Biotope conservation with ruminants in Germany: the example of goats on shrub-infested slopes

Pera Haumann

Department of International Animal Husbandry, University of Kassel, Germany

Introduction

In Germany, goats have always been housed and kept in small herds of one to five animals, mostly by crofters or workers but not by full-time farmers. The more recent requirement to cultivate cultural landscapes, makes it necessary to develop a new management and grazing system for goats in Germany. All existing German breeds have adapted to housed conditions. Only two native dairy breeds, the *Weisse* and the *Bunte Deutsche Edelziege*, and, to a smaller extent, for a few years, the South African Boer Goat for meat production, are of any importance. None of the three named breeds is suitable for our aim of extensive grazing on marginal land. In order to develop a hardy alternative breed which can cope with extensive conditions, the breeding programmme for the *Witzenhäuser Landschaftspflegeziege* was set up (Tawfik & Rahmann, 1995).

If the agricultural use of land in less favoured areas is abandoned, biotopes created by grazing animals are endangered. This paper deals with shrub control on infertile grassland biotope sites (*Nardion, Gentiano-Koelerietum*). The main aspect was if, and in what way, secondary succession on abandoned farmland can be reduced by browsing goats. So far in Germany there has been considerable research done on cattle and sheep in biotope conservation. It has always been pointed out that their browsing ability is low. Goats are known for their high percentage of browsing but due to the small-sized and widespread flocks there has never been a significant initiative to undertake research on goats. The present research aims to develop a grazing system based on using goats in individual or mixed herds, and focuses on grazing behaviour and impact on the grazed areas.

Up to 50 per cent of a goat's intake can originate from feeding on shrubs. At pasture, goats have advantages over cattle or sheep. With their low body weight they cause no ground damage. On slopes, goats do not create terraces. Also, sloping pastures fulfill their natural need for climbing.

In Summer 1996, a comparison of different animal groups grazing infertile grassland was carried out. In the chosen experimental site fifteen per cent of the plots was covered with shrubs. In addition to *Juniperus* spp., mainly *Rosa* spp., *Cornus sanguinea* and *Crataegus* spp. were found. At the beginning of the trial their height was between 50 to 100 cm, shrubs over 200 cm rarely existed. It was decided to graze this area during the following years more intensively to stop secondary succession. The aim of the project was to record and compare the different grazing behaviour of goats as a single species and in mixed herds[1]. In addition to the behaviour of the animals, the impact of grazing on the vegetation was analysed.

Another experimental site was located on a shrub-infested infertile grassland slope with a shrub coverage of 50 per cent. The area had been abandoned for many years and was invaded by *Rosa* spp., *Cornus sanguinea, Prunus spinosa* and *Crataegus* spp.. For a three-year trial four plots with different conservation strategies were established and evaluated for ecological and plant sociological changes.

Animals, material and methods

Behaviour of goats during single species and mixed grazing

During one trial at the experimental site, "Keßstieg" in 1996, all goats originated from the breeding programme of the *Witzenhäuser Landschaftspflegeziege* while the sheep used for the mixed herd belonged to the endangered local breed *Coburger Fuchsschaf*. The stocking rate was 100 goats and 80 sheep per hectare during one week of grazing. As both herds/flocks had a total liveweight of 600 kg, the liveweight per hectare amounted to 3,000 kg on all plots. Such a high stocking rate for a short period of time simulates transhumance conditions. For landscape protection reasons it was prohibited to build a shelter for the animals. Water was provided in troughs with daily refill. Minerals and salt were offered as licks.

The experiment was carried out with goats, sheep and goats and sheep in a mixed herd. For this article it is only of interest how the goats behaved in a single species herd compared to a mixed herd. During the experiment the animals were observed for three days each at single species (G) and at mixed (G+S) grazing (Figure 1). For every day, all behaviour was recorded. The observation started at 6.30 a.m. and finished at 9 p.m.

The time-part-method, according to Fassnacht (1979), was used to quantify the behaviour. Records were made of feed intake from herb layer, browsing shrubs and trees, lying, resting, dozing - often combined with ruminating, standing without feeding, looking around - often caused by noises outside the enclosure, walking/running without the intention of feeding farther than three steps, often flight caused by unknown influences from outside the enclosure, drinking, social contacts, suckling lambs, fighting, urinating; defaecating, body care and comfort behaviour.

Goats in single species and mixed herds grazing shrub infested infertile grassland

For the same trial period, in every enclosure (G, G+S)

[1] Mixed herds: goats with sheep.

fourteen shrubs of the leading species (*Juniperus communis*, *Prunus spinosa*, *Crataegus* spp., *Rosa* spp.) were selected. Before and after grazing they were measured to estimate the degree of usage according to the method of Riehl (1992). The degree of usage gives the reduction of shrubs through browsing (in per cent). In addition, the proportion of shrub-browsing (in per cent) was estimated (0 per cent = no browsing of leaves, 100 per cent = full defoliation).

To estimate the animals' feed intake, the amount of biomass (in kg dry matter) was recorded before and after grazing. For this purpose four samples were taken at random in each paddock (G, G+S) before grazing started. Additionally two samples near the shrub area were taken. The samples after grazing were located adjacent to the previously taken samples. In this way, it was ensured that the same type of vegetation was sampled. In non-shaded-areas 1m^2 areas were cut, under shrubs ¼m^2. Subsequently the samples were dried at 105°C.

The vegetation of the herb layer was mapped. Two areas in each paddock were used for mapping. One was located in a shaded spot (20 m^2) and the other were placed in an area without shrubs (2 m^2). Six paddocks were mapped before and after grazing respectively with the same amount of plots in shaded and in sunny areas. For the precise evaluation of the plant layers' feed value, two mixed samples in every paddock were taken- one of each in the shade of shrubs. These were examined for their feed value with Weender and van Soest analyses.

Shrub control with goats - a comparison

Additionally, the results of a three-year trial comparing different biotope cultivation methods are reported here. On shrub-infested infertile grassland, with a shrub coverage of 50 per cent, three different cultivation methods were compared for their ecological conservation achievements and their impact on plant sociology:

M3G: Mechanical treatment before grazing with goats during three successive periods.
3G: Grazing with goats in three successive periods.
M: Mechanical treatment before the first period.
Suc: No measure undertaken.

The mechanical treatment was done by a power scythe at the start of the trial. In autumn (November), at end of the trial, all paddocks were mechanically treated to achieve a similar level of biomass removal. The biomass cut was weighed as green matter, labour input for this was documented.

Goats from the breeding programme *Witzenhäuser Landschaftspflegeziege* were used for the three years of the grazing trial. Table 1 shows the stocking density as well as the grazing times and periods. During grazing, no supplementary feeding was given. The goats were weighed at the beginning and at the end of the grazing period. All labour and material input of every husbandry operation was documented. For tracing ecological impacts, three mapping sites of 25 m^2 each were set up. Every year before grazing started, a plant sociology maps according to Braun-Blanquet (measures degree of cover) and according to Klapp (measures the yield portion) was prepared.

Results

Behaviour of goats during single species grazing

From the first day, the goats used different areas of the paddock to perform different types of behaviour (Figure 1). This pattern was maintained for the whole week. The goats spent 38 per cent of the observation time resting. Sixty-three per cent of the time was spent on feeding. The whole herd of goats coordinated its movements during feeding.

Figure 2 shows that the main feeding times of the goat herd which were in the early hours of the morning and evening. Up to 78 per cent of the goats had their peak feeding periods between 7.30 a.m. and 5.20 p.m. Common resting-times during morning and afternoon feeding were marked. In the late afternoon and in the evening only a small part of the herd rested together. Three different resting times were observed: 9.30 a.m., 11.30 a.m. and 3.30 p.m. At these times most goats lay down. In the early morning and evening, the goats browsed shrubs communally. The explanation for this might be that the visiting of the shrub area had to be done with the intention of browsing and for that reason the whole herd went there together. At times of the day when only a small proportion of the herd was lying down, the others grazed in the areas close by.

Behaviour of goats and sheep during mixed grazing

Both herds divided the enclosure into different areas. The interests of each group were interacting. Figure 3 shows that the resting places of goat and sheep were located close together. Also, they were placed at the highest point of the slope. The two species never mixed but orientated their activities in relation to each other. Most of the time the sheep followed the goats. Shrubs were browsed, almost exclusively by goats, in the lower part of the enclosure.

During mixed grazing, the spectrum of feed chosen changed widely. The goats spent 61 per cent of the whole feeding time browsing and 39 per cent grazing (vs 30 per cent browsing, 70 per cent grazing in individual grazing) (Table 2). The sheep changed their behaviour in a similar way: browsing decreased from 12 to 8 per cent while the proportion of grazing rose from 88 to 98 per cent of the total feeding time.

Table 1. Grazing periods and stocking rates.

	Year 1	Year 2	Year 3
Grazing period	13 June to 26 July	14 July to 28 July	20 June to 28 June
Rate of stocking (kg LW ha^{-1})	1.736	3.008	5.006
Total stocking (kg LW ha^{-1} day^{-1})	48.608	42.112	40.048

Compiled by Rahmann (1998)

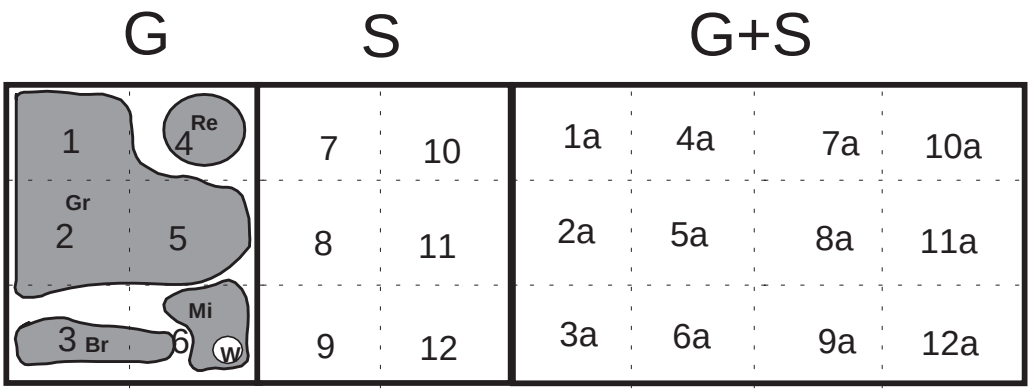

Figure 1. Areas for different behavioural pattern of the goats grazing alone on Plot G.

Br: Browsing, GrG: Grazing of goats, W: Water bowl and mineral licks.
Compiled by Rahmann and Haumann (1998) according to Krehl (1997).

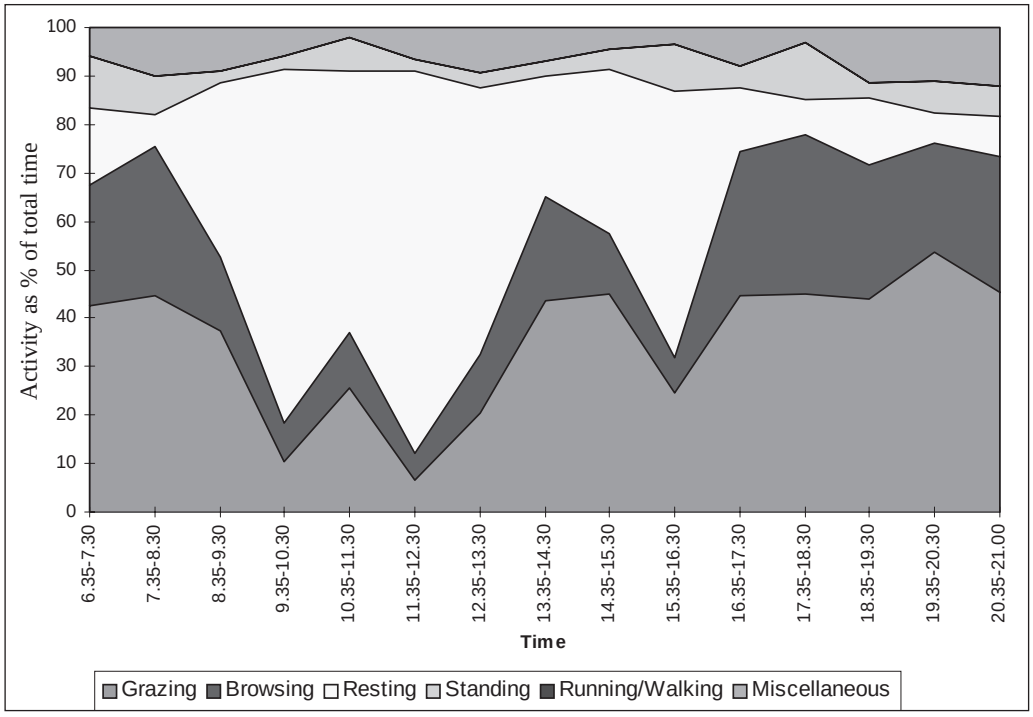

Figure 2. Daily pattern of the goats during single species grazing (average of three observations)
Source: Krehl (1997).

Goats in single species and mixed herds grazing shrub infested infertile grassland

In paddock G, all occuring shrub species were browsed. Height as well as diameter were reduced. The needles of *Juniperus communis* were browsed the least. In this case, the goats preferred peeling the bark off. The species was nearly destroyed in this paddock. The bark of other shrub species was not browsed. It was noticed that the peeling of bark was influenced principally by the thickness of branches and stems and less by shrub species. This means that small shrubs are not peeled but branches and stems thicker than 4 cm in diameter. The goats browsed the leaves of shrubs intensively. After grazing no shrub or wood species could be found whose leaves had not been browsed, altogether branches were not completely defoliated. During behaviour recording, it was also registered that the goats spent most of their time near or in the shrubs.

In paddock G+S differences in both height and diameter were noticed. During mixed grazing the extent of leaf-browsing of shrubs increased. Since sheep did not browse and goats had much higher times of browsing during mixed grazing, it is likely that the goats were responsible for this. The degree of usage in paddock G+S was higher than the one of paddock G.

During the grazing period total live weight of the sheep and of the goats increased. This proves that infertile grassland is an appropriate pasture for small ruminants. The dams of both herds lost a little live weight (-3.3 and -8.5 kg) while the kids and yearlings gained live weight (+3.5, +6.0 and +16.3 kg). The live weight loss of dams resulted from their higher energy requirements. Besides their own maintenance requirements, they had to produce milk for their kids. This additional demands could not be covered by the available feed on the pasture and for this reason live weight was reduced. As long as these liveweight losses are in a range of less than 10 per cent, they are considered acceptable. Even under housing conditions

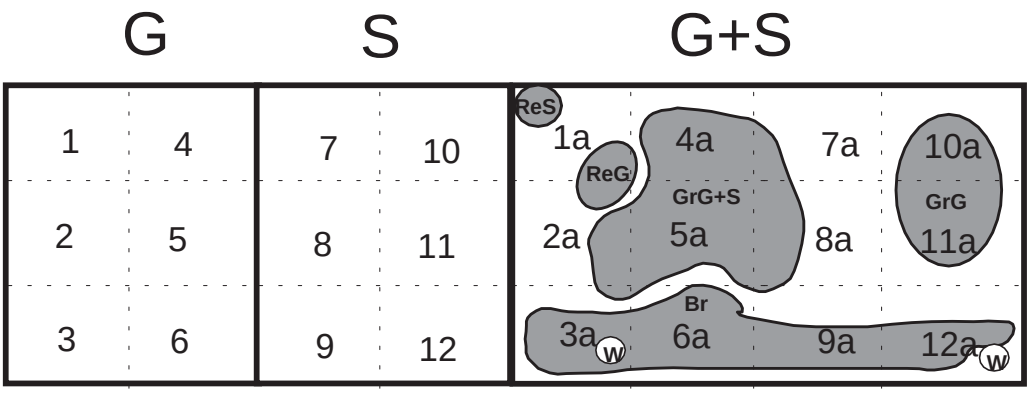

Figure 3. Areas of different behavioural patterns of the goats and sheep in Plot G & AS.
Br: Browsing, GrG: Grazing of goats, GrS: Grazing of sheep, GrG+S: Grazing of goats and sheep, W: Water bowl and mineral licks.
Compiled by Rahmann and Haumann (1998) according to Krehl (1997).

dams can lose body condition. This finding proves that grazing infertile grassland with goats without supplement feeding can meet the animals' demands.

The difference in dry matter before and after grazing results in 0.54 t/ha of intake by the sheep from the herbage layer. In a 0.2 ha sized paddock this amounts to 0.1 t of total intake. With an energy content of 600 starch equivalents/kg DM, an average 9,143 starch equivalents were eaten every day. Sheep need about 8,571 starch equivalents per day for maintenance and grazing activities. These numbers prove that the sheep covered their needs nearly exclusively from the herbage layer.

For the goat paddock the difference in dry matter was 0.38 t/ha which is equivalent to 0.08 t per 0.2 ha. According to these results 6,515 starch equivalents/day were eaten from the plant layer. The energy requirements of 11,429 starch equivalents per day (maintenance + 50 percent for grazing activities) leads to the conclusion that the goats covered more than 40 per cent of their energy requirements from browsing shrubs.

Changes in vegetation

The three years of the trial with 50 days of grazing already brought changes in vegetation (Table 4). The degree of cover of the grass/herb-layer increased, especially in paddock M3G. This is due to the smaller amount of matted grass in the grazed plots. Also the feed value of grass and herbs increased in grazed paddocks.

Achievements in shrub control

Using goats for shrub control, compared to only mechanical treatment, definitely helped to reduce shrub mass (Table 5). Also, the number of shrub species decreased in grazed paddocks. Shrub volume and average height of shrubs was less in paddock 3G than in other paddocks. Biomass growth per year was lowest in paddock 3G, followed by paddock M3G, paddock Suc. and paddock M.

Discussion

In Germany, grazing animals have always had a major influence on the development of landscapes. Grassland in less favoured areas was mostly formed by grazing sheep and cattle. Changes in agricultural structure make it impossible for small-scale farms to keep up traditional husbandry systems in these areas. Consequently landscapes are no longer being created as a free by-product, and traditional pasture land, now longer used for grazing, is endangered by proliferation of shrubs. At the same time, the desire to use historic landscapes as recreational areas is growing. Many people connect grazing animals with the idea of a specific image of landscape, and there is a growing public demand for preserving "open" landscapes.

If the agricultural use of land in less-favoured areas is abandoned, biotopes created by grazing animals are also lost. Shrub clearance has a fundamental impact on maintenance or even improvement of infertile grassland in its typical appearance. For this, it is one of the main conservation tools. The use of

Table 2. Average proportions of time spent on verifying activities, expressed as a percentage, by goats and sheep grazed as single species and in mixed grazing.

Activity	Goats, individual grazing	Goats, mixed grazing	Sheep, individual grazing	Sheep mixed grazing
Feeding	63	65	58	69
Browsing	30	61	12	2
Grazing	70	39	88	98
Resting	26	22	35	24
Standing	5	7	5	6
Walking/running	1	3	1	0
Miscellaneous (e.g. playing)	5	3	1	1

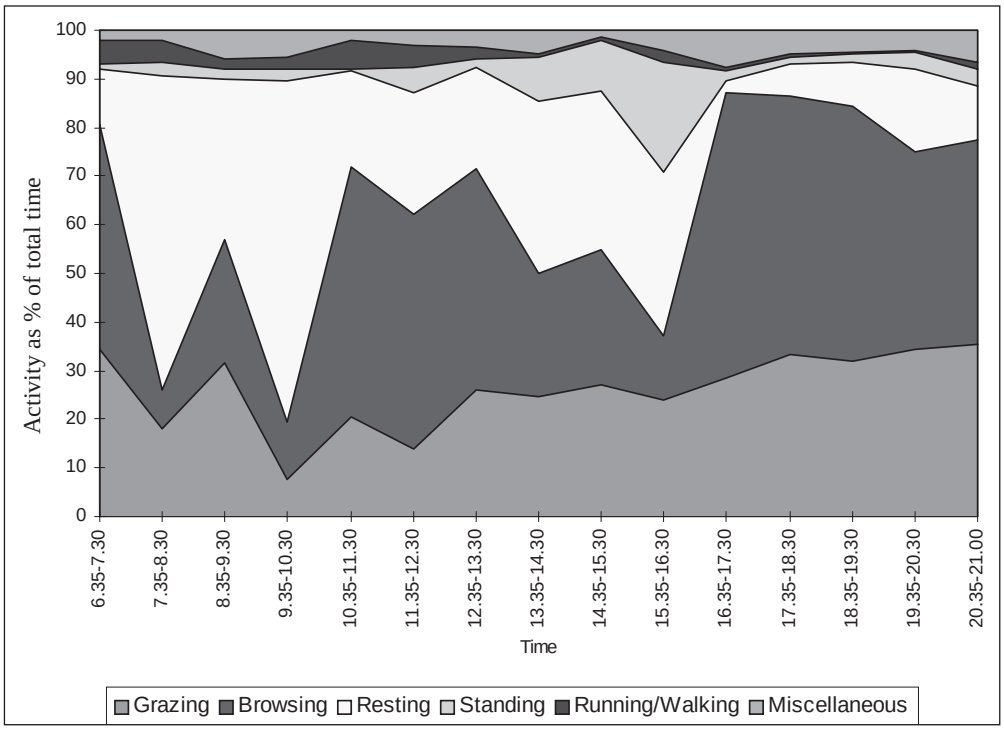

Figure 4. Daily pattern of the goats during mixed grazing (average of three observations). Source: Krehl (1997).

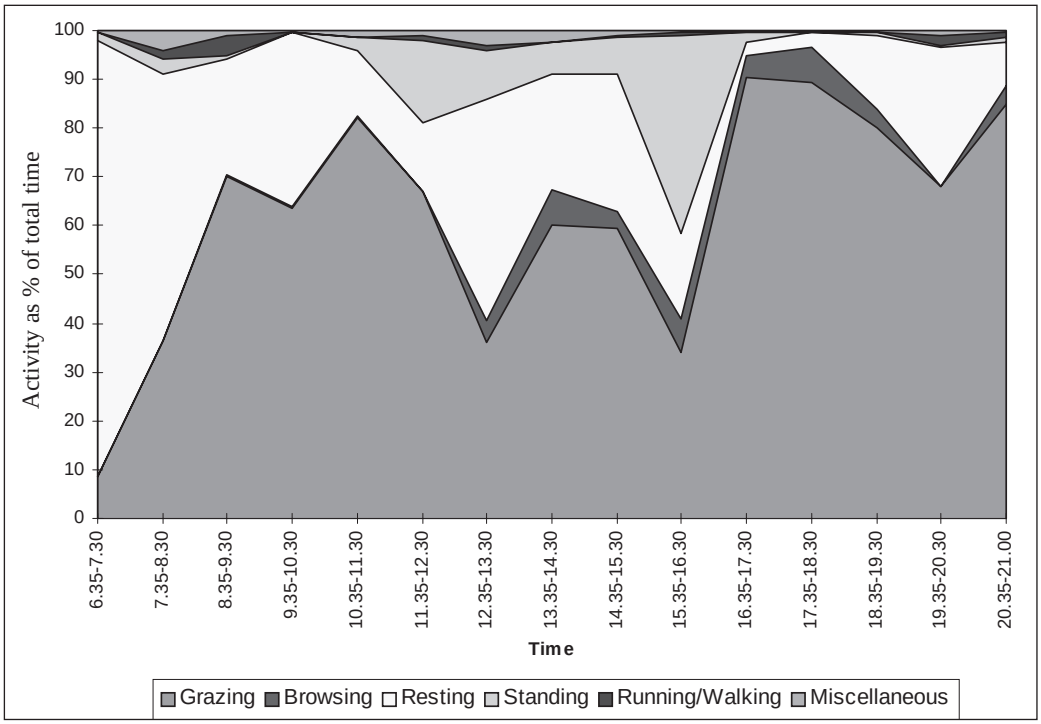

Figure 5. Daily pattern of the sheep during mixed grazing (average of three observations). Source: Krehl (1997).

goats in shrub control does not only help to reduce biomass, it also saves the costs of taking away and disposing of cut biomass. Also, the animal products, meat or milk, can be sold and provide supplementary income.

If grazing livestock are used for biotope conservation, their special behaviour has to be taken into consideration. In Germany, considerable research has been done on feeding and spatial behaviour of cattle, sheep and horses but goats have always been neglected. With the breeding programme of the *Witzenhäuser Landschaftspflegeziege* now the interest in goat behaviour is growing. Useful for introducing goats in biotope conservation was the finding of Krehl (1997) that goats adapt their feeding behaviour depending on whether they are kept in a single species or mixed herd. Goats and sheep in a mixed herd seem to adjust their feeding behaviour. While sheep are nearly exclusively grazers, goats are browsers.

Table 3. Differences in live weight before and after the grazing period. Compiled by Haumann (1998) according to Winterfield (1997).

	Nannies	Kids	Total	Ewes	Lambs	Total
Number of Animals	7	13	20	6	10	16
Live weight at start (kg)	301.0	299.5	600.5	327.5	276.5	601.0
Live weight at end (kg)	297.7	309.0	606.7	319.0	292.8	611.8
Difference in live weight (kg)	-3.3	+9.5	+6.2	-8.5	+16.3	+7.8

Other experiments on landscape management (Schömig, 1987; Kleinpeter & Kleinpeter, 1987; Riehl, 1992; Stahmann, 1994; Schröder, 1995) have shown that the exclusive use of goats is only appropriate if shrub coverage totals over 40 per cent. For this reason, it is not recommended to graze infertile grassland with only goats over several years. Also, the choice of a grazing livestock species and the decision to use a single species or mixed herd depends on the management goal for the particular type of biotope. In general, a new management system is planned which uses goats for shrub clearance for the first years after mechanical treatment. Additionally, mechanical maintenance is required to cut back problem plants. After two or three years, depending on shrub coverage, the goats should be joined by a flock of sheep. As soon as the shrubs are under control, a single-species grazing system with sheep should be established. Finally, it has to be pointed out that evaluating the abilities for shrub clearance is only one step in the development of biotope conservation strategies. Another important aim, which has to be taken into consideration too, is the economic evaluation of biotope conservation with grazing animals. Livestock grazing systems are only meaningful if they allow the farmer an appropriate living.

Table 4. Effect of different management strategies on herbage layer. Compiled by Rahmann (1998).

	M	M3G	3G	Suc
Degree of cover of grass/herb-layer[1] (%)	55	100	80	80
Height of grass/herb-layer (cm)	60	40	40	60
Feeding value of grass/herb-layer	2.08	2.43	3.17	2.42
Cover of matted grass (%)	45	0	20	60
Height of matted grass (cm)	0.15-0.20	0	0.05-0.10	0.15-0.20
Number of herb species	17	29	21	19
Proportion of herbs in biomass[2] (%)	25	50	30	20
Feeding value of herbs	1.62	1.97	2.03	1.70
Shannon-index[3] for herbs	2.74	2.24	2.64	2.79
Number of grass species	4	7	8	4
Proportion of grassess in biomass[2] (%)	75	50	70	80
Proportion of grasses as *Brachypodium pinnatum* (%)	53	5	18	65
Feeding value of grass	2.23	2.88	3.66	2.6
Shannon-index[3] for grass	0.94	1.38	1.92	0.66

[1] According to Braun-Blanquet.

[2] According to Klapp. The mapping sites @ 25m2 were located in the same altitude, approximately 2.5m from each other.

[3] The Shannon-index is the international used form of evaluating variance of species and their distribution. It is calculated with the formular $H'=-\sum p_i \ln p_i$ where p is the frequency of the species. The higher the value the more even is the spread of species of a certain amount of species. Number of species and yield portion were used for the calculations in these tables.

Table 5. Effect of different management strategies on shrub layer.
[1] In kg green biomass. Compiled by Rahmann (1998).

	M	M3G	3G	Suc
Shrub mass at beginning (1994) (kg)	5,200	5,200	5,200	5,200
Removed at beginning (kg)	5,200	5,200	0	0
Removed at end[1] (kg)	9,906	1,148	5,803	9,297
Removed at beginning and end (kg)	15,106	6,348	5,803	9,297
Biomass growth in total (kg)	9,906	1,148	603	4,097
Biomass growth per year (linear) (kg)	3,302	383	201	1,366
Number of shrub species at end ($25m^2$)	3	2	2	7
Average height of shrubs (m)	1.84	1.18	0.52	2.05
Shrub volume (m^3/ha)	10,172	2,480	4,856	8,836
Biomass per 10cm height of shrubs (kg)	0.974	0.463	1.173	1.053
Shannon-index for shrubs	0.61	0.49	0.47	1.09

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