FACTORS CONSTRAINING ANIMAL PRODUCTION IN GRAZING MANAGEMENT

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INTRODUCTION

In the first figure constraints are shown under which animal production on pasture comes about. As far as our part is concerned, we will talk about 3 major factors, namely intake, quality and antiquality components and constraints coming from the management of pastures. These factors again depend on subordinate influences, which are drawn on the figure, so to say as the frame of our paper. Of course, this consists of a few examples only and is not an over all review. Therefore we mentioned another major factor, "other constraints" which we are not talking about.

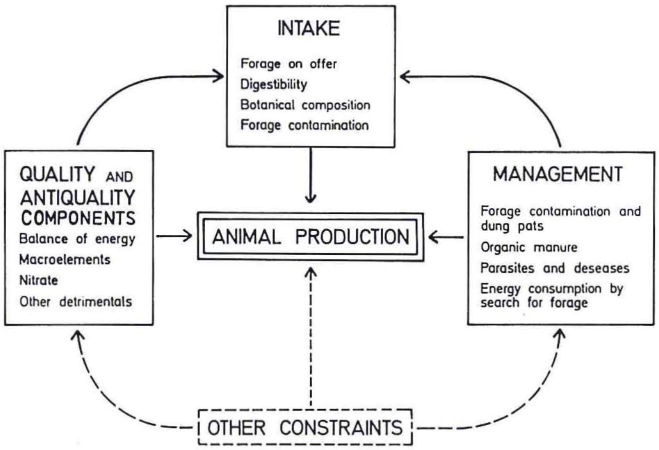


Fig. 1: Constraints on animal production from pastures

CONSTRAINING FACTORS

1. Intake

Forage on offer

There is a strict relationship between intake and forage on offer (ROTH 1971, STEHR 1974). This fact is demonstrated in Fig.2 by the parallel course of mean offer and intake as measured with cows in 2 year experiments over an 18 weeks period.

At what extent the intake was ruled by DM offer can be seen from the regression equations: $y(1972) = 1.51 + o.35\ x;\ r^2 = o.61;\ p < o.oo1$. $y(1973) = 1.82 + o.27\ x;\ r^2 = o.66;\ p < o.oo1$. That means that with a 1 kg increase in offer forage intake per animal could be enhanced by o.35 and o.27 kg DM in the 2 experiments respectively. Moreover merely by the offer of forage the variance of intake could be explained up to 66 %.

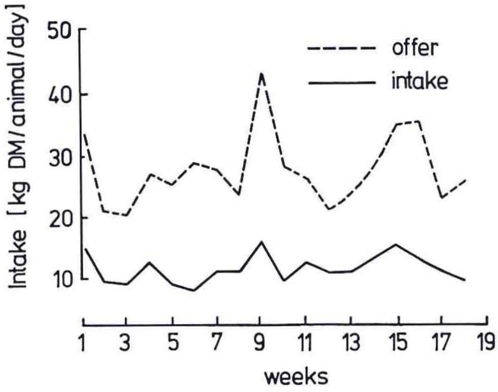
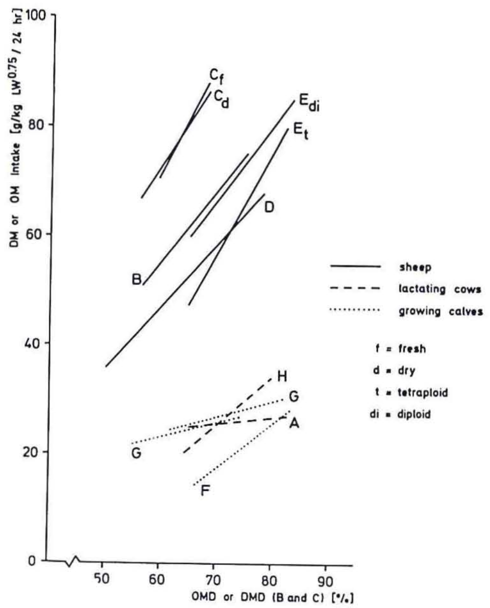


Fig. 2: Forage intake as influenced by forage on offer in a grazing system. - STEHR 1974. y(1972) = 1.51 + o.35 x; r^2 = o.61. p < o.oo1. y(1973) = 1.82 + o.27 x; r^2 = o.66; p < o.oo1.

Digestibility

Also digestibility is a limiting factor on intake by animals as well. In the last years many results have been published, including cattle and sheep, all of them demonstrating a positive relationship between intake and digestibility within limits relevant for practical feeding. In Fig.3 a few examples are given out of a voluminous literature.

Fig. 3:
Relationship between digestibility and intake with different forages in grazing and indoor trials. - CORBETT et al. 1963 (A), REID and JUNG 1965 (B), HEANEY et al. 1966 (C), WILSON and McCARRICK 1966 (D), OSBOURN et al. 1966 (E), HODGSON 1968 (F), RODRIGUEZ and HODGSON 1974 (G), STEHR and KIRCHGESSNER 1976 (H).



If we assume that nutrient intake is the product out of intake x digestibility x efficiency of utilization of digested material (RAYMOND 1969), it becomes clear that digestibility is significant in animal production in a two-fold way. (1) Only those nutrients of feed are transformed into animal output which actually were digested. (2) Intake per se is positively influenced by digestibility. This basic relationship only can be modified by variation of dry matter (DM) concentration, for instance in fresh forage, or various proportions of dead material (DEMARQUILLY et al. 1965).
At this point one should remind that the variance of digestibility depends a lot on age of plants and therefore on the management of a pasture as well. Additionally other constraints act on digestibility of forage such as the plant species and seasonal and climatic effects.

In Fig.4 you see the well known frequency distribution in digestibilities of tropical and temperate grasses (Δ = 13 %) as found by MINSON and McLEOD (1970) analyzing more than a thousand samples. We will not stick on it and give you the next figure (Fig.5) which demonstrates the possible influence of species and season on digestibility examplified by Lolium perenne and Dactylis glomerata.

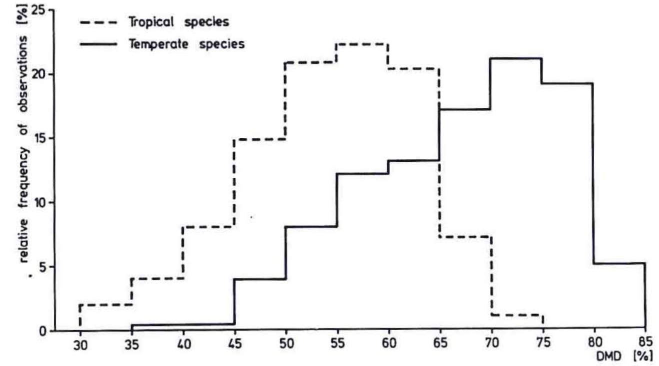


Fig.4: The frequency distribution of tropical and temperate grass digestibilities (DMD), calculated out of 543 cuts of tropical and 592 cuts of temperate grasses. - MINSON and McLEOD 1970.

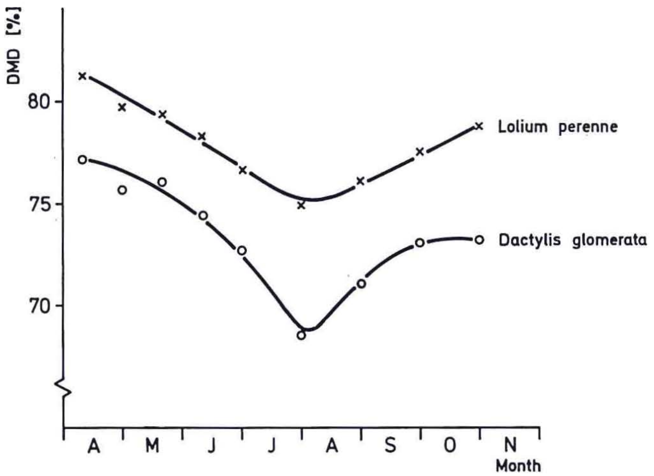


Fig.5: Percentage of digestibility (DMD) of Lolium perenne and Dactylis glomerata over the year in a grazing management system. - Adapted from DENT and ALDRICH 1968.

In this experiment of DENT and ALDRICH (1968) the clear decrease in digestibility during the mid summer season came along with higher percentages of crude fiber. Also differences between the species may be explained by chemical constituents. Especially during the summer crude fiber values of Dactylis exceeded by far those of Lolium. Lolium, on the other hand, is known as rich in sugar content. This kind of, let us say, seasonal and climatic constraints has been proved by many investigations, where single factors of climate, like temperature and radiation, were followed as influencing chemical constituents and digestibility (ALBERDA 1957, DEINUM 1966, DEINUM et al. 1968, SMITH 1969 and 1970, LANG et al. 1972).

Botanical Composition

According to LAMPETER (1971) the various plant species of permanent grassland are quite differently preferred by milking cows. Often it is hard to decide whether or not taste, smell, growth stage or physical structure rules their decision. Trifolium repens, Festuca pratensis, Lolium perenne and multiflorum, Trifolium pratense, Festuca rubra and Poa pratensis were readily* initiation of flower. Phleum pratense was less preferred at the early growth stage. Later on, however, it was much attractive to the animals until initiation of flower. In contrast to that, Dactylis glomerata after panicle emergence was accepted reluctantly, whereas Agrostis gigantea was hardly acceptable at any time. N-fertilization, o-3oo kg N/ha equally subdivided into 4 portions, significantly increased the acceptability of all grasses. However, P-, K- and Ca-fertilization, and mineral concentration in the pasture grass had no influence on it. Varieties within one species showed different acceptability by the animals. But not always the late heading varieties were preferred or even those with the higher leaf portion. Mixtures out of many species principally produced no forage of better acceptability compared to those consisting of 2 or a single species. Even though cattle loves changes in feed, disliked components coming along with this change may drastically reduce the animals preference. Thus the intake of Festuca pratensis decreased by 2.5 to 3.5 kg DM/cow/day with 3 % Matricaria discoidea in the stand. Comparing high valuable forage crops, however, it was shown that only the digestibility (OMD) determined the acceptability and the intake.

In addition, LAMPETER fed Dactylis glomerata, Festuca pratensis, Phleum pratense and Festuca rubra at grazing stage each to 3 stalled milking cows (Table 1). Within the 22 days experiment the animal kept or increased in weight, the average daily milk production being 17 to 25.6 kg. With decrease in digestibility (DMD) from 83 to 76 % DM-intake increased in all of the 4 groups; whereas with DMD-values lower than 76 % also DM intake decreased. This fact was interpreted so that with DMD values higher than 76 % the chemothermostatic mechanism of intake regulation prevails, whereas below the 76 %-value rumen tension and filling capacity of the digestive tract are decisive.

*taken until

Table 1: Mean daily intake of pasture grass by milking cows. - VOIGTLÄNDER 1977.

	intake/cow (kg DM)	year	plant stand	refusal	authors
grazing	14.6	1968	22 % Dactylis glomerata		ROTH 1971
	14.1	1969	20 % Agropyron repens	30-40%	
			15 % Festuca pratensis		
			10 % Poa pratensis		
	11.5	1972	8 % Trifolium repens		STEHR 1974
	12.1	1973	9 % Taraxacum offic.	40-50%	
			16 % 26 other species		
	13.7	1971	65 % Lolium perenne		VOIGTLÄNDER 1974
			4 % Poa pratensis		
			8 % Dactylis glomerata		
	12.6	1972	7 % Poa trivialis	22-35%	
			6 % Taraxacum offic.		
			10 % 36 other species		
in stall[x)]	13.2	1968	Dactylis glomerata		LAMPETER 1971
	11.9		Festuca pratensis		
	12.3		Phleum pratense		
	13.6		Festuca rubra		

[x)] fed to three cows each

In table 1 the in stall values of intake reported from LAMPETER are compared with those of different pastures (the latter including many species). The intake with all pasture trials varied largely from day to day and obviously this variation was smaller with the stall trials.
This may be explained by the fact that a high intake on the one day is compensated right after by low intake on the other day and vice versa. The intake curves of ROTH (1971) and STEHR (1974), however, partly show big variances in intervals of several days up to one week which not always can be interpreted by the amount on offer. Probably change of feed from higher to lower quality forage and vice versa works as an additional influence on acceptability during the grazing period. This is supported by experiments of MOTT (1974), who found distinct lower intake with reduced offer of medium or low quality forage, compared with high quality, whereas with increased offer the differences due to forage quality became smaller, obviously because the animals could select.
MARTEN and JORDAN (1974) proved palatability and lamb performance in trials with Phalaris arundinacea, Dactylis glomerata and Bromus inermis. In a cafeteria experiment the lambs preferred Bromus inermis to Dactylis glomerata and Dactylis glomerata to Phalaris arundinacea. The lack of palatibility of Phalaris arundinacea could be associated with the presence of alkaloids. Palatability in this experiment was positively related to average daily gain by lambs grazing the three grasses in an experiment without choice. Differences in digestibility or nutrient composition of the three grasses did not explain lamb performance differences. Carrying capacity of Phalaris arundinacea and Dactylis glomerata was much greater than that of Bromus inermis, but lamb liveweight gain per ha with Phalaris was less than with either Bromus or Dactylis.

Table 2: Response of grazing lambs to 3 grasses of varying palatability and productivity of the grasses, expressed as carrying capacity and lamb gain per ha, 1971 and 1972. - MARTEN and JORDAN 1974

Measurement	Br.inermis	D.glomerata	Ph.arundinacea
Average daily gain (g/lamb)	112 a	80 b	66 c
Carrying capacity (lamb days/ha)	4988 b	7534 a	7798 a
Lamb liveweight gain/ha (kg)	546 a	562 a	486 b

Means within rows followed by different letters are different ($p < 0.05$)

Preceding utilization

'T HART and KLETER (1974) reported about various grazing systems. Thereby grazing with oxen was conducted in a way so that with initiation of grazing the average amount of feed available was equivalent to normal, top and bottom grazing (22, 23, 11 dt DM/ha). In table 3 in addition refusals and intake are shown.

Table 3: Offer, refusal and intake of forage by 1-1^{1}/2-year old oxen under normal-, top- and bottom-grazing. - 'T HART and KLETER 1974

	normal	top	bottom
offer (dt/ha)	22	23	11
refusal (dt/ha)	3.6	11	3.7
intake (kg/animal/day)	6.5-7	8-9	4.5-6

In table 4 kind and statistical significance of this experiment are shown.

Table 4: Some factors affecting intake of grazing cattle. - 'T HART and KLETER 1974

	normal	top	bottom
offer/animal/day	+ (xxx)	+ (xxx)	+ (xxx)
frequency of grazing	- (n.s.-xx)	- (n.s.-80 %)	- (n.s.-x)
rain during grazing	- (n.s.)	- (n.s.)	- (n.s.)

level of significance: x > 99 %, xx > 99.9 %, xxx > 99.99 %, n.s. = not significant

The positive influence on intake coming from the amount of feed on offer also in this experiment turned out clearly.
In addition, it will be noticed that intake decreased the faster, the more often a plot was grazed during the period before. This decrease in many cases was statistically significant. With the second turning out on an already grazed plot the animals always showed smaller intake during the same period of time.
TAYLER and RUDMAN (1965) carried out investigations to find out the effect of grazing and cutting on the forage consumption and live-weight gain of yarded 250 kg steers.

Table 5: Effect of method of harvesting and previous grazing on herbage consumption; DM, kg per head per day. - TAYLER and RUDMAN 1965

	mower and chopper-blower	Forage harvester (lacerated herbage)
previously cut	6.38	6.26
previously grazed	4.76	3.59

Consumption from plots previously grazed was 25 % less than that from plots previously cut, when the grass was mown, or 43 % when forage harvested.
In another experiment the effect of method of grazing on live-weight gain was found (Table 6).

Table 6: Effect of method of grazing on live-weight gain of 250 kg steers, kg per head per day. - TAYLER and RUDMAN 1965

season	leaders	followers
spring	o.94	o.59
summer	o.94	o.7o
	alternate grazing and cutting	grazing only
spring	o.72	o.81
summer	o.8o	o.54

Live-weight gains per head were significantly higher on the alternate grazing and cutting system in the second half of the grazing season. The authors conclude that alternate grazing and cutting offers a method, whereby both herbage quality and availability to grazing cattle can be at high level. The same is true for the utilization of the total crop, where both grazing and conservation are carried out on a given area of land. Other findings were: Herbage consumption was greater on top than on bottom herbage and increased with greater amounts of forage on offer. This is in full agreement with the above mentioned results of 'T HART and KLETER (1974).

2. Quality and antiquality components in pasture grass

Balance of protein, energy and structure

An important quality factor of pasture grass fed to ruminants is the balance of its valuable components, that is energy, protein and structure. In the next table (Table 7) you have an example from our station, showing at what extent the animal output is restricted with young pasture grass by imbalanced ratio of energy and protein. We assumed a cow of 550 kg live-weight, with an intake of 12 kg DM/day, equivalent to 1.8 to 2.3 kg digestible protein and 6.6 to 7.2 kStE respectively. With the digestible protein we could have had a milk production of 24 to 33 kg (maintenance taken into account), with the energy available, however, only 13 to 16 kg. In fact, in our situation energy is always the limiting factor on pastures. Only with supplementation by 3 to 5 kStE, equivalent to 4 to 7 kg cereal meal we fully can use the output potential of protein.

Table 7: Potential of performance out of crude protein (CP) and kStE, respectively, as offered by 12 kg DM of a Lolium-free pasture (stage 15-25 dt/ha) fertilized with 60 kg N/ha/growth; location South Bavaria.

	DM[x)]	CP[xx)]	dig.CP	kilo-StE
intake (kg)	12	2.4 to 3.0	1.8 to 2.3	6.6 to 7.2
performance (l milk)	-	-	24 to 33	13 to 16
supplement	-	-	none	2.9 to 5.3

x) 20-25 % CP (dry weight basis); 550-600 StE. xx) 75 % digestible CP.
Conditions accepted: live weight: 550 kg. maintenance per day: 320 g dig. CP, 3000 StE. 1 kg milk: 60 g dig. CP, 263 StE.

Also physical structure of feed, say crude fiber, deserves attention. Depending on production in question, milk or meat, higher (up to 22 %) or lower (< 18 %) crude fiber concentration are optimal (KAUFMANN 1962). Under extreme situations the crude fiber content also may serve as a criterion, how far there exists a danger of acidosis on the one side (rumen-pH < 5.3) or ketosis (rumen-pH > 6.6) on the other.

Macroelements

For the macroelements Ca and Mg there exists a marked seasonal and climatic variability that may drastically influence animal performance on pastures. By a large number of literature it is supported that during the summer season higher concentrations of Ca and Mg compared to spring are found (ref. to MÜLLER et al. 1971). The obvious seasonal trend of Ca and Mg appeares in practically each of our pasture experiments. In table 8 this trend is exemplified for pasture over organic and mineral soils as well.

Table 8: Seasonal variation of Ca and Mg concentration (% dry weight) in pasture grass grown on organic and mineral soils. - VOIGTLÄNDER 1976, unpublished.

Cut-No.	Ca m[x)]	Ca o[xx)]	Mg m[x)]	Mg o[xx)]
1	0.67	0.56	0.19	0.15
2	0.68	0.68	0.22	0.18
3	0.74	0.68	0.23	0.20
4	0.82	0.82	0.26	0.20
5	0.88	0.90	0.26	0.24
6	0.91	0.86	0.26	0.28
7	0.86	-	0.26	-
8	0.90	-	0.26	-

x) Ø over 4 years; xx) Ø over 2 years; m mineral soil; o organic soil

These results agree with the practical experience that tetany becomes acute mainly in spring, when growth and K-uptake exceed Ca- and Mg-uptake. In addition, a special influence of plant species exists. Thus in general cattle are more in danger grazing on grassy pastures compared to less grassy stands.

We put the K x N- and Mg-values respectively of our grassy pastures into the scheme developed from DILZ and ARNOLD (1970) to predict the tetany situation of milking cows. According to this in most instances we hardly could expect tetany. This is consistent with our actual observations. Additionly we try to avoid such a kind of constraint by feeding mineral supplements during the grazing period. In the spring, however, with grass-rich stands and sudden start of grazing without additional feed always a certain danger by tetany exists.

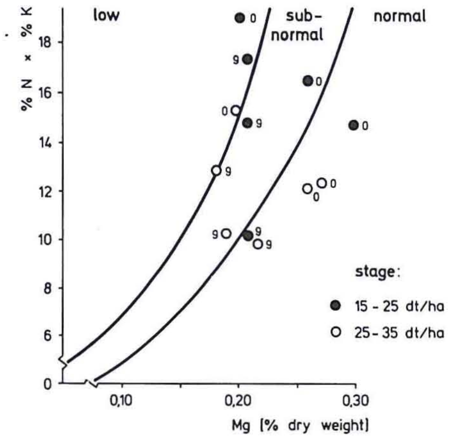


Fig. 6: Estimated concentration of Mg in the blood serum of milking cows as predicted from percentages of N and K (% N x % K) and Mg in the grass. Adapted from DILZ and ARNOLD (197o) to pasture grass in South Bavaria 1969 (9) and 1970 (O). - VOIGTLÄNDER and KÜHBAUCH, unpublished.

Na-deficiency does not operate as strong on health and output of animals as Mg-deficiency does, because the animals are able, at least for a while, to replace it by Na stored in the saliva. This, in turn, may be exchanged for K, of which there is always a surplus in the forage.
Nevertheless grazing animals may heavily suffer from Na-deficiency. Thus, VOIGTLÄNDER (1950) reported that plants over dung patches spread with NaCl were greedily accepted by milking cows whereas unspread plants were not attractive.
Increased frequency of grazing and better utilization due to higher Na contents also were observed by ERNST (1973) at Infeld (Table 9).

Table 9: Frequency of grazing and utilization of forage as influenced by Na percentage. - ERNST 1973.

frequency of grazing[x)]	utilization of forage (%)	Na (% dry weight)
53.1	56.6	o.o8
64.1	62.4	o.16
68.2	65.5	o.26
73.9	66.2	o.31

[x)] average number of animals; quarterly hour observations from 6 a.m. to 6 p.m.

In another experiment with Na-fertilization of 100 and 200 kg Na_2O/ha respectively the Na contents (% dry weight) increased up to o.33 and o.29 %. Because of the Lolium-rich stand at Infeld this increase could be expected.
FINGER (1971) reported increase of Na contents in soils of pasture plots from 3.4 to 8.5 mg/100 g soil and in the forage from o.12 to o.21 (% dry weight) within 3 years of Na-fertilization. The same author also reported higher frequency of grazing as a consequence of Na fertilization. FINGER and WERK (1972) found on poor sandy soils effects of fertilization with "Magnesia-Kainit" (12 % K_2O, 6 % MgO, 24 % Na_2O): (1) increase of Na- and Mg-concentration in the soil and forage (% dry weight), (2) enough Na (for milking cows) in the forage without supplement, (3) less refusal on fertilized plots.
On the other hand we also know results showing no influence of Na-fertilization on frequency of grazing and only small effects on Na percentages in the forage. Thus, on Lolium-rich stands we found a fairly good increase of Na percentage applying only 60 kg Na_2O/ha, whereas on other locations (including organic and mineral soils) Na-increase remained poor in spite of fertilization up to 240 kg Na_2O/ha. It follows that, as far as Na-deficiency is concerned, losses of output may be best avoided by direct supplementation.

Nitrate

Nitrate concentration in plants depends primarily on 2 factors: Weather and N-fertilization or kind of N-fertilizer respectively (KLEPPER et al. 1971, LIEBENOW 1971). In a number of investigations the practical influence of light and available assimilates for NO_3-reduction has been demonstrated. Thus, DARWINKEL (1976) found extremely high NO_3 concentrations in newly sown plants. He argued that smaller amounts of assimilates were available for NO_3-reduction, say protein synthesis, because a larger amount of reserve-carbohydrates is stored in the roots during the first stages of growth. From the Netherlands several times NO_3 poisoning is reported, where rations are fed which consist at a greater part of fall grown fodder beet and rape (KEMP et al. 1977). In these instances low radiation during fall and, in consequence, a lack of reduction equivalents might have increased NO_3 concentrations over a critical level. N-fertilization per se generally must not be a problem in respect to NO_3 contents of pastures. Even though along with N-fertilization NO_3 concentration of pasture grass is enhanced continuously, with economically handled fertilization NO_3 concentration hardly exceeds o.6 to o.8 % (dry weight) as you may see from Fig. 7.

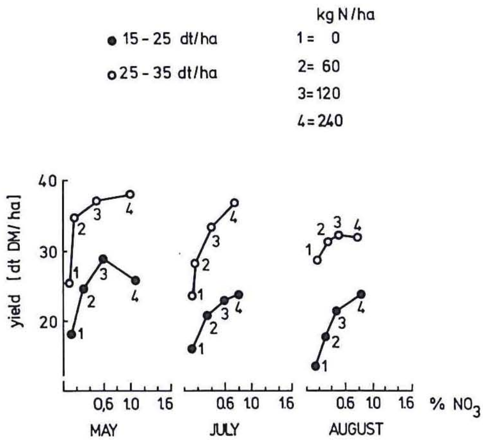


Fig. 7: Yields and NO_3-contents (% dry weight) of pasture grass as influenced by increased N-fertilization. - VOIGTLÄNDER 1973.

Beyond this point, small or even no increase of yield takes place. These findings are consistent with those of VAN BURG (1965). In addition, there is some scope over the o.8 %-level so that with normal intake animal health may be not affected until NO_3 percentages of 1.6.

Other detrimental factors

This point gives us the opportunity to introduce specific constraints as related to some selected plant species.

Phalaris arundinacea

Phalaris is used in the wet and low areas throughout the northern part of the United States, most extensively in the north central area and the Pacific North West. It is one of the highest yielding perennial forage grasses used for grazing. Since it grows well in low, wet areas, many low-land pastures in the North of U.S. are predominantly Phalaris (SMITH 1975).
Lambs often do not perform well on lush Phalaris pasture and lambs and ewes frequently get diarrhea when grazing this grass. This is the point of the gravest disadvantage of Phalaris, namely its poisonous alkaloids (MARTEN 1973). The most important drawback of this grass is that digestibility declines rapidly so that it must be grazed early and properly to obtain quality forage with regard to the other important components. However, right at the early and leafy stages alkaloid concentration is extraordinarily high. SIMON (1970 ref. to MARTEN 1973) showed that alkaloids (% dry weight) of Phalaris decreased over a 30-days period at about 40 %, growing from vegetative stage to flower. Similar results have been reported from FRELICH and MARTEN (1972) with about 50 % less alkaloids in a 5 weeks compared to 2 weeks vegetative regrowth of 4 clones (cultivated under controlled environment).

In fact, alkaloids of Phalaris are mainly localized in the leaf portion (HAGEMAN et al., unpublished; Table 10).

Table 10: Alkaloid concentration (% dry weight) in different plant parts of Phalaris arundinacea L.; average out of 12 clones. - Data adapted from MARTEN 1973.

plant part	alkaloids (% dry weight)
leaf blades, upper half	o.29
leaf blades, lower half	o.23
sheaths	o.o7
stems	o.o4
panicle[x)]	o.o5

x) one clone flowering only

These examples demonstrate that especially under grazing management with Phalaris losses of animal output must be taken into account. The tryptamine alkaloids of Phalaris may be associated with "Phalaris staggers" and "sudden deaths" in ruminants grazing Phalaris species, even though insufficient evidence may exist to claim that alkaloids cause these toxicities when they are consumed in usual grass rations (MARTEN 1973).
In the near future, however, varieties may come on the market, which are lower in alkaloid concentration and, as additional advantage, those may be superior in overall vigor and yield potential (MARTEN 1973 unpublished).

Festuca arundinacea
GENTRY et al. (1969) investigated the contents of perloline in tall fescue. They observed a distinct maximum during the summer season. A negative effect on animal performance then could be the consequence of higher perloline concentration as shown in Fig. 8.

In contrast to Phalaris (MARTEN 1973) however, with Festuca ar. alkaloid concentration, at least at some stages, seems to be higher in the stem than in the leaves. As far as age is concerned, the younger plants generally show the higher alkaloid concentration (GENTRY et al. 1969, MARTEN 1973).

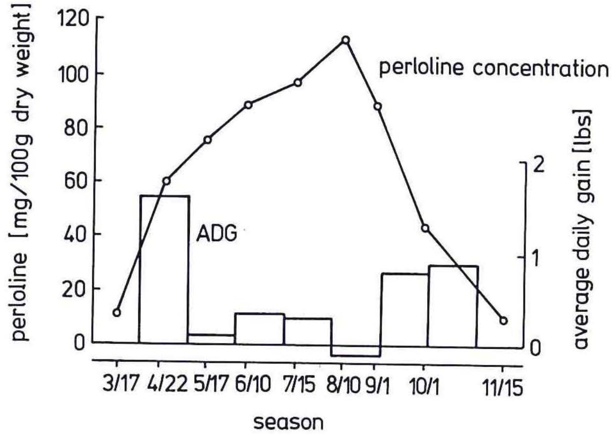


Fig. 8: Perloline concentration of tall fescue pasture plants and average daily gain of steers grazing tall fescue during 28-day periods. - SMITH 1975, adapted from GENTRY et al. 1969 and MOTT et al. 1971, ref. to SMITH 1975.

Trisetum flavescens

In the alpine area, from the sixties on increasingly, a chronic cattle disease is reported, which probably is of extreme economical importance in the respective farms (DIRKSEN et al. 1970). According to DIRKSEN et al. (1970), HÄNICHEN et al. (1970) and DÄMMRICH et al. (1970) this disease is clinically characterized by emaciation, irregular movement of animals and pathologically anatomically by calcination of various tissues in the animals body especially in the cardiovascular system. The animals obviously suffer from pain, their over all behaviour is indolent. Along with proceeding disease often the health situation deteriorates so much that animals must be slaughtered. In advance of this gain of weight and/or milk production are diminished (SIMON et al. 1975). In the year 1973 it has been proved that the calcinogenic effect was induced by relatively high amounts of Trisetum flavescens in the forage (DIRKSEN et al. 1974). It is remarkable that calcinosis occurs preferably on well fertilized Trisetum-rich intensively used mowing pasture (DIRKSEN et al. 1970, SIMON et al. 1975).

Table 11: Calcinogenic effect on sheep fed with fresh material of Trisetum flavescens, Dactylis glomerata and pasture grass without Trisetum over 123 or 125 days; (sheep at start of experiment about one year old). - DIRKSEN et al. 1974.

fodder	slaughter weight (kg)	calcination of the aorta
Trisetum only	21.1 x)	+++
Dactylis only	26.9 x)	-
pasture grass without Trisetum	27.o xx)	-

+++ = extremely high; x) average out of 4 animals
- = negative xx) average out of 3 animals

In Table 11 a simplified example is given out of these experiments demonstrating the calcinogenic effect on sheep with Trisetum compared to two Trisetum-free forages. The Trisetum-group showed significantly less gain of weight. The extremely high calcination coming along with this, meanwhile has been confirmed several times and also could be reproduced quite pertinent with rabbits (DIRKSEN et al. 1972 and 1973).
About the nature of the substance which causes the calcinosis exact information is not possible up to now. The symptoms of the disease and research work at München (ZUCKER et al., personal comm.), however, indicate that the calcinogenic effect of Trisetum comes from a substance similar but unidentical to vitamin D. Probably both substances act on a similar or even the same receptor in the animal. By the way, the symptoms of Trisetum-calcinosis are similar to those observed in South America after feeding of Solanum malacoxylon.
After exclusion of Trisetum from the feed, up to a certain degree, the disease is reversible. Supplementation with commercial mixtures of minerals with or without admixture of vitamin D should be stopped completely if smaller amounts of Trisetum - < 15 % - are in the ration. Instead of this, mixtures with trace elements only should be used, adapted to the actual demand. By no means further application of vitamin D is acceptable for calcinose suspicious herds.

NEWTON and BETTS (1974) investigated oestrogenic activity of Trifolium pratense (Tp) and Trifolium repens (Tr) and its effect on reproduction of ewes. They found Tp as to be oestrogenic as Tr but the mean litter size and lambing percentage in the three years of the experiment was significantly reduced by Tp only (Table 12).

Table 12: Effect of three swards on the reproduction of ewes in three years. - NEWTON and BETTS 1974.

sward	litter size			lambing percentage		
	1.	2.	3.	1.	2.	3. year
Control (Lolium perenne)	2.35	2.3o	2.24	175	225	218
Trifolium pratense	1.6o	1.67	1.78	16o	128	118
Trifolium repens	2.2o	2.33	2.23	21o	222	189

The lambing date of ewes grazing Tp was also delayed. Tr although oestrogenic, had no apparent effect on reproduction.

Bloat

According to REID and JUNG (1975) bloat in animals may be observed under different feeding circumstances. The causes of the disease are extremly complex. The production of a stable foam in the rumen, the retention of gas, the increase of pressure in the chamber and finally an inhibition of the eructation mechanism are characteristics of bloating animals. They are due to a complex interaction of animal, plant and microbiological factors. In this 3 directions many investigations were carried out but without a definite success. REID and JUNG (1975) expect the long-term solution of the problem of bloat from programs of plant breeding designed to select legume species and cultivars of low bloating potential but adequate nutritional quality and from selection of animals with a low hereditary susceptibility to the disease.

Other substances in pasture plants, like HCN, alkaloids and oestrogenic substances other than those mentioned above, especially on extensive pasture land may stimulate or limit the animal output or even kill some animals. However hardly quantitative information is available on this point.

3. Constraints due to management

Treading and dung patches

The area per large animal unit (LAU) covered with dung is given from several authors within the limit of 11o-2oo m^2 per grazing season, the avoided area with 1o-2o % of total pasture. VOIGTLÄNDER (195o) calculated out of 31o single measurements a mean area per dung patch of 6oo cm^2. Assuming 16 to 17 patches a day, this is 1 m^2 per day or 18o m^2 per grazing season. The measured marginal effect is about the 3-fold area of the patches, so that 4 m^2 per day are affected by the dung of one cow, hence 24oo m^2 or 24 % of total area with 6oo LAUs-days/ha/grazing season. Treading and spreading of patches during the grazing period is not yet included into this calculation. MOTT et al. (1972) stated that without pasture husbandry 4o % of the total pasture were covered with patches at the end of the season. However, it must be taken into account, that a certain portion of grass, growing over the early originating patches, was accepted again by the animals at the end of the grazing season (Table 13).

Table 13: Variation of the proportion of dung patches (% total pasture area) as average of 5 rotations in each of 3 years. Figures in ( ): observed after 5. rotation. - MOTT et al. 1972.

management	increase	decrease	finally present
without additional cutting	15.2 (9)	9 (14)	35.2 (4o)
cutting after each rotation	7 (8)	6 (8)	9.2 (11)
cutting after 2. and 4.rotation	7.8 (7)	7 (10)	10.8 (11)

Also RÖTSCHKE and LAMPETER (1973) stated that the refusal was reduced with grazing followed by cutting. Additionally the proportion of Dactylis decreased from 75 to 38 % and digestibility increased probably. If the patches were distributed crosswise with a pasture-harrow, the refusal fell down to 8 %. According to the above mentioned fact, one might fear that the losses by dung patches grow enormously if nothing is done against it. However, refusals increase within limits. MOTT and MÜLLER (1971) increased intake and yield only by 5 dt/ha/season with cuttings after grazing compared to uncut areas. On the other hand, 2 cuttings per season right after grazing, caused smallest losses of area and thus smallest restrictions of animal output by patches and other refusals. Moreover, Lolium perenne increased drastically with cuttings after grazing rotations at the cost of Dactylis glomerata whereas without cuttings some deterioration of the stand must be expected with time.

Organic manure

Table 14: Effect of manuring in spring on refusal of forage by cattle under grazing vs stall-feeding. - MARTEN and DONKER 1966.

Pasture of	Bromus inermis				Phalaris arundinacea			
Manure of	Cow	Sheep	Turkey	Control	Cow	Sheep	Turkey	Control
				First crop				
Refused on pasture %	8o	8o	92	26	83	88	7o	16
lb DM consumed in stall	3.9	4.o	1.8	2.7	7.5	8.8	7.o	5.3
				Aftermath forage				
Refused on pasture %	4o	49	93	4o	62	64	53	53
lb DM consumed in stall	5.7	1o.8	6.2	13.1	8.7	8.1	6.2	9.6

All three manures caused considerable forage refusal of first crop by cattle on both grass pastures. But no statistically significant differences occurred between treatments in dry matter consumed in stall.
Bromus inermis receiving turkey-manure was the only aftermath forage rejected by cattle on pasture. Under stall feeding this forage did not differ statistically from the consumption of the other treatments. The authors conclude from their results, that the factor, or factors, causing non-acceptability of dung-affected pasture grass were associated directly with the dung itself and were not inherent in the forage. Therefore the grass on the pasture near the dung patches is rejected and in the stall it is accepted as normal grass from the control.

Parasites

Infection with parasites may cause drastic reduction of animal output with cattle and sheep. Especially young animals are sensitive to parasites. Liver fluke, worms in the lung and digestive tract are most dangerous. During one grazing period 2 generations of liver fluke may develop and up to 6 generations of the worms mentioned. In contrast to that with warble fly only one generation comes up, a fact that makes control a lot easier.

According to ENIGK (1967) the weight gain of sheep is much influenced by infection with larvae of liver fluke as shown in Fig. 9.

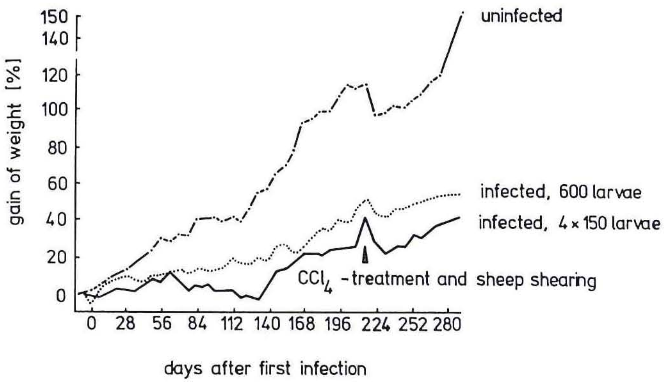


Fig. 9: Average gain of live-weight with sheep as influenced by experimental infection with liver fluke. - ENIGK 1967.

In own experiments, infection with parasites in the digestive tract was not realized early enough after weaning of the lambs at the end of July. As a consequence, losses in weight never could be compensated so that as average over the whole grazing period only 7o-8o % of the normal daily gain could be attained (SCHNEIDER, 1976).
CALDER and SMITH (197o) carried out experiments to determine the relative levels of production in steer live-weight on irrigated and non-irrigated upland and dikeland pastures (Table 15). One group (control) of steers was treated with thiabendazole, the other group was designated the parasitized group.

Table 15: Average daily gain (ADG) of parasitized and healthy cattle and gains converted to total digestible nutrients (TDN) expressed for maintenance and gain in kg/ha. - CALDER and SMITH, 1970.

Pasture	Animal status	ADG kg/ha	Maintenance	Gain	Total
Upland	Parasitized	o.33	2,oo2	917	2,919
irrigated	Control	o.7o	2,o13	1,353	3,366
Upland	Parasitized	o.47	1,977	728	2,7o5
non-irrigated	Control	o.85	1,725	1,529	3,254
Dikeland	Parasitized	o.45	1,428	631	2,o59
irrigated	Control	o.96	1,424	1,432	2,856
Dikeland	Parasitized	o.74	1,247	9o3	2,15o
non-irrigated	Control	o.89	1,3o3	1,185	2,488

The average daily gain in kg/ha was significantly better for the control group on upland irrigated and non-irrigated pastures and on the irrigated dikeland pasture. The mean average daily gain of cattle shows a distinct advantage for dikeland over upland and an advantage of non-irrigated over irrigated. Ostertagia ostertagi and Cooperia oncophora were the two common species of parasites present. Burdens up to 200 000 worms were found in clinically parasitized animals, while only small numbers were recovered from animals of the control group.
The experiment demonstrates the role that irrigation may play in the development of gastrointestinal parasitism in cattle. Irrigation may ensure adequate moisture in the sward and may have some effect on disintegration of dung patches and spreading of worm eggs into a favourable environment.

Non-productive demand of energy

SCHÜRCH (1967) stated that energy demand is higher for grazing compared to stalled animals. Especially on pastures at the alpine area not only longer distances and gradients have to be managed but also with extreme weather conditions additional energy is necessary to keep at the animals temperature. SCHÜRCH (1967), working on this matter, showed the following table (Table 16) which includes results from GRAHAM (1964), CLAPPERTON (1964), HALL and BRODY (1934).

Table 16: Additional demand of energy for cattle and sheep to support grazing and moving on and up. - SCHÜRCH 1967 according to several authors.

	cattle	sheep
grazing (cal/h/kg live-weight)	-	54o-84o
moving on (cal/m/kg live-weight)	o.48	o.59
moving up (cal/m vertical/kg live-weight	6.8o	6.45

Grazing versus in-stall feeding already causes distinctly higher energy demand, whereas active grazing itself causes only a small increase of energy demand. In contrast to that moving on and up requires distinctly more energy. From the figures given in table 16 the surplus of energy demand can be calculated approximately for moving on and up. In this calculation 1 kcal is accepted as equivalent to o.42 StE.

Example 1:
Increased demand of StE for a 6oo kg cow moving on 2ooo m: o.48 cal x 6oo kg x 2ooo m = 57o kcal x o.42 StE = 24o StE. This is about 8 % of the regular demand for maintenance.

Example 2:
Increased demand of a 6oo kg cow moving up 5oo m (vertical): 6.8 cal x 6oo kg x 5oo m = 2o4o kcal x o.42 = 86o StE = 28.7 % more than regular maintenance.

The influence of low environment temperatures, is less critical for cattle and unsheared sheep in contrast with sheared sheep (SCHÜRCH 1967). Additional demand of energy exists if temperature drops below a certain level, as for cows 0°C, heifers 6-8°C, sheep (10 cm wool) 3°C, sheep (just clipped) 25-30°C.

SUMMARY

Three major factors were discussed, which constrain animal output from pastures: intake, quality and antiquality components and management.

All the 3 factors again act on one another and are influenced by subordinate factors. It must be stated, however, that some of the latter might have been handled alone as main factors.

Talking about quantitative influence in many instances it is hard to decide which of the various factors contributes most to animal output. However, we understand the sense of this paper to show up from what directions limitations of animal output may come.

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