kid
On farm	0.94	1.38	2.80	1.03
Deaths	0.06	0.25	0.31	0.15
Sales	1.13	0.28	0.49	0.24
Slaughter	0.16	-	0.01	-
Other offtakes	0.28	-	0.64	-
Births	-	1.30	-	1.30
Purchases	0.15	0.08	0.14	0.03
Other entries	0.08	0.05	0.20	0.21
Disease incidence (%)[1]	-	-	7.27	7.40
Costs (NRs per year)				
Purchase	331	100	125	21
Feed	733	574	1456	321
Veterinary treatment[2]	-	-	4	2
Service or castration	9	14	119	44
Income (NRs per year)				
Sales	2495	249	612	170
Saving from consumption of home produced goat[3]	353	-	12	-
Margin (NRs)	1775	-438	-1080	-218
Gross margin (NRs)			38	

[1]Data taken from experiment investigating means of reducing the incidence of disease in the wet season.

[2]Data taken from longitudinal study.

[3]Data taken from consumption data in study investigating the effect of the strategic supplementation of does, combined with estimated cost (from sales data) of buying a goat for home consumption.

Table 30. *Estimated gross margin from goat flocks adopting the strategic supplementation of kidding does in the Dhanusha district of Nepal.*

Numbers per year	Type of goat			
	Buck	Buck kid	Doe	Doe kid
On farm	0.94	1.38	2.80	1.03
Deaths	0.06	0.36	0.31	0.24
Sales	1.48	0.40	0.87	0.32
Slaughter	0.16	-	0.01	-
Other offtakes	0.28	-	0.64	-
Births	-	1.90	-	1.90
Purchases	0.15	0.08	0.14	0.03
Other entries	0.08	0.05	0.20	0.21
Disease incidence (%)[1]	-	-	7.27	7.40
Costs (NRs per year)				
Purchase	331	100	125	21
Feed	733	574	1589	321
Veterinary treatment[2]	-	-	4	2
Service or castration	9	14	119	44
Income (NRs per year)				
Sales	3268	356	1086	226
Saving from consumption of home produced goat[3]	353	-	12	-
Margin (NRs)	2547	-331	-739	-161
Gross margin (NRs)		1316		

[1]Data taken from experiment investigating means of reducing the incidence of disease in the wet season.

[2]Data taken from longitudinal study.

[3]Data taken from consumption data in study investigating the effect of the strategic supplementation of does, combined with estimated cost (from sales data) of buying a goat for home consumption.

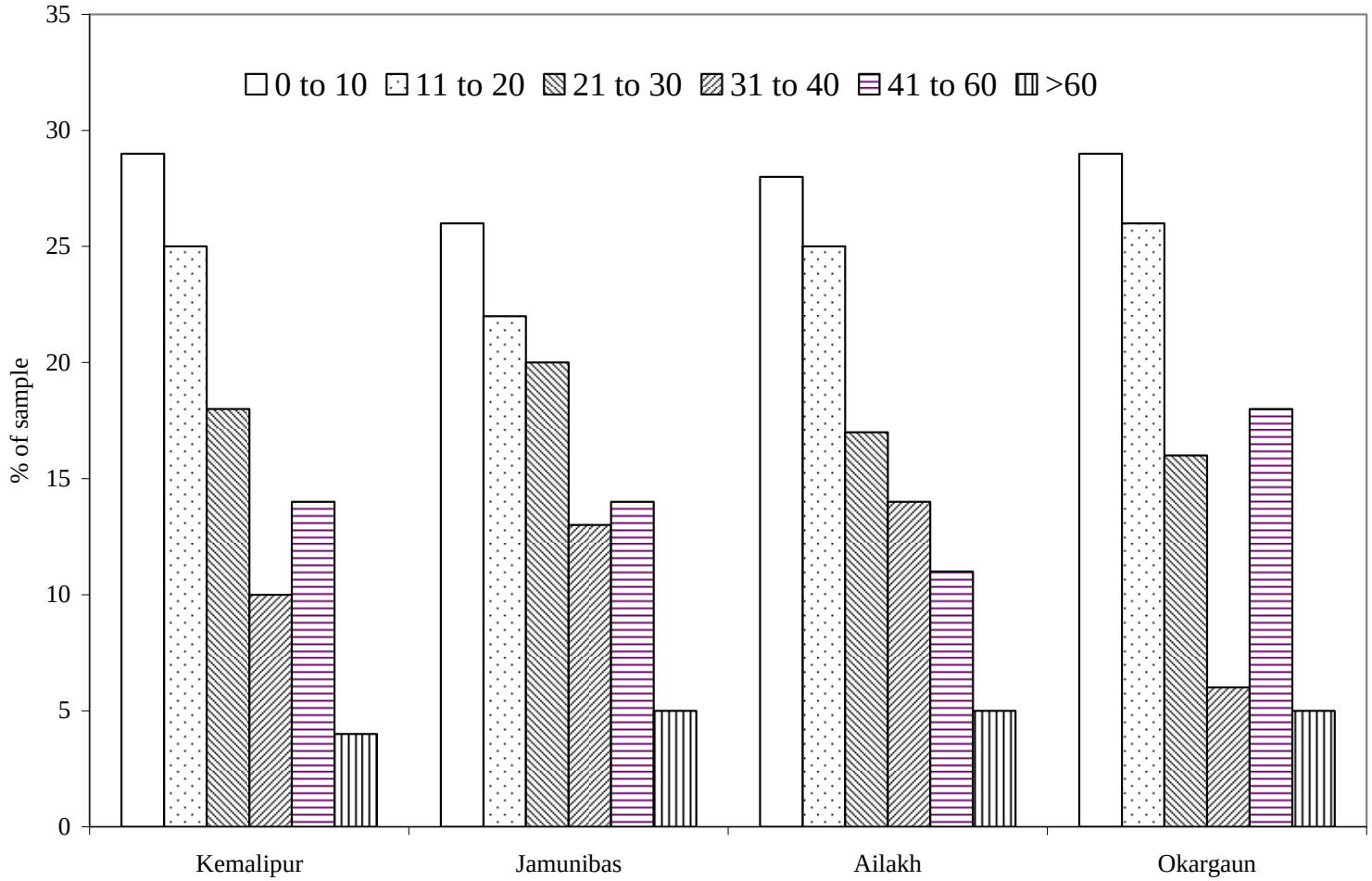

Figure 1. *Age composition of the households monitored in the longitudinal study.*

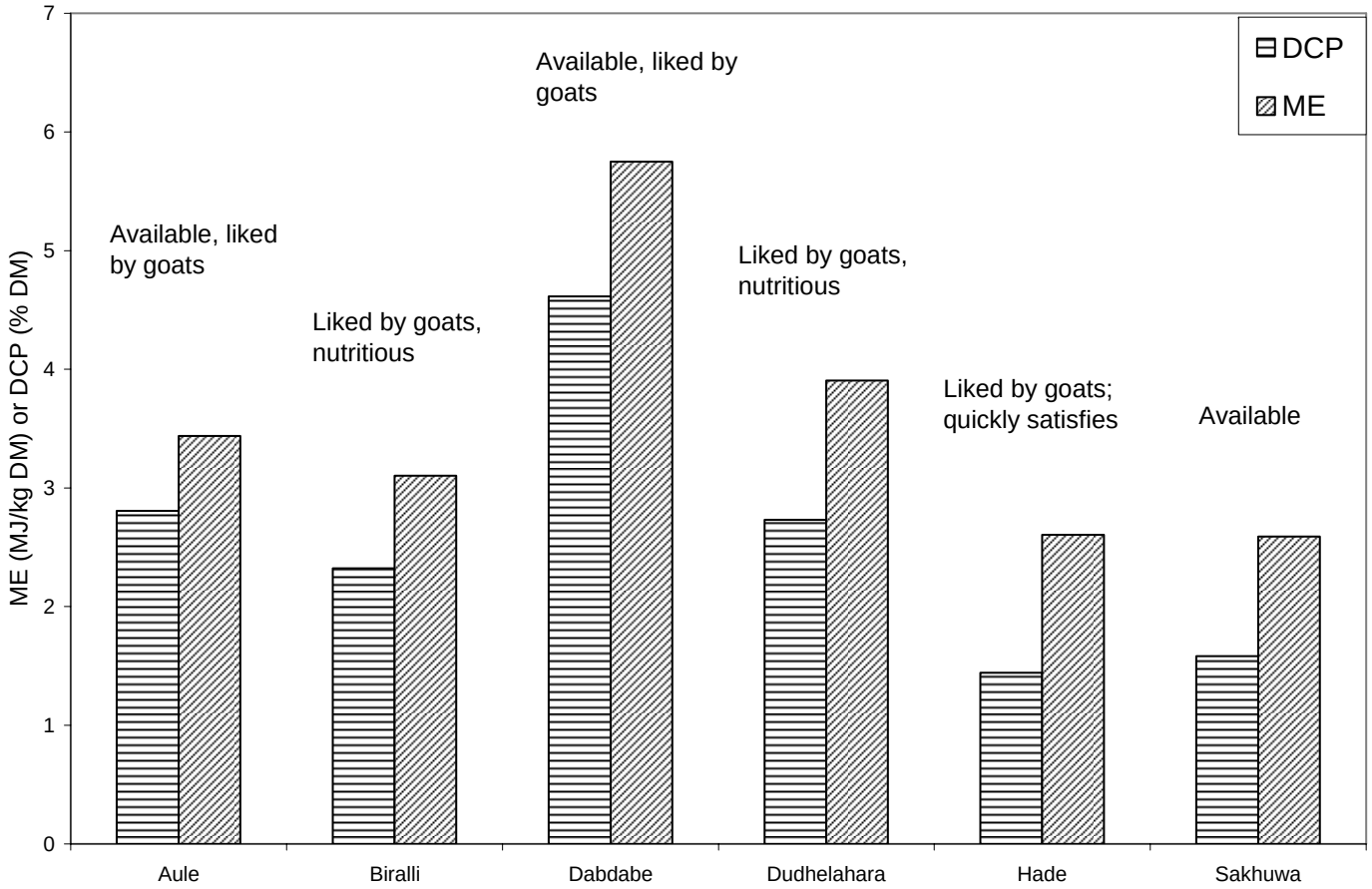

Figure 2. *Estimated digestible crude protein (DCP) and metabolisable energy (ME) contents of six forages and the farmers' evaluation of those forages.*

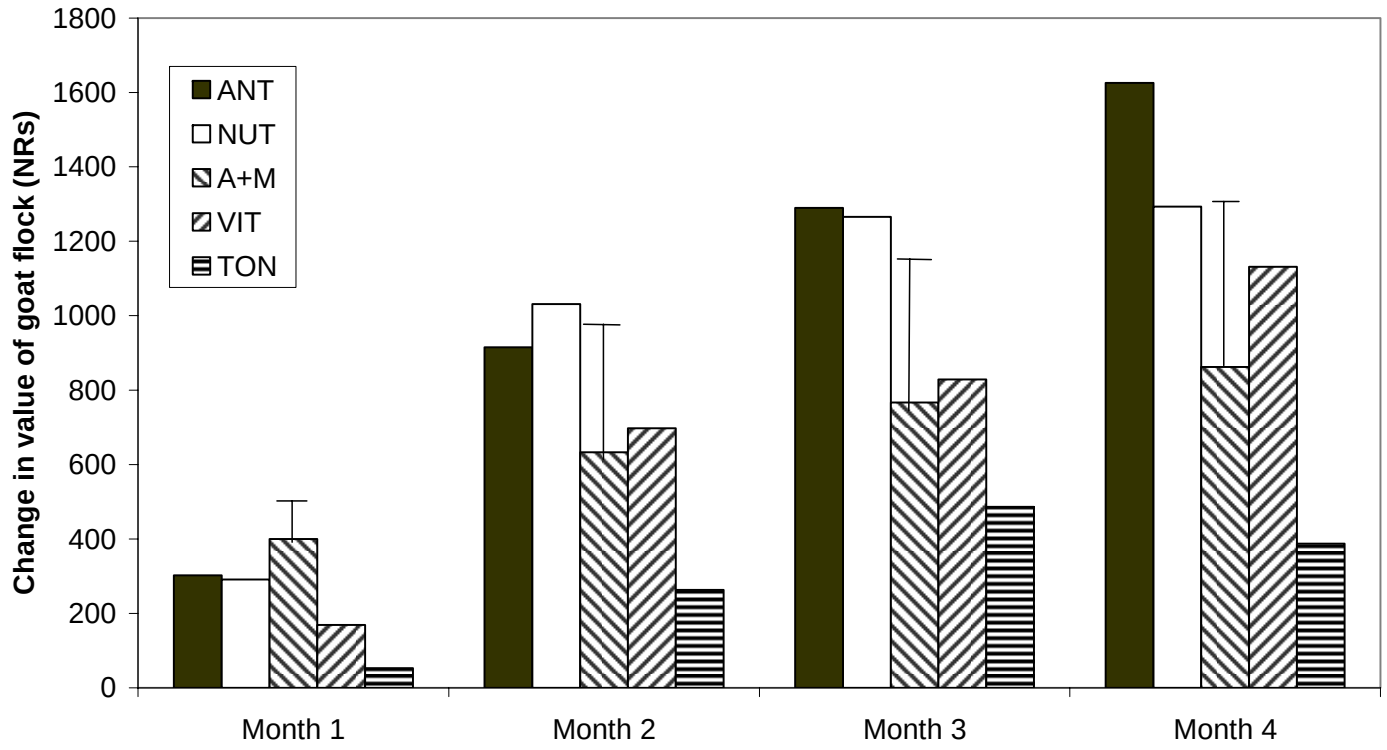

Figure 3. *Cumulative changes in the combined asset value of goat flock and income from all goat sales during the study investigating different strategies to reduce the incidence of disease in goats during the wet season.*