OVERVIEW OF FASCIOLOSIS-AN ECONOMICALLY IMPORTANT DISEASE OF LIVESTOCK IN NEPAL

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ABSTRACT

Fasciolosis is the most common animal disease and one of the important causes of deterioration in livestock productivity in Nepal. It is widespread throughout the country affecting all species of ruminants. Despite increased awareness of the disease and massive increase in the use of anthelmintics, there appears to be no impact on the prevalence of the disease in the last two decades. Failure to control the disease was mainly due to lack of information about its epidemiology in the country. In recent years, however, a substantial amount of information has become available to understand the environment-host-parasite interrelationships. Some control approaches based on these informations have been discussed in this paper.

INTRODUCTION

There are about 6.3 million cattle, 3.0 million buffaloes, 5.4 million goats, 0.9 million sheep, 0.3 million pigs and 11.6 million chickens in Nepal (DFAMS, 1990). Cattle, buffaloes and goats are maintained by the most farm families. The rural household keeps on average 1.6 buffaloes, 3.8 cattle and 2.2. These figures indicate that Nepal has the highest livestock population per household and possibly per unit of cultivated area too. The demand for livestock products, however, is not being met by domestic production. DFAMS (1990) reported that food aid to Nepal in 1988 included 1700 tonnes of skimmed milk powder and 279 tonnes of butter oil. The export of livestock and livestock products (excluding woollen goods) in 1987-88 amounted to Rs.503 million, and the import of livestock and livestock products (excluding wool) amounted to Rs.549 million in the same year.

The failure of such a large population of animals to meet the nation's requirement is largely due to their poor productivity. Typically the lactation milk yields of cattle and buffaloes are 836 and 455 kg respectively, the growth rates of goats to one year of age is 31 g per day, and the egg production of chickens is 80 eggs per year (Gatenby *et al.,* 1990). There are various factors responsible for limiting livestock productivity, which need to be identified, analysed and resolved. There is no doubt, however, that poor health is one of the important factors that reduce the productivity of animals in Nepal.

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Among the diseases of ruminants, fasciolosis is probably the most common disease, and perhaps, one of the important causes of livestock deterioration in Nepal. The disease is widespread throughout the country affecting all species of ruminant livestock; including yaks and yakows of the Himalayas (Joshi and Tewari, 1975). The different local names of this disease, such as *namle*, *mate*, *lew* etc., in different regions, are proof of its continued existence for many years in the animal population of the country. In 1973, Singh *et al.* (1973) reported an infection rate of 50 to 90 percent in animals in areas below 1800 m and estimate an annual economic loss of Rs.200 million (US$ 20 million) due to this disease alone. Recent studies have indicated a similar prevalence of the disease (Morel and Mahato, 1987; Joshi, 1988; Oli *et al.*, 1989; Mahato 1993), but a higher estimate of the economic loss i.e. US$ 37 million due to decreased buffalo milk and buffalo meat production only (Mahato, 1995). It appears therefore, that despite increased awareness of the disease and massive increase in the use of anthelmintics, there has been no control on the prevalence of the disease in the last two decades. In this paper, some important features of the epidemiological cycle of *Fasciola* spp. in eastern Nepal is briefly described, and its implications on the control of fasciolosis is discussed.

CONDITIONS REQUIRED FOR THE ESTABLISHMENT OF *FASCIOLA* SPP. IN AN AREA

The life cycle of the parasite involves an alteration of generations and requires a suitable species of *Lymnaea* snail, as an intermediate host. Eggs passed out from the infected animals hatch and the resulting miracidia infect the molluscan host. Following asexual multiplication as sporocysts and rediae, cercariae are released and encyst as metacercariae on herbage. Encysted metacercariae are swallowed by the animal and the young flukes excyst in the gut and migrate through the gut wall and across the peritoneal cavity to penetrate the liver capsule. Then they migrate through the liver parenchyma for some weeks before entering the bile ducts where they mature.

The success of the life cycle depends on the development and hatching of eggs, infection of the snail host by a miracidium, development of larval stages within the vector, cercarial emission from the snail and formation of metacercariae on herbage, and finally establishment within the final host. Completion of such phases of cycle eventually depends on how successfully the parasite can overcome complex interactions continually present in the environment and host.

Thus, before there can be any possibility of the life cycle of *Fasciola* species occurring in any particular area the following conditions must be satisfied. There must be an initial presence of infected final hosts, the intermediate snail host must be present and there must be an opportunity for transmission of the parasite from the final host to the snail habitat and for its return.

AVAILABLE MEASURES TO CONTROL FASCIOLOSIS

The methods to control fasciolosis generally include strategic application of anthelmintics to eliminate the parasite from the host at the most convenient time for effective prevention of pasture contamination, reduction of the number of intermediate host snails through drainage and other practices and reduction of the chances of infection by efficient farm and grazing management. In fact control of fasciolosis requires intervention in the labyrinth of relationships between the environment, ruminant hosts, snail hosts, the parasite life cycle, agricultural cycles and animal husbandry procedures. Therefore, good understanding of the environment-host-parasite interrelationships are essential for formulating the control measures suitable for an area.

APPOACHES TO CONTROL FASCIOLOSIS IN NEPAL

In general, the interrelationships have not been adequately studied in Nepal, although a substantial amount of information is available for the eastern region as a result of the studies conducted by the Pakhribas Agricultural Centre (PAC), Dhankuta (Morel and Mahato, 1987, Mahato, 1993). In this region, the density of *Lymnaea* habitats and source of food and grazing site are the major determinants of the prevalence of fasciolosis, these in turn, are influenced by the season and the farming systems. Except in a few instances, there is no reason to suppose that the information available from the eastern Nepal does not apply to the other regions of the country.

From the epidemiological point of view, the pre-monsoon and the monsoon rains, together with rice cultivation practices are important factors that create numerous temporary *Lymnaea* habitats over a wide area and disperse the infected snails to these habitats. Both these factors prevent grazing of animals near the habitats during the mid and late monsoon thus preventing contamination with *Fasciola* eggs and also animal infection. However, after the monsoon when rice is harvested, the roadsides and rice-fields that are heavily contaminated with metacercariae are available for grazing. Keeping the animals away from these areas during the pre-monsoon and again after the monsoon until the end of the viable period of the metacercariae would e of great value in the control of fasciolosis. However, this might not be acceptable to farmers, as alternative forage resources are scarce during these periods.

Rice-straw, which is the principal food of large ruminants during the dry season (December-April) is another important source of *Fasciola* infection, especially in stall-fed animals. In eastern Nepal, where the relative humidity is generally above 60% during the winter, the metacercariae encysted on rice-straw remain infective until March; although, it was found that only the bottom portion of rice-straw contain *Fasciola* metacercariae (Mahato, 1995). These findings clearly indicate that managing the feeding of rice-straw could prevent fasciolosis in stall-fed animals. Although the most important advantage of this approach is that it does not require any external input, its application will require a considerable extension effort.

Attempting to control snails using molluscicides during the dry season would be of doubtful value due to the large number of permanent habitats, the great biotic potential and aestivating ability of the snails (Mahato *et al.*, 1995) and recurrent labour and equipment costs. Furthermore, chemical molluscicides may be toxic for mammals and their drainage into streams may kill fish and other aquatic fauna including frogs and insects. Planting certain tree spp., the leaves and seeds of which are molluscicidal such as *Eucalyptus* spp, *Sapindus emarginatus. Acacia concinna, Caesalpinia corearia* and *Embelica officinalis* etc. round the edges of habitats has been found as a potential method of vector snail control. It seems unlikely that farmers in the hills would plant trees around springs in their rice-fields because of the adverse effects of shade on rice production. However, tree species with marked molluscicidal properties could be included in the present on going road-sides and canal bank plantation programme run by the Ministry of Forest in the Terai.

It has been observed that when infected with duck fluke larvae, snails are resistant to *Fasciola* infection. The introduction of large number of ducks into rice fields after harvest is a traditional practice in many south Asian countries. This practice help to reduce the number of snails, as these comprise a large proportion of the food eaten by the ducks and at the same time, contaminate the fields with eggs from the duck flukes. The larvae of these flukes subsequently infect some of the snails, preventing them from being infected with Fasciola larvae. This system could achieve a degree of biological control of fasciolosis in ruminants. Therefore, there is need to study the possibility of introducing ducks in rice growing areas of the country. This may help farmers to prevent losses resulting from fasciolosis and at the same time provide source of additional income from the sale of ducks.

Morel and Mahato (1987) and Mahato (1993) found that the bulk of the infection in snails is derived from fluke eggs deposited on the pasture during March-May and again in October and November. Thus there is a good case for administration of anthelmintics in February and again in late August to control the pasture contamination. However, this approach would only be effective if all stock including goats and sheep are treated with an efficient anthelmintic.

In Nepal, over 90 percent of the population depend largely on farming for their livelihood. Most of the Nepalese farmers are small holders and they keep animals mainly for converting low quality forage and crop by-products to milk and meat for their home consumption and manure and work power required for their subsistence farming. Huge quantity of anthelmintics required for the strategic dosing of all the ruminant animals (mass drenching) twice a year might not be affordable for the poor Nepalese farmers. It is likely, therefore, that small farmer may not adopt this approach unless there is a huge subsidy on the cost of anthelmintics by the government.

In this situation, alternative means to minimise the effect of the disease are needed for small-scale farmers. Experiments have shown that animals on lower protein diet lost weight more rapidly, developed anaemia and hypoalbuminaemia and died earlier than their better-fed counterparts. Possibly supplementation using locally available feeds could be an option in alleviating the effects of the disease in growing ruminants in Nepal.

CONCLUSIONS

It can be concluded that, because of the great biotic potential of *Fasciola* spp. and their intermediate host snails, only the continuous and co-ordinated strategic application of the available measures based on the epidemiology can provide economic control of the disease.

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CONTROL OF FASCIOLOSIS IN STALL-FED BUFFALOES BY MANAGING THE FEEDING OF RICE-STRAW

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INTRODUCTION

There are about 3.4 million buffaloes in Nepal. Although they contribute the major proportion of the milk and meat produced in the country, their productivity is low. Among the various factors responsible for limiting the productivity, fasciolosis has been known to be the most important one. Based on reduced live weight gain and milk yield resulting from fasciolosis in buffaloes, Mahato (1993) estimated that there is an annual loss of NRs 1685 million or US$ 33.7 million to the national economy. This estimate gives an indication of the enormity of the problem in Nepal when one compares this with the per capita gross domestic product of only US$ 234 in 1997 when the total population was estimated to be 20.8 million (CBS, 1998).

The prevalence of fasciolosis in buffaloes varies between 50 to 90%. About 60% of buffaloes are kept stall-fed and surprisingly the prevalence is higher in the stall-fed than in the out grazed. A detailed study on the epidemiology of fasciolosis in eastern Nepal revealed that rice fields are the main habitats of lymnaeid snails (Mahato, 1993). As rice straw is the principal food of stall-fed buffaloes, this could easily be attributed to the higher prevalence of *Fasciola* infection.

Several workers (Abu and Shiramizu, 1985; Shiramizu and Abu, 1988) have reported the prolonged survival of *Fasciola gigantica* metacercariae encysted on the rice-straw. However, this survival appears to depend on temperature, relative humidity and the moisture content of the stored products. Kimura and Shimizu (1978) reported that metacercariae of *F. gigantica* can survive for up to 4 months on the rice straw kept in barns where the relative humidity is more than 60%. In the hills of western Nepal, Joshi (1986, 1989) found that *F. gigantica* metacercariae in the rice straw bundles, which were kept in an open place, remained infective at least for two months. These reports suggest that in eastern Nepal, where the relative humidity is generally above 60% during the winter, the metacercariae may remain infective for a considerable period of time. However, no experiment has been conducted to determine the duration of their viability. Therefore, recommendation for a safe period for rice-straw feeding could not be made.

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Although encystment may occur on any object, cercariae of *F. gigantica*, in particular, encyst on fully submerged vegetation or herbage (Mahato, 1993). Dumag, Batalos, Escandor, Castillo and Gajudo (1976) reported that the cercariae of *F. gigantica* encysted on parts of plants at least about two centimetres below the water and that no metacercariae were found on parts of the plants above the water level. From these reports, a hypothesis can be generated that the top parts of rice-straw are free from the infective metacercariae. Therefore, a series of experiment was conducted with the following objectives:

- to verify whether the top parts of rice-straw are free from the infective metacercariae
- to determine the duration of infectivity of *F. gigantica* metacercariae on the rice-straw stored under local conditions
- based on the above two to develop a suitable rice-straw feeding regime in order to control fasciolosis in stall-fed buffaloes

MATERIALS AND METHODS

Experimental design

Eighteen buffalo calves (9-12 months old), all negative for *Fasciola* spp. infection on faecal examination and the agar gel diffusion test were used in each of the three experiments The calves were randomly divided into three groups of six animals. Animals in the group A received bottom parts (40 cm length) of rice-straw *ad libitum*, and approximately 7 kg tree fodder and 300 g commercial concentrate feed per head daily. Animals in the group B received similar food except that the bottom parts of rice straw were replaced by top parts while group C which were kept as control were provided only 300 g of commercial concentrate feed and *ad libitum* tree fodder (Table 1). Except for the starting and terminating dates, a similar design was used for the all three experiments (Table 1).

Rice straw used in the study was obtained from the fields which were known to be the habitats of fasciola infected snails. After the harvest and threshing of rice during last week of November, the straw was stored outdoors in stacks as per the local practices. Straw from each field was equally divided for all the stacks and a separate stack was made for the each experiment. Moisture content of straw in the stacks was determined at a weekly interval.

Monitoring of the experiment

Faecal, blood and serum samples of the buffalo calves were collected at weekly intervals. The faecal samples were examined for fasciola eggs while the blood sample were examined for eosinophilia using the standard techniques. Within 2 weeks of the termination of experiments, all calves were slaughtered humanely. Autopsy included careful examination of all internal organs for any abnormality, recovery of flukes from the livers and other organs, if any, counting and measuring the recovered flukes.

Table 1: Experimental details of the study on control of fasciolosis in stall fed buffaloes by managing the feeding of rice straw

Expt	Grou	No. of animal	Treatment (feed provided)	Starting Date	Stop Date
	A_1	6	bottom parts of rice-straw +concentrate feed + tree fodder		
1	B_1	6	top parts of rice-straw + concentrate feed + tree fodder	15 Dec	31 Jan
	C_1	6	concentrate feed + tree fodder only		
	A_2	6	bottom parts of rice-straw + concentrate feed + tree fodder		
2	B2	6	top parts of rice-straw + concentrate feed + tree fodder	27 Jan	12 March
	C_2	6	concentrate feed + tree fodder only		
	A_3	6	bottom parts of rice-straw + concentrate feed + tree fodder		
3	B_3	6	top parts of rice-straw + concentrate feed + tree fodder	10 Mar	23 April
	C_3	6	concentrate feed + tree fodder only		

RESULTS

Haematological data

There was a rise in the mean eosinophil counts from 3rd to 4th week of rice straw feeding and remained raised in the buffalo calves which were fed with the bottom parts of straw.

Pathological data

The livers of the buffalo calves that were fed with bottom parts of rice straw were relatively enlarged. On the liver surfaces there were perforations of 1 to 3 mm diameter. The cut surfaces showed haemorrhagic fluke tracts and immature flukes in the liver parenchyma. No flukes were seen in the bile ducts or gall bladder.

Parasitological data

No fasciola eggs were detected in the faeces of any animals during the experimental period and flukes were recovered from only those animal, which were fed with bottom parts of rice straw. Number of flukes recovered from the

individual animals and their measurements are presented in Table 2. Measurements of the flukes suggested that all these were immature *F. gigantica.* No flukes were recovered from any of the control animals and those that were fed with top parts of rice straw.

Table 2: Details of the fluke counts and their measurements

Experiment	Group	Animal positive (%)	Mean fluke counts*	Average fluke size (mm)*
1	A	100.0	18.7 (6-42)	8.3 X 1.9
	B	0.0	-	-
	C	0.0	-	-
2	A	100.0	13.7 (3-28)	7.9 X 1.7
	B	0.0	-	-
	C	0.0	-	-
3	A	50.0	0.5 (0-1)	11.8 X 3.0
	B	0.0	-	-
	C	0.0	-	-

* Figures in parenthesis indicate ranges

DISCUSSION

Results of these experiments demonstrated that only the bottom portions of rice straw contained metacercariae of *Fasciola* spp. Some of these metacercariae remained viable until March. Therefore, feeding of the bottom portions should be avoided in order to control fasciolosis in stall fed animals. However, the top portions were free from the viable metacercariae, even just 2 weeks after the harvest and therefore these could safely be fed at any time. Although, the timing when bottom portions of rice straw become free from viable metacercariae could not be determined from these experiments, there were some evidences that these could safely be fed from mid April. It can be concluded, therefore, that managing the feeding of rice-straw could prevent fasciolosis in stall-fed animals. The most important advantage of this approach is that it does not require any chemical agent or external input, however, its application in the field will require a considerable extension effort.

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THE RESPONSE OF *FASCIOLA GIGANTICA* INFECTED SHEEP TO DIETARY NITROGEN

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SUMMARY

Chronic Fasciola gigantica infections were established in lambs maintained on diets differing in their protein and nitrogen content. The course of the disease and their production parameters were compared with that of similarly maintained uninfected controls. Parasitological, haematological, serological, biochemical and post-mortem data indicated light F. gigantica infections were successfully established in the experimentally infected sheep. Nutritional and production parameters indicated little difference in the growth rates of infected and control sheep maintained on medium (14%) protein diets and that a proportion of the dietary nitrogen (2.4%) could be derived from urea without detrimental effect on production parameters. In contrast infected sheep maintained on either high (>19%) or low (7%) protein diets did not grow as well as their respective controls and the former group displayed a degree of inappetance. It is therefore suggested that a diet containing approximately 14% protein may help alleviate the negative production effects often associated with fasciolosis. This level is close to that generally recommended for ruminant diets but since many ruminants in Nepal are maintained on diets of a lower protein content, feed supplementation to increase the overall protein content of the diet may be a suitable option. Similarly diets with too high a protein content (>19%) should be avoided in areas endemic for fasciolosis.

INTRODUCTION

Fasciolosis is well recognised as a serious constraint to animal production in Nepal, accounting for a losses of 20% and 14% to buffalo and goat producers alone (Mahato, 1993). The extent of the problem, as recognised by farmers, is reflected in the high percentage of the total drug sales (60% Mahato, pers. comm.) that are devoted to drugs for the treatment of fasciolosis. Consequently, a high priority is placed on the control of fasciolosis by the Nepalese Government. There is relatively little quantitative information known about the negative effects of fasciolosis, particularly for *F. gigantica* (Roberts and Suhardono, 1996) but studies into the epidemiological basis for the control of fasciolosis in Nepal have been conducted (Mahato, Harrison and Hammond, 1997). While strategic and symptomatic drug treatment are an option for control (Shrestha and Joshi, 1997), farmers often cannot afford to treat their animals with expensive drugs, even if they are available locally. A more economic and feasible management strategy may be to supplement the diet of the animals with locally available feeds to improve their nutritional status, as was found to help in the closely related parasite *Fasciola hepatica* (Berry and Dargie, 1976; Dargie, Berry and Parkhins, 1979). This experiment was designed to test the hypothesis that the amount and source of dietary nitrogen can influence the progress of the infection, inappetance and rate of growth in *F. gigantica* infected sheep. The effect of sourcing some of the dietary nitrogen from urea was investigated because of the interest in Nepal of using urea molasses blocks as a feed supplement.

MATERIALS AND METHODS:

Experimental design:

A total of 48 Suffolk Cross lambs were split into four diet groups and maintained in individual pens. The sheep were fed *ad libitum* (Table 1). The composition of the diets and analysis of the diets, which were made up at the Scottish Agricultural College, were as detailed in Tables 2 and 3. The diets were prepared in batches of 2000Kg. The sheep were also give 150-200g of hay every day to ensure that rumination was maintained. The sheep were infected with *Fasciola gigantica* (2 metacercariae/Kg at week 15) and examined at *post-mortem* 24 weeks later.

Table 1 Experimental design - numbers of sheep in each dietary groups.

Diet Group (crude protein)	Infected with *Fasciola gigantica*	Uninfected Controls
High protein (20%)	6	6
Medium Protein (14%)	6	6
Medium Protein plus Urea (14% includes 2.45% urea)	6	6
Low Protein (7%)	6	6

Table 2 Composition of the diet batches for the four different dietary groups.

Diet Group Protein/ % content	High	Medium	Medium plus urea	Low
Barley	20.6667	19.5000	42.8500	40.8550
Oatfeed	19.3333	22.5000	17.0000	21.5000
Citrus pulp	29.9667	29.8750	30.0000	30.0000
Hi-Pro Soya	20.6667	20.5000		*
Molasses (CMS20)	5.0000	5.0000	5.0000	5.0000
Salt	0.6800	0.6800	0.5350	0.68000
Dicalphos	0.4800	0.4900	0.7900	0.7900
Limestone flour	1.0067	1.2550	0.9950	0.9750
Scotmin ewe/lamb	0.2000	0.2000	0.2000	0.2000
Sodium sulphate	*	*	0.1800	*
Urea	2.000	*	2.4500	*
Total	100	100	100	100

Monitoring:

The sheep were monitored regularly throughout the entire experimental period and the following parameters determined:

Diets: The feed batches were monitored regularly during storage to ensure consistency of nitrogen content, neutral detergent fibre, acid detergent fibre and organic matter.

Intakes: The feed intakes/refusals were monitored following every feed so that the total dietary intake could be determined.

Parasitological: Faecal samples were collected every week and the numbers of fluke eggs per gram calculated using standard procedures,

Haematology: Blood samples were collected weekly in order that total red and white blood cell counts could be taken. Differential cell counts were noted. The haemoglobin level in the blood and the packed cell volumes were determined so that, along with the total red blood bell counts, the Mean Corpuscular Volume, Mean Cell Haemoglobin and Mean Cell Haemoglobin Concentration could be calculated.

Table 3 Feed analysis for the four different dietary groups.

Diet Group Protein/ Analysis (Vol 100.0)	High	Medium	Medium plus urea	Low
Dry Matter	872.9733	871.6500	873.2950	871.3885
Crude Protein	199.4793	140.9575	140.5550	69.4600
ERDP 5%	145.7237	98.6963	108.6490	51.3461
ERDP 8%	133.9983	87.0763	105.1365	47.8884
DUP 5%	28.91	28.7590	9.850	9.8965
DUP 8%	39.2610	39.0263	12.5833	12.5640
ME RUM	9.5086	9.5151	9.4981	9.5111
FME	9.0119	9.0075	9.0495	9.0461
FIBRE	101.7867	108.6600	96.5110	106.3933
MADF	161.8767	172.2975	147.7675	162.8703
NDF	255.1817	272.3363	250.4590	274.8877
STARCH	125.9127	123.4225	228.0750	222.9345
SUGAR	102.4233	101.9175	86.9990	86.7197
STA+SUG	229.0284	226.0413	315.5455	310.1457
ASH	69.7791	73.2862	64.2909	65.2171
CALCIUM	9.9972	10.9914	10.0063	9.9892
PHOSPHORUS	3.5040	3.5173	3.5018	3.4994
MAGNESIUM	1.2325	1.2169	0.9370	0.9193
SODIUM	2.9912	3.0040	3.0004	3.0012
POTASSIUM	10.2588	10.3341	6.1276	6.2893
SULPHUR	1.7447	1.7545	1.5042	1.1203
COBALT	0.8701	0.8694	0.8479	0.8473
COPPER	6.6192	6.6689	4.3369	4.4351
IODINE	4.8556	4.8554	4.8350	4.850
MANGANESE	53.6163	54.0213	47.7705	48.4112
SELENIUM	0.2503	0.2492	0.1971	0.1963
ZINC	56.7703	57.0088	51.7410	52.1223
VIT A (K)	8.0000	8.0000	8.0000	8.0000
VIT D	1999.9980	1999.998	1999.998	1999.998

Biochemistry: Serum samples were collected weekly so that the serum levels of the enzymes, γ-glutamyl transferase, glucose-6-phosphate dehydrogenase, β-hydroxybutarate and the serum glucose, nitrogen, protein and albumin levels determined, all by standard procedure using kits prepared by Randox Ltd.

Serology: A routine indirect antibody detection ELISA was employed in order to determine the antibody responses of the sheep to *F. gigantica* infection. Excretory/secretory products collected from adult flukes maintained in culture for 24 hours was used as the antigen, diluted to optimum concentration, as determined by titration. Following addition of the test serum diluted to an appropriate concentration, the presence of anti-parasite antibody was detected by the addition of commercial rabbit anti-sheep (H+L chain) serum/ horseradish peroxidase conjugate, followed by tetramethylbenzidine substrate (Sigma Ltd). The colour reaction was stopped using 0.2M H_2SO_4 and the optical density of the reaction product measured at 450nm.

Physiological: The sheep were weighed twice weekly so that their weight gain and metabolic weights could be determined.

Post-mortem: At the time of slaughter, the carcass condition was recorded. The dressed out carcass weights were determined and the degree of liver pathology noted. The number of flukes present in the livers of the infected animals was calculated by slicing the livers carefully to look for the flukes. Bile was collected and examined to determine whether there were any fluke eggs present.

RESULTS

Feed analysis indicated that the omposition remained constant throughout the experimental period. None of the sheep in the control groups gave any indication of being infected with *F. gigantica* by any of the monitoring parameters. All the indications were that the infections established in the exposed animals were mild with small numbers of flukes (in the range 1-11) being recovered from the infected groups, but there was no statistical difference in the number of flukes recovered form each dietary group. This conclusion was confirmed by the haematological and biochemical data. The serological results also indicated infection in the exposed group (Fig 1).

There was no difference in the weight gain following infection in either of the medium protein (14% crude protein groups) whether the protein was derived totally from crude protein (medium protein group) or partly derived from urea (2.45%), medium protein including urea group.

Unfortunately during the course of the experiment two of the sheep in the high protein (20% crude protein) group died. This group also exhibited a degree of inappetance as compared to the corresponding uninfected controls.

Regression analysis indicated a significant difference between infected and control sheep in both the high and low protein groups. The infected sheep grew less well than the uninfected controls over the entire post-infection monitoring period, although this was not the case in the pre-infection period. This effect was slightly more pronounced in the high protein infected group (Fig 2).

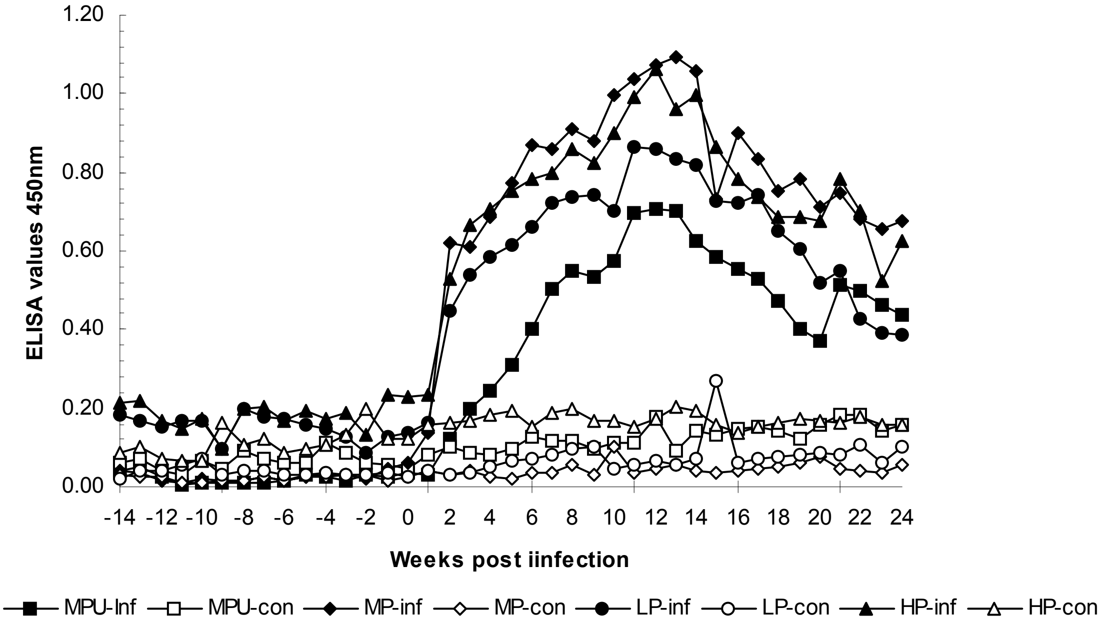

Figure 1: The antibody responses as measured by enzyme-linked immunosorbent (ELISA) of *Fasciola gigantica* infected and control sheep maintained on different diets medium protein plus urea (MPU) medium protein (MP) high protein (HP) or low protein (LP). The sheep were infected with metacercariae on week 15.

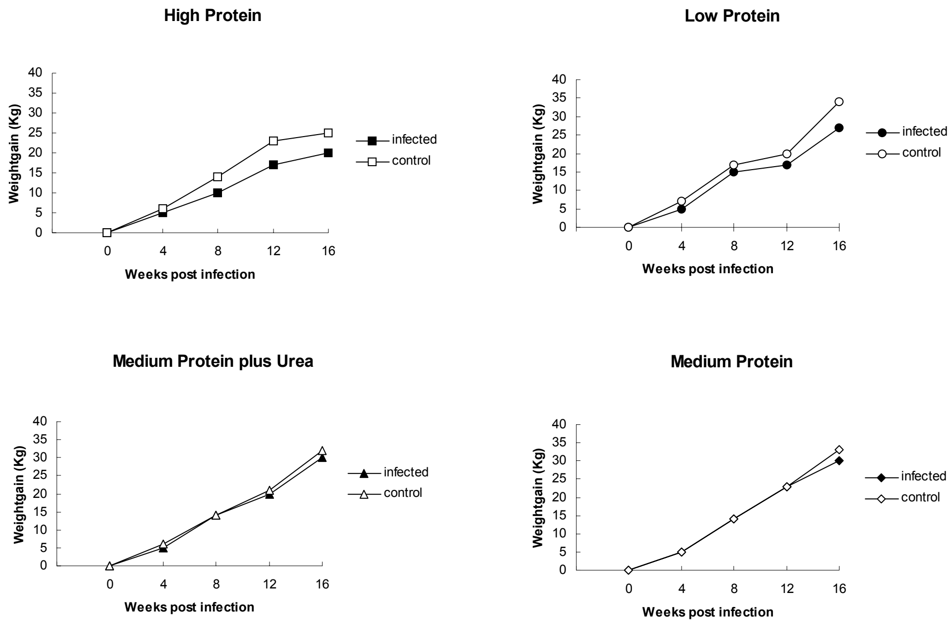

Figure 2: The weight gain following infection of *Fasciola gigantica* infected and control sheep maintained of different diets either high protein, medium protein, medium protein including urea or low protein.

DISCUSSION

Flukes specifically damage the livers of infected hosts. The liver plays a pivotal role in the physiology of the body, as it is responsible for a large proportion of the body's amino acid metabolism along with other important roles. At the same time, the liver has remarkable functional redundancy and, unlike most other organs in mammals is able to regenerate functional tissue after physical or chemical injury. Although only a few aspects of liver function have been directly examined in fluke-infected hosts, significant disturbances have been detected, even when only small areas are obviously damaged. Thus even small numbers of flukes have been associated with changes. It seems likely that the availability of amino acids for protein synthesis would be an important factor in determining the extent to which the liver can compensate for the damage caused by the flukes (Behm and Sangster, 1998).

This study indicate an appropriate level of dietary protein for *F. gigantica* infected sheep would appear to be c14% crude protein and that some of the dietary nitrogen can be derived from urea with minimal negative affect. However, the indications are that deviating too far from this level >19% and <8% crude protein has a deleterious effect.

Unfortunately many ruminants in Nepal are thought to be maintained on diets which have less that 14% protein. The suggestion therefore is to investigate the effect of using locally available feed supplementation to determine whether raising the protein content of the diet in ruminants managed under Nepalese conditions would help to alleviate the negative production effects of fasciolosis. Such supplementation may form a useful alternative to drug treatment (either strategic or symptomatic), which currently is the main control method available. Unfortunately many Nepalese farmers find this method difficult to apply either because of cost or lack of easy availability of the appropriate drugs. If suitable, such food supplementation may form a useful adjunct to drug treatment regimens or even avoid potential problems with drug treatment such as drug residues in meat and milk and drug resistance.

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THE INTERACTION BETWEEN *FASCIOLA GIGANTICA* INFECTION AND DIFFERENT LEVELS OF NUTRITION IN NEPALESE HILL GOATS

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INTRODUCTION:

Fasciolosis is an important constraint to the development of goat production in Nepal and in the tropics. Fasciolosis is a disease of domestic ruminants caused, primarily by infection with the trematodes, *Fasciola gigantica* and *Fasciola hepatica*. It is indisputably a cause of serious production losses to cattle, buffalo, sheep and goat producers particularly in areas where conditions favour the survival of the snail intermediate hosts (Pearson and Harrison, 1995).

In the tropics, the forage base is of medium to low quality, made available to the animals by grazing and cut and carries system. The quality and availability of these resources declines seasonally, coinciding with the onset of the dry season. During the dry season, productivity of the animals declines unless dietary supplements are introduced (Klesse, 1997).

Food conversion and thus efficient use of animal food resources is additionally compromised by this disease and further exacerbated in many areas, where the ruminants are undoubtedly maintained on a poor plane of nutrition.

Anthelmintics for the treatment of this disease are very costly and also are not readily available at the areas where fasciolosis is the major problem.

With the emergence of a search for sustainable control strategies in the development of domestic ruminant livestock production systems in the tropics, this study aims to see if modifications to animal feed management can ameliorate the production losses caused by fasciolosis.

MATERIALS AND METHODS:

Experimental goats:
Fifty male goats aged between 6 and 8 months and free from patent fasciola infection were procured locally from mid and high altitude (above 1100 m) areas in the eastern hills of Nepal. They were castrated with the help of burdizzo castrator.

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All goats were treated parentally against ecto and endo parasites with Ivermectin (Ivomec, MSD-AGVET, and UK). They were also immunised against pasteurellosis, lamb dysentery, struck, pulpy kidney, tetanus, braxy, black leg and black disease using Heptavac-P (Hoechst UK Limited).

Regular treatment against gastrointestinal nematodes and coccidia infections was also carried out at monthly intervals for the duration of the experiment.

Experiment design:
After pre infection monitoring of one-month period, the goats were divided randomly into five groups (A, B, C, D and E) each group consisting of 10 goats. (Table 1). For identification, colour coded ear tags (colour for the groups and number for individuals) were used.

Table 1: Experimental design

Group	Tag colour	No. of goats	Fasciola infection	Diet	Treatment with Triclabendazole
A	Red	10	Yes	Basal only	Yes
B	Yellow	10	Yes	Basal only	No
C	Green	10	Yes	Basal plus good fodder	No
D	Blue	10	Yes	Basal plus concentrate	No
E	White	10	Yes	Basal plus urea molasses block	No

The goats belonging to the group A were treated with Triclabendazole against fasciolosis at 20 weeks post infection.

Housing and feeding:
The goats were housed in slatted floor pens with one group of goats in one pen at nights. But during the day, they were tethered to the feeding racks on gravelled ground under a sun shed.

All goats received a basal diet i.e. about 5 hours grazing plus cut grasses. However, the goats belonging to group C, group D and group E were supplemented with good fodder (i.e., high nitrogen fodder available during the experimental period) at the rate of 3% of the body weight, commercial concentrate feed at the rate of 1% of the body weight and urea molasses block free access over night respectively. The supplementary feed was offered daily at 7.30 to 8.30 am.

Infection of the animals:
After one-month pre infection monitoring period, all goats were infected during the second week of April 1997 with *Fasciola gigantica* metacercariae at the rate of 8 metacercariae per kg body weight as described by Mahato (1993). *Fasciola*

gigantica metacercariae used to infect the goats were obtained from naturally infected snail, *Lymnaea auricularia* race *rufescens* in the eastern hills of Nepal.

Monitoring of the experiment:

Quantity and quality of feed:
Feed intake (basal and supplement) of the goats were determined daily. Daily dry matter estimation of only supplementary fodder and concentrate was carried out at PAC. While basal feed (pasture grass and cut grass samples) were only dried and stored. The stored dried samples of basal as well as supplementary fodder and concentrate feed were pooled each week and stored for dispatching to Centre for Tropical Veterinary Medicine (CTVM), Edinburgh University. There, detailed nutritional analysis such as Crude protein, Acid detergent fibre (ADF), Neutral detergent fibre (NDF), Gross energy (GE), Ash, Organic matter (OM) etc was carried out.

Measurement of weight gain:
The animals were weighed at weekly intervals at 8.0-8.30 am before feed and water was provided. The weighing was done with the help of Rudweigh electronic balance (Rudweigh Australia Limited).

Sample collection and examination:
Faecal samples were collected directly from the rectum and examined on the same day for helminth eggs. The differential centrifugal floatation technique developed by Sewell and Hammond (1972) were used for the faecal examination.

The blood samples for haematological studies were taken from the jugular vein into vacutainers containing ethylene di-amine tetra acetic acid (EDTA) as an anticoagulant and examined on the same day. The following studies namely, total and differential leucocyte counts, erythrocyte counts, eosinophil counts, packed cell volumes and haemoglobin estimation were carried out at PAC.

The blood samples for biochemistry and serology were also obtained from the jugular vein into OX-F and plain vacutainers (Becton, Dickinson & Co. Ltd. UK). The biochemical study was carried out at Central Veterinary Laboratory (CVL) Kathmandu which includes Total serum protein, Serum albumin, Serum globulin, Plasma glucose, Beta hydroxybutyrate, while serological study namely, Serum glutamate dehydrogenase (GLDH) and Serum gamma glutamyl transpeptidase (GGT) was carried out at PAC.

All sampling were carried out at weekly intervals between 8.30 and 9.30 am.

Recovery, counting and measuring the flukes:
The procedure for the recovery, counting and measuring the flukes was used as described by Mahato (1993).

Pathology:
Post-mortem examination was carried out on all animals as soon as possible after they were humanely killed. A careful examination was made of all internal organs for abnormalities, with particular attention to the size, weight, colour and appearance of the livers.

Histopathology:
Samples of liver and other tissues were fixed in 10% buffered formal-saline and dispatched to CVL, Kathmandu for Histological study.

Carcass evaluation:
After post-mortem examination, the goat carcasses were processed for dressing out percentage. This includes weight of dressed carcass including shaved skin and edible offal as a percentage of the live weight of the animal.

RESULTS:

The analysis of samples is being done at CTVM, CVL and Central Lab PAC. The results that are present at hand are summarised and presented below.

Growth rate:
The growth rate 60.9 g/d is higher in group D (Concentrate supplement) followed by 52.53 g/d in group C (Good fodder supplement), 46.9 g/d in group E (Urea molasses block), 40.51g/d in group B (Basal diet only) and 38.89 g/d in group A (Basal diet and treatment) table 2.

The mean body weight at 33 week post infection (wpi) and the mean body weight gained by goats over 33 weeks are also higher in group D followed by group C, group E, group B and group A.

Table 2: Growth rate of the goats

Observations	Group A	Group B	Group C	Group D	Group E
Mean growth rate (g/d)	38.89	40.51	52.53	60.90	46.90
Initial mean body weight (kg)	11.44 ±1.73	11.42 ±1.69	11.46 ±1.79	11.41 ±1.65	11.39 ±1.43
Mean body weight at 33 weeks (kg)	20.44 ±4.60	20.71 ±2.95	23.60 ±4.42	25.48 ±4.52	22.23 ±3.15
Mean body weight gained (kg)	9.00	9.29	12.14	14.07	10.84

Dry matter intake:
The total dry matter intake by goats can only be summarised and estimated when detail result of feed (basal and supplementary) and concentrate would be available from CTVM. However, total dry matter intake by goats belonging to group C and group D and total urea molasses block consumed by goats belonging to group E are presented in table 3.

Table 3: Feed intake by the goats (during entire 33 weeks)

Feed	Group C	Group D	Group E
Tree fodder (DM kg)	29.41	-	-
Concentrate (DM kg)	-	35.31	-
Urea molasses block (kg)	-	-	272.4

Slaughtering of animals:
The goats were slaughtered at 33 weeks period. Immediately after slaughter a careful post-mortem examination was carried out to observe any pathological changes in the internal organs. But no any major pathological changes except some changes in the liver and gall bladder were observed. Liver flukes recovered from the slaughtered animals are presented in table 4.

Table 4: Liver fluke Recovery

Fluke	Group A	Group B	Group C	**Group D**	**Group E**	**TOTAL**
Small	1	0	0	2	4	7
Large	±0	33	23	53	57	166
Total	1	33	23	55	61	173

The dressing out percentage of individual animal and groups is presented in table 5. This includes weight of dressed carcass including shaved skin and edible offal (as per local practice) as a percentage of the live weight of the animal. The edible offals are heart, lungs, kidney, spleen, liver, fat, and gut including intestines.

Table 5: Dressing out percentage

	Group A	Group B	Group C	Group D	Group E
Mean	62.83	61.10	64.29	67.08	61.33
SD	±2.74	±6.03	±5.11	±6.07	±4.79

GENERAL OBSERVATIONS:

In group A, animal number 2 achieved negative growth rate (-1.29 g/d). This animal was exhibiting clinical sing of gid (*Coenurus cerebralis*) 2 months after the running of experiment. It was losing weight at every weighing up to 20 week post infection (wpi) with *Fasciola gigantica* metacercariae. However, it started to regain its weight right after drenching with Triclabendazole at 20 wpi. At the time of slaughtering it merely achieved it's initial weight. At post-mortem examination fully grown cyst of *Ceonurus cerebralis* was isolated from the posterior part of the brain.

The goats observed losing daily intake of feeds when there were foggy as well as rainy days. This resulted into losing of body weight in comparison to the last week record.

The goats were also affected by respiratory disease when there were foggy days. The clinical signs include nasal discharge and coughing. The goats having serious problem with this condition found swelling of face, mucopurulent nasal discharge, intermittent coughing and respiratory distress. The sick goats were treated successfully with corticosteroid and antibiotics after conducting sensitivity test.

CONCLUSIONS

- The growth performance of goats belonging to concentrate group was higher followed by Fodder group and Urea molasses block group in comparison to control group and treatment group

- The dressing out percentage of goats belonging to concentrate group was also higher followed by Fodder group, Treatment group, Urea molasses group and Control group

- Liver fluke recovery was higher in the goats belonging to the Concentrate group followed by Urea molasses block group, Control group and Fodder groups. However, the condition of liver was fine, without prominent damage in the supplement groups in comparison to control group. This suggests that the goats supplemented with extra nutrition on top of their daily diet are capable of tolerating ill effects of flukes than the non-supplement goats

- Least liver fluke recovery from Fodder group suggests that the tree fodder are capable of reducing establishment of flukes in the liver of goat

- Above results indicate that the tree fodder supplement along with basal diet would be the best strategy to ameliorate the losses caused by fasciolosis in goats.

- In our context, tree fodder are easily available and affordable by the farmers in comparison to broad spectrum anthelmintic, concentrate feed and urea molasses block, and therefore, this technology would probably be an alternative for combating fasciolosis.

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THE INTERACTION BETWEEN *FASCIOLA GIGANTICA* INFECTION AND NUTRITION IN GROWING NEPALESE HILL BUFFALOES

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SUMMARY

A feeding trial of UMB (Urea molasses block), Tree fodder (@3% live wt), Concentrate (@1% live wt) and a Control (local feeding practice) fitted in a completely randomised experimental design was conducted for 1 year in 5 equal groups of 40 growing local buffalo calves experimentally infected with metacercariae. One group was maintained on the diet similar to the control group, was treated with Fasinex (@24mg/kg live wt) at 20 WPI (weeks post infection). The animals were routinely monitored for any changes in the haemato-biochemical values including the activities of the serum enzymes GGT (γ-glutamyl transpeptidase) and GLDH (Glutamate dehydrogenase), faecal fasciola egg counts and the live weight gains. At 37 WPI, the animals were slaughtered and the carcasses were evaluated. The benefits of the feed supplements were compared with the anthelmintics and the most cost-effective method of managing fasciolosis locally has been identified.

INTRODUCTION

Fasciolosis is now a well recognised parasitic disease of economic importance since it is one of the major causes of losses of livestock production and productivity in Nepal. The disease is widely spread at all ecological zones of the country including in the Yaks of the Himalayas (Joshi and Tewari (cited by Mahato *et al* 1997). The prevalence of fasciolosis in buffaloes in the hills and Terai are 57.9 and 41.3% respectively (Mahato, 1993). The prevalence of the disease depends upon the various feeding and management practices. Therefore, reduction or the control of the prevalence of this disease could be either through the improvement in the existing feeding management systems or through drenching with appropriate anthelmintics. Various anthelmintic drugs are available in the country to control the problem but they are expensive for a farmer to afford, those available are often found inferior in quality. Drenching with anthelmintics twice a year is the recommended practice to control fasciolosis in Nepal, however the local farmers find it tedious to follow this as a routine procedure or find the drug unaffordable or drench the animals once a while only when the animals are already ill.

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Over the past, various efforts have been made to control the disease from both the private or the government sectors. However, the overall efforts to control this disease through the use of drug have largely been a failure. The control measures must be appropriate to the livestock production systems practised by the local farmers, otherwise the intended beneficiaries simply will not use them. Therefore, an alternative cost-effective approach to control the production losses due to fasciolosis would be through correcting the existing feed management system of the farmers. This approach which requires no extra investment would be an effective alternative system to counter-act the problem associated with low production due to fasciolosis. In this perspective a study was taken to see whether the improved nutrition including the use of local nutrient resources (e.g. tree fodder) could be an alternative means to control the fasciolosis problem in buffaloes in the hills of east Nepal.

MATERIALS AND METHODS

Grouping of animals and allocation of treatment diets

A total of 40 male buffalo calves, aged between 7 months to 1.5 years having approximately 75 to 100kg live weight were purchased locally from mid and high altitude (above 1100 m) areas of Dhankuta district. The animals were grouped into 5, each group representing 8 animals and the groups were then randomly selected to represent the treatment. The details of the experimental plan is shown in Table 1, as follows:

Table 1: Experimental design

Group	No. of	Fasciol	Live wt	Diet	Treatment
Red	8	Yes	104+22	Basal plus	Yes
Yello	8	Yes	103+20	Basal only	No
Green	8	Yes	104+23	Basal plus Tree	No
Blue	8	Yes	104+24	Basal plus	No
White	8	Yes	105+20	Basal plus UMB	No

All the animals received basal diet i.e. seasonally available forages that include crop-residues, tree fodder and cut grasses.

As a basal diet, the top portion of the rice straw was provided *ad libitum* from February until April and the bottom portion of it from May until July whereas Monsoon grasses were supplied during July and September. These diets were supplied with portions of other forages including tree fodder, maize stover and husks and grasses depending upon their availability. The supplementary diets were concentrate feed (i.e. cattle feed from Hetauda cattle feed industry), good fodder (seasonally available tree fodder) and Urea Molasses Block (UMB) (Hetauda cattle feed industry).

The concentrate and the tree fodder were fed at 1% and 3% live wt basis respectively while the UMB was left in the night for *ad libitum* licking. Prior to the experiment all the animals were treated with Ivermectin, immunised against clostridia infections and dewormed using Albendazole (2.5%). The animals received drinking water at free access and the heat of the sun during winter.

Animal housing

The animals were accommodated in shed constructed with local materials to represent the local barn. The animals were tethered in separate groups in the shed or out side to allow animals to bask under the sun. During the middle of the experimental period, the animals at the extreme east pen were exchanged with the animals at the extreme west pen of the house and so on. The health status of the animals was regularly monitored and the animals were treated as necessary.

Infection of animals with metacercariae

All the experimental animals were infected with fasciola metacercariaea at the rate of 2.5-numbers/kg live weight. One group of animals (Red group) was drenched with Fasinex (at double dose rate) against fasciolosis at 20 weeks post infection (WPI).

Prior to the experiment, the animals were allowed to undergo approximately 45 days adaptation period in order to accustom the animals with the diet. During the adaptation period the animals received their respective treatment diets on top of the basal diet. The control group received the “normal feed” available for feeding at that day or season.

Haematology and bio-chemical tests

The eosinophil counts were measured using the method of Dacie and Lewis (1963) using a modified Fuschs Rosenthal Chamber (Weber Scientific International Ltd, Lancing, England). The packed cell volume using Hawksley micro-haematocrit centrifuge and reader (Hawksley and Sons Ltd, lancing, England). The haemoglobin was measured in the form of cyanmethaemoglobin. The activities of the serum enzymes Glutamate dehydrogenase (GLDH) and γ-glutamyl transpeptidase (GGT) were also measured *in-vitro* using kits, γ-GT and GLDH activated (Randox Laboratories Limited) at weekly interval.

Faecal examination

Faecal samples were collected weekly, directly from the rectum and examined on the same day for helminth eggs using the differential floatation technique (Sewell and Hammond, 1972).

Live weight gain

The animals were weighed at 8.00AM in the morning every week before feed and water was offered. The animals were weighed using an electronic scale (Electronic weigh bar system – model no 1200 KM3 Basic) until 28 WPI. From 29 WPI, because of the problem with the electronic scale, the animals were weighed out by measurement using the following formula by Yazman (1987):

W = -71.1+1.74L+1.05H
W = wt in kg
L = body length from collar-bone to pin bone (cm)
H = heart girth (cm)

Statistical analysis

Comparison of the difference between the means of the treatments was analysed by the analysis of variation using MINITAB software computer programme. The difference between or within means, the post-test was carried out using GraphPad Instat software computer programme.

Economic analysis

The economic value of the feed supplementation and anthelmintic drenching was calculated by subtracting the purchase price, the total supplement cost and the cost of fasciolocide from the carcass value.

RESULTS

Intake of feed supplements

The average intake of concentrate feed on dry matter basis was 0.80±0.39kg/d and that the average intake of the UMB was found to be 0.93±0.46 kg/d. Although the intake of the Concentrate and the UMB during the initial period was low, a gradual increase in the intake of the both diets was recorded over the period as compared to the intake at the initial periods. The average intake of the dry matter of tree fodder was found to be 0.91±0.29kg.

Live weight gain

The average body weight (kg) gained by the Blue group was the highest followed by the White and the Green groups of animals. The Yellow (control) and the Red groups (anthelmintic drenched) were the groups with lowest live weight gains. The percentage of the weight gains at 37 WPI with respect to the original average live weights were 26%, 31%, 44%, 69% and 43% for the Red, Yellow, Green, Blue and White groups respectively (Table 2). The overall mean live weight (kg±SD) from 0 to 37 weeks post infection is 109±10, 108±11, 121±14, 133±21 and 127±12 for Red, Yellow, Green, Blue and White Groups respectively (Table 2). The one way (repeated measure) analysis of variance indicated that the differences between the group means are extremely significant ($p<0.0001$). The mean live weight gained by the animals between the Red or Yellow groups and the other groups of animals was significantly different ($p < 0.05$).

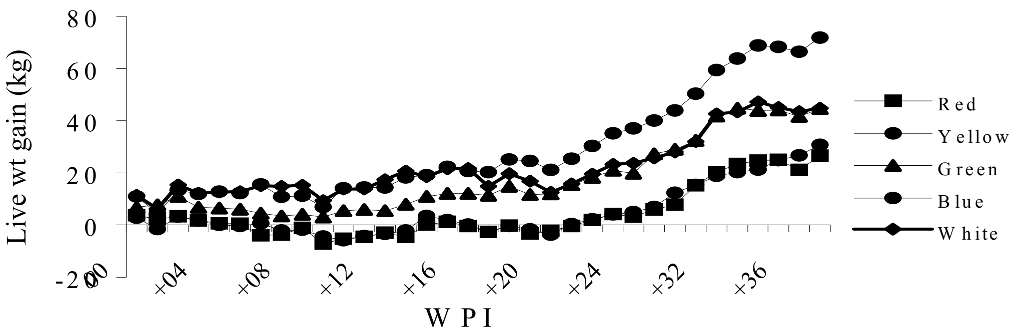
Table 2: Average live weight of Buffaloes

Group	Average Initial Body wt (kg)	Average live wt. at 37 WPI	Average gain in wt (Kg)	Mean live wt ±STD
Red	104±22	132±33	28	109±10[a]
Yellow	103±20	135±32	32	108±11[a]
Green	104±23	148±35	44	121±14[b]
Blue	104±24	176±47	72	133±21[c]
White	105±20	150±36	45	127±12[bc]

The group means with different subscripts in a column differ significantly from one another.

The growth rate trend based on the calculation of a difference between the weekly weight gain and the initial weight is shown in the Figure 1. The animals in the Red and Yellow groups gradually lost their body weights after they were infected with metacercariae but gained some weights from 26 weeks after infection.

Fig. 1 Average weekly live wt. gain



Blood values and serum enzymes

To monitor the fasciola infection, the serum enzymes were measured for the activities of GLDH and GGT. The results showed an increasing trend in the activities of GLDH after the animals were infected with metacercariae until 12 weeks post infection. Thereafter, the activity remained almost stationary until the end of the experiment. The GLDH level in the Red group of animals was found to be least followed by the Green, White and Blue groups of animals. The activity was the highest in the Yellow groups of animals. No general trend in the levels of GGT was observed between the groups of the animals. The blood values were also measured for Eosinophil counts, Hb and PCV levels so as to monitor the intensity of the infection.

In all the animal groups, the general trend of the Eosinophil counts was that the levels raised at 9, 17 and 18 weeks post infection with metacercariae. The level dropped at 20 with a sharp rise in the 30 weeks periods. The difference in the means of the Eosinophil counts among the groups was highly significant ($p<0.001$). The counts between the Red and Green or Blue groups was also highly significant ($p<0.001$).

The Haemoglobin (Hb) and Packed cell volume (PCV) levels were found to be comparatively lowest in the Yellow groups and lower in the Red groups as compared to the other treatment groups of animals. The difference in the Hb and PCV among the mean values of the groups was extremely significant ($p<0.0001$). While making multiple comparisons, the difference between the means of Hb or PCV of the Yellow group was extremely significant ($p<0.001$) from the means of Hb or PCV of the other treatment groups. Whilst the Hb or PCV means of the other groups were not significantly different ($p>0.05$). The animals of the Yellow group showed a progressive drop in the mean Hb and PCV levels from 2 to 3 weeks after infection while, the other groups maintained their original levels i.e. the other groups including the Red group (anthelmintic drenched animals) have shown more or less similar pattern in the levels of PCV and Hb. However, it was found that the Hb or PCV levels was comparatively the highest in the Green group followed by the White, Blue and the Red groups of animals.

Fasciola infection and post-mortem examination

Fasciola eggs were detected in the faeces of the animals in the Yellow groups at 5 weeks after the animals were infected with metacercariae. However, from 12 to 13 weeks post infection only the eggs were detected from all other groups of animals. The egg counts rose sharply from 15 weeks which remained more or less in the same pattern until the end of the experiment except in the red groups. As no any helminth eggs were recovered from the faeces of the Red group of the anthelmintic drenched animals, this has shown that the anthelmintic treatment was effective to control the animals from fasciola infection. The weekly recovery of the helminth eggs recovered from the Yellow, Green, Blue and White groups of animals are shown in Figure 10.

The one way analysis of variance showed that there are significant differences among the EPG counts among the means of the groups. The multiple comparison between the means revealed that the Red and the Yellow groups are very significant ($p<0.01$) whereas the other means are insignificant ($p>0.05$) when compared one another.

At the end of the experiment i.e. 37 weeks post infection the animals were slaughtered using a humane killer. The internal organs were examined for any abnormalities. The examination included size and colour of the liver, size and condition of the gall bladder, condition of the bile and any abnormalities of these organs. The carcasses were examined with particular attention given to the condition of the liver. The number of flukes found in each liver and the duct was noted.

Only one fluke was recovered from one of the animals of the Red group. An average of 45 to 65 numbers of adult flukes was recovered from the ducts of the other groups of animals. The number of flukes recovered was ranging from a minimum of 10 to a maximum of 110. The average percentage of flukes recovered from each of the Yellow, Green, Blue and White groups was 23±9, 18±6, 20±16 and 15±11 respectively.

Dressing out percentage and body condition score

The dressing-out percentage given in Table 3 was calculated considering the weight of dressed carcass including edible offal (heart, spleen, liver and guts) calculated as a percentage of the live weight of the animal at slaughter (Table 3). The difference in the dressing out percentage among the group means was found highly significant ($p<0.001$).

The mean dead weights of the groups of animals were compared (Figure 2). The dressing out percentage was highest in the Blue group followed by the Green group. The difference between the means was insignificant ($p > 0.05$).

Fig. 2 Average dead weights of buffaloes

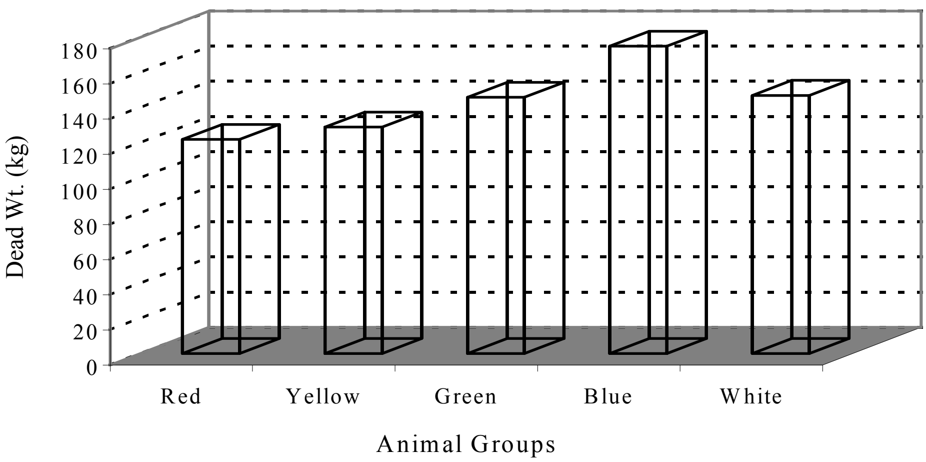


Table 3: The dead wt and dressing out percentages

Animal group	Total carcass	Carcass+Offa	Dead wt	Dressing-
Red	37.61±12.85	50.00±16.85	121.94±32.6	40.40^{a}±3.43
Yellow	40.75±11.79	53.76±14.02	129.28±28.2	41.30^{a}±2.54
Green	52.13±16.62	66.36±18.97	146.38±36.6	44.98^{b}±4.03
Blue	66.97±22.79	83.63±26.61	175.04±49.0	47.33^{b}±2.61
White	47.93±17.56	61.92±20.72	146.98±37.6	41.51^{a}±3.00

Note: Offals include liver and guts. The group means with different subscripts in a column differ significantly from one another.

On the slaughter day, the animals were inspected for the body condition score. The average body condition score (1 to 5 scale) of the Red, Yellow, Green, Blue and White groups were 1.5, 1, 2, 3 and 2 respectively. The Blue group of animals looked heavier and healthier followed by the White or the Blue groups of animals.

The post-test following ANOVA (F test) for comparison of the means are presented in Table 4.

Table 4 : Post-test following ANOVA (F test) for comparison of the means.

Comparison of groups	**Mean difference**	**Bonferroni p value***
Red group vs. Yellow group	1	NS (p>0.05)
Red group Vs Green group	-11	** (p<0.01)
Red group Vs Blue group	-21	*** (p<0.001)
Red group Vs White group	-16	***(p<0.001)
Yellow group Vs Green group	-12	** (p<0.01)
Yellow group Vs Blue group	-22	*** (p<0.001)
Yellow group Vs White group	-17	***(p<0.001)
Green group Vs Blue group	-10	* (p<0.05)
Green group Vs White group	-5	NS (p>0.05)
Blue group Vs White group	5	NS (p>0.05)

Probability is only 5% that any one (or more) of the comparisons would be significant with ‘p<0.05’ by chance alone.

Economic analysis

Considering the economy of feed supplementation, it appeared that the greatest profit, Rs. 514.00 was achieved from the group C i.e. the animals in the tree fodder supplemented group. The cost of the other feed costs, housing and labour have been made to zero assuming that these are available with a farmer (Table 5).

When the cost of tree fodder and the crop-residues were halved assuming that 50% of them are available to a household for feeding to their animals, the benefit was found to be negative for all treatments. The loss was calculated to be 4117, 3875, 3251, 5128 and 6778 for the Red, Yellow, Green, Blue and White groups of animals respectively.

As the animals were bought through a chain of 2 to 3 contractors, the real purchase price should have been different. To confirm this it was understood from a few of the suppliers that the real price was approximately Rs1000 to 1200 less than the price offered by ARSP. Therefore, if we consider the real purchase price then the Red, Yellow and the Green groups will be in profit whereas the Blue and White group will still be in loss.

Table 5: Economic value of feed supplementation and use of fasciolicide

Value	Cost /kg	Animal Groups				
		Red	Yellow	Green	Blue	White
Carcass wt.	56	210	2282	2919	3750	2684
Guts	40	430	454	485	566	482
Liver	56	92	94	118	141	110
Head	150	150	150	150	150	150
Skin	150	150	150	150	150	150
Carcass value		292	3130	3822	4757	3575
Supplements						
Tree fodder	0.25	0	0	68	0	0
Urea molasses block	12	0	0	0	0	3348
Concentrate feed	12	0	0	0	2880	0
Triclabendazole	0.5	80	40	40	40	40
Total supplement costs		80	40	108	2920	3388
Other feeds						
Tree fodder	0	0	0	0	0	0
Green forages	0	0	0	0	0	0
Rice straw	0	0	0	0	0	0
Maize stover	0	0	0	0	0	0
Maize sheath	0	0	0	0	0	0
Total other feed costs		0	0	0	0	0
Others						
Housing	0	0	0	0	0	0
Labour cost	0	0	0	0	0	0
Purchase price of	3200	320	3200	3200	3200	3200
NET Profit		-	-110	514	-1363	-3013

DISCUSSION

Effect of treatments on live weight gains

As expected, the animals supplied with concentrate diets (Blue group) and the UMB (White group) gained more or less similar weights ($p > 0.05$). Interestingly, the Green group of animals fed with tree fodder also attained statistically similar ($p > 0.05$) weight gains to the White group. This has clearly indicated that the tree fodder supplied only at 3% live wt (fresh wt basis) could supply as much of nutrients as UMB could supply. This has clearly shown that the biological requirements of the nutrients by animals are related to the protein types rather than the other nutrients only. The tree fodder considered as the potential nutrient suppliers for ruminants particularly during the dry season in the hills of Nepal, are rich in protein content as well as anti-nutrients such as tannin (Subba, 1999). The supplementary tree fodder that was fed to the animals was composed largely of the *Ficus spp* trees supplying more than 12% of Crude protein. The protein fractionates available in these species are both the rumen soluble protein and the tannin bound protein. The bound protein could be freed in the lower gut for complete availability to the host ruminants at tissue level. However, the positive role of the phenolic compounds and their association with the improvement in the livestock performances has not yet been fully understood.

There was no effect of the treatment on the weight gains in the animals of the Red group although they were treated against liver flukes. It appears therefore that the animals in the Red and Yellow groups did not receive sufficient amount of nutrients from the supplied basal diets for growth as compared to the other 3 groups of animals. Both the groups of animals were loosing their weights until 21 WPI and regained weights from 21WPI onwards. The negative weight gains between 8 and 17 weeks post infection could be associated with the poor dry matter intake of the supplied feeds by the animals. The animals received rice straw in the form of basal diet until 18 WPI; the top portion of the rice straw was fed until 12 WPI and the bottom portion until 18 WPI. The poor performance could also be related to the animal housing which had been severely effected by the heavy and persistent rainfall of the monsoon. As a result the animals were partially limited to the access of fresh fodder as basal diet and the rice straw has low voluntary feed intake with poor digestible crude protein and dry matter digestibility as a result of the contents of lignin and biogenic silica. On the other hand, apart from the basal diets, the other three groups of animals received additional nutrients through the supplementary feed i.e. tree fodder, Concentrate feed and UMB. It can therefore be argued that the low body weight gains in the Yellow and Red groups of animals was related to the inadequacy in the dietary supply of nutrients. To support this argument, however, there is a need to experiment on the nitrogen balance of these diets.

While comparing the body condition score among the groups, the feed supplemented groups scored higher than either the Yellow (control) or Red (anthelmintic) groups. It is anticipated that the Green, Blue and White groups of animals might have compensated through supplementary feeds for protein losses as a result of fasciolosis. Whilst, the Red or the Yellow groups of animals might have lacked the nutrients particularly nitrogen to counter balance protein losses, hence the poor body conditions in the Yellow or Red groups as compared to the other groups of animals.

The study has shown that the local practice of supply of feed is not enough to improve immunity and compensate protein losses as a result of fasciola infection. Therefore, additional supply of nutrients particularly nitrogen is required to optimise the productivity of animals infected with liver flukes. The animals whether requires rumen degradable nitrogen supply or duodenum available protein supply is an area worth investigating. As the tree fodder (Green group) (which contains both rumen degradable and rumen by pass protein) and the UMB (White group) (contains rumen degradable protein only), the performances of the animals of both the groups are similar. It appears therefore that if animals were supplied with more tree leaves (i.e. more than 3% live wt.), the performances of the animals could have been further improved.

Fasciola infection and post-mortem examination

The recovery of the flukes was ranged from a minimum of 4% (in the animal no 3 of the White group) to a maximum of 45% (in the animal no 2 of the Blue group). Although the recovery of flukes in buffaloes in another experiment by Mahato (1993) was more or less similar, the low recovery of the flukes in this experiment could be because of either poor viability or the poor infectivity of the metacercariae. Due to some reasons, the metacercariae were stored for a quite longer period before being used to infect the animals. The viability of the metacercariae might have been lost during storage as a result of lack of dissolved oxygen. The other reasons involved could be the nutrition and management practices of the host animals. At this range of the fluke burdens, the animals did not show any signs of fasciolosis. The clinical signs of fasciolosis could be evident at fluke burdens in excess of 144 (Mahato, 1993). However, one of the other 3 animals of the Yellow group that died during the experiment had carried a total of 421 flukes and had shown prominent features of fasciolosis e.g. depraved appetite, bottle neck etc. The other 2 animals from the Yellow and 1 from the Red group which carried less than 32 flukes, did not show any clinical signs of fasciolosis. The death of these animals could have been due to the association of the infection of flukes and the reduced feed intake as a result of weakness through an outbreak of severe dermatitis. One animal each of the Red and the Yellow group, which also suffered from dermatitis, were recovered after treatment with Ivermectin. This study has also shown that anthelmintic drenching to the animals is effective, however, the treatment is not sensible at lower fluke loads. In other words, the anthelmintics become meaningful only when treated to the animals loaded with heavier flukes that have profound effect on the productivity.

Dressing out percentage

The dressing out percentage was highest in the Blue group followed by the Green group (Table 2) as compared to the other treatment groups. It is interesting to note that the mean dressing out percentage was insignificant between Red, Yellow or White groups of animals. As the measurement of body wt alone could underestimate the extent of production losses in ruminants (Mahato, 1993), the measurement of dressing out percentage or carcass yield becomes a necessary step to evaluate the efficiency of feed supplementation. In comparison to the 72% weight attained by Blue groups, the weight lost by the Red, Yellow, Green and White groups was 61%, 56%, 39% and 38% respectively (Table 1). The rationale behind these heavy losses in the Red group of animals is unclear. As earlier mentioned, the only reason of reduced productivity could be attributed to the poor quality of the basal diet. However, further study should be made to confirm and understand the consequences.

Economic analysis

As the anthelmintic drugs or the UMB or the Concentrate feeds did not justify the cost (Table 3), the alternative methods of managing the disease to employ will be the use of tree fodder as every house hold maintains tree fodder sufficient for their animals at least for the dry winter season.

Although, the Blue group of animals performed better than either the Green or White groups of animals, promotion of the Concentrate or UMB feeding is not cost effective. Considering the cost involved and the accessibility of the Concentrate or UMB, the tree fodder could be genuine supplementary feed resource for nutrients for ruminants particularly the buffaloes. Along with the feeding of tree leaves, prevention of animals grazing fasciola infected forages will further lower the incidence rate of fasciolosis thereby increasing the productivity of the animals.

CONCLUSIONS

The results showed that the supplementation of concentrate feed daily at the rate of 1% per kg body weight is the best among other treatments in terms of the production yield i.e. live weight gain and carcass weight. However, considering the cost effectiveness and technology adoption risks, feeding of tree leaves at 3% live weight would be most appropriate for consideration. The efficiency of feed conversion can further be improved, if the animals are prevented from eating fasciola infected forages.

Future areas of research

It has been understood that the use of tree fodder as a supplement is an effective approach to minimise production losses in livestock caused by fasciolosis. The positive response could be associated with Tannin or the compensation of protein of the trees to the losses due to fasciola infection. It is necessary to study on the use of tannin rich tree fodder and examine their fasciola inactivating properties. Also, screening of local herbal materials recognised by local farmers having molluscicidal properties need to be fully investigated to effectively use to control this important disease.

The study has also shown that the quality of the local feed supply was not enough to a level sufficient to the production of an animal. Nutrients balance trials of the local feeds would therefore be worthwhile to confirm this argument.

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A FINANCIAL ASSESSMENT OF STRATEGIES TO MANAGE FASCIOLOSIS IN GOATS IN EASTERN NEPAL

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INTRODUCTION

The purpose of this study was to construct simple financial models using data available from the experiment investigating locally derived feed management techniques compared to drug treatment in *Fasciola gigantica* infected goats (see paper by Dr B Pakhrin). The economic value of different management techniques in the control of fasciolosis was examined. The economics of dietary supplements were compared with the economics of drug control to help identify the most cost-effective techniques to manage fasciolosis in goats in Eastern Nepal. The models can be used as an aid to decision making in determining cost-effective and appropriate control measures for fasciolosis.

METHODS

The information collected from the previously described, goat experiment on intake of supplements, and the comparative effects of the nutritional treatments and drug treatment, on live weight gain, were used along with current information (1998) on supplement, product and meat prices to construct simple financial models. The following figures were used in the financial analyses. The cost of the drug used in the analysis was 32.5 NRs per 900 mg tablet of triclabendazole. A dose of triclabendazole of 1.2 mg/kg was used to drug treat the goats when they weighed approximately 22 kg. Tree fodder was costed at 5 NRs /kg fresh weight. Each goat in the fodder-supplemented group was estimated to have consumed a total 95 kg of tree fodder as supplement during the period of study. Concentrate was priced at 11.3 NRs / kg with goats in the concentrate treatment group having consumed a total of 41 kg during the study. Consumption of urea molasses block by each goat was estimated at 29 kg and a blocks were costed at 13 NRs/kg. Performance and intake data was taken from the five goats in each group, which at examination *post-mortem* had been shown to have a positive fluke count.

ASSUMPTIONS

In creating the spreadsheet models certain assumptions were made:

No cost was included for routine husbandry or the basal diet. Also no account was taken of the cost of additional drugs, vaccinations, cost of buildings or infrastructure. The reasons for this were that such values were considered to be constant or similar for each group and so would make little overall difference when comparisons of profitability were made. Furthermore, for most subsistence farmers the majority of these inputs will not carry any significant monetary cost.

RESULTS

Spreadsheet 1:

This spreadsheet represents the scenario when the actual costs of the drugs and food supplements used during the course of the experiment are used in the financial model. From this spreadsheet it can be seen that the greatest profit, 387 NRs, occurred in the group treated with triclabendazole at 20 weeks post infection. The second most profitable management method was feeding supplementary concentrates with a net profit of 334 NRs. Following this the most profitable form of management was the control group where the goats received no supplement or fasciolocide. The use of the urea molasses block was barely profitable at all and the tree fodder group actually made a loss.

Spreadsheet 1: Incorporating the Actual Cost of Supplements and Fasciolocide Used in Goat Experiment

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,20**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.9
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.8
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.5
Killing out percentage	61.10	62.80	64.30	62.80	61.3
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.2
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,58**
Supplement cost (NRs/kg)	0	0	5	11.3	13
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**479**	**466**	**380**
Fasciolocide cost (NRs/mg)	0.40	0.40	0.40	0.40	0.40
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x. cost (NRs)	**0**	**107.52**	**0**	**0**	**0**
Net profit (NRs)	**285**	**387**	**-62**	**334**	**7**

Spreadsheet 2

In this model the cost of tree fodder has been reduced to zero. This assumes that most farmers are able to collect their own tree fodder without charge from communal or private sources. When the cost of the tree fodder is reduced to zero then the tree fodder supplement, becomes the most profitable group (416 NRs), followed by the drug treated group (387 NRs), then the concentrate group (334 NRs). This suggests that tree fodder can be an extremely effective form of supplement in fasciolosis control if it can be provided at very low cost and no labour charges are incurred in collection.

Spreadsheet 2: The Cost of the Tree Fodder Supplement is Reduced to Zero While all Other Supplement Costs Remain Unchanged

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,20**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.9
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.8
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.5
Killing out percentage	61.10	62.80	64.30	62.80	61.3
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.2
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,58**
Supplement cost (NRs/kg)	0	0	0	11.3	13
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**0**	**466**	**380**
Fasciolocide cost (NRs/mg)	0.40	0.40	0.40	0.40	0.40
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x. cost (NRs)	**0**	**107.52**	**0**	**0**	**0**
Net profit (NRs)	**285**	**387**	**416**	**334**	**7**

Spreadsheet 3

Here the price of the fasciolocide has been increased by 100%, from 0.4 NRs/mg to 0.8 NRs/mg. In this situation there is no financial benefit in treating with fasciolocide because the additional liveweight gain achieved is outweighed by the cost of the drug. The net profit from the control group, 285 NRs, is approximately the same as that from the triclabendazole treated group, 280 NRs. Thus the use of triclabendazole is only of economic advantage when its cost is not too high, in this situation less than 0.8 NRs/mg.

Spreadsheet 3: The Cost of the Fasciolocide is Doubled While all Other Costs Remain Unchanged from the Actual Goat Experiment

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.90
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.86
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.57
Killing out percentage	61.10	62.80	64.30	62.80	61.30
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.22
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,587**
Supplement cost (NRs/kg)	0	0	5	11.3	13
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**479**	**466**	**380**
Fasciolocide cost (NRs/mg)	0.80	0.80	0.80	0.80	0.80
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x. cost (NRs)	**0**	**215.04**	**0**	**0**	**0**
Net profit (NRs)	**285**	**280**	**-62**	**334**	**7**

Spreadsheet 4

In this spreadsheet the cost of the concentrate has been halved. This assumes that the farmer is able to provide a comparable concentrate diet of his own making at a reduced cost. Since the majority of farmers feed their own selection of concentrates this is a reasonable assumption. If this is the case the financial gain from such a system is good. The profit from the concentrate fed group, becomes 565 NRs, almost 50 percent greater than the profit from the drug treated group, 387 NRs, where the goats are treated with fasciolocide. This serves to emphasise the importance of feeding supplementary concentrates when they are available as low cost 'by products.'

Spreadsheet 5

Here the price of the fasciolocide has been reduced by 50 percent from 0.4 NRs/mg to 0.2 NRs/mg. This might occur if the government were willing to subsidise the cost of the fasciolocide. This occurred in Thailand as part of a strategic liver fluke control programme (Srihakam and Pholpark, 1989). In view of the severity of the problem of fasciolosis in Nepal it is possible that the funding for such a programme might be made available.

If the price of fasciolocide is reduced in this way then the profitability of treating for liver fluke greatly increases. The profit from the drug treated group then becomes 441 NRs per goat, much higher than that of the concentrate supplemented group, where the net profit is 334 NRs per goat. Many farmers fail to treat their goats for fasciolosis because they doubt the economic benefit. If such a scheme could be implemented then farmers would be more likely to treat their goats and thus reap the economic benefit of doing so.

Spreadsheet 4: The Cost of the Concentrate Supplement is Halved While all Other Costs Remain Unchanged from the Actual Goat Experiment

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.90
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.86
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.57
Killing out percentage	61.10	62.80	64.30	62.80	61.30
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.22
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,587**
Supplement cost (NRs/kg)	0	0	5	5.7	13
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**479**	**235**	**380**
Fasciolocide cost (NRs/mg)	0.40	0.40	0.40	0.40	0.40
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x cost (NRs)	**0**	**107.52**	**0**	**0**	**0**
Net profit (NRs)	**285**	**387**	**-62**	**565**	**7**

Spreadsheet 5:The Cost of the Faciolocide is Halved While all Other Costs Remain Unchanged from the Actual Goat Experiment

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.90
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.86
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.57
Killing out percentage	61.10	62.80	64.30	62.80	61.30
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.22
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,587**
Supplement cost (NRs/kg)	0	0	5	11.3	13
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**479**	**466**	**380**
Fasciolocide cost (NRs/mg)	0.20	0.20	0.20	0.20	0.20
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x cost (NRs)	**0**	**53.76**	**0**	**0**	**0**
Net profit (NRs)	**285**	**441**	**-62**	**334**	**7**

Spreadsheet 6

If it were possible to distribute urea molasses blocks free of charge to farmers then the benefits of this would be approximately equal to those treating with fasciolocide. The net profit from both groups under these circumstances would be 387 NRs. Such a scheme could again be made possible through foreign aid perhaps administered through government projects in certain poorer. However in view of the poor performance of the urea molasses block in comparison to concentrate feeding or the use of fasciolocides it may be that this is not the best method of nutritional management of fasciolosis.

Spreadsheet 6: The Cost of the Urea Molasses Block is Reduced to Zero While all Other Costs Remain Unchanged from the Actual Goat Experiment

	Basal	+	+	+	+
Purchase price (NRs)	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
Mean initial weight (kg)	11.48	11.82	11.64	11.94	11.90
Mean live weight gain (g/d)	37.96	46.18	40.30	63.20	41.86
Total weight gain (kg)	8.77	10.67	9.31	14.60	9.67
Body weight at 33wks	20.25	22.49	20.95	26.54	21.57
Killing out percentage	61.10	62.80	64.30	62.80	61.30
Carcass weight (kg)	12.37	14.12	13.47	16.67	13.22
Meat value (NRs/kg)	120	120	120	120	120
Carcass value (NRs)	**1,485**	**1,695**	**1,616**	**2,000**	**1,587**
Supplement cost (NRs/kg)	0	0	5	11.3	0
Total supplement intake	0	0	95.7	41.2	29.2
Total supplement cost	**0**	**0**	**479**	**466**	**0**
Fasciolocide cost (NRs/mg)	0.40	0.40	0.40	0.40	0.40
Fasciolocide dose (mg)	0	268.8	0	0	0
Fasciolocide x cost (NRs)	**0**	**107.52**	**0**	**0**	**0**
Net profit (NRs)	**285**	**387**	**-62**	**334**	**387**

CONCLUSIONS

These spreadsheets are examples of the simple financial models, which can be produced to help identify the most cost-effective way of controlling fasciolosis within a location or on a farm. Issues such as availability and efficacy of the drugs for treatment and the range and availability of feed supplements that the farmers have access to also enter into the scenario. The choice of drug made by a farmer will usually have more to do with availability and cost than efficacy. Feeds available as supplements will also change during the season. Few farmers may purchase commercial concentrates for goats, but may buy some by-product concentrates such as brewers residue and mustard seed cake (Gatenby *et al.,* 1990). The majority of concentrates fed, such as maize flour, rice bran and vegetable waste are likely to come from farmers' own. Likewise farmers are more likely to collect their own fodder rather than purchase it at present, although shortages of tree fodder in some areas may mean that this becomes a tradable commodity in the future.

Because prices do not remain stable, and resources vary, so options change for farmers . Hence it is important in decision making to make use of financial models when planning and determining which strategies are currently economically attractive to farmers. The above simple models illustrate what can be done.

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REPORTS ON THE AFTERNOON DISCUSSION SESSIONS

Chaired by

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Delegates split into three discussion groups to consider

- Messages for immediate dissemination to Nepalese Farmers and dissemination pathways
- Further extension and development of findings
- Priorities for further research (adaptive and / or strategic)

Following detailed discussion, the rappoteurs prepared summaries of the group conclusions and recommendations, which are presented below.

DISCUSSION GROUP NO. 1

Topics for discussion: Messages for immediate dissemination to Nepalese Farmers and dissemination pathways

Co-ordinator: Mr. Shyam Paudel

Group members: Mr. A.S. Ranjit, Dr. B. Parajuli, Dr. P.S. Kushwaha, Dr. R.M. Shrestha, Dr. N.P. Ghimire, Dr. N.B. Rajwar and others

Recommendations:

1. Drug treatment messages

- Strategic drug treatment for fasciolosis (usually February and August) - listen to announcements on radio, TV, news papers or messages from extension workers for the time to treat animals
- Treat clinical cases of fasciolosis as and when they arise
- Do NOT use Triclabenzadole (Fasinex) for the treatment of buffalo fasciolosis use Oxyclosanide, Rafoxanide or Albendazole. Use Triclabendazole (Fasinex) for the treatment of cattle, sheep and goat fasciolosis.
- Do NOT use carbontetrachloride for the treatment of fasciolosis as it is toxic

2. Feed management messages

- The bottom parts of rice straw are a potential source of fluke infection especially just after harvest. To reduce the risk feed only the top half of the rice straw. Either send the bottom halves of the rice straw to the paper mill or store it and use as feed from the 1st of April onwards.

- Aim to feed a diet which contains up to 14% protein. To help achieve this level of protein feed supplement the basic diet with either tree fodders or feed concentrate or urea/molasses blocks as available.
- Tree fodder has added advantages as a supplement: it is nutritious, can be grown and harvested on farm and it reduces the severity of fasciolosis.
-

3. Make use of the available sources of information

- Radio, television, newspapers
- Information literature video and audio tape, posters, pamphlets, booklets and brochures.
- Listen to extension workers messages and information given at farmers group meetings

4. Adoption and uptake of ideas

- It is important for extension workers to hear farmers responses to suggested control measures, whether the measures are practical, whether the farmers carry out the suggested control measures and if not why they don't.
- Such information can be relayed to decision-makers to help them develop the best and most appropriate control plans.

DISCUSSION GROUP NO. 2

Topics for discussion: Further extension and development of findings

Co-ordinator: Dr. D.R. Ratala

Group members: Dr. L. Sherchand, Dr. B.K.P. Shah, Mr. S.K. Shrestha, Mr. J. Bajracharya Dr. S.C. Ghimire, Dr. K. Bhattarai, Dr. K. Chand Thakuri, Dr. S.M. Amatya, Dr. R.P. Ghimire and others

Recommendations:

1. Drug Treatment

- The value of strategic drug treatment for fasciolosis has been verified in a series of farmers field trials/demonstration projects conducted in the Eastern and Western Regions of Nepal. This needs to be extended to the Far West, Mid West and Central Regions. Apart from an east to west variation in the duration of the Monsoon (which is known from meteorological data) the epidemiology of fasciolosis is similar between regions. However, because of the differences in the Monsoon, there may be slight differences in the optimum dates for strategic drug treatment for fasciolosis. This should be investigated.
- Routine evaluation of efficacy of locally available anthelmintics against fasciolosis. This work will be co-ordinated by the central / regional laboratories but carried out on selected farms in collaboration with the farmers and district staff.
- Financial evaluation of the all strategic control programme based on opportunity cost of the inputs and outputs

2. Feed Management

Rice Straw

- Verify optimal storage times for the bottom parts of the rice straw under different climatic conditions in order to ensure that the metacercariae are dead before the rice straw is used as feed.
- In some areas there is a shortage of rice straw fodder to feed animals. An investigation should be conducted to determine whether, instead of cutting the rice straw in half, if it can be cut further down the stalk. This would ensure that there was enough rice straw to feed the animals until it was safe to feed the stored bottom parts of the straw.
- Studies should be conducted to obtain feed-back on rice straw use and the acceptability of handling and storing the straw in the suggested manner.

Diet

- Studies should be carried out to determine the protein content of the diets fed to ruminants in the various area of Nepal to determine if the diets vary from the generally recommended level of c14% crude protein.
- The reasons for the non-uptake of the urea treatment of rice straw should be examined
- An investigation should be conducted to determine whether ensiling rice straw (with of without urea) kills metacercariae.
- On-farm trials should be conducted on the practicality of feeding tree fodder in the country as a whole.
- Economic verification should be conducted on different feeding regimes, e.g. fodder, rice straw, concentrate etc. in relation to fasciolosis control
- Financial evaluation of feed management based on cost of the inputs and outputs.

3. Making use of and developing messages for dissemination - Extension methods

- Develop dissemination messages to increase awareness regarding the control of fasciolosis, incorporating feed management techniques.
- Develop audio-visual, poster, pamphlets, booklets, agricultural diaries etc. media for the use of extension workers.
- Conduct mass awareness campaigns through organised extension outlets, farmers groups, institutions and other agents.

4. Other suggestions:

- Research is required on the treatment of rice straw with chemicals and herbs to reduce the viability or kill metacercariae and thus reduce the infectivity of the bottom parts of rice straw.
- Due to the method of spring-fed irrigation, some fields remain water logged after harvest. These fields are a better habitat for the intermediate snail hosts of *Fasciola gigantica* and represent a greater risk than fields that are dry after harvest. The management of rice straw from the water-logged fields should be investigated as should methods to avoid water logging.
- Food laws prohibit use of urea in concentrates, but not in medicine or for treatment of roughages. If the research results support the conclusion that urea treatment is effective, the act should be amended appropriately.

GROUP NO. 3

Topics for discussion: Priorities for further research (adaptive and / or strategic)

Co-ordinator: Dr. A. Pradhan

Group members: Dr. S.K. Singh, Dr. P. Pathak, Dr. K.R. Regmi, Dr. B.R. Thapa, Mr. S.B. Panday, Dr. J.N. Rai, Dr. Ranjana Gupta, Mr. J.P. Thikey, Dr. B.R. Joshi, Mr. Raju Chhetri, Dr. Banshi Sharma, Mr. Kishor Panday and others

1. General comments and suggestions

- Institutional strengthening is required to improve the research capabilities of animal health research stations / institutions in Nepal
- A regulatory veterinary authority is required in order to conduct quality control and efficacy trials on anthelmintics supplied within the country. This would be organised centrally but the testing would be conducted on selected farms.
- Available data on tree fodders their tannin content, nutritional value and toxicity levels, at various times of year, should be collated and presented in an easily available form. This data can then be updated on a regular basis.
- Research proposals have to be prioritised in order of importance. While assessment of field problems, economic analysis of the disease etc. are important aspects of research, it is a proven fact that fasciolosis is widely prevalent in Nepal. Almost 60% of veterinary drugs sold in Nepal are used to control this disease. Farmers realise its importance. Efforts should not therefore be wasted just to "reinvent the wheel". Instead available resources should be directed to adaptive research such as verifying and promoting promising control strategies.

2. Drugs

- Screening of local herbs having flukicidal / molluscicidal properties should continue. However, such work may be considered of low priority since its was noted that a large proportion of local herbs in the Eastern hills were screened for their flukicidal / molluscicidal properties, but none were found effective.

3. Feed Management techniques

- Complete database on various aspects of fodder trees in relation to nutrient content, such as performance, anthelmintic properties, nutrient and balance trials of local tree fodders
- The role of tannins as flukicide should be investigated, especially since as pointed out elsewhere a balance will have to be struck between the beneficial effects of tannins in killing flukes and the negative effects tannins have as nutrient inhibitors.
- Studies have concentrated on protein balance in the diet but the interaction between fasciolosis and energy metabolism also required investigation.

4. Integrated Approaches

- Integrated approach on fluke control using anthelmintic, biological methods and feeding management
- Effect of fasciolosis in ruminants under different feeding regime and field management
- Effect of interaction of fasciolosis and nutrition on draught power of animals