EASING SEASONAL FEED SCARCITY FOR GOATS IN SEMI-ARID INDIA

FINAL TECHNICAL REPORT

LIVESTOCK PRODUCTION PROGRAMME PROJECT R6953

(NRI Project A0712)

February 2003

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Acknowledgements

This project was jointly developed and designed by Czech Conroy of NRI and Dr DV Rangnekar of BAIF. Dr Rangnekar's extensive knowledge of goat-keeping in north-west India, and of BAIF's work in the region, was invaluable, and he provided strategic guidance to the project during the first two years. When Dr Rangnekar retired from BAIF, Dr AL Joshi took over responsibility for coordinating BAIF's inputs to the project and providing general guidance and support. Dr Rangnekar and Dr Joshi are both livestock scientists, and their inputs were complemented by those of Dr Ashwini Ghorpade, who is a sociologist. Dr Ghorpade, who became involved in the project around the same time as Dr Joshi, advised the field staff on socio-economic aspects of the fieldwork.

Czech Conroy is a socio-economist at NRI and was project leader throughout the duration of the project. He jointly coordinated the project with his BAIF counterparts, and was responsible for developing and advising on the participatory aspects of the project. He also coordinated inputs from other NRI staff, namely Dr Richard Matthewman, Dr Rob Paterson and Dr Dannie Romney, and liaised with the LPP Manager.

We would like to thank all of the many BAIF staff who took part in the field trials for this project, and in particular:

- Mr G Bausar, Mr Chaura, Dr A Jape, (Bhavnagar)
- Mr M Vadher. Mr Panchal, Mr Shyam Singh Lakhawat, Dr M Sharma (Bhilwara)
- Mr Y A Thakur Mr P R Desai, Mr M D Halli (Dharwad)
- Dr R B Ghokale (Pune)
- Mr M Pandya, Dr D Shindey, Mr LR Singh, Mr Rawal, Mr Patel (Udaipur)
- Dr A Pande (Vidisha)

BAIF's silvipasture case studies were coordinated by Dr Ashwini Ghorpade, with assistance from Sandeep Naik. Other contributors were Mr B. Rathod, Mr A Chourasia and Mr M Vadher. Five other NGOs and their staff were also involved in preparing case studies. We would like to thank:

- Kishore Saint and Jagdish Kumar Purohit (Ubeshwar Vikas Mandal)
- Narendra Jain, Rohit Jindal, Prakash Kashwan, Neeraj Negi and Mamta Vardhan (Seva Mandir)
- Mohan Dangi, Maneesh Pandey and Mini Thakur (Prayatna Samiti)
- Rajkaran Yadav and Anil Vyas (Hanuman Van Vikas Samiti)
- Viren Lobo (Society for Promotion of Wastelands Development).

This project would not have been possible without the financial support of DFID's Livestock Production Programme (LPP). Dr Wyn Richards, the Programme Manager, has been very supportive throughout. He has been flexible in allowing the project to respond to the priorities expressed by goat-keepers, some of which took the project into unanticipated areas: such flexibility is essential if participatory research is to be effective. Dr Andy Frost and Ms Sarah Godfrey of LPP have also been extremely helpful, responding quickly to queries and requests.

Abbreviations/Glossary

Anas	Anas were part of the old Indian currency: 16 Anas were 1 Rupee. For some rural people in Rajasthan it is their equivalent of percentages (e.g. 8 anas is 50 percent).
Anthelmintic	Chemical used to kill internal parasites in livestock
APRLP	Andhra Pradesh Rural Livelihoods Project
BAIF	BAIF Development Research Foundation
C group	Control group
DFID	Department for International Development
ET	Entero toxaemia
EU	European Union
Gujars	Agro-pastoralist caste specialising in livestock-keeping, particularly sheep
Gayris	Agro-pastoralist caste specialising in livestock-keeping, particularly sheep
ILRI	International Livestock Research Institute
ISGP	Indo-Swiss Goat Project
Jaggery	Sugary substance
KAWAD	Karnataka Watershed Development Society
LLGS	Landless goat specialists
LLWL	Landless wage labourers
NRI	Natural Resources Institute
OBC	Other backward castes
PHH	Participatory herd history method
PJ	*Prosopis juliflora,* a common tree in semi-arid India
PRA	Participatory rural appraisal
PSPA	Protected Silvi-Pasture Area
PTD	Participatory technology development
Rabaris	Agro-pastoralist caste specialising in livestock-keeping
SC	Scheduled castes
SMF	Small and marginal farmers
ST	Scheduled tribes
T group	Treatment group
UMG	Urea molasses granules
WIRFP	Western India Rainfed Farming Project
WORLP	Western Orissa Rural Livelihoods Project

1. EXECUTIVE SUMMARY

The project aimed to identify ways of alleviating seasonal feed scarcity for goats in semi-arid regions of India. Goats were selected because they are particularly important for poor groups and have been relatively neglected by livestock research and extension services. The research was carried out in five semi-arid districts of four states, namely Gujarat, Karnataka, Maharashtra and Rajasthan.

The way in which seasonal feed scarcity manifests itself can vary from one agro-ecological zone to another, and between different production systems, villages or social groups. Thus, it was important to characterise goat production systems and undertake needs assessments before deciding what to focus on in each project location.

The project conducted numerous trials with resource-poor goat-keepers, in which a variety of treatments was tested to address several constraints and opportunities. Most trials involved selective supplementation of high quality feeds that were locally available, such as grains and tree pods. However, some involved de-wormers to improve feed utilisation; and one focused on addressing seasonal water scarcity, which was closely related to issues of feed utilisation. In all but one of the trials the treatment had a beneficial effect on the goats.

The project also studied silvipasture development on common lands and its effect on goats and other livestock. Harvested grass from the treated sites can make an important contribution to alleviating seasonal feed scarcity for large ruminants. However, goats and sheep generally do not benefit and can even be negatively affected by the reduction in grazing area, since grazing is not normally permitted on the protected sites. The project has published a report that contains recommendations on how this kind of intervention can be made more beneficial for people keeping small ruminants.

The main project methodology adopted was participatory technology development (PTD), which had previously been used only infrequently by livestock researchers. Participatory methods for use with livestock-keepers were tested and developed. The project's experiences showed that PTD can increase the probability of developing technologies that have a high chance of adoption by livestock-keepers. Two guides have been published by the project to assist livestock professionals in using participatory approaches.

The project has developed two technologies that appear to have excellent prospects for widespread adoption in India. One involves the collection and storage of tree pods, from *Prosopis juliflora*, for use during times of acute feed scarcity. In Bhilwara district, Rajasthan, this resulted in significantly higher kidding rates for goats belonging to resource-poor people. The other involves the use of the trichomes of the pods of *Mucuna pruriens*, a leguminous creeper, as an anthelmintic. In Dharwad district, Karnataka, this was applied to pregnant females, and resulted in their kids growing more rapidly – it might also reduce the mortality rate of kids born in the rainy season.

Goat-keeping is an important livelihood activity for a large proportion of India's rural poor. Thus, improving goat productivity through the widespread application of this project's outputs and findings has the potential to make a significant contribution to DFID's goal of eradicating extreme poverty and hunger.

2. BACKGROUND

BAIF Development Research Foundation (BAIF), India, and the Natural Resources Institute (NRI) of the University of Greenwich, UK, jointly implemented this project, which aimed at alleviating goat production problems caused by seasonal feed shortages in semi-arid India. The title of the project was: "Easing seasonal feed scarcity for small ruminants in semi-arid crop/livestock systems through a process of participatory research". The project was a multi-disciplinary one: the Project Leader for NRI is a socio-economist, whereas the Project Leader for BAIF is a veterinarian; and contributions were made by other staff from both organisations, who were from a variety of disciplines, including ruminant nutrition and agronomy. One of the NRI researchers transferred to ILRI in the middle of the project, but was allowed to continue her involvement in the project subsequently.

2.1 The Importance of the Constraints Addressed

Goats have a reputation for being hardy animals, but their productivity in semi-arid regions of India tends to be low. Seasonal fodder scarcity can be a significant constraint on goat production in semi-arid regions of India. The nature of the problem varies from place to place, and includes: poor reproductive performance, associated with low conception rates; high mortality of young goats in the rainy season; and slow growth rates of young goats and late maturation. Given the large number of goats in India – 117 million in 1992 – overcoming these constraints would have a major impact on meat and milk production. It would also improve the livelihoods of a large proportion of India's poor rural households, most of whom keep goats primarily for sale to generate income.

2.2 Demand for the Project

Goats have been relatively neglected by livestock research and development agencies. Prior to this project BAIF was aware of the importance of goats to resource-poor families, and was involved in goat development work in Rajasthan's Bhilwara District. An important exception, apart from BAIF's activities, was the work of the Indo-Swiss Goat Project (ISGP) in Rajasthan, during the late 1980s and early 1990s. ISGP carried out and commissioned a number of studies that improved understanding of goat production systems and constraints (Sagar and Ahuja, 1993) and marketing systems (Rathore, 1993) in Rajasthan.

Prior to this project, there had been little research on seasonal feed availability and utilisation as a constraint on goat production and productivity in semi-arid India. Indeed, some livestock researchers and practitioners may have been under the impression that it was not a constraint, given the goat's ability to survive under harsh, dry conditions. Nevertheless, some ISGP studies described the feeding systems of goats and other livestock in Rajasthan (Hocking and Kapila, 1992; Hocking *et al*., 1992).

2.3 Rationale for Participatory Approach

Scientists have acquired a tremendous amount of knowledge about the feed resources and nutrition of ruminants, both large and small (Acharya and Bhattacharyya, 1992). Despite this, the adoption of technologies developed by researchers, for enhancing fodder production and improving grazing management systems, has been poor (*ibid*.; Sidahmed, 1995). This is partly because feed technologies have often been developed without the involvement of the intended users, and without an adequate understanding of their farming systems and constraints: a systems approach "has been singularly lacking in the past" (Devendra, 1999). The BAIF/NRI project applied a systems-based and participatory approach.

There is reason to believe that a participatory approach to technology development (PTD) can help to ensure that new technologies are appropriate to farmers' and livestock-keepers' needs and circumstances, and hence increase the likelihood of adoption (Conroy *et al*., 1999; Reijntjes *et al*., 1992). Greater participation of the intended users can mean, *inter alia*, that: farmers' knowledge and experience can be incorporated into the search for solutions, and highly inappropriate technologies can be 'weeded out' early on; and researchers receive rapid feedback, enabling promising technologies to be identified, modified and disseminated more quickly.

Livestock research and development work has tended to lag behind crop production work in the development and application of methods for participatory technology development (PTD). There are relatively few documented examples of PTD projects in which livestock are a central focus, particularly ones addressing feed issues. However, there has been increasing recognition that livestock research needs to give greater emphasis to farmer participation (Devendra, 1999; Sidahmed, 1995). This project, by taking a participatory approach to the development of feed technologies for goats, sought to enrich the experience of PTD in the livestock sector and to develop participatory methodologies that are appropriate to the sector.

3. PROJECT PURPOSE

The project purpose, as specified in the logical framework (see Appendix 1), was: Seasonal availability and utilisation of local feed resources for livestock production in semi-arid crop/livestock systems improved and appropriate feed management strategies promoted.

3.1 Addressing Opportunities and Constraints

The way in which seasonal feed scarcity manifests itself can vary from one agro-ecological zone to another, and between different production systems, villages or social groups. The project conducted numerous trials with resource-poor goat-keepers, in which a variety of treatments were tested to address several constraints and opportunities. The various development challenges and the ways in which they were addressed are summarised in Table 1. As defined here, a challenge can be a problem or an opportunity.

Most trials involved selective supplementation of high quality feeds, but some involved anthelmintics to improve feed utilisation, and one focused on addressing seasonal water scarcity, which was closely related to issues of feed availability and utilisation. The majority of treatments tested were based on locally available materials and resources.

The project also studied silvipasture development on common lands in Rajasthan, and its effect on goats and other livestock. The poorer rural livestock-keepers in Rajasthan tend to be small or marginal farmers (or landless people) who do not have sufficient land to grow forage crops, preferring to give priority to food crops and cash crops. For them, common lands, such as village grazing lands and state-owned forest lands, are often the most important source of forage for their goats and other livestock. Use of common lands in Rajasthan has been primarily open access during the last few decades, and a large proportion of them has become degraded. During the last 15 years or so there have been many initiatives to rehabilitate them, but the impact of such initiatives on livestock was poorly understood.

All of the trials listed in Table 1were conducted *'in situ'*, i.e. where the goat-keepers who had identified the challenge lived. This term is used here because the usual one, 'on-farm', is not appropriate for trials involving landless people or research on common lands. One trial was conducted at BAIF's Central Research Station near Pune in Maharashtra.

Table 1 Challenges Addressed by the Project Trials

Challenge addressed (and location)	Treatment/ technology tested	Key indicators	Monitoring period
Low conception rate of female goats (Bhilwara, Rajasthan)	Tree pods supplement (combined with barley in first trials)	Conception and number of kids born	7-8 months, from mid-May to end of kidding season in December
High mortality in kids (< 120 days) in rainy season (in Dharwad, Karnataka)	Dewormer: - commercial OR - based on locally available material	* Mortality during first 120 days after kidding * Growth rates	4-5 months, from late July.
High mortality in kids (< 120 days) in rainy season (in Dharwad, Karnataka)	Feed supplement - mixture of sorgum & horse-gram OR - tree pods	* Mortality during first 60 days after kidding * Growth rates	4-5 months, from late July.
High mortality of young goats (6-9 months) in the rainy season (in Udaipur, Rajasthan)	Urea molasses granules (UMG)	Mortality during early rainy season	4 months
Low milk yields in late dry season (in Bhavnagar, Gujarat)	Urea molasses granules (UMG)	Milk yields in late dry season.	3 months
Low milk yields & herder fatigue in late dry season (in Bhavnagar, Gujarat)	Construction of water trough close to main grazing area.	* Milk yields in late dry season * Herding times & distances in late dry season.	6 months ('before and after' design required collection of baseline data)
Sub-optimal reproductive performance of does (in Pune, Maharashtra)	Complete feed supplement	* Kidding rate	7-8 months, from mid-May to end of kidding season in December
Faster growth of young male goats to increase income (in Udaipur, Rajasthan)	Barley supplement	Sale price and weight at time of sale	About 9 months – from start of treatment to age at which most males had been sold
Earlier sexual maturity of young females, to increase no. of kids produced (in Udaipur, Rajasthan)	Barley supplement	Age at which females reached sexual maturity	About 15 months[1] – from start of treatment to age at which females came into heat or conceived

4. RESEARCH ACTIVITIES

4.0 Project Outputs

The descriptions of the research activities will be grouped according to the project output to which they correspond, so the outputs are described first. Originally, the project had four objectives (outputs in the logical framework). These were:

1. a better understanding of goat-keepers' current feeding and production systems for goats, and the rationale for them;
2. the development of a set of recommendations for improving local feed resources and feed management strategies;
3. the development of participatory methodologies for the analysis of feed resources and constraints and for the testing of interventions;
4. dissemination of the project's findings and recommendations on feed resources and strategies and participatory methodologies.

Modifications 1. Originally, the project envisaged working on sheep as well as goats. However, towards the end of the first year it became apparent that this was over ambitious, and the LPP Manager agreed that the focus could be narrowed to goats alone.
2.Two sub-outputs (2A and 4A) were added in 1999, which were associated with supplementary funding for more in-depth work on silvi-pasture development.
3. Three new outputs were also added in 2000 that were linked to a one-year extension to the project. These additions (2 and 3) are described below, together with the rationale for them.

All planned inputs to the project were achieved.

4.0.1 Additional sub-outputs concerned with silvipasture development

The poorer rural livestock-keepers in Rajasthan tend to be small or marginal farmers (or landless people) who do not have sufficient land to grow forage crops, preferring to give priority to food crops and cash crops. For them, common lands, such as village grazing lands and state-owned forest lands, are often the most important source of forage for their goats and other livestock. Use of common lands in Rajasthan has been primarily open access during the last few decades, and a large proportion of them has become degraded. During the last 15 years or so there have been many initiatives to rehabilitate them.

Given the importance of common lands in livestock feeding systems, the project was interested in the potential of silvi-pasture interventions for relieving seasonal feed scarcity for goats and other livestock. However, a review of the literature on silvi-pasture development in Rajasthan (Conroy, 2000) found that there was very little information in the existing literature on the effect of these initiatives on livestock,

including their feeding systems and numbers. Extra funding was obtained to investigate these and other issues, and the project commissioned 15 case studies.

The additional sub-outputs are as follows:

2A Set of recommendations on silvi-pasture development on common lands developed.

4A Findings and recommendations on silvi-pasture development disseminated.

4.0.2 Additional outputs associated with one-year extension

During the extra year the project was extended to two districts in states (Karnataka and Maharashtra) where landless goat-keepers are more common than they are in Rajasthan. This was done in order to ensure that the project's findings and recommendations were relevant to this group, as well as to small and marginal farmers.

5. Ways of increasing profitability of supplementation using Prosopis juliflora pods evaluated.

In one of the 1999 supplementation trials the treatment was a mixture of *Prosopis juliflora* pods and barley in equal proportions. The trial (and a pilot trial in 1998) provided clear evidence that the treatment results in does producing significantly more (31-38%) kids than they would otherwise have done (Conroy *et al*., 2000). These benefits exceeded the costs, but not by a large margin: the cost:benefit ratio was about 2:3. Thus, the project sought to find ways of increasing the profitability of the technology, either by reducing its costs without significantly reducing its benefits or by increasing its benefits more than its costs.

6. Suitability of pods of other tree species for storage and supplementation assessed

This new output was added because trials on one or more other tree species would give a clear indication of: (a) how generic the technology is; and (b) whether its coverage could be widened beyond areas where *Prosopis juliflora* is found.

7. Impact of increased kidding rates resulting from effective supplementation assessed

The number of kids produced by a given number of does in the project's treatment groups in Bhilwara had increased by about 30-40% as a result of supplementation with *P. juliflora* pods and barley. The project did not know how the higher kidding rates resulting from supplementation affected herd size in the medium term, and hence what additional demands they might have been placing on forage resources as a result. Nor did the researchers have a precise idea of how the additional kids benefit the owner. To answer these questions, a survey was planned, involving individual interviews with participating goat-keepers.

4.1 Understanding Systems: Output 1 Activities

Initially, the project worked in three districts of north-west India - two in south Rajasthan (Bhilwara and Udaipur) and one in Gujarat (Bhavnagar). These districts were selected so that different goat production systems would be covered by the project (see Table 5.1), in order to produce findings that would be of wider relevance in India. Limited diagnostic and needs assessment work was also done in Vidisha District of Madhya Pradesh. During 2000 similar work was done in two new districts – Dharwad (Karnataka) and Pune (Maharashtra); and subsequently further trials were undertaken there.

4.1.1 Production systems and agro-ecological features

In each of the districts where it has worked the project began by conducting surveys in a few villages in areas where BAIF has an operational presence. The districts represent a range of situations in terms of mean annual rainfall and other agro-ecological parameters (see Table 2).

The surveys, which lasted about three days/village, involved rapid rural appraisals with groups of goat-keepers, using semi-structured interviews and mapping and diagramming. The surveys generated descriptions of the farming and livelihood systems, goat production and feeding systems, and the constraints faced by goat-keepers.

Table 2 Agro-Ecological Characteristics of the Survey Districts

District (State)	Mean annual rainfall (mm)	Other Agro-Ecological Characteristics
Bhavnagar (Gujarat)	435	Little forest. Some areas experiencing groundwater depletion and seawater ingress.
Bhilwara (Rajasthan)	660	Plains area. Little forest.
Udaipur (Rajasthan)	624	Hilly area. Some forest.
Vidisha (Madhya Pradesh)	1000-1200	Plains area. Forest coverage is relatively high.
Pune (Maharashtra)	400	Plains area. Little forest.
Dharwad – A (Karnataka)	835	Slightly hilly area. Some forest.
Dharwad - B (Karnataka)	590	Plains area. No forest.

4.1.2 Systems description and characterisation

Livelihood systems The information collected on this topic was quite basic, and was obtained in various ways. Secondary data were identified, where available; and

primary data were obtained primarily though semi-structured group and individual interviews. Different livelihood activities were identified.

Goat production and feeding systems Three different basic types of production system were identified, and these were reflected in differences in feeding systems.

Preliminary identification of constraints and needs Towards the end of the survey work, the goat-keepers were asked to list any problems they considered to be important: and rank them in terms of their relative importance (for example, water scarcity 1st , disease 2nd, feed scarcity 3rd). In villages where people from different castes keep goats for different reasons, or use different production practices, these groups were interviewed separately, as their ranking of problems could also differ. The results of the ranking were generally cross-checked with other survey findings. If an important feed-related problem was identified through the group discussions, further information about it was sometimes obtained through two other methods that the project developed, namely: *participatory problem tree analysis* and *participatory herd histories*. These are described in section 5.3.

4.2 Trials with Goat-keepers: Output 2 Activities

The production systems are different in each district, hence the feed-related problems are too (see Table 1). Initially, the trials conducted by the project focused on supplementation of feed at critical points in time to address the problem identified. Subsequently, trials were also conducted in which the effect of anthelmintics was tested. The trials that were undertaken are summarised in Table 3. The numbers of goats and goat-keepers involved are given in Table 4. Altogether, the project worked with more than 400 goat-keepers; and a total of 1265 goats were involved in the various trials when they began, 660 in the treatment groups and 605 in the control groups.

4.2.1 Prosopis juliflora pods and barley – Bhilwara

In Bhilwara District of Rajasthan there was evidence that feed scarcity in the dry season could be acting as a constraint on the reproductive performance, particularly conception rates, of female goats belonging to poor people. Feed supplementation trials were organised to address this constraint. The trials took place during the later part of the dry season, when fodder scarcity is most acute; and early in the monsoon season when heavy rains frequently deter goats from grazing.

In on-farm trials in 1998 and 1999 (Trials 2 and 5 respectively) breeding does were fed a mixture (250 grams/day) of *Prosopis juliflora* pods and barley for 10 weeks, in equal proportions. The average weight of the does, most of which were of the Sirohi breed, was 25 Kg. The project suggested that half of the treatment be fed to the does in the morning and half in the evening, but most goat-keepers preferred to give it in the morning. The daily quantity to be fed was based on discussions between BAIF staff and the goat-keepers. It was thought that it would amount to 30-35% of a doe's daily dry-matter intake, and would result in minimal substitution effects.

Prosopis juliflora pods are a good source of protein and energy, possessing 12-14% crude protein on a dry basis (Wood *et al*., 2001a). This tree species is widely distributed in arid and semi-arid India. The pods were collected when they appeared on the trees in April and early May and stored (usually in gunny bags) for use later. This was a completely new practice in the all of the villages where the trials were conducted. Goat-keepers were advised to dry the pods thoroughly before storing them, otherwise there is a risk of infestation by pod-borer.

The goats in the treatment and control groups were also dewormed. Two of the commonest endo-parasites in the Bhilwara area are *Fasciola hepatica* and *Nematodirus spathiger*. This was done partly because it gave goat-keepers in the control group an incentive to participate in the trials, and partly because BAIF wanted to be of assistance to the goat-keepers. A potential disadvantage of deworming the animals is that this could mask any anthelminthic effect that the treatment might have. On the other hand, it can reduce variability between animals caused by differences in worm burdens.

4.2.2 Reducing disease-related mortality in Udaipur

These trials sought to investigate whether there was a relationship between feed scarcity in the late dry season and disease-induced mortality early in the rainy season, which goat-keepers had identified as their major problem. It was hypothesized that the poor condition of young goats at the end of the dry season, due to inadequate feed, made them more vulnerable to disease-related mortality; and that supplementation of high quality feeds for a few weeks before the onset of the rainy season would reduce mortality.

In 1998 two trials (Trials 3 and 4) were undertaken to address this constraint. In one village the treatment was urea molasses granules (UMG), and in the other it was barley. In both cases the original intention was to provide young goats (of 3-6 months age) with a daily supplement of 250 grams during the late dry season and early rainy season (from mid-May to late July), to see if this affected the mortality of young goats during the rainy season. However, at the request of the goat-keepers, who were contributing 33% of the costs in the barley trial, the treatment was continued until the end of October.

The feed supplements were combined with health control measures for both treatment groups, and for the control group in Khakad. (See previous section for further details.) All goats were weighed every fortnight.

4.2.3 Increasing the growth rates of goats in Udaipur

During the rainy season in 1998 there was virtually no disease-related mortality among goats in the treatment groups *or* the control groups in both trials. Nevertheless, participants in the barley-supplement trial observed that goats in the treatment group grew faster than those in the control group, and that females reached sexual maturity earlier than usual. According to the goat-keepers their does did not normally conceive until they were about 18 months old, whereas many in the treatment group had conceived at 9-10 months of age.

The 1998 barley trial had had certain weaknesses, largely due to the inexperience of the field staff in conducting livestock research and the speed with which it had had to be initiated. These were:

- the animals selected varied considerably in terms of their ages at the start of the trial;
- they were all prescribed the same quantity of supplement, despite age differences;
- there were significant differences between the general feeding regimes of the treatment and control group animals;
- half-way through the trial, goat-keepers in the control group started giving the treatment to their animals; and
- the supplementation period had been six months, which was unrealistic in terms of the feasibility of goat-keepers adopting it without support from the project.

It was decided, therefore, to conduct similar trials (Trials 7 and 8), but with modifications to remove these weaknesses, and with the focus on growth rates and maturation rather than reduced mortality. The goats selected were from a narrower age range, and the daily quantity of barley was increased (from 200 gms to 250 gms) in line with the age of the animals. The duration of the treatment was shortened to 2-3 months; and the field staff were asked to ensure that goats in the treatment and control groups were on broadly comparable diets and that their owners were of similar socio-economic status. The trial was conducted in a new village, Kirat. There were 23 goats in the treatment groups and 23 in the control groups.

Table 3 Challenges, Treatments and Classes of Goats in the 'In-situ' Trials

District (State)	Feed-related challenge	Treatment	Timing of treatment	Goats targetted
Bhavnagar 1998	Low milk production in dry season	Trial 1. Urea/molasses granules (UMG) 250g/day	Daily for 8 weeks during late dry season and early rainy season (mid-May to mid July)	Lactating does
Bhilwara 1998	Sub-optimal reproductive performance of does	Trial 2.Mixture of *Prosopis juliflora* (PJ) pods and barley 250g/day	Daily for 10 weeks during scarcity period (mid-May to end July)	Breeding does
Udaipur 1998	Disease-related mortality in young goats early in rainy season	Trial 3. Barley – 250 mg/day Trial 4 Urea/molasses granules – 250 g/day	Daily for 10 weeks during scarcity period (mid-May to end July)	Young goats
Bhilwara 1999	Sub-optimal reproductive performance of does	Trial 5.Mixture of *Prosopis juliflora* (PJ) pods and barley – 250 g/day Trial 6. PJ pods only – 250 g/day	Daily for 10 weeks during scarcity period (mid-May to end July)	Breeding does
Udaipur 1999	Faster growth of young male goats	Trial 7. Barley - 200-250 g/day, depending on age	Daily for 2-3 months	Male goats aged 3-6 months
Udaipur 1999	Rapid maturation of females	Trial 8. Barley - 200-250 g/day, depending on age	Daily for 2-3 months	Female goats aged 3-6 months
Bhilwara 2000	Sub-optimal reproductive performance of does	Trial 9. *P.Juliflora* pods alone – 250 g/day Trial 10. *Acacia nilotica* pods – 250 g/day	Daily for 10 weeks during scarcity period (mid-May to end July)	Breeding does
Bhilwara 2001	Sub-optimal reproductive performance of does	Trial 11. P.Juliflora pods alone – 250 g/day	Daily for 10 weeks during scarcity period (mid-May to end July)	Breeding does
Dharwad 2000	High mortality of kids in rainy season	Trial 12. Feed supplement – 200 gm mixture of sorghum and horsegram (ratio of 3:1)	Applied to does in last 4-6 weeks of pregnancy and for one month after kidding	Kids (< 60 days)
Dharwad 2000	High mortality of kids in rainy season	Trial 13. Fenbendazole dewormer @7.5 mg/kg body weight.	Applied to does 15-30 days before, and on day of, kidding	Kids (< 60 days)
Pune 2000	Sub-optimal reproductive performance of does	Trial 14. Complete feed supplement – 300 gms.	Daily during late dry season and early rainy season, from 15 May to end of July	Breeding does
Dharwad 2001	High mortality in kids in rainy season	Trial 15. 2 treatments: T1 – Fenbendazole @7.5 mg/kg body weight. T2 - based on local plant material (Mucuna), @20 mg/kg body weight,.+ jaggery	Applied to does 15-30 days before, and on day of, kidding	Kids (< 60 days)
Dharwad 2001	High mortality in kids in rainy season	Trial 16. Feed supplement T1: mixture of sorghum and horsegram (ratio 3:1) 200 gms T2: *Prosopis juliflora* pods – 200 gms/day	Applied to does in last 4-6 weeks of pregnancy and for one month after kidding	Kids (< 60 days)

4.2.4 Increasing milk production in the late dry season – Bhavnagar

Supplementation trial In Bhavnagar, the decline in milk production during the dry season and into the rainy season seemed to be a serious problem. (Since Gujarat is a vegetarian state milk is a major source of protein.) It was hypothesized that the decline was partly due to scarcity of feed during this period, and that supplementation would reduced the rate at which milk production declines. Urea molasses granules (UMG) had been tested recently by BAIF and Appropriate Technology India in Gujarat in informal on-farm trials, and had been received positively by goat-keepers. The researchers decided, therefore, to adopt UMG as the treatment for this trial (Trial 1), which took place in 1998.

Forty goat-keepers were involved, 20 in the treatment group and 20 in the control group. Goats were given 250 gms/day, half in the morning and half in the evening. Milk production was measured every 15 days. The trial started on 16 May 1998, when the first measurement was taken.

Alleviating water scarcity trial The UMG trial was not particularly effective, and the following year a different intervention was tested. Livestock-keepers (*Rabaris*) in Kumbhan village identified seasonal water scarcity as the most important constraint on goat production (see section 5.1.4). They said that they have to walk long distances during the hot dry season (March-June inclusive), because of a lack of water near their main (communal) grazing area, which obliges them to go elsewhere for drinking water, thereby limiting the amount of time they can spend in the grazing area. The *Rabaris* suggested that this problem should be addressed by constructing a water trough and storage tank near to a privately owned well, in the vicinity of the main dry season grazing area.

Although the research project was focusing on feed scarcity, rather than water scarcity, the researchers decided to provide financial support for the construction of the trough, since water scarcity and feed scarcity appeared to be closely inter-related in three ways. First, inadequate water intakes would be expected to have a negative impact on feed intake *per se*, and hence direct and indirect effects on animal productivity. Second, the longer distances covered by the livestock in search of water would increase their energy expenditure, and hence feed requirements; and, third, walking long distances reduces the amount of time available for grazing.

Before a decision was taken on whether to proceed with construction of the water trough, the local BAIF staff collected data that would enable an informed but basic appraisal to be made. Once the decision had been made (in November 1998) to proceed with the trough, some more detailed baseline data were collected (in late 1998 and the first quarter of 1999), regarding animal numbers, types, and daily activity patterns and herding routes and distances. A rudimentary financial cost/benefit analysis and environmental impact assessment were also undertaken.

The project agreed to pay for the construction materials and skilled labour (about £200), while the Rabaris agreed to provide unskilled labour voluntarily and to maintain the trough subsequently. The trough was constructed in April 1999, and came into use on 9 May, in the middle of the dry season. Milk production of 12 goats and 12 cows was monitored every two weeks from late March until late June.

Table 4 Numbers of Goat-Keepers and Goats in the Project Trials

Trial No.	District	Village(s)	Type of Goat-keeper[1]				Caste(s)[2]	Initial Number of Goats[3]		
			SMF	LLGS	LLWL	TOTAL		Treatment		Control
1	Bhavnagar	Kumbhan	21	1	13	**35**	Rabaris, SC (15)	20		20
2	Bhilwara	PatiyokaKheda	11			**11**	SC/ST	25		25
3	Udaipur	Khakad	23			**23**	ST	33		37
4	Udaipur	Gopir	18			**18**	ST	23		24
5	Bhilwara	Iras	27?			**27**	SC/ST	56		63
6	Bhilwara	PatiyokaKheda				**11?**	SC/ST	30		28
7	Udaipur	Kirat					ST	23		23
8	Udaipur	Kirat					ST	23		23
9	Bhilwara	Udalpura	16			**16**	Kumawat	48		50
10	Bhilwara	Rampuriya	18			**18**	Kumawat	63		55
11	Bhilwara	Baga ka kheda	40			**40**	Kumawat (16), SC/ST (15), Gujar (11), others (8)	87		82
12	Dharwad	Naiknoor, Boganoor, Shelwadi		9	7	**16**	SC (6), ST(5), Muslim (5)	26		26
13	Dharwad	Nigadi, Devarhubli, Bekanatti, Lalgatti	10	4	7	**21**	Lin.(10), SC (3), ST (2), Muslim (2), Maratha (4)	34		34
14	Pune	Walti, Dahitane, Bharatgaon, Kasurdi, Bori Aindi, Koregaon Mul	49	0	85	**134**		69		65
15	Dharwad	Nigadi, Devarhubli, Bekanatti	13	1	4	**18**	Lin.(8), SC(1), ST(3), Mus.(2),Maratha (4)	**T1** 26	**T2** 26	26
16	Dharwad	Naiknoor, Boganoor, Shelwadi		9	12	**21**	SC (9), ST (8), Muslim (3), Lin.(1)	**T1** 24	**T2** 24	24

[1] SMF = Small and marginal farmers. LLGS = Landless goat specialists. LLWL = Landless wage labourers
[2] SC = Scheduled castes ST = Scheduled tribes Lin. = Lingayat
[3] These are the numbers of goats at the start of the trials. The numbers usually decrease during the trial due to sales, mortality etc.

4.2.5 Reducing kid mortality through supplementation - Dharwad

In the Karnataka project area high kid mortality during the rainy season was identified by goat-keepers as their main problem, and the project conducted trials in 2000 and 2001 to address this.

Goat keepers in the project villages were aware that goats, particularly pregnant and lactating does, do not like to graze when it is raining, even though there is an abundance of vegetation, because they abhor getting wet. They also thought the low dry matter content of wet season fodder was associated with lower nutrient content. They believed that these two factors were associated with lower milk production, lighter kids and higher kid mortality in the rainy season.

Trial 12 In 2000, the BAIF/NRI team, together with goat-keepers in the project villages, decided to test the effectiveness of feeding 200 gms of sorghum + Horse gram mix (ratio of 3:1) on the performance of does, kid mortality rates and growth of kids. The idea for the treatment, including the daily quantity, came from one of the goat-keepers, who had already tried something similar himself. The timing of the treatment varied, with goat-keepers in two villages (Shelwadi and Naiknoor) feeding it in the morning, and those in the other village (Boganoor) in the evening. Goat-keepers contributed 25-50% of the cost of the treatment.

The trial was conducted on 34 pregnant does due for kidding in the rainy season, with the treatment being provided for 30-45 days before kidding and during the first 30 days of lactation.

Trial 16 In 2001 the trial was repeated, but with an additional treatment, namely *P. juliflora pods*. The PTD Team selected 21 research partners, most being landless goat keepers. All the partners had at least three does due to kid in the rainy season. A total of 72 does gave 24 per group. Goats were randomly allocated to treatment, with the proviso that at least one goat from each keeper appeared in treatment group, and the age of the goats was balanced across groups. The groups were:

- T1, control, goats were not supplemented (C)
- T2, does were supplemented with 250 g *Prosopis juliflora pods*/day (PJ)
- T2, does were supplemented with 200g of a mixture of sorghum + horse gram/day (SHG).

All the material required for feeding was procured locally. *Prosopis juliflora* pods were collected in summer and preserved in neem leaves, followed by weekly fumigation of the store with green leaves of neem to avoid pest infestation.

4.2.6 Reducing kid mortality through deworming - Dharwad

The BAIF/NRI project team thought that the high kid mortality in the rainy season might also be linked to the worm burden of the goats at that time of the year, as there is evidence that mortality rates are higher for kids of does that have a heavy worm

burden. Thus, at the researchers' suggestion[4], deworming trials were also carried out. It was hypothesized that de-worming would enable the does to utilise feed more efficiently, and hence would improve their condition at the time of kidding and enable them to produce more milk for their kids.

The treatments were given to does in late pregnancy and on the day of kidding. The does were of varying ages and weights (ranging from 15 to 45 kg). Equal numbers of does were selected from the different age and weight groups for inclusion in the treatment and control group respectively.

Treatments In the first trial (Trial 13) the treatment was a commercial de-wormer, *Fenbendazole*, which was applied to the pregnant does (@ 7.5 mg/kg. body weight) 15 days to 1 month before kidding and on the day of kidding. *Fenbendazole* was chosen because it is a broad-spectrum anthelmintic with no known side-effects. The cost was shared equally between the participants and the project.

In the second trial (Trial 15), another treatment was added - a locally available material known to have anthelminthic properties. The locally available material that was used was the trichomes (hairs) from the pods of a leguminous creeper, *Mucuna pruriens*. The dose, which was mixed with a lukewarm sugary solution (jaggery), was 20 mg per kg body weight. The idea for this treatment came from the fact that members of a local caste specialising in buffalo-keeping were known to use it.

As far as we are aware, this is the first time that the use of MPT as an anthelmintic for livestock has been documented or tested in trials, although it has been mentioned as a possible anthelmintic for children. An internet search using Google, and the terms '*Mucuna*' and 'helminths', failed to identify any documents referring to the use of *Mucuna* products to control helminths in livestock. Similarly, no such reference was found in a recent and voluminous annotated bibliography of materials on ethnoveterinary medicine (Martin *et al*., 2001). However, as a cover crop *M. pruriens* has shown good potential for preventing the reproduction of nematodes (Haroon and Abadir, 1989, cited in Anderson *et al*., 2001). Its use in the control of external parasites has also been noted in Malawi (Kambewa *et al*., 1999).

Collection and analysis of faecal samples Faecal samples from 20 pregnant does before and seven days after treatment were collected and analysed to determine the parasitic burden. Faecal pellets, collected directly from the anus, were preserved in a 10% formalin solution before testing. Representative samples were collected from all three villages. Care was taken to collect faecal samples for all treatment groups from goats belonging to the same goat keeper. Egg counting was done by the method of Stoll.

4.2.7 Increasing kidding rates through supplementation - Pune

The needs assessment exercise concluded that the core problem for goat-keepers in the survey villages was feed scarcity in late summer and early rainy season; and that this resulted in low reproductive efficiency and reduced numbers of kids. It was

[4] Most of the participants had only taken up goat-keeping during the last few years, and they were not aware of the possible effect of internal parasites on their animals.

hypothesized that supplementation during the scarcity period would lead to higher kidding rates.

The lead researcher was from BAIF's Central Research Station, which had developed and was manufacturing a complete feed. It contained: 1. TDN- 58%; 2. CP – 14%; 3. Fiber – 18%; 4. Dry matter – 92%; and 5. Molasses – 7%. He proposed that this be the treatment used in the trial, at 300 grams per day. The trial (Trial 14) was conducted in six villages, in collaboration with women's self-help groups, who selected the trial participants.

4.2A Silvipasture Development and Management: Output 2A Activities

In late 1999 the project commissioned 15 case studies of silvi-pasture development interventions that had been initiated in the 1980s or the early 1990s, with a view to filling in knowledge gaps concerning the effect of protected silvi-pasture areas (PSPAs) on livestock. The case studies were undertaken by BAIF, and four NGOs based in Rajasthan's Udaipur district, namely: Hanuman Van Vikas Samiti, Prayatna Samiti, Seva Mandir, and Ubeshwar Vikas Mandal. The Society for the Promotion of Wastelands Development also provided inputs, through its western region programme office in Udaipur.

A survey guide was developed by the project leader, in collaboration with staff of the NGOs involved (see Annex 2). The case studies were published in five separate reports; and a more general report was written, summarising the case study findings.

4.2A.1 Assessing the impact of PSPAs on livestock numbers

The researchers collected data on the current populations of each kind of livestock in the village, and attempted to obtain similar data for the year in which work on the PSPA was initiated. The historic data can only be obtained via people's recall or from census data, neither of which is particularly reliable, unless baseline data were collected at the time. Nevertheless, the best possible data were obtained, so that some sort of comparison could be made.

4.2A.2 Incorporation of PSPA forage in livestock feeding systems

The main tool used to collect this information was seasonal feed calendars, an example of which is given in
Figure **2**. Case study researchers were asked to obtain separate information for large ruminants and small ruminants, with one calendar for each.

4.3 Participatory Methods: Output 3 Activities

4.3.1 Diagnostic and needs assessment phase

A wide range of PRA tools were used during this initial phase. A checklist of the topics typically covered, and the tools used to collect information about each, is given in Box 1. More detailed descriptions of the methods used, with examples, can be found in Conroy, 2001.

Box 1 CHECKLIST, TOOLS AND ILLUSTRATIVE SURVEY SCHEDULE

Day 1 Livelihood Systems

* Introduction

* Identify and rank activities making up the livelihood systems (matrix ranking)

* Seasonality of activities, labour and cash flow (seasonal diagram)

* Identify and analyse long-term trends affecting people's livelihoods (timeline)

* Daily schedule of activities for men and women, including goat-keeping (Activity schedule)

Day 2 Livestock Production System, Benefits and Constraints

* Historical trends in livestock ownership (Timeline)

* Benefits/reasons for keeping small and large ruminants (SRs and LRs) (Matrix Scoring)

* Goat production system over a year - showing breeding and kidding seasons, disease and marketing times (Seasonal production calendar)

* Production constraints for goats (Simple Ranking)

Day 3 Forage Resource Mapping and Transect

* Forage Resource Map (Participatory Mapping) - Current (and Historical?)

* 2 Dry season forage maps - for an average year and a drought year
(showing: (a) tree tenure - owners' trees, communal, & purchased lopping rights;
(b) typical daily herding route.)

* Visit key forage resource points, based on maps (Village Walk)

Day 4 Feeding Systems and Seasonality

* Sources of feed at different times (Seasonal Feed Calendar, by source)

* Types of feed at different times (Seasonal Feed Calendar, by type)

* Discussion about nature of goat feed problems, if any (Participatory Problem Tree)

* Discussion about what happens to goats in the dry season (Average and Severe)
- in terms of weight, milk production, herding time etc.

* Coping strategy in Average and Severe Years (e.g. distress sales, longer distance migration)

* Preliminary Discussion of Possible Interventions/Solutions (if there is a scarcity problem).

Characterisation of goat production systems Matrix scoring (see Figure 1 for an example) was used to determine the relative importance of different contributions that goats and other livestock make to people's livelihoods (e.g. income, milk, manure). Seasonal production calendars provided a valuable overview of the timing of conception, kidding, sales and disease.

Description of goat feeding systems The principal tools used were seasonal calendars, to show temporal aspects; and participatory mapping of forage resources to show spatial ones. Different types of seasonal calendars were used to explore different aspects of feeding systems – some calendars focused on fodder species, while others looked at sources (e.g. common grazing lands, private grazing lands, owners' fields, others' fields).

Needs assessment To ensure the active involvement of goat-keepers in PTD it is essential that the research is addressing a need that they regard as important. The researchers generally sought to address a priority need of the goat-keepers. If an important feed-related problem was identified through the group discussions, further information about it was sometimes obtained through two other methods that the project developed, namely: *participatory problem tree analysis* and *participatory herd histories*. These are described in section 5.3.

4.3.2 In-situ trials

A participatory approach was also taken when preparing for and implementing the trials.

Determination of treatment Ideas for treatments came from various sources (see Box 2 for some examples). However, in most of the trials it was the researchers who identified the type of supplement to be used, although this was based on knowledge of livestock-keepers' experiences with similar technologies in other localities. In most trials, the participants appeared to agree that the proposed treatment was a sensible one, and contributed 33-100% of the cost of the treatment.

Box 2 IDENTIFYING INTERVENTIONS – SOME EXAMPLES

Members of the local communities In a feed supplementation trial in Dharwad, Karnataka, the idea for the treatment came from one of the goat-keepers. The treatment was a mixture of sorghum and horsegram.

Other livestock-keepers in the region In a de-worming trial in the same district the idea for the treatment came from the practice of another ethnic group from a nearby area, the Gawalis, who specialise in keeping buffaloes. The treatment was the trichomes (hairs) from the pods of a leguminous creeper, mixed with jaggery, a lukewarm sugary solution.

Researchers or extensionists In a supplementation trial in Bhavnagar, Gujarat, the researchers suggested the use of Urea Molasses Granules, which they had recently tested in a pilot project elsewhere in Gujarat.

Trial design The supplementation trials, which all took place during the dry season, were designed with a treatment and control group in the same village, so that a 'with/without' comparison could be made. In the Rajasthan trials all goats in the two groups belonged to people in one village, partly to reduce the variability between them in the feeding systems and sources. In most trials all of the goats in the two groups were from herds of broadly similar size (e.g. 5-10). In all but one of the Rajasthan trials, goat-keepers participating in any particular trials were from the same, or similar, ethnic groups, e.g. in some trials they were from scheduled tribes (STs) and scheduled castes (SCs).

In the Rajasthan and Gujarat trials the goats in the treatment group were from different herds to those in the control group; whereas in the Dharwad trials treatment and control group animals were from the same herds (e.g. 2 T group and 2 C group goats from the same herd). Each of these approaches has its advantages and disadvantages (actual or potential), which are discussed in section 5.3.2. The Dharwad trials were also different in that goats (in both the T group and C group) came from 3-4 villages. These villages were close together, however, in order to minimise any variability that might be caused by spatial differences.

Other variables Non-experimental variables, such as supplements provided by owners independently of the trial, were not controlled. In addition, the owners were free to dispose of trial goats during the trial if they so wished, although they were made aware that it would be preferable not to do so.

Incentives In the 1998 trials the project contributed 66% or 100% (in the case of UMG, which was completely new to the goat-keepers) of the cost of the treatment. In subsequent trials in the same or nearby villages, the subsidy was reduced. In the Dharwad trials, participants contributed 50% of the treatment, financially or in kind, in the first year of trials (2000). The intention was to reduce the size of the subsidy each year, as the value of the technologies was demonstrated, and as their efficacy was improved through design modifications. Participants in the control group were given a different incentive to participate, which was usually the provision of a breeding buck.

Selection of villages Trial villages were selected primarily on the basis of three criteria. They: (a) were located in an area where BAIF was working, and ideally had already had dealings with BAIF; (b) contained goat-keeping households that were below the poverty line; and (c) contained enough goats (at least 50 and preferably more) in the relevant class (e.g. breeding does) to enable a meaningful trial to be undertaken. Field staff were advised not to select villages that they knew to be atypical in some way.

Numbers of goat-keepers and goats The project developed two 'rules of thumb', namely: (a) that the minimum number of goats required in each group was 25, and (b) the minimum number of goat-keepers in each trial group should be 6 or 7. The former was intended to facilitate meaningful statistical analysis and tests. The latter was to avoid a situation in which goats belonging to one or two goat-keepers accounted for a large percentage of the goats in a particular trial group, thereby introducing the possibility that inter-group differences could be due to owner differences rather than the treatment. (This situation arose in the first Bhilwara trial, in which there were only

three goat-keepers in one group, one of whom owned 12 of the 25 goats in that group.)

Selection of participants *One criterion* applied in all trials was that the participants must be goat-keepers. *Another criterion* was their caste or status, the majority of trials having deliberately involved people from poorer groups, such as SCs and STs. In two trials in Bhilwara it was not feasible to involve people from the poorest groups, so people from other castes were selected instead. In one case the SCs and STs in the selected village had a high level of risk-aversion, and hence were not interested in participating in a trial that involved a new technology. As a result, the project team were obliged to work with a slightly better-off caste.

Sometimes, the above two criteria would limit the number of potential participants from one village to a small number, and there would be no scope for applying any further criteria, given the need to include minimum numbers of goat-keepers and goats. In the Pune and Dharwad trials, priority was given to involving landless goat-keepers, since this was a major reason for extending the project area to these districts. In Pune, the project was specifically working with women, and was coordinating the work through self-help groups (SHGs) to which they belonged.

Monitoring and evaluation In most trials there was fortnightly monitoring of relevant goat productivity parameters (e.g. milk production), and monthly meetings with participants to discuss how the trials were progressing. Local people (usually not participants) were trained to undertake the fortnightly monitoring. Joint evaluation meetings were held at the end of the trials.

4.4 Dissemination: Output 4 Activities

Various dissemination media have been utilised, including project reports, workshops and conference papers.

4.5 Increasing the profitability of *P. juliflora* treatment: Output 5 Activities

4.5.1 Prosopis juliflora only

Two possible ways of increasing the profitability of this kind of treatment were investigated. One was to remove barley and replace it with *P. juliflora* pods. Thus, in 2000 and 2001 similar trials (Trials 9 and 11 respectively) were conducted in Bhilwara District, but this time the treatment (again 250 grams/day) was entirely *Prosopis julifora* pods.

4.5.2 Digestibility trial

The other was to study the potential for increasing feed utilisation from the pods by grinding them so that the seeds (which are highly nutritious) would not be able to pass through the goats undigested. The field staff were under the impression that a high proportion of the seeds were not digested. Thus, in 2001 another trial was carried out at BAIF's Central Research Station, in which *Prosopis julifora* pods were fed to goats, to measure what percentage of the seeds in the pods were digested and what percentage were excreted intact in the faeces.

The trial was carried out on six goats that were four years old and weighed about 30 Kg. Each goat was tethered separately. They were fed 150 g of pods daily, combined with their routine diet, namely lucerne and green fodder. Feed offered, residues remaining and total dung collected were all measured over a 12-day period; and on each day total seeds collected from each animals were separated and counted. (The typical number of seeds found in 150 g of pods was estimated by crushing 10 or more sets of pods of that weight and counting the total number of seeds present in each.)

4.6 Suitability of pods of other tree species: Output 6 Activities

In 2000 a trial (Trial 10) was undertaken in Bhilwara using *Acacia nilotica* pods, instead of *P. Juliflora* pods, to see if they were also effective in improving the reproductive performance of does. The pods contain about 10% crude protein (Wood *et al*., 2001a), and are a highly valued feed that is given primarily to goats. They have a thicker and harder seed coat than *P. juliflora* pods. The tree has good timber qualities, and is found primarily on private land. Some goat-keepers purchase lopping rights to *A. nilotica* trees belonging to other farmers, temples etc. Some farmers with *A. nilotica* trees on their own land store the pods, but this practice has not been documented and it is not known how widespread it is.

The treatment was 250 gms/day of pods, which were fed whole. As in the *P. juliflora* trials, they were dried and stored. The treatment period lasted from 1/5/2000 to 15/7/2000. The goats in both groups were also dewormed.

4.7 Impact of Treatments on Herd Size and Environment: Output 7 Activities

For the reasons given in section 4.0.2, a survey was planned in two of the project districts (Bhilwara and Dharwad) to clarify the effect of higher kidding rates on herd size and, in turn, on the environment. Another issue investigated was whether higher twinning rates, arising from project treatments, were having a negative effect on kid mortality.

It was decided that the information required to answer these questions should be obtained primarily by interviewing individual goat-keepers who had been involved in trials.

4.8 Resources and Facilities Used by the Project

The vast majority of the research was undertaken in the field by BAIF staff and goat-keepers based in the area concerned. All of the goats involved in these trials belonged to local people. BAIF offices in each of the project districts were used for meetings of the project team members.

Altogether, about 25 BAIF staff were involved in the project at one time or another, including 3-5 in each of the project districts. Most of them had experience of livestock development, albeit primarily with large ruminants. However, almost none of them had previously been involved in research, so a considerable effort went into training them

One trial was carried out at BAIF's Central Research Station (CRS) in Maharashtra - see 4.5.2 above. Staff at CRS also carried out egg counts on faecal samples sent to them from the Dharwad project area.

The project coordinator for BAIF was initially Dr DV Rangnekar, who was based in Ahmedabad, and subsequently Dr AL Joshi, based at BAIF's head office in Pune, Maharashtra. BAIF's Pune offices have been used for planning meetings, and also for the second of two training courses in PTD for project team members, led by Czech Conroy.

NRI staff who contributed to the project were:

- Czech Conroy, Socio-economist and Project Leader;
- Richard Matthewman, Ruminant Production specialist; and
- Deborah Romney, Animal Nutritionist.

Dr Romney moved to ILRI during the course of the project, but was allowed by ILRI to continue to make inputs to the project after her move.

This project was linked to another LPP-funded project (R6995), *Application of Laboratory Feed Evaluation to Identify Methods of Easing Feed Scarcity in NW India*. That project was led by Dr Chris Wood of NRI, who was a useful source of advice and information.

5. OUTPUTS

The research results and products achieved by the project. Were all the anticipated outputs achieved and if not what were the reasons? Research results should be presented as tables, graphs or sketches rather than lengthy writing, and provided in as quantitative a form as far as is possible.

5.1 Results of Work on Understanding Systems and Constraints

5.1.1 Types of goat-keeping systems

The project's surveys identified three main types of goat-keepers, namely:

1. Smallholder agro-pastoralist
2. Landless Wage Labourer and
3. Landless livestock specialist.

Table 5 Types of Goat-keepers

1. Smallholder agro-pastoralist		**2. Landless Wage Labourer**	**3. Landless livestock specialist**	
1.1 Small ruminant specialist	*1.2 Non-specialist*		*3.1 Only goats*	*3.2 Mixed livestock*

Within types 1 and 3 there are also two sub-categories, as shown in Table 5. Each of these types will now be described.

Smallholder agro-pastoral systems These systems can be subdivided into those of *small ruminant specialists* and *non-specialists*. In South Rajasthan, there are many tribal people, who are non-specialists, who sometimes live in the same village as specialist castes (mainly Gujars or Gayris). What they have in common is the sources of feed, although the proportions of feed from different sources vary between the two groups (for an example of this, see Wood *et al*., 2001b). *Specialists* have larger herds, comprising mainly sheep, with flocks of 30-100, which are kept for their meat and wool; but also some goats. Specialists are generally better-off, and better endowed with on-farm feed resources, such as crop residues and private 'wasteland' for grazing. In specialist systems the high value of the larger herds dictates that the animals are herded by adult males.

The relatively large herd sizes of specialists may require the owner to migrate with them in times of feed scarcity, either seasonally every year or in drought years (i.e. every 3-4 years). Seasonal migration tends to be for less than six months, whereas migration by Rajasthan's Gujars in drought years is from September through to the following June.

Non-specialists tend to keep goats but no sheep. They have smaller landholdings. Herds are small, typically between 1 and 10 does, and the goats are herded by children

or women. Adult males from non-specialist households are often involved in seasonal migration for wage labour, which may be a constraint on the numbers and types of animals that can be kept.

Landless wage-labourer system In some of the project districts, (e.g. Bhavnagar, Dharwad and Pune), many scheduled caste goat-keepers are landless. Their livelihoods depend primarily on wage labour, usually by both adult males and females, most of which is agricultural labour. These households keep 1-4 breeding does, primarily as a liquid asset (except in Bhavnagar, where milk production is important).

Marginal/landless livestock specialist This category of goat-keeper was found in Bhavnagar, Dharwad and Pune. They spend most of their time herding their animals. Livestock production is their main livelihood activity, providing nearly all of their income - with goats being both a liquid asset and a regular source of income. There are two sub-categories, one which keeps a mixture of goats and large ruminants (*mixed livestock* sub-category)and another which keeps *only goats*. The *Rabaris* of Bhavnagar keep both large ruminants and goats, herds of 30-50 goats being common. However, many of the goats may belong to others, whose herds are too small to make it worthwhile for them to do the herding themselves.

In the other two districts people (primarily belonging to SCs and OBCs) tended to keep *only goats*, herds being typically 20-30 in number. Most or all of the goats may belong to the herder, but share-rearing of other people's goats is quite common.

Livestock and goat specialists tend to have higher levels of expertise than non-specialists, and are likely to provide better health care to their animals. For example, they are more likely to be aware of internal parasites and to de-worm their animals.

Figure 1 Matrix Scoring of Livestock Product Benefits by Tribals in Khakad, Udaipur (Anas)

Benefits	Buffalo	Cow	Bullock	Goat	Poultry
Manure	2	3	2	1	
Milk	4	2		2	
Ghee	5	2		1	
Income	4	8		8	8
Meat [1](home consumption)				1	8
Draught power			13		
Leather	1	1	1	1	
Liquid asset[2]				2	

[1] In some areas/societies, there is a custom that goat-keepers do not consume their own goats. Thus, the score given to meat may need to be interpreted carefully.
[2] Since this is not a tangible product, goat-keepers may not identify it without prompting. In this example, they were deliberately prompted by the survey team, who wanted to know the relative importance of sales to meet contingencies versus sales to maximise net income.

5.1.2 Benefits of Goat-Keeping

The main benefit from keeping goats is usually the cash obtained from selling them to traders or consumers: ultimately, they will be consumed as meat. (The situation in the vegetarian state of Gujarat is different: there they are kept primarily for their milk, and sale of male goats for consumption is frowned upon.) The vast majority of male goats are sold when they are 4-12 months of age, while young female goats are usually retained to maintain or increase herd size. Sales of goats can either be planned to take place when prices are good, or forced to take place when the owner needs cash to meet a contingency. The balance between these two types of sale will depend on what other liquid assets, if any are available to the owner, and also on how many goats (s)he has.

In the project's preliminary surveys, goat-keepers were asked to indicate the relative importance of different benefits provided by goats and other livestock, using matrix scoring. An example of this is given in Figure 1. This shows that income is the main benefit. Home consumption of meat is of minor importance: even milk consumption is more important than that. Among wealthier families, home consumption of meat would probably assume greater significance, although some goat-keepers are vegetarian (even outside Gujarat).

5.1.3 Feeding systems

Most feeding systems are heavily dependent on grazing (including browsing), with little stall-feeding. However, goat-keepers in Rajasthan and Gujarat provide high quality supplements to does at certain times of the year, such as barley (in Rajasthan) and groundnut cake (in Gujarat). This is done primarily in the kidding season.

Smallholder agro-pastoral systems The feed resources include: crop residues from their own land; forage from their private wasteland; and forage from common lands. An example of how different sources vary over the course of a year is given in Figure 2, for SC smallholders. In this case common lands are the main source of forage in all three seasons, although private crop land also makes a significant contribution, particularly in the summer season. Other smallholders (non-SC) in the same village or elsewhere might have larger and/or more productive farms, enabling them to be less dependent on common lands.

Landless wage-labourer system In Bhavnagar, the feeding system is a combination of stall-feeding, with forage collected in the fields where the labourers work or on their way home, and some herding by old family members or children. Labourers also pay landless livestock specialists to herd their animals for them – there is a daily fee per goat. In Pune, women usually take their goats to the fields where they are working, and tether them there. (To do this, they have to have the permission of their employers, who tend to insist that no more than two goats are allowed in: thus, this limits herd sizes.) Here, the goats graze on field boundaries or are given weeds. The women also bring home some forage and store it for use at times when they are not working in the fields.

Figure 2 Seasonal Feed Utilisation Diagram for SCs in Indrapura, Bhilwara (Anas)

Feed Sources & Types	**SUMMER**				**RAINY**				**WINTER**			
Community land	12	-	4[1]	10	8	14	12	10	10	6	8	8
Crop land (own)	-	16	4	2		-				4	4	4
Crop land (paid for)	-	-	2	-		-						
*Bida** land (own)	3	-	4	2	8[2]	-			2	4	4	4
*Bida** land (paid for)		-	2[1a]	-		-	4	4				
Home supplements	1	-	-	2		2[3]		2	4[4]	2[5]		

* *Bida* is private 'wasteland' that is not good enough for crop production.

[1] The principal species used at this time is Deshi Babul (*Acacia nilotica*) [1a] This is purchased tree loppings

[2] They use their own bida land for 8-10 days before the rains start. They repair the boundary fences and during August they stop grazing on the bida land, and make full use of the communal land.

[3] When the rain is heavy they have to cut grass for the goats

[4] They give barley (which they have grown) to lactating does. [5] Cotton

Marginal/landless livestock specialist Being landless, they graze them primarily on common lands, often forests, and on other people's agricultural fields after harvesting.

5.1.3 Constraints

Tables 6-11 show the rankings of constraints that were given by male goat-keepers in 16 villages to members of the project team during 1997-1999. (Women were also interviewed, but it was sometimes more difficult to get rankings from them. Their answers are often, but not always, similar to men's. This is discussed in Conroy, 2001.) Disease is an important constraint in all three districts, but otherwise there are some significant differences.

Table 6 Ranked constraints in three villages of Bhavnagar District - *Rabaris*

Rank	Kumbhan	Valukad	Hanol
1	Water scarcity – summer	Water scarcity - all year	Disease
2	Forage scarcity – summer	Forage scarcity – summer	Quantity of crop residues in late winter/summer
3	Disease	Disease	Water scarcity

Table 7 Ranked constraints in five villages of Udaipur District - Tribals

Rank	Gopir	Jothana	Khakad	Kirat	Masinghpura
1	Disease	Fodder scarcity, water scarcity and disease*	Disease (diarrhoea)	Disease	Disease
2	-		Drinking water scarcity	Theft	-
3	-		Insufficient concentrates	Shortage of tree fodder	-

** The goat-keepers in Jothana saw these problems as inter-related.*

Table 8 Ranked constraints in three villages of Bhilwara District

Rank	Iras	Laxmipura	Udaipura
1	Feed scarcity in summer season (lack of trees)	Feed scarcity in summer season (lack of trees)	Insufficient trees/shrubs for grazing
2	Lack of breeding buck	Lack of breeding buck	
3	Disease - mainly in rainy season	Disease - mainly in rainy season	

Table 9 Ranked constraints in two villages of Bhilwara District

Rank	Patio ka khera (Bhils)	Patio ka khera (Gujars)	Indrapura (Gujars)
1	Shelter from rain (waterproof roof)	Disease (outbreak of E.T.)	Manpower for herding
2	Disease	Shelter from rain (waterproof roof)	Fodder scarcity, combined with cash constraint
3	Fodder scarcity in June	Fodder scarcity in June	

Table 10 Ranked constraints in 2 villages of Vidisha District, Madhya Pradesh

Rank	Navela	Mahavan
1	Theft	Theft
2	Disease	Predators
3	Predators	Diseases
4	Infected hoofs in rainy season	

Table 11 Ranked constraints in two villages in Dharwad District

Rank	Naiknoor	Devarhubli
1	Diseases (Kid mortality) in rainy season	Diseases (Kid mortality) in rainy season
2	Fodder Scarcity (summer)	Fodder Scarcity (summer)
3	Water Scarcity (summer)	Water Scarcity (summer)

Several constraints were identified in villages in Pune district, but they were not ranked. The overall results can be briefly summarised as follows, although there may be exceptions.

In all of the villages with *low rainfall* (i.e. mean annual rainfall of less than 450 mm), namely the Bhavnagar villages, water scarcity is given as one of the constraints and it is the most serious one in two of the villages. Feed scarcity and disease were the only other constraints mentioned in these low rainfall villages.

In *medium rainfall* villages (550-625 mm mean annual rainfall), i.e. Naiknoor and those in Udaipur, water scarcity is mentioned in some of them, but not as the most serious constraint. Disease is the most frequently mentioned and most serious constraint. Feed scarcity is also mentioned in some of these villages.

In Bhilwara, with its slightly higher rainfall, water scarcity was not included as an issue in the rankings (but was mentioned in discussions in the drought year of 1999), and feed scarcity and disease are of roughly equal importance. Lack of a breeding buck was also mentioned in two villages, as was the need for a waterproof roof in another two. In Devarhuballi, however, which is in Dharwad's higher rainfall area,

villagers did see water scarcity as a constraint, although less important than fodder scarcity and disease.

In the *high rainfall* (1000-1200 mm) villages of Vidisha, which also had more forests nearby, the picture is different again, with theft the most serious problem: more goats are lost through theft than through disease. This is at least partly related to the cover afforded by the forests to the thieves. Predators (such as jackals and species of wild cats) are another new problem in Vidisha, which is again related to the relative abundance of forests. Feed scarcity in the dry season is not a constraint here, partly because of the feed available in the forest and partly because the goats graze on nutritious crop residues during the first two months of the dry season.

Note of caution These rankings were a valuable early step in problem identification and needs assessment. However, a highly reliable and deeper understanding can only be gained through more thorough survey work (using, for example, participatory problem tree analysis and participatory herd histories) and observations. For example, goat-keepers may give an unduly high ranking to the need for a breeding buck or a waterproof roof, partly in the hope that the researchers will provide them. Conversely, two constraints that are seldom mentioned, but which appear to be of widespread importance, are marketing and the availability of family labour for herding. Rankings may also be influenced by recent events: e.g., disease may be given a higher ranking after a recent and serious epidemic.

5.2 Results of Trials

In all of the trials except one (see section 5.6) the treatment had a beneficial effect on the goats.

5.2.1 Prosopis juliflora pods/barley and conception rates - Bhilwara

Conception The treatments had the anticipated effect, with does in the treatment groups having higher conception rates than those in the control groups. The conception data are summarised in Table 12. The difference in conception rates between the treatment and control groups is significant at the 5% level for the 1998 data, using an exact chi-squared test; whereas the p-value for the 1999 data was almost significant at that level, at 0.055.

Table 12 Conception Data for Mature Does in PJ Pods and Barley Trials

	1998		1999	
	Pregnant	Not Pregnant	Pregnant	Not Pregnant
Treatment	24	0	39	11
Control	18	5	34	22

Twinning The incidence of twinning was also higher in the treatment groups (see Table 13), but the difference was not significant at the 5% level. An exact chi-squared test gives values of 0.37 and 0.35 for the 1998 and 1999 data respectively.

Table 13 Twinning Rates* in PJ Pods and Barley Trials, Bhilwara

	1998		1999	
	Twins	One	Twins	One
T	4	19	11	28
C	1	16	6	26

* Does that aborted are excluded
T = Treatment Group C = Control Group

Kidding rates The combination of higher conception rates and higher twinning rates results in higher kidding rates in the treatment groups, as can be seen from Table 14. Another way of expressing the data is in terms of the mean number of kids per doe. To see if the differences are significant an asymptotic Mann-Whitney test, adjusted for ties, was used. The p-values show that at the 5% significance level there is clear evidence that the treatment results in does producing more kids than they would otherwise have done.

Table 14 Kidding Rates (%) in PJ Pods and Barley Trials, Bhilwara

Group	**1998**	**1999**
Treatment	116.6	100.0
Control	78.3	69.1
P-value	*0.01*	*0.02*

5.2.2 Reducing mortality in the rainy season – Udaipur

There was virtually no disease-induced mortality in young goats during the trial in either the treatment or control groups, which may have been linked to the unusually low rainfall during the early monsoon period. Liveweight gain was estimated from the slope of regressions fitted to the data; and the results were then analysed using a mixed model with treatment as a fixed effect and treatment within farmer as a random effect. Supplemented groups both gained more than their unsupplemented controls, though the difference was only nearly significant for the UMG supplement (p=0.052).

However, it should be noted that there were problems with both trials that render the results of little value. First, in the UMG trial the second batch of UMG had a foul smell, which meant that goat-keepers did not want to use it, and goats did not want to eat it. Some goat-keepers mixed it with other supplements, but a large proportion of it remained unused. Thus, most goat-keepers stopped using the treatment in the middle of the trial, while others persisted but only after modifying the treatment.

Second, in the barley trial there was some confounding between the treatment and control groups, which were from different hamlets of the same village, but had different grazing areas. The grazing area of the control group was superior in quality to that of the treatment group. The two groups of goat-keepers were not entirely similar either, the control group members being slightly better off than those in the treatment group.

Participants observed that the treatment had another, unanticipated, benefit, namely that female goats reached sexual maturity earlier than usual. This was investigated in the following year's trial.

5.2.3 Accelerating growth rates and sexual maturity in Udaipur

Data from the Udaipur 1999 trial were not analysed, because one of the weaknesses of the 1998 trials was repeated in the 1999 trials. Members of the control and treatment groups were selected from different hamlets of the same village. The hamlets were on different sides of a stream, and the goats had different grazing areas. This made it difficult to draw any meaningful conclusions from the trial, as differences between the two groups could be due to differences in grazing areas. Repetition of the design flaw was partly due to changes in field staff, with the new staff member not being thoroughly briefed by the outgoing one.

5.2.4 Increasing milk production in the late dry season - Bhavnagar

Supplementation trial The UMG treatment increased milk production, as hypothesized (see Table 15), and participants from the treatment group observed that the health of their goats had improved. However, the size of the increase was limited, as was the duration. Milk production in the treatment group increased by 0.307 litres during the first two weeks, but then declined by 0.522 litres during the following two weeks. It seems that this may have been at least partly due to the onset of pregnancy: by the end of the trial period 17 of the 20 does in the treatment group had become pregnant and 14 of those in the control group. (The mean kidding rates of does in the treatment and control groups were quite similar, at 1.5 and 1.4 kids per doe respectively.)

In view of the effect of pregnancy on milk production, it did not seem sensible to conduct further trials of this nature. Furthermore, goat-keepers said that they would like any further feed supplementation trials to take place around the time of kidding, rather than in the dry season.

Table 15 Mean milk yields of Goats in UMG Trial, Bhavnagar

Group	**16/5**		**31/5**		**14/6**		**29/6**		**14/7**	
	Yield	*No.*	Yield	*No.*	Yield	*No.*	Yield	*No.*	Yield	*No.*
Control	1.11	*20*	1.04	*20*	0.84	*20*	0.57	*15*	0.36	*11*
Treatment	1.34	*20*	1.64	*20*	0.96	*20*	0.52	*12*	0.41	*8*

Alleviating water scarcity A comparison can be made between the monitoring data from the water trough goats and similar data collected during the same period in 1998 from the goats in the control group of the UMG trial, which was in the same village. Mean daily milk production was substantially higher in the water trough goats in 1999 (see Table 16); and, more importantly, it declined much more slowly in this group. It should be noted, however, that the two sets of data are not for the same goats, so part of the difference could be due to this. The 1998 data are from the goats that were in the control group for the UMG trial.

In addition, daily herding distances and durations were also reduced, as compared with the same period in the previous year, and qualitative improvements for herders were noted (for details, see Conroy and Rangnekar, 1999). Large numbers of domestic animals (200-300) used the trough each week, including large ruminants, as did some wild ones (deer, bluebull).

Table 16 Mean milk yields of water trough and UMG control group goats

Year	No. of goats	16/5-21/5	31/5-4/6	14/6-18/6	29/6-3/7	Percent Change*
1998 – UMG control	15-20	1.11	1.04	0.84	0.57	51.4
1999 – water trough	9-12	1.98	1.94	1.83	1.64	82.8

* Final yield as a percentage of first yield.

Three factors related to better availability of water appear to have contributed to the increase in milk production, and a general improvement in the condition of the animals. These are: increased appetite; reductions in the daily distance walked (and hence energy required); and an increase in the amount of time available for grazing. These factors are all related to feed intake or requirements, showing the close inter-relationship between water scarcity and feed scarcity.

5.2.5 Improving reproductive performance - Pune

Mean litter size was much higher in the treatment group than in the control group. The mean service period was also slightly shorter in the treatment group.

Table 17 Service Periods and Litter Sizes in Pune Trial

Trial groups	Service period (days)		Litter size (No.)	
	Number	Mean	Number	Mean
Control	19	230	64	1.64
Treatment	15	222	67	2.31

5.2.6 Supplementation trials - Dharwad

Year 2000 trial The treatment had a number of beneficial effects (see Table **18**). Kid mortality was significantly lower (chi-square = 10.124) in the treatment group (12 %) than in the control group (45 %). The mean birth weight was recorded in the treatment group (2.3 kg) was higher than in the control group (2.1 kgs), and more abortions were reported in the control group than in the treatment group.

Table 18 Number of kids born, birth weight, mortality and abortions: Dharwad

Sr. No.	Parameters	Treatment	Control
1.	No. of does	19	15
2.	No. of kids born	33	24
3.	No. of kids died in 0-30 days age	04	11
4.	Percentage of kids mortality	**12 %**	**45 %**
5.	Average birth weight in kgs	**2.321**	**2.08**
6.	Percentage of abortions	**9 %**	**28 %**

Year 2001 trial The results were as follows. The mean birthweight of kids from does receiving *Prosopis juliflora* pods supplementation (T2 group) was a little higher than in the control and T3 groups (see Table 19). At four weeks, weight gain was also higher for T2 than for kids in the control group, suggesting does receiving pods were producing more milk (Anttila *et al*., 1993). There were no differences in weight gain between the two treatment groups.

Table 19 Kid weight (kg) at Birth and in First Four Weeks of Life: Dharwad

	No of kids	Weight at Birth	Week1	Week 2	Week 3	Week 4	Gain, birth to week 4
T1 (C)	29	1.9	2.8	3.6	4.2	4.8	2.9
T2 (PJ pods)	23	2.1	3.4	4.1	4.8	5.3	3.2
T3 (S-H)	28	1.9	3.0	3.9	4.5	5.1	3.2

PJ = P. juliflora. S-H = sorghum & horsegram mixture.

5.2.7 Anthelmintic trials - Dharwad

Preliminary trial (2000) The results are summarised in Table 20. Lower kid mortality (8%) was observed in the dewormed group than in the control group (24 %). Mean birth weight and weight gain were slightly higher in the treatment group than the control, but the difference was not significant at the 5% level ($p = 0.08$). The lower mortality rate in this control group as compared with that for the control group in the feed supplementation trial is thought to be due to the fact that this trial occurred outside of the rainy season[5].

2001 trial The mean birthweights of kids in the treatment groups were higher than that for the control group, but the differences were not significant (see Table 23). However, a significant difference ($p<0.01$) in growth rate of kids was observed between the groups one month after kidding, kids from dewormed does being heavier (see Table 23).

[5] It was not possible to set up the trial in time for the rainy season, because a considerable amount of time had to be spent (a) winning the confidence of the goat-keepers in the trial; and (b) researching the suitability of various commercial dewormers for pregnant does.

Table 20 Results of the De-worming Trial, 2000: Dharwad

Sr. No.	Parameters	Treatment	Control
1.	No. of does	27	23
2.	No. of kids born	38	33
3.	No. of kids died in 0-30 days age	03	06
4.	No. of kids died in 30-60 days age	00	02
5.	Mortality rate, 0-60 days age (%)	7.9	24.2
6.	Average birth weight in kgs	2.076	2.025
7.	Average wt. Gain at 4^{th} week of age in kgs	2.525	2.342

Mortality in kids less than one month old was low in the treatment groups and control group, as is shown in Table 21. A chi-square test indicated that mortality of goats during the period 30-120 days after birth was significantly higher ($p = 0.04$) in kids of control does than in those of treatment does, but there was no significant difference at 30 days (see Table 21). The difference between the control group and the treatment groups is not significant ($p=0.12$) for the whole period (0-120 days). However, if one compares mortality in the control group with that in the two treatment groups combined, the difference is significant ($p= 0.04$). The lower mortality rates for the first 30 days in this trial as compared with the previous year's trial might due to the fact that rainfall was much less in 2001, and also later than usual. The late arrival of the rains might have contributed to the differences in mortality rates after the first 30 days.

Table 21 Mortality* of kids from birth to four months of age, 2001

	No. of kids born	No. of kids died			Mortality rate (%)
		1-30 days	31-120	Total	
T1 (control)	35	3	11	14	40.0
T2 (MP)	31	3	2	5	16.1
T3 (F)	30	2	4	6	20.0

* Kids that died accidentally were not considered for analysis.

Table 22 Parasitical Egg Count of Does Before and After Treatment*: Dharwad

Sr. No.	Group	No.of does	Mean number of eggs/g of faecal sample		Difference between mean number of eggs on Day 0 and Day 7	't' value	'P' value
			Day O	Day 7			
1.	C	6	717	983	+ 267	- 5.59	.003
2.	T1	7	971	271	-700	9.72	.0001
3.	T2	7	757	114	-643	6.03	.0009

* In group T1 the treatment was the trichomes of *Mucuna pruriens* pods, and in T2 it was *Fenbendazole*. C = control group.

The parasitical faecal egg counts were significantly lower on the 7th day after deworming in both of the treatment groups, whereas the faecal egg count in the control group increased significantly, as shown in Table 22. The predominant types of endoparasites were: *Strongyloides sp*. (31.1%), *Haemonchus sp.* (23.8%), *Chabertia sp.* (16.5%) and *Bunostomum sp*. (10.4%).

Table 23 Mean Weekly Weight of Kids (Kg): Dharwad

Sr. No.	Group	*Weights*					
		Birth	1st week	2nd week	3rd week	4th week	Weight gain at 4th week
1.	Control	2.12	2.77	3.24	3.71	4.12	2 .00
2.	T1	2.28	2.99	3.72	4.23	4.88	2 .60
3.	T2	2.23	2.94	3.56	4.19	4.81	2.58

Statistical analysis of the data summarised Table 23 shows that the mean growth rates of kids in groups T1 and T2 were significantly higher than that of the kids in the control group. The difference in mean growth rates between the two treatment groups was not significant.

The faecal egg count data and the growth rate data strongly suggest that the *Mucuna pruriens*-based treatment is as effective against helminths in pregnant does as the commercial anthelminthic, *Fenbendazole*. Two factors could have caused the faster growth of kids in the treatment groups. First, it may be that the lower parasitical load in treatment group does during the preparturient period resulted in less parasitical infestation of their kids (Smith and Sherman, 1994). Second, it may also have resulted in increased milk production, and hence greater availability of milk to the kids.

The low mortality rate of kids in the control group (8.5%), as compared with an observed rate of 45% the previous year (see Table **18**), is thought to have been due to differences in rainfall between the two years. Total rainfall in 2001 was 447 mm., whereas in 2000 it was 764 mm., and the monsoon rains arrived later than usual. As a result, worm burdens of does may have been lower in 2001.

5.2A Silvipasture Development and Management on Common Lands

The case studies covered a wide range of topics, not all of which are directly related to livestock. The results presented here are only those that are related to livestock. (For other results see Conroy and Lobo (reproduced as Annex 1).

5.2A.1 Utilisation of forage from PSPAs

In all but two of the cases the grass from the PSPA was harvested, usually in November or December, and then stored for a period of time, which varied considerably (see Table *24*). In several villages people stored the grass for a few months, feeding it in the dry season (March-June) or even in the early rainy season. The harvested grass was fed almost entirely to large ruminants. In a few cases small ruminants were given grass in May/June: but even then it only constituted a small proportion of their diet.

The period of time over which the grass is stored before being fed to the animals depends on: (a) the availability of forage from other sources; and (b) the storage space available to the owner. The former factor is illustrated by the case of Fila, where there are two groups: the Dangis, who are relatively well-off; and the Rawats, who are poorer. Dangis are able to store and use the grass over a much longer period of time than the Rawats are, because they have larger private sources of their own that they can use first.

Table 24 Timing of Grass Utilisation from PSPAs, Rajasthan

Village	Period of feed utilisation from PSPA
1. Sagatadi	December to March
2. Fila	Rawats - Jan- Feb Dangis - Nov- August
3. Patukheda	Jan - March
4. Selu	Nov- Feb, March to June partial
5. Salukhera	Cut and carried , fed year round
6. Suali	*Nov- June (grazing)*
7. Bada Bhilwara	Nov- June
8. Jodha ka Khera	*Grazing* August, also September in 1999-2000
9. Gudha Gokulpura	40 days
10. Chota Saradhna	Harvested Nov – Dec used till April
11. Jogio ka Guda	Nov - August
12. Keli	March - August
13. Seedh	Jan - August
14. Tank	April to June
15. Barawa	-

5.2A.2 Changes in livestock populations

The case study findings on changes in livestock populations are given in Table 25. The findings were mixed as far as the numbers of cows and bullocks is concerned, with numbers increasing in some cases and decreasing in others, and in two cases remaining fairly constant. The picture is also mixed for goats.

Table 25 Changes in Livestock Populations in PSPA Case Study Villages

Trend	Buffalo/ milch cattle	Bullock	Cow	Goat	Sheep

Increased	10	6	4	5	-
Decreased	3	4	5	6	5
Stable	1	2	2	1	2

Much clearer trends emerge, however, for buffalo and sheep. In most villages there have been marked increases in the buffalo (and in some cases cross-bred cow) populations. This is also partly associated with the commercialisation of milk production and the improved milk marketing infrastructure, in which buffalo milk fetches a higher price than cow's milk by virtue of its higher fat content. PSPAs may help to ensure a more even year-round supply of forage, which is needed for buffalo dairying.

For those maintaining milch animals, the fodder availability from the PSPA has reduced the demand for purchased fodder and consequently enhances the viability of dairying. Some families have managed to change their livestock composition in favour of milk animals as a result.

The research found that livestock-keepers who primarily own **small ruminants** are adversely affected by enclosure of common lands when the enclosed site constitutes a large proportion of the common grazing land in the vicinity of their village. This was more common under government programmes, such as JFM, but sometimes occurred under NGO programmes as well. The size of the goat herds owned by these households was found to decline by as much as two-thirds (Jindal, 2000; Kashwan, 2000), for example from 15 to five. The *Gayri* caste, who own large flocks of sheep and are more dependent on livestock than the other castes, were perhaps the worst affected. In one case, they were obliged either to sell-off their sheep or migrate for several months to grazing areas distant from their village (Vardhan, 2000).

5.3 Participatory Methods

5.3.1 System characterisation and needs assessment

The project developed two new low-cost methods that enable a more thorough and reliable assessment to be made of the nature of constraints. One of them also enables the productivity of goats to be quantified. These will now be described.

Obtaining livestock productivity data through participatory herd histories The project did not have the resources (especially time) to undertake herd monitoring studies, and in any case their value is questionable, (Roeleveld, 1996). Nevertheless, there was often a need for more detailed, and moderately reliable, livestock productivity data (e.g. on kid mortality) than that generated by conventional group PRA methods, to confirm and quantify constraints identified in the group discussions. During the first year of the project such data were often sought through individual interviews. It quickly became apparent, however, that goat-keepers often had difficulty recalling all key events (births, sales etc.) for each breeding doe in the herd[6].

[6] Other researchers have concluded that recall can be reliable. It may be that reliability is lower for small ruminants than for large ruminants, as one of the former is less valuable and important than one of the latter. In addition, herds of small ruminants tend to be larger than herds of large ruminants, and changes in the herd are more frequent, making accurate recall more difficult.

Thus, its second year the project developed a method for collecting this kind of data, which the project called the *participatory herd history* (PHH) method.

The method is based on the owner's recall and use of cards to symbolise each goat in the herd. It involves the owner making an inventory of the current herd, and working backwards over 1-2 years to record what changes to the herd have taken place and when, either in terms of acquisitions or removals, and hence the productivity of the animals. (For a more detailed description see Conroy, 2001.) Thus, it provides information about births, deaths, slaughter, sales, and purchases. It can provide quantitative data on various matters including: productivity issues, such as the incidence of disease-related mortality in kids, or the reproductive performance of does; and the pattern of marketing goats (e.g. seasonality, age of animals at sale).

The herd history method is related to two other methods that have been termed "Herder recall" and "Progeny history" (Waters-Bayer and Bayer, 1994). A key difference, however, is that the herd history method uses symbols, and is a form of diagramming by the livestock-keeper, which is then copied by the researcher; whereas the other methods are more extractive, with the enumerator recording the data in written form.

Participatory problem tree analysis Participatory problem trees were used to analyse highly ranked problems identified in group discussions and to gain a more in-depth understanding of their nature. Problem tree analysis involves identifying a core problem, the factors causing it, and the effects that it has: the core problem is represented as the trunk of the tree, the causes as its roots and the effects as its branches (Peacock, 1996).

Participatory problem tree analysis involved the following steps. Participants identified all the factors they could think of that are related to the core problem. Each of these was then symbolised on a largish piece of paper or card. The livestock owners then discussed the relationships between them, classifying them into causes and effects, and placed the cards at the appropriate place on the ground. Where a causal relationship was identified between two factors this was indicated by placing a stick, or similarly shaped object, between the relevant cards. (For a more detailed description see Conroy, 2001.) For an example of a problem tree see Figure 3.

This method has the following advantages:

- It shows the relationships between different factors, or at least how livestock-keepers perceive those relationships;

- It facilitates the inclusion of human dimensions of livestock constraints (such as 'Herders tired at end of the day', as shown in Figure 3) that might otherwise be overlooked.

5.3.2 Technology development

Trial design There are three basic options for trial design: 1. *before and after* comparisons; 2. *with* (i.e. treatment) *and without* (i.e. control) comparisons in which

both treatment and control animals are from the same herds (i.e. one herd supplies one or more animals for both the treatment group and the control group); and
3. *with* (i.e. treatment) *and without* (i.e. control) comparisons in which treatment and control animals are from different herds. The project's experiences with trial designs can be summarised as follows.

For trials of longer duration than a few weeks, *with and without* comparisons are likely to be more reliable than *before and after,* provided proper care is taken to minimise inter-animal variations. It is easier to achieve this, and avoid bias, by having animals from different groups within each herd, rather than making a 'between herds' comparison. However, the 'within herd' approach can be problematic for certain types of treatments, particularly ones involving feed supplementation. Nevertheless, it can work if the owner understands and agrees with the purpose of the trial design; and if there is a good rapport between the researchers and the livestock-keepers, and frequent visits by the researchers.

The *before and after* method is not well-suited to experiments lasting several months, in which the before and after data are from different years or different seasons. The *with and without* method would be preferable in this kind of situation. Both *with and without* comparisons and *before and after* ones have their potential weaknesses. When experiments are being conducted using the *with and without* design it can be useful to collect baseline data as well so that a *before and after* comparison can be made, provided this can be done at a reasonably low cost (e.g. by using the PHH method – see section 5.3.1). The two sets of data can then be cross-checked with each other.

Some trials have two or more treatment groups, but no control group, the comparison being between the different treatments. However, the project's experience suggests that it is important to have a control group in certain kinds of trials. Suppose, for example, that baseline data show kid mortality in the rainy season to be high (e.g. > 40%), and a trial is then conducted the following year to reduce kid mortality in the rainy season. The trial has two treatments and no control group, and kid mortality is low in both groups. Researchers might conclude that both treatments have been effective in greatly reducing kid mortality, when in fact the reductions could be entirely due to other factors, as was found in one of the trials done by this project (see **Table 21**).

Feasibility of PTD with livestock-keepers Various problems have been identified as being commonly associated with 'on-farm' livestock trials (see, for example, Amir and Knipscheer, 1989). These are briefly described in Appendix 2, as is the project's overall experience in relation to them. Nevertheless, this project has shown that it can be feasible to undertake PTD effectively with livestock-keepers. It has demonstrated that two concerns previously expressed about *in situ* livestock trials need not always apply. First, we have seen that it is possible to have participatory in-situ livestock trials, in which only the treatment, goats (stratified sample) and participants (stratified sample) are controlled, and still be able to detect statistically significant differences between treatment and control groups. Second, we have also seen that goat-keepers were usually prepared to participate in such trials, despite there being a certain degree of risk involved from the use of technologies about which they sometimes had little prior knowledge.

The fact that it was possible to avoid or overcome all potential problems at least some of the time is probably due to a combination of factors: (a) BAIF staff had a good rapport with the goat-keepers from the outset; and (b) goats are in some ways easier to work with in on-farm experiments than large ruminants are (see Annex).

5.4 Dissemination

This is discussed later in sections 6.3 and 6.4.

5.5 Increasing the profitability of *Prosopis juliflora* supplementation

5.5.1 Feeding pods alone

The difference in conception rates between the treatment and control groups (see Table 26)was significant at the 5% level for the 2000 data, using an exact chi-squared test. The 2001 data were only received on 31 May 2002, and it has not yet been possible to carry out any statistical tests on them.

Table 26 Conception Data for Serviced Does in PJ Pods Trials, Bhilwara

Group	2000		2001	
	Not Pregnant	Pregnant	Not Pregnant	Pregnant
Treatment	3	35	0	72
Control	7	28	7	50

Twinning The incidence of twinning was also higher in the treatment groups (see Table 27), but the difference was not significant at the 5% level. An exact chi-squared test gives values of 0.37 for the 2000 data.

Table 27 Twinning Rates* in *P. Juliflora* Pods Trials, Bhilwara

	2000		2001	
	Twins	One	Twins	One
T	8	19	20	40
C	3	14	3	26

* Does that aborted are excluded
T = Treatment Group C = Control Group

Kidding rates The combination of higher conception rates and higher twinning rates results in higher kidding rates in the treatment groups, as can be seen from Table 28. Another way of expressing the data is in terms of the mean number of kids per doe. To see if the differences are significant an asymptotic Mann-Whitney test, adjusted for ties, was used. The p-value shows that at the 5% significance level there is clear evidence that the mean number of kids per doe is higher in the treatment group. This 'pods only' treatment gave comparable results to a mixture of pods and barley.

Table 28 Kidding Rates (percent) in *P. Juliflora* Pods Trials, Bhilwara

Group	2000	2001
Treatment	116.6	138.7
Control	70.4	110.3
P-value	*0.006*	*0.02*

In addition to the effect on kidding rates, participating goat-keepers in the treatment group in Udalpura (in the year 2000 trial) observed that their does had shinier coats and produced more milk. Having initially been sceptical about using the pods as a supplement, their attitude changed dramatically and became very positive.

5.5.2 Seed digestibility trial

The trial results showed that the vast majority of seeds were digested by the goats: only 5-6% were excreted undigested.

5.6 Suitability of pods of other tree species for storage and supplementation

The results of the *Acacia nilotica* trial were as follows. There was no significant difference in conception rates between the treatment and control groups, but kidding was higher in the treatment group – see Table 30. Does that were not serviced have been excluded.

Table 29 Conception and twinning data in the *Acacia nilotica* trial

Group	Conception		Twinning	
	Not pregnant	pregnant	Twins	One
Treatment*	1	43	5	20
Control	0	32	2	21

* one of the 26 does in this group aborted.

The higher twinning rate meant that the kidding rate was higher in the treatment group, but this was counter-balanced to some extent by the slightly higher conception rate in the control group and the fact that one does in the treatment group aborted. Thus, the difference in kidding rate is quite small and is not significant (see Table 30).

Table 30 Kidding data in the Acacia nilotica trial

Group	Number of does	Number of kids	Kidding rate
Treatment	26	30	1.15
Control	23	25	1.09

One possible explanation for the limited effect of *A. nilotica* pods on kidding rate is as follows. The does belonged to relatively better off farmers (Kumawats), and so the

quality of feed available to goats in the control group may have been quite high without supplementation with *A. nilotica* pods.

Despite the lack of any evidence of the efficacy of this treatment, participants observed that it increased the strength and health of their goats, and also milk production. There was a case, therefore, for repeating the trial. However, it was not repeated, because even if this technology had been effective its potential impact would be more limited than that of *P. juliflora* pods, particularly for resource-poor goat-keepers. This is because the tree is less common, and can usually only be accessed by the owner of the land on which it is found, or though a payment to the owner. Resource-poor people are less likely to have them on their own land, and less likely to be able to purchase lopping rights.

5.7 Impact of supplementation on herd size and environment

5.7.1 Twinning and weaning rates

In the supplementation trials that sought to improve the reproductive performance of does or reduce kid mortality (the relevant trials are 2, 5, 6, 9, 10, 11, 12, 14 and 16 – see Table 4), one effect of the treatments was to increase the twinning rates. This effect was observed in all of these trials, irrespective of the treatment, as has already been noted, but was not statistically significant. The LPP Manager pointed out that mortality rates are sometimes higher among twins than among single kids (and that goat-keepers sometimes prefer to have single kids), and requested the research team to investigate whether weaning rates were lower for twins than single kids.

Table 31 shows mortality rates for kids born to goats in Trial 12. It shows that, as expected, the mortality rate was higher for twins than for singles. However, it is important to bear in mind that any disbenefit from higher twinning rates needs to be balanced against the fact that overall kid mortality was 33% lower in the supplemented group (12%) than in the control group (45%).

Table 31 Mortality Rates for Singles and Twins in the Karnataka Supplementation Trial, 2000 (Trial 12)

	Total	**Singles**	**Twins**
Kids born	57*	20	34
Deaths	17	5	12
Mortality rate (%)	*29.8*	*25*	*35.3*

* There was one set of triplets.

5.7.2 Herd size and the environment

All of the treatments tested increased herd size in the short term, either by increasing the number of kids born or by reducing mortality among kids. It is conceivable, therefore, that if these treatments were adopted by goat-keepers they could result in larger herds, and thereby put greater pressure on forage resources. Thus, in the Karnataka supplementation and deworming trials that took place in 2000, the fate of kids was investigated, through a monitoring programme and a retrospective survey of their owners. In addition, household surveys of all goat-keepers and goats in the project villages were carried out in July 200 and in September/October 2001.

Table 32 Status of kids born in Karnataka Supplementation Trial, 2000 (Trial 12)

Parameter	**Total numbers**	
	M	F
Kids born	28	29
Deaths	10 (35%)	7 (24%)
Sale	17 (61%)	17 (59%)
Slaughtered	0	0
Transferred	0	0
Retained	1 (4%)	5 (17%)

Table 33 Status of kids born in the Karnataka Deworming Trial, 2000 (Trial 13)

Parameter	Total numbers			
	M		F	
Kids born	37		34	
Deaths	11	(30%)	6	(18%)
Sale	18	(49%)	5	(15%)
Slaughtered	2	(5%)	0	
Transferred	1	(3%)	1	(3%)
Retained	5	(13%)	22	(65%)

The status of male and female kids born to the experimental animals in the two groups of villages is presented in Tables 32 and 33. It was found that non-adult goats (male and female) were typically sold at around 4-5 months of age. In the case of males, only 4% and 13% were retained respectively. The retention rates for females were higher, but with a marked difference between the two sets of villages: only 17% in the supplementation trial, but 65% in the deworming trial.

The retention rates for females suggest that the additional female goats could have increased the sizes of herds involved in the deworming trial, depending on whether or not they replaced older does; but probably did not do so in the supplementation trial. This is confirmed by data that were collected on total numbers of goats owned by participants before and after the two trials (Table 34). These data show that there has been a modest increase in the numbers of goats owned by participants in the deworming trial, but a dramatic reduction in the number of adult goats owned by participants in the supplementation trial. This suggests that the comparatively low retention rate of the latter group was insufficient to even maintain the herd size.

Table 34 Number of Adult Goats Belonging to Project Participants

	Villages in deworming trial	Villages in supplementation trial
Goatkeeper no. before	17	17
Goatkeeper no. after	15	14
Adult goats before	121	153
Adult goats after	133	83
Percent change in adult goats	*+10*	*-54*

The changes in the numbers of adult goats owned by participants are in line with general trends in the project villages, as can be seen from Table 35 This shows that there are other factors exerting a strong influence on goat ownership.

Table 35 Percent change in adult goats, project participants and all goat-keepers

Group of goat-keepers	Villages in deworming trial	Villages in supplementation trial
Project participants	+10	-54
All	+27	-14

Goat-keepers' views on the environmental impact of goats Goat-keepers in the project villages in Karnataka were asked for their views on whether their goats had a negative impact on the environment. Although they may be biased, their answers were interesting. In the supplementation trial villages all the goat keepers reported that there is no negative impact of goats on environment, as they maintained their goats on crop residues.

In the deworming trial villages, 75 % of the goat-keepers said that they believe there is no adverse effect of goats on the environment. The reasons they gave were:

1. goats feed on weeds, which reduces pressure on forests;
2. goats feed on small shrubs and bushes, which helps to stimulate them and ultimately results in more fodder;
3. goats excrete faecal pellets during grazing, which increase soil fertility, resulting in good growth of the vegetation; and
4. goats don't graze on mature trees.

The other 25 % of the goat-keepers believed that there is negative effect of goat on environment for the following two reasons:

1. Goats feed on small plants, which hamper the growth of those plants; and
2. During drought periods goats place more stress on tree fodder.

5.8 Capacity Building and Training

Implementation of the project has been a valuable learning experience for all members of the project team in both BAIF and NRI. Most of the BAIF field staff had previous experience of participatory rural appraisal, but not of participatory technology development and *in-situ* trials.

Most of the learning experience has come from learning by doing, as with the testing and development of the participatory herd history and problem tree methods. In addition, in November 1998 and again in March 2000, Czech Conroy gave a one-week course in PTD to field staff involved in the project. The first course was also attended by two NRI staff, Dr. D. Romney and Dr. C. Wood.

BAIF sees the project as having contributed to the strengthening of its capabilities in the following ways:

- orientation and training of its staff, including field functionaries, in participatory research and technology development in livestock production;

- developing approach and techniques of participatory research and technology development in livestock production, while implementing a project;

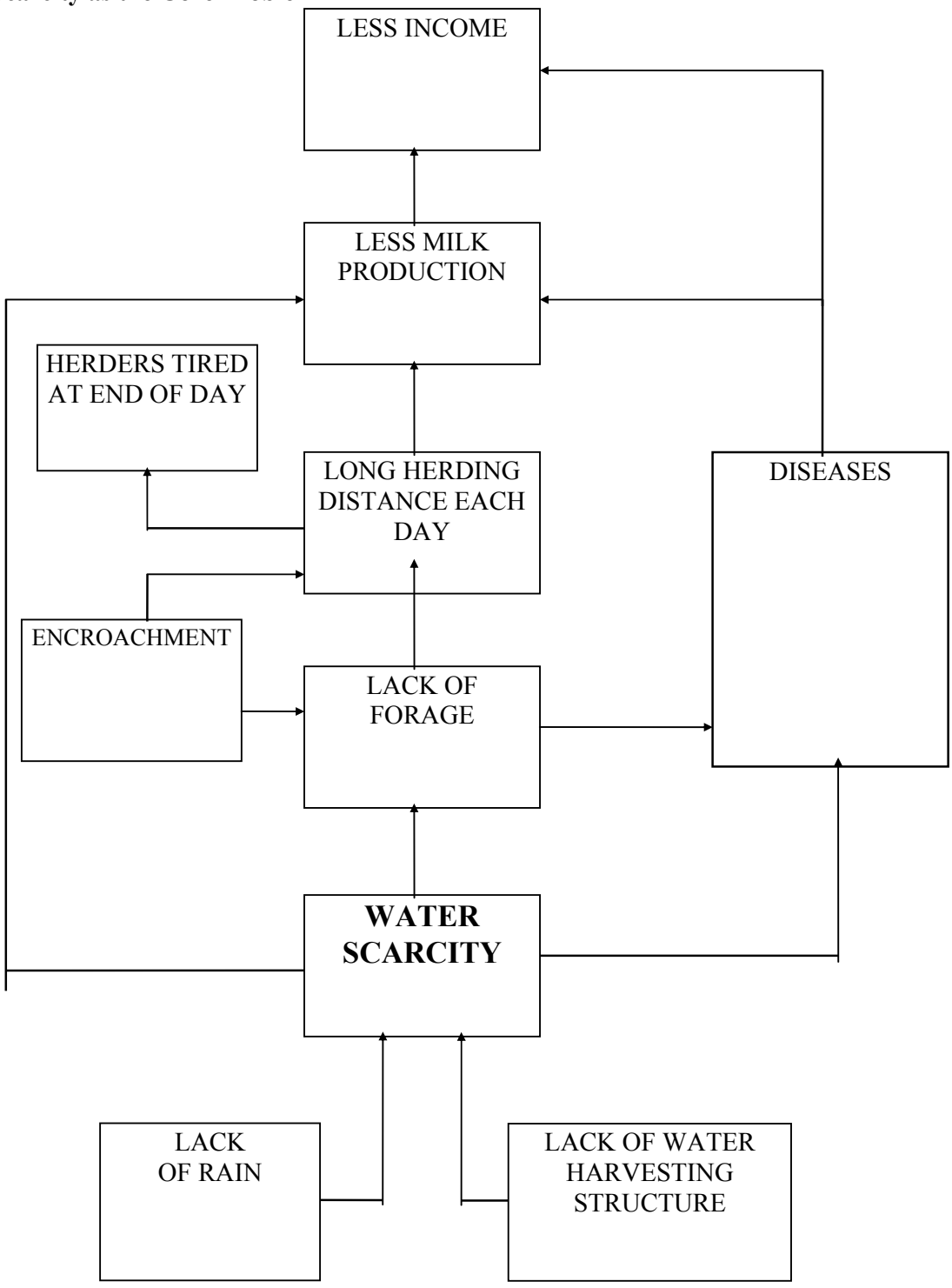
- developing in-depth understanding of goat production systems, constraints and perceptions of goat owners under rainfed conditions; and

- refinement of on-farm research and field recording with goats.

The growth in confidence of field staff in their ability to carry out research, after a number of months of involvement, has been clear for all to see.

The guides to PRA and PTD with livestock-keepers that the project had published are valuable learning resources for others who want to undertake this kind of work. To maximise their effectiveness, however, training is also needed.

Figure 3 Problem Tree Constructed by Rabaris in Gujarat, Showing Water Scarcity as the Core Problem



6. CONTRIBUTION OF OUTPUTS

6.1 Prospects for Adoption of Technologies

6.1.1 Prosopis juliflora pods

There are several reasons why the *Prosopis juliflora* pods technology has excellent prospects for widespread adoption by poor livestock-keepers in India, namely:

- the pods do not have to be purchased;
- this tree species is found across a large area of the country;
- the trees grow on common lands and by roadsides, making them available to the landless; and
- the collection time occurs at a time of the year when many livestock-keepers are not particularly busy.

The benefit:cost ratio for this technology, when used to increase kidding rates, is in the range 2:1 to 13:1, depending on the assumptions made (see Table 36).

Table 36 Estimated Profitability of Tree Pods as a Supplement (Indian Rupees)

1. Cautious Assumptions	2. Optimistic Assumptions
COST	
Price of pods = Rs 3/kg	Price of pods = Rs 1/kg
Cost of pods treatment per doe = Rs 3 x 0.25 kg/day x 70 days = Rs 52.5	Cost of pods treatment per doe = Rs 1 x 0.25 kg/day x 70 days = Rs 17.5
1A. Cost of pods treatment for 10 does = Rs 525	2A. Cost of pods treatment for 10 does = Rs 175
BENEFIT	
Extra 3.5 kids per 10 does	Extra 4.5 kids per 10 does
Value of 1 kid = Rs 300	Value of 1 kid = Rs 500
1B. Value of extra 3.5 kids = Rs 1050	2B. Value of extra 4.5 kids = Rs 2250
PROFIT	
Net benefit (profit) per 10 does = Rs 525 (1B – 1A)	*Net benefit (profit) per 10 does = Rs 2075* (2B – 2A)
BREAK-EVEN POINT	
Minimum extra kids (per 10 does) needed to break even = 1.75 (525/300)	Minimum extra kids (per 10 does) needed to break even = 0.35 (175/500)
BENEFIT:COST RATIO	
2:1 (1B:1A)	12.9:1 (2B:2A)

6.1.2 Deworming technologies

Both of the deworming treatments have very favourable cost: benefit ratios. That for Fenbendazole is 1:39, while that for the *Mucuna pruriens* treatment depends on what opportunity cost, if any, is attributed to the labour involved. The participating goat-keepers said that in future they intend to use the *Mucuna pruriens* treatment, rather than the commercial one, because no cash expenditure is required. *Mucuna pruriens* is

also quite widely distributed in India, and the labour required to collect the necessary number of pods, and process them, is minimal.

6.1.3 Other treatments

The prospects for adoption of some other treatments tested by the project, such as barley and UMG, are less promising. In south Rajasthan, barley is valued by goat-keepers as a high quality supplement, but there are problems with its adoption. If the barley is grown by the farmer it competes for plot space with other crops, notably wheat, which is an important staple: so more food for the goats means less food for the family. If barley has to be purchased, a similar dilemma arises for the family over allocation of scarce resources.

UMG, which is manufactured in Gujarat, makes use of another locally available waste material, molasses. Nevertheless, it was more expensive (per kg) than other high quality supplements, such as barley or groundnut cake. In addition, livestock-keepers had a general preference for the traditional products.

6.2 Contribution towards DFID's Developmental Goals

The project's findings are relevant to DFID's first goal, i.e. to "eradicate extreme poverty and hunger". Poor people in India keep goats primarily as a source of income. This project has developed ways of improving kidding and weaning rates, and hence increasing the numbers of goats that people can sell. Increasing the income from goat-keeping would contribute to DFID's first target, which is to "halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day".

The project, through its work on water scarcity in Gujarat, has also shown how milk production can be increased. In Gujarat, a vegetarian state, this is the main reason for keeping goats, and milk is an important component of people's diets, particularly children's. Thus, in this state the project's findings can contribute directly to reducing hunger and malnourishment.

6.2.1 Contribution of findings to livelihoods and poverty reduction

India There were 117 million goats in India in 1992. Goat-keeping is an important livelihood activity for a large proportion of India's rural households, particularly the resource-poor (including women). Improving the productivity of goats would directly benefit a substantial number of them.

The potential beneficiaries of the *Prosopis juliflora*- and *Mucuna pruriens*–based technologies are goat-keeping households living in the vicinity of either of these species, whether they be **landless households** or **farmers**. *Prosopis juliflora* is common in most of India where annual rainfall is less than 1000 mm., i.e. most of the country, and is the dominant species in many arid and semi-arid areas. It is found by roadsides and on common lands, including highly degraded land. **These factors make it widely available and accessible to resource-poor people**. *Mucuna pruriens* is also quite widespread, but may not be found in arid regions. Outside of the project

areas, we are not aware of any situations where goat-keepers in India are already using either of these technologies.

We are not aware of any situations where goat-keepers in India are already using either of these technologies. The collection and storage of tree pods for feeding to livestock may be an established practice for certain tree species in certain parts of the country. This appears to be the case, for example, with *Acacia nilotica* in Bhilwara district, Rajasthan. Generally speaking, however, the vast majority of fodder trees, outside of forests, are found on private land, and hence are not accessible to the landless. *P. juliflora* appears to be the only tree species producing nutritious pods that is abundant on common lands.

On average, a goat-keeping household owning 10 breeding does would have an increase in net income of between Rs 525 and Rs 2075 per year (see Table 36). This is a significant amount of money for a poor rural family, and can enhance household food security. Three women interviewed by the project leader in 2000 said that they had spent their income primarily on food grains, to feed their families in what was a drought year.

Table 37 shows what the total net benefit would be if the technology were adopted by 30,000 households. This assumes that the average number of does per household is 2.5, in which case 75,000 goats would benefit.

Table 37 Possible Net Benefits of PJ pods Technology

		Cautious	Optimistic
Per annum	Rupees	3,937,500	15,562,500
	Pounds	*60,577*	*239,423*
Over 10 years	Rupees	39,375,000	155,625,000
	Pounds	*605,770*	*2,394,230*

* This assumes an exchange rate of £1 = Rs 65.

There were 117 million goats in India in 1992. Thus, the above estimates assume that only 0.0064 percent of India's goat population benefit from the technology. It is clear, therefore, that, given a very vigorous promotion of the technology, the number of beneficiaries and the size of the benefits could be much greater than that shown in the table.

We have not made similar estimates for the *Mucuna pruriens* technology, but they are likely be of similar magnitude per household in areas where rainy season kid mortality is high in a typical rainfall year.

Outside of India *M. pruriens* is found in numerous tropical countries, so there is considerable potential for using it as an anthelmintic outside of India. It has been described as "an exemplary multipurpose legume" (Peters *et al*., 2001), and is widely promoted as a cover crop (Anderson *et al*., 2001; Kiff and Pound, 1996). There are two varieties (Kiff and Pound, 1996, pp 66-67): one (*M. pruriens var. Deeringiana*) with detachable hairs that are highly irritable (the one used in this research), and another (*M. pruriens var. Utilis)* whose hairs are less easily detached and that is not

irritable (B. Pound, *pers. comm*.). The former is found in: India; parts of central America (e.g. Yucatan, Mexico) and the Caribbean (e.g. Barbados, where it is known as 'cow-itch') (Anderson *et al*., 2001, p. 27); and Nigeria (B. Pound, *pers. comm*.).

A presentation (Conroy and Thakur, 2002) by the Project Leader at a recent livestock conference in the Yucatan, Mexico, generated interest among Mexican researchers in testing the *M. pruriens* technology there (Torres-Acosta, pers. comm.).

6.3 Dissemination

By the middle of 1999 the project was generating interesting findings, and hence took advantage of relevant conferences and workshops to present papers, abstracts and/or posters about the findings. In addition, various project reports have been published since early 2000, and meetings have been held with target groups (e.g. DFIDI) to brief them on the project's work and findings.

6.3.1 Conferences

The project staff have contributed papers, abstracts and/or posters to four conferences.

IXth Animal Nutrition Conference of the Animal Nutrition Society of India, Hyderabad, 2-4 December, 1999 Three abstracts describing different aspects of the project's work were reproduced in the Conference's volume of abstracts. Three members of the project team attended the conference, and presented three posters there. The conference provided a valuable opportunity to publicise the project's work among the Indian research community, and also to find out about other, related work.

VIIth International Conference on Goats, France, May 2000 The project submitted four papers to the organisers of the seventh International Conference on Goats, which took place in France in May 2000. These were published in the conference proceedings. The conference was attended by the project leader, who gave presentations on three of the papers - one in the session on Economic and Social Issues, and the others in the session on Feeding Strategies in Arid Range Lands.

International Conference on Smallholder Livestock Production Systems in Developing Countries, Kerala, India, November 2000 This conference was attended by a few hundred people, the vast majority of whom were from India. Four abstracts were submitted, and were published in the conference's volumes of abstracts. Three papers were presented by the project leader at the conference.

International Conference on Responding to the Increasing Global Demand for Animal Products, 12-15 November, 2002, Merida, Mexico The project leader presented a paper entitled "Increasing the productivity of indigenous goat production systems through participatory research in ethno-veterinary medicine: a case study from India". This was published in the conference papers.

6.3.2 Workshops

The project staff have contributed papers to five workshops.

Joint CGIAR/NRI Workshop on Participatory Research for Natural Resource Management, 1-3 September, 1999 This workshop was hosted by NRI, and took place in Chatham, England. Czech Conroy and DV Rangnekar prepared a case study paper (Conroy and Rangnekar, 1999) for the workshop about the Kumbhan water trough experience. An abridged version of the case study will appear in a book containing the workshop proceedings.

Promoting Inter-organisational Linkages for Sustainable Livestock Development in Rajasthan BAIF organised this workshop, which took place in Udaipur, Rajasthan, on 13 &14 December 1999. Czech Conroy presented a paper on the project's on-farm trials.

End of project workshop, Udaipur, September 2000 A project workshop was held in Rajasthan, at which the findings of this project and the related laboratory one (R6995) were presented to a wide range of livestock specialists from the extension and research communities in north-west India. The workshop lasted three days, one of which was devoted to discussing the findings of the silvi-pasture research. It was attended by 85 people altogether, including project staff, and it attracted coverage in state and national newspapers. Participants included scientists involved in related research in Tanzania and Zimbabwe, whose attendance costs were covered by a link project that is facilitating exchange of information and experiences (R7798). The workshop proceedings were published under the auspices of project R6995.

End of project workshop, Bangalore/Tiptur, March 2002 A dissemination workshop was held in Bangalore, Karnataka, on 28 March 2002; this was attended by about 50 people. In addition, a field-level interaction workshop took place in the Dharwad project area on 21/22 March 2002. These workshops were aimed at livestock researchers and development workers in southern India, particularly Karnataka and Maharashtra, who would not have attended the previous dissemination workshop that was held in Rajasthan in September 2000.

International Workshop on *Browse Plants and Small Ruminant Productivity in the Tropics* (held at Sokoine University of Agriculture, Morogoro, Tanzania, in January 2002) Two members of the project team attended this workshop where they presented two papers on the project's work.

6.3.3 Project reports

Silvipasture reports The silvipasture case studies have been published in five project reports, one by each of the NGOs involved (see references). In addition, The project is about to publish a report summarising key findings from the case studies and identifying key lessons for policies and practices, so that development agencies can learn from these experiences (Conroy and Lobo, 2002).

Guides on participatory methods Two Project Guides have been published on how to do: (a) participatory situation analysis (Conroy, 2001) and (b) participatory technology development (Conroy, 2002) with livestock keepers.

6.3.4 Project posters and picture books

Two posters and a cartoon picture book were prepared, in Hindi and in Kannada (the main language used in Karnataka), for use by livestock extensionists and goat-keepers. They show how to use the *Prosopis juliflora* and *Mucuna pruriens* technologies. These will be distributed in June 2002. Copies will be made available to the LPP Manager when they are ready.

6.3.5 Radio

The project was the subject of a 15 minute radio programme, broadcast by BBC World Service on 10 January 2001, in a special series called '*In the Field'*. The BBC has also been disseminating written information about the project, and information is also available from a BBC website about the series.

6.3.6 Articles

An article was published in the June 2002 issue of the journal *Livestock Research for Rural Development*, entitled "The Efficacy of Participatory Development of Technologies: Experiences with Resource-Poor Goat-Keepers in India".

6.3.7 Meetings

The project leader has had meetings with numerous people in India about the project's work and findings. These include:

- DFID advisers in Delhi;
- Staff of the Western India Rainfed Farming Project (WIRFP), including the Project Manager;
- Senior officials of the Government of Andhra Pradesh who are associated with the Andhra Pradesh Rural Livelihoods Project (APRLP);
- Senior officials of Andhra Pradesh's Department of Animal Husbandry;
- NGOs involved in livestock and rural development, including Heifer Project International and Action for Food Production (AFPRO).

Similarly, BAIF staff have also briefed many livestock and rural development professionals about the project, including staff of the KAWAD project.

6.4 Promotion pathways to target institutions and beneficiaries

6.4.1 DFID TC Projects in India

In **Rajasthan** the Western India Rainfed Farming Project (WIRFP) is a potentially important uptake pathway. For this reason, the project team liaised closely with WIRFP's Project Manager and the livestock staff working in Rajasthan. In addition, WIRFP staff attended the end-of-project workshop in Udaipur.

In **Karnataka** the DFID-supported Karnataka Watershed Development (KAWAD) project is becoming involved in livestock development. Small ruminants have been identified as a priority focus, and inadequate forage as the primary constraint facing

livestock (Thomas, 2000). The district of Dharwad is quite near to one of KAWAD's project areas. Thus, the project team has been liaising with KAWAD, including:

- project reports have been sent to Mr Mukherjee, Director of the Karnataka Watershed Development Society;
- KAWAD staff attended the end-of-project workshop in Bangalore;
- BAIF has been contracted by KAWAD to provide livestock inputs, and this may provide an opportunity to promote technologies developed by the project with goat-keepers.

In **Andhra Pradesh**, DFID is supporting a new project, the Andhra Pradesh Rural Livelihoods Project (APRLP). Czech Conroy has had discussions with the APRLP Project Director, Mr Tucker, about promoting the project findings on a pilot basis with small ruminant owners in APRLP's project area. APRLP is aware of the importance of small ruminants to resource-poor people, and of the widespread presence of *Prosopis juliflora*, and has indicated strong interest in collaborating on this.

Although not semi-arid, **Orissa** is another state where livestock, including goats, make an important contribution to people's livelihoods. DFID is supporting a new project here, the Western Orissa Rural Livelihoods Project (WORLP). *Mucuna pruriens* is found in the project area. This project has not yet reached the stage where livestock-related inputs would be appropriate. However, copies of the project's PRA and PTD Guides have been given to the team leader, and preliminary discussions have been held with him about goat-related inputs.

6.4.2 BAIF projects in India

BAIF is involved in a large EU-funded project that is working in five different states (including Rajasthan, Gujarat, Maharashtra and Karnataka), called Transfer of Technologies for Sustainable Development. This project has a wide range of interventions, including goat-keeping, and therefore provides another pathway for dissemination of project findings. In Rajasthan's Bundi district (adjacent to Bhilwara District) BAIF is implementing a watershed development project that is funded by the Indo-Canadian Environment Facility, which is another possible uptake pathway.

BAIF staff in Dharwad, Karnataka have already started disseminating project findings to goat-keepers in their area. As of the middle of March 2002 they had trained 178 goat-keepers in 15 villages of the project area. Further dissemination work of this kind is expected.

6.4.3 International Livestock Research Institute

Copies of the two guides to participatory research with livestock-keepers were sent to Dr Dannie Romney, the project's collaborator at ILRI, for circulation within ILRI.

6.5 Follow up Dissemination Action and Research

Copies of all major project publications were sent to staff of the target institutions listed above, and to organisations and individuals in Europe that were likely to be interested in them.

The technologies developed by the project may be capable of producing similar productivity benefits in **sheep**. The Project Coordinator of APRLP (which is supported by DFID) has expressed strong interest in collaborating with NRI and BAIF in adaptive research with sheep and goats in APRLP's project area, where sheep are predominant. He has suggested that this could be linked to livestock inputs to APRLP from ICRISAT. Financial support would be needed from LPP to ensure that this collaboration takes place.

The project findings are almost certainly relevant to other DFID-supported TC projects that are working with livestock-keepers, such as KAWAD and WIRFP. However, as noted earlier, the way in which seasonal scarcity manifests itself tends to be quite location-specific. It would be desirable, therefore, to conduct needs assessment studies in the areas covered by projects like KAWAD and WIRFP and to conduct adaptive trials there. Such trials, if effective, could also serve as 'demonstrations' of the technologies to both project staff and goat-keepers, and provide a basis for farmer-to-farmer extension. Although the project has published a wide range of extension materials, some training of staff involved in these other projects would be desirable.

If there were strong interest within ILRI in the project's work, particularly the participatory methods, it could be desirable for the project leader to visit ILRI and give a presentation to its staff.

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Paper within edited proceedings	CONROY, C. and THAKUR, Y.A. (2002) "Increasing the productivity of indigenous goat production systems through participatory research in ethno-veterinary medicine: a case study from India". Pp. 67-68. In: Proceedings of international conference on Responding to the Increasing Global Demand for Animal Products, 12-15 November, 2002, Merida, Mexico.
Authored report	CONROY, C and LOBO, V. (2002) *Silvipasture Development and Management on Common Lands in Semi-arid Rajasthan*. BAIF Development Research Foundation, Pune; and Natural Resources Institute, Chatham. 38 pp.
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APPENDIX 1 LOGICAL FRAMEWORK FOR THE PROJECT

Date of preparation of this logframe: 19 April 2000

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
Performance of livestock (including draught animals) in semi-arid crop/livestock and livestock production systems improved	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Purpose			
Seasonal availability and utilisation of local feed resources for livestock production in semi-arid crop/livestock systems improved and appropriate feed management strategies promoted.	To be completed by Programme Manager	To be completed by Programme Manager	To be completed by Programme Manager
Outputs			
1. Understanding of goat-keepers' production systems and constraints and current feeding systems, particularly during scarcity periods, improved. 2. Set of recommendations for improving seasonal aspects of feed resources and feed management strategies of goat-keepers developed.	1.1 Results of initial surveys of 15+ villages in four original districts written up in years 1 and 2. 1.2 Results of surveys of landless goat-keepers in 5+ villages in 2 new districts written up by 31/3/01. 2.1 Feed interventions tested & evaluated in years 1-3 in trials in 3 districts, involving > 200 goat-keepers, by end of year 3. 2.2 Feed interventions tested and evaluated with landless goat-keepers in 2+ villages in new districts by 30/9/01.	Reports containing survey results and analysis. Progress reports & report containing results of on-farm trials and recommendations. .	- Goat-keepers are able to adopt improved technologies and strategies. - Feed resources introduced through the project are allocated specifically to goats
2A Set of recommendations on silvi-pasture development on common lands developed.	*2A.1 10+ case studies of silvi-pasture development initiatives completed by 30/6/00.* *2A.2 General report containing key lessons & recommendations completed by 31/8/00.*	*2A.1 Copies of case studies* *2A.2 Copies of general report*	*- Livestock-keepers are able to adopt improved technologies and strategies.*
3. Participatory methodologies for analysis of feed resources and constraints, and testing of interventions, developed.	3.1 Participatory techniques tested in 3 districts in year 1, & modified versions tested in years 2 & 3.		

4. Project findings and recommendations on feed resources and strategies and participatory methodologies disseminated.	4.1 Meetings with extensionists during on-farm trials. 4.2 PRA and on-farm trials methodology guides published in year 3. 4.3. Articles/papers/abstracts about surveys and on-farm trials written and submitted to conferences and/or journals in year 3. **4.4 Comprehensive report on 4th year's work (100+ copies) produced by 30/9/01.** **4.5 Extension materials about tree pods produced by 30/9/01.** **4.6 Meetings with KAWAD and WIRFP staff held by 30/9/01. 4.7 Journal article about tree pods technology submitted by 30/9/01.**	4.1 Progress reports 4.2 Copies of guides 4.3 Copies of articles/papers/abstracts. **4.4 Copies of report.** **4.5 Copies of extension materials on tree pod technologies.** **4.6 Progress reports and records of meetings.** **4.7 Copy of article submitted.**	
4A Findings and recommendations on silvi-pasture development disseminated.	*4A.1 50 copies of each of 10+ case studies of silvi-pasture development initiatives distributed by 30/9/00.* *4A.2 150 copies of general report containing key lessons & recommendation distributed by 30/9/00. 4A.3 Workshop attended by 50+ people held in Rajasthan by 30/9/00.*	*4A.1& 2 Lists of recipients* *4A.3 Progress reports, invitation letter, list of participants*	
5 Ways of increasing profitability of supplementation using *Prosopis juliflora* pods evaluated. **6 Suitability of pods of other tree species for storage and supplementation at critical times assessed** **7 Impact of supplementation on herd size and environment assessed.**	**5.1 One or more further trials conducted involving 70+ goats, and treatment and preliminary analysis completed by 30/9/01.** **6.1 One or more further trials conducted, using pods of other species & involving 70+ goats, and treatment and preliminary analysis completed by 30/9/01.** **7.1 Results of survey of 30+ goat-keepers written-up & analysed by 30/6/01.**	**Progress reports and preliminary report on on-farm trial(s).** **Progress reports and preliminary report on on-farm trial(s).** **Report containing survey results and analysis.**	

Activities	Inputs	Means of Verification	Important Assumptions
1.1 Informal surveys undertaken of goat-keepers' feeding systems in Rajasthan, Madhya Pradesh and Gujarat, particularly during scarcity periods, in relation to the overall farming & livelihood systems.	**Budget** Current 183,647 1-year Extension 43,617 TOTAL 227,264	Quarterly, annual and final reports of project	
1.2 Collection of baseline data on goat ownership and performance.		Quarterly, annual and final reports of project	
1.3 Informal surveys conducted of landless goat-keepers' livelihood systems, and goat production & feeding systems and constraints. 1.4 Collection of baseline data on goat ownership and performance.		Quarterly, annual and final reports of project	
2.1 Analysis of survey & secondary data *in original 3 districts* to identify potential improvements in feeding strategies		Quarterly, annual and final reports of project	
2.2 Discussions with goat-keepers *in original 3 districts* about promising interventions for testing. 2.3 Programme of on-farm/common land research *in original 3 districts* to test & evaluate modifications to local feed resources & feed management strategies.		Quarterly, annual and final reports of project Quarterly, annual and final reports of project	Goat-keepers are willing to collaborate in research programme and trials.

2.4 Analysis of survey & secondary data to identify potential improvements in feeding strategies for landless goat-keepers. **2.5 Discussions with landless labourers about promising interventions for testing.** **2.6 Conduct, monitor & evaluate programme of research with landless to test promising technologies.**		**Quarterly, annual and final reports of project**	**Goat-keepers are willing to collaborate in research programme and trials.**
3.1 Application and assessment of various participatory research techniques, in conjunction with formal monitoring system.		Quarterly, annual and final reports of project	
4.1 Meetings with government extension agencies and NGOs throughout project to discuss progress and research findings. 4.2 Writing up and distribution of research results in extension manual 4.3 Writing and distribution of manual/guide & articles describing participatory research methodologies developed by the project.		Quarterly, annual and final reports of project. Copies of written outputs.	
4.4 Production of a comprehensive report on the extra year's work.		**Copies of report**	
4.5 Extension materials will be produced in Hindi describing the use of the tree pods technology.		**Copies of extension materials**	
4.6 The project team will keep KAWAD staff informed of the work being done in Dharwad District, and will arrange a meeting with them to brief them on the findings.		**Quarterly, annual and final reports of project**	

4.7 The project team will do the same (see 6.3) with WIRFP staff in Rajasthan.		**Quarterly, annual and final reports of project**	
4.8 Writing & submission of a journal article about the research on tree pods.		**Copy of article submitted**	
4A.1 Write a general report summarising the experiences, lessons & recommendations derived from activities related to output 2A (re.silvi-pasture development). *4A.2 Hold a workshop in India with NGOs & other development agencies at which report is presented & discussed.* *4A.3 Write three articles for different media and audiences.*		*Quarterly, annual and final reports of project.. Copies of written outputs.*	
5.1 Conduct further trial(s) with modified versions of the *Prosopis juliflora* pods/barley technology.		**Quarterly, annual and final reports of project**	
6.1 Conduct one or more trials in which the treatment is pods (possibly combined with barley) from other tree species.		**Quarterly, annual and final reports of project**	**Goat-keepers are willing to collaborate in the trials.**
7.1 Conduct individual interviews with participants from previous supplementation trials in Bhilwara, Rajasthan.		**Quarterly, annual and final reports of project**	

APPENDIX 2 PROBLEMS IN LIVESTOCK TRIALS: PROJECT EXPERIENCES

Various problems have been identified as being commonly associated with livestock trials (Amir and Knipscheer, 1989). These are described below.

Life cycle duration Evaluation of animal performance often requires a longer period than crop performance evaluation: it has been suggested that experiments involving the former generally last for more than a year, whereas those involving the latter are generally less than four months in duration (Amir and Knipscheer, 1989). This may be incompatible with the ceilings imposed by donors on the duration of research projects (Morton, 2001), which often have a maximum of three years; and livestock-keepers may lose interest in the experiment after a while, or animals may die during the trial. The monitoring periods for a range of trials are given in Table 1, the longest being about 15 months.

Life cycle synchronization Animal production is not synchronized (to the extent that crop production is), so it can be difficult to find enough animals in the same age category and the same production phase, and to ensure comparability between animals in treatment and control groups.

Monitoring effort Animals may need to be monitored once or twice a month, whereas crops usually can be checked less often. This can be a problem for researchers. It can also make demands on the owner's time that (s)he may resent, particularly if (s)he does not see the need for such detailed quantitative data.

Mobility The mobility of livestock means that environment-animal interactions are difficult to describe and measure, and factors that are not included in trial treatments are difficult to control. (Difficult to measure and control non-experimental factors.)

Number of observation units. Animal performance in a small farm setting is measured as production per animal (whereas crop yield data are averages of a large number of plants): consequently, statistical variability of treatments between animals or animal groups tends to be greater than between, for example, fertiliser treatments.

Risk-bearing: Owners reluctant to risk experimentation As animals are large and valuable, compared with crop plants, the owners may perceive controlled trials and experimental interventions on their animals as too risky, particularly where they are unfamiliar with the technology.

Inter-annual variability in livestock productivity Productivity varies considerably from year to year due to factors such as rainfall and outbreaks of disease, which may make it difficult to isolate the effect of a treatment.

Identification of experimental animals This can be a problem if they belong to herds that include non-experimental animals. The larger the herd, and the more similar the animals, the greater the potential problem.

Ensuring the treatment is only given to experimental animals Animals belonging to the same herd often eat from the same feed container. Thus, for example, if a feed supplement is only intended for breeding does, it may be difficult to ensure that kids do not consume it too. The experience of the BAIF/NRI project has shown that on-farm trials can 'work' for goats. The project's experience in relation to the potential problems is summarised in Table A2.1. The fact that it was possible to avoid or overcome all potential problems at least some of the time is probably due to a combination of factors: (a) BAIF staff had a good rapport with the goat-keepers from the outset; and (b) goats are in some ways easier to work with in on-farm experiments than large ruminants are.

Table A2.1 The Project's Experience with Common Difficulties

Type of Difficulty (D)	Yes	No	Some-times
1. Life cycle duration		✓	
2. Life cycle synchronization			✓
3. Monitoring effort – problem for researchers		✓	
4. Monitoring effort – problem for goat-keepers			✓
5. Mobility/variability of non-experimental factors			✓
6. Number of observation units			✓
7. Owners reluctant to risk experimentation			✓
8. Inter-annual variability in livestock productivity			✓
9. Identification of experimental animals			✓
10. Ensuring treatment only given to trial animals			✓

The project's experience suggests that a number of factors make goats more amenable to on-farm trials than large ruminants are. First, the life cycle duration of goats is shorter, making it possible to conduct trials on an annual basis and generate results within a few months. Second, many households own several goats, which makes it easier to include a reasonable number of observation units in the trials. Third, owners are probably less averse to involving their goats in experiments, than their large ruminants, due to their relatively low unit value. However, the project's experience suggests that PTD can be undertaken with large ruminants too, provided that trials are not unduly long and do not pose any significant risk to the animals.