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Feed Supplements for Young Dairy Breed Calves After Turn-Out to Pasture: Effect on Weight Gain and Subclinical Coccidiosis in Organic Production Systems

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On two organic farms, the effect of supplementation with either home-grown barley or organic commercial concentrates primarily based on local protein sources and barley, on weight gain and subclinical coccidiosis was investigated in 3–5 months old dairy breed calves in the period after turn-out to ryegrass/clover pastures. The calves (mean liveweight $\pm$ SD, 124 ± 24 kg and 133 ± 24 kg on Farm I and II respectively) were supplemented daily with 3 kg energy and protein-rich commercial concentrates (group EP), 3 kg barley (group E) or $\frac{1}{2}$ kg barley (group Eres) for 8 weeks following turn-out on pasture.

Daily weight gains in the 8 weeks were for Farm I: 1216 and 1042 g/day for group EP and E ($P < 0.01$) and for Farm II: 1071, 671 and 770 g/day for group EP, E and Eres respectively ($P < 0.001$). However, liveweights were similar between groups at housing, although group EP had significantly higher liveweight at housing on Farm I ($P < 0.01$). Initial liveweight had effects on daily gain in the grazing season, but supplementation with energy and protein reduced this effect on Farm I. No clinical signs of coccidiosis were observed, but markedly higher levels of oocysts per gram faeces (opg) were observed on Farm II, using pastures previously grazed by cattle compared to Farm I. Calves having a maximum oocyst count above 5 000 opg were subclinically affected by coccidiosis, as indicated by low faecal dry matter and reduction in daily gain of 222 g/day ($P < 0.05$). It is concluded that liveweight can be increased when supplementing calves

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with organic concentrates rich in energy and protein in the period following turn-out compared to supplementation with barley alone. However the overall gain at the end of the grazing season is limited due to compensatory growth in the grazing period following supplementation.

Key words: beef, health, organic farming, protein, ryegrass/white clover pasture.

Introduction

Turn-out of dairy calves on pasture at a young age often results in low weight gains and diarrhoea and is identified as an area with severe problems in organic dairy production (Vaarst et al., 2001). Turn-out of very young calves on pasture is not uncommon on many farms in Europe, i.e. on conventional farms in Ireland (Flynn, 1985) and on organic farms in Denmark, as calves reared in such systems are pastured at an age of 3 months in summer in order to fulfil the national standards for organic farming (Anonymous, 2000). Whereas calves from suckling herds perform well while grazing together with the dam, dairy calves normally graze without their dam. The time of turn-out may be especially critical for organically reared calves at 3 months of age, as it coincides with the change from milk to solid feeding. Young calves that are inexperienced grazers appear to be less able to achieve high herbage intakes under good sward conditions (Hodgson & Jamieson, 1981; Cazcarra & Petit, 1995). Protein supply from ryegrass/white clover pasture in spring may be low as the protein is extensively degraded in the rumen, (Fox et al., 1991; Grigsby et al., 1991).

The organic farmer can use feed supplementation to improve performance in the period after turn-out, and typically home-produced concentrates as cereal grains are used on organic dairy farms (Nielsen & Thamsborg, 2002). Commercial supplements are another possibility with higher palatability and content of undegradable protein compared to cereals. However, high prices for organic commercial supplements, and absence of performance data, discourage farmers from the latter option.

In organic production systems in Europe, protein resources with low degradability in the rumen, such as soybean and fishmeal can only be used in restricted amounts and will possibly not be allowed at all in organic production in the future. Apart from the risk of introducing genetically modified organisms in soybeans, local resources are preferred in organic production. Additionally, growth promoters are commonly used in many cattle production experiments, making the research results inapplicable to organic production. Thus, the few papers on supplementation with undegradable protein to grazing calves (Goetsch et al., 1990; Grigsby et al., 1991), have limited relevance to organic production systems and more information is needed on locally available concentrates.

Pastures close to the farm are often used for calves year after year, allowing the possibility for frequent observation. However, the risk of coccidiosis may increase markedly when pastures are used for calves in consecutive seasons, as found by Svensson (1995), where calves turned-out on pastures grazed by calves the year before, excreted more oocysts of *Eimeria alabamensis* than calves turned out on pastures grazed by older cattle or horses the previous year. It is well known that a high level of nutrition, particularly undegradable protein supply can reduce the establishment and the pathogenic effects of gastrointestinal helminth infections (Coop & Holmes, 1996). However, no information is available concerning the effect of supplementary protein feeding on coccidiosis in young calves. It has also been demonstrated that susceptibility to parasite infection may be age dependent. An analysis of 85 studies of gastrointestinal nematode infections in first grazing season calves has shown that calves <6 months are more prone to clinical disease compared to older calves (Shaw et al., 1998).

The objective of this study was to compare the effects on young calves (3–5 months old) in the period after turn-out to pasture of feeding an energy-rich supplement (organically grown barley) with a supplement rich in energy and protein based on local protein sources and barley (organic commercial concentrate). Assessments were made of weight gain and subclinical coccidiosis.

Materials and methods

Design and treatments

The experiment was carried out on two organic farms in the summer of 2000. Farm I was a crop farm buying all calves at an age of 2–4 weeks from one organic dairy farmer. After arrival at the farm the calves were fed milk and they were offered silage, hay, dried sugar beet pulp and rolled barley. Farm II was an organic dairy farm, where all calves were fed a mixed feed ration containing roughage and concentrates in addition to milk. Five days before turn-out, all calves were fed with 1 kg barley and 1 kg commercial concentrates rich in energy and protein supplied with silage ad lib. The experiment started at turn-out

(2/3 May). On Farm I, 40 entire Holstein Friesians bull calves (age 3–5 months, mean liveweight 124 ± 26 kg) were randomly allocated to 2 treatments balanced for age and liveweight. Group E was supplemented with 3 kg barley per animal per day and group EP with 3 kg energy and protein-rich concentrates per animal per day. All calves were castrated at 2 months following turn-out. On Farm II, 36 castrated Holstein Friesians steers (age 3–5 months, mean liveweight 133 ± 24 kg) were randomly allocated to 3 treatments (supplementation per animal per day with 3 kg energy and protein-rich concentrates (group EP), 3 kg barley (group E) or $\frac{1}{2}$ kg barley (group Eres)) balanced for age and liveweight. The energy and protein-rich commercial concentrate on both farms was certified as organic feedstuff and contained 57% barley, 13% heat-treated rapeseed cake, 10% peas, 7% soybean cake, 5% wheat bran, 3% sugar beet molasses, 2% fish meal and minerals and vitamins. The supplement was group-fed on both farms, so an intake of exactly 3 kg per animal could not be attained. The supplement was given twice daily for 8 weeks, but only once daily in group Eres. On Farm II the calves had access to a pen with deep litter. On both farms, grazing areas were rotated every week between the groups from day 14 to 56 following turn-out to ensure the groups had equal quantities of grass on offer. Barley straw, minerals and vitamins were supplied during the 8 weeks following turn-out.

All calves were grazing a second year ley of white clover (*Trifolium repens*)/perennial ryegrass (*Lolium perenne*) pasture (36% and 7% ground cover of clover measured by visual judgment on Farms I and II, respectively). The pasture had been grazed by calves the year before on Farm II whereas the paddock was cut but not grazed in 1999 on Farm I. After the experimental period the calves on each farm were pooled and stayed on the paddock until August (Farm I) or October (Farm II). Thereafter on both farms all calves were moved to another paddock with white clover/perennial ryegrass that had not been grazed by cattle in this grazing season. The calves were housed on 22 November (Farm I) and 8 November (Farm II).

Samplings and recordings

Intake of supplementary feed was recorded daily for each group. The calves were weighed on days 0, 1, 10, 55, 56 after turn-out and at housing. Rectal faecal samples were taken on days 1, 7, 10, 14, 21, 28, 42 and 56 after turn-out. Faeces were analysed for dry matter (FDM) and for nematode eggs and coccidia oocyst counts by means of a modified McMaster method (Henriksen & Ågård, 1976). The method had a sensitivity of 20 eggs/oocysts per g of faeces (epg and opg), and nematode eggs were classified as strongyle-type eggs and eggs of Nematodirus. Faecal egg counts (FECs) were made up by adding strongyle-type egg counts and Nematodirus egg counts. Oocysts in samples from days 1, 10 and 21 were differentiated to species level from 4–5 randomly selected calves per group. Herbage samples were taken weekly by hand shears to a height similar to that consumed by the steers (4–5 cm above ground level). A minimum of 20 samplings of 1×1 m was taken at regular intervals along a predetermined zigzag transect within the paddocks. Herbage samples within paddock were pooled and analysed for standard feed analysis, including in vitro solubility of organic matter (IVSOM). The values were corrected to *in vivo* digestibility (OMD%) by the regression function $\text{OMD} = 4.1 + 0.059 \times \%\text{IVSOM}$ (Møller et al., 1989). Sward height was measured with a plate meter (30×30, 3.8 kg/m^2) weekly using about 25 measurements per ha. Animal performance was recorded weekly until day 56, including condition score (1 = skinny, 5 = fat), dirtiness, wetness, brightness of coat, swelling, wounds, dermatomycosis (ringworm), respiratory diseases, leg problems and diarrhoea.

Statistical analysis

Data from the two farms were analysed separately. Data for daily weight gain were analysed by an analysis of variance with treatment as the main factor and liveweight at turn-out as covariate. The effect of liveweight at turn-out on daily gain was also tested as main factor with two groups of liveweight at turn-out (< 130 kg and ≥ 130 kg). This boundary was chosen to achieve groups of about same number of calves. The prevalence of coccidian oocysts in each group was analysed using χ^2-test. Geometric mean counts were used to summarize the opg data. Log transformed $(x + 10)$ opg were analysed by an analysis of variance. FDM was analysed by an analysis of variance with group and log transformed opg as main factors. The correlation between FDM, opg and daily gains were tested by an analysis of variance. In this analysis, calves were classified according to oocyst excretion in opg-low (opg < 1000), opg-moderate ($1000 \leq \text{opg} < 5000$) and opg-high (opg ≥ 5000) at one or more sampling occasions and according to faecal consistency as follows: FDM-low (FDM $\leq 11\%$) and FDM-high (FDM $> 11\%$) at one or more sampling occasions. The borderlines for opg are based on observations by Boughton (1943) and Waggoner et al. (1994) and for FDM on Pedersen et al. (2000). The analysis of variance was performed by GLM procedure of SAS (SAS Institute Inc., 1999). A

Table 1. Chemical composition of supplement feed and herbage

	Barley		Commercial concentrates		Herbage	
	Farm I	Farm II	Farm I	Farm II	Farm I	Farm II
No of samples	2	2	2	2	14	27
Dry matter, %	86.6	85.5	86.2	86.4	20.9 ± 1.9	20.6 ± 3.6
Crude protein, (% DM)	11.4	10.3	18.7	18.2	15.0 ± 3.7	17.1 ± 2.5
Ash, (% DM)	4.4	2.6	6.4	5.8	6.7 ± 0.9	8.1 ± 0.9
Metabolizable energy:						
(MJ/kg DM)[1]	12.6	13.4	13.8	14.1	–	–
In vivo OMD	0.92	0.91	0.91	0.93	0.77 ± 0.43	0.78 ± 0.31

[1] Metabolizable energy was calculated from net energy by dividing with 0.65 and Scandinavian Feed Unit (SFU) were converted to MJ by a factor of 7.89 MJ/SFU.

level of $P < 0.05$ was considered significant. Other data are presented as mean ± SD and estimates were performed by lsmeans.

Results

Chemical composition of pasture and supplementation

Crude protein content in dry matter in the protein-rich concentrate (PC) was about 7–8% higher compared with barley (B) (Table 1). Pasture composition and *in vivo* OMD was not different between the groups on each farm; however, crude protein content was lower on Farm I compared to Farm II (Table 1). At turn-out the sward height on the pastures was about 120 mm on both Farms (Fig. 1). From mid-May the sward height on Farm II was reduced to 47 mm in late June, whereas sward height was maintained above 130 mm up to June and above 70 mm in June on Farm I.

Intake

The concentrates offered were completely consumed except for group E on Farm II, which had an average intake of only 1.8 rather than 3 kg/animal/day (Tables 2 and 3).

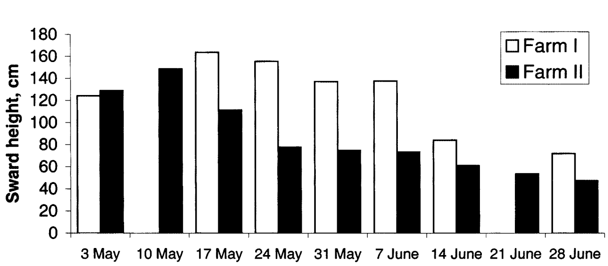

Fig. 1. Mean sward height on pastures on Farm I and II in the experimental period (week 0–8).

Weight and weight gain

On Farm I, the calves in group EP and E had a daily weight gain during the experimental period exceeding 1000 g (Tables 2 and 3). However, on both farms supplementation with protein resulted in a higher daily gain compared to the other groups (E and Eres), with means of 17% and 49% on Farms I and II respectively (Tables 2 and 3). In the period after supplementation to housing daily gain in group EP was lower on both farms and significantly lower on Farm I ($P < 0.05$). There was no statistical difference in liveweight gain between group E and Eres on Farm II. However, in the period with supplementation group Eres had a higher daily gain (100 g/day) and in the period after supplementation group E had a higher daily gain (100 g/day). Liveweight at housing in group EP was 7 kg higher than group E on Farm I ($P < 0.01$). On Farm II calves in group Eres were 9 kg lighter than in the other groups at housing.

Liveweight at turn-out affected significantly the daily weight gain as animals with low liveweight had lower daily gain during the entire grazing season on Farm I ($P < 0.01$–0.001) and in the experimental period on Farm II ($P < 0.05$). On Farm I, a 10 kg increase in liveweight at turn-out resulted in 50 g/day increased gain in the experimental period (Fig. 2). The general effect of liveweight at turn-out on daily gain during the 8 weeks grazing period following turn-out is given in regression equation 1 (Farm I) and 2 (Farm II) (Fig. 2):

1. Daily gain (kg) $= 0.50 + 0.0050 \times$ (liveweight at turn-out) $(R^2 = 0.45)$
2. Daily gain (kg) $= 0.56 + 0.002 \times$ (liveweight at turn-out) $(R^2 = 0.52)$

Table 2. Intake of feed supplements, liveweight and weight gains of Holstein Friesian calves (3–5 months) supplemented with energy (E) or energy and protein (EP) for 2 months after turn-out on pasture (Farm I)

Farm I	Group EP	Group E	*P*-values of treatment
Number of calves	20	20	
Intake of feed supplement:			
Total, kg/animal/day	3.0	3.0	
Crude protein, g/animal/day	486	300	
Metabolic energy, MJ/animal/day	35.9	32.8	
Liveweight:			
Turn-out (d 0), kg	124 ± 27	125 ± 26	NS
d 10, kg	128 ± 27	129 ± 26	NS
End of experiment (d 55), kg	191 ± 36	182 ± 36	$P<0.01$
Housing (d 204), kg	304 ± 26	297 ± 39	$P<0.01$
Daily gain on pasture:			
Turn-out to end of experiment (d 0–55), g	1216 ± 200	1042 ± 252	$P<0.01$
End of experiment to housing (d 55–204), g	734 ± 110	749 ± 103	$P<0.05$
Whole period on pasture (d 0–204), g	870 ± 78	831 ± 91	$P<0.01$

Table 3. Intake of feed supplement, liveweight and weight gains of Holstein Friesian calves (3–5 months) supplemented with energy (3 kg barley = E and $\frac{1}{2}$ kg barley = Eres) or energy and protein (EP) for 2 months after turn-out on pasture (Farm II)

Farm II	Group EP	Group E	Group Eres[1]	*P*-values of treatment
Number of calves	12	12	12	
Intake of feed supplement:				
Total, kg/day/animal	3.0	1.8	0.5	
Crude protein, g/day/animal	0.47	0.16	0.04	
Metabolic energy, MJ/animal/day	36.7	20.1	5.7	
Liveweight:				
Turn out (d 0), kg	131 ± 29	136 ± 26	136 ± 18	NS
d 10, kg	143 ± 31	146 ± 26	146 ± 20	NS
End of experiment (d 56), kg	$191^{a} \pm 39$	$174^{bc} \pm 26$	$179^{b} \pm 24$	<0.001[1]
Housing (d 189), kg	271 ± 48	271 ± 42	262 ± 52	NS
Daily gain on pasture:				
Turn-out to end of trial (d 0–56), g	$1071^{a} \pm 241$	$671^{c} \pm 198$	$770^{c} \pm 143$	<0.001
End of trial to housing (d 56–189), g	599 ± 212	727 ± 210	622 ± 284	NS
Whole period on pasture (d 0–189), g	739 ± 158	710 ± 200	666 ± 221	NS

[1] Values in the same row with different superscripts are different (a and b differs $P<0.05$; a and c differs $P<0.001$).

However, the effect of liveweight at turn-out was reduced when protein-rich concentrates were fed in the 8 weeks following turn-out. Interactions between liveweight at turn-out and feeding regime were observed in relation to daily gain in the period after supplementation and during the whole grazing period (Farm I) ($P<0.05$–0.01). Thus, calves with a liveweight at turn-out below 130 kg benefited from supplementation with energy and protein resulting in an increased daily gain compared to supplementation with energy alone (Fig. 3 and Table 4). There were no such interactions on Farm II.

Health

On Farm I, no clinical illness was observed. On Farm II, several calves in all three groups were treated with antibiotics for pneumonia and two calves were treated repeatedly. At the end of the experimental period (56 days) these two calves were housed due to poor performance. Data from the two calves were not included in the analysis. On both farms, dermatomycosis (ringworm) was observed on about 50% of all calves. Condition score was 3 for 75–85% of all animals. In general, all calves were clean. On Farm

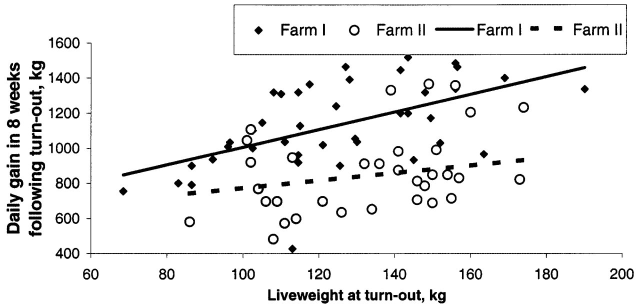

Fig. 2. Relation between liveweight at turn-out and daily gain in the 8 week period following turn-out (Farm I and II).

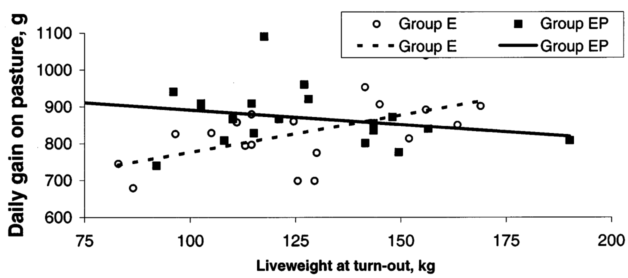

Fig. 3. Interactions between liveweight at turn-out and feeding in relation to daily gain in the whole grazing period (Farm I).

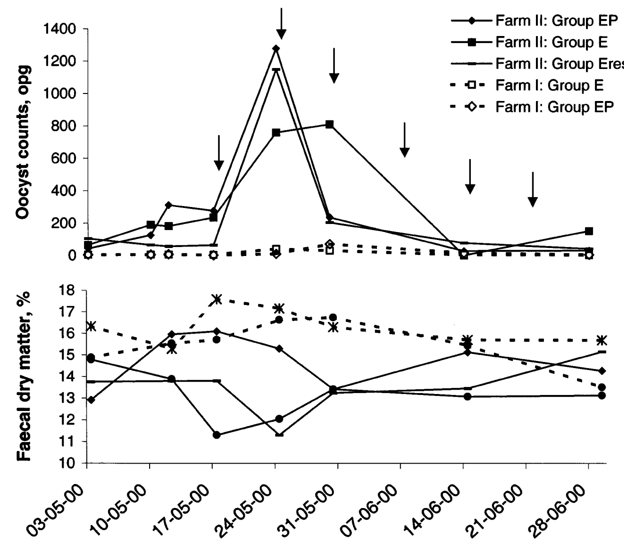

Fig. 4. Mean faecal dry matter and oocyst counts (geometric mean) in calves grazing clover grass pastures and supplemented with energy (E and Eres) or energy and protein (EP) for 8 weeks following turn-out. Arrows indicate pasture rotation between the groups.

II, more calves in group EP had a good brightness of coat (7/12) compared to group E and Eres (2–3/12).

On Farm I, 40% of all calves excreted oocysts at turn-out. The number of calves with oocyst excretion peaked after 3–4 weeks on pasture with 60–70% of all calves infected. At the end of the experiment 20–30% of the calves excreted oocysts. On Farm II, 75 to 100% of all calves excreted oocysts at turn-out. This infection rate was stable during the experimental period. The geometric mean oocyst count was low at turn-out and peaked at 1043 opg 3 weeks following turn-out (Fig. 4). On both farms there was no statistical difference between the two groups either on prevalence, number of animals with a moderate (> 1000 opg) or heavy excretion (> 5000 opg) or on the geometric mean of opg. On Farm I, after 3–4 weeks the geometric mean peaked for both groups, but generally counts were very low (Fig. 4).

All calves had a mixed infection in relation to species. At turn-out *Eimeria alabamensis* was identified in 0/8 and 4/12 calves on Farm I and II respectively, increasing to 2/8 and 8/13 on day 10 following turn-out. Other species identified are shown in Figs. 5 and 6. There were no differences between dietary treatment groups in species distribution. Additionally *E. subspherica*, *E. cylindrical*, *E. pellita*, *E. burkidnonensis* and *E. canadensis* were identified occasionally.

Nematode infections were low on both farms, and on Farm II group mean FECs never exceeded 117 ± 128 epg in the whole grazing season. On Farm I there was no nematode egg excretion during the 8 weeks following turn-out. The mean FDM following turn-out was in the range of 14–17% (Farm I) (Fig. 4). There was no difference between the 2 groups. On Farm II group E and Eres had generally lower mean FDM (13.8% and 12.6% respectively) than group EP (16.0%) in the period 10–21 days following turn-out ($P < 0.05$–0.01) (Fig. 4).

Table 4. Estimates (lsmeans) for daily gain (g/day) in the experimental period (Farm I and II) and for the whole grazing period (Farm I)

	Calves < 130 kg	Calves ≥ 130 kg	Period	Probabilities
Farm I	1049	1263	Experimental period	< 0.01
Farm II	735	903	Experimental period	< 0.05
Farm I:				
Group E	788	892	Whole grazing period	< 0.01
Group EP	895**	827	Whole grazing period	NS

** Estimates are significantly different from group E, calves < 130 kg at a 1% level.

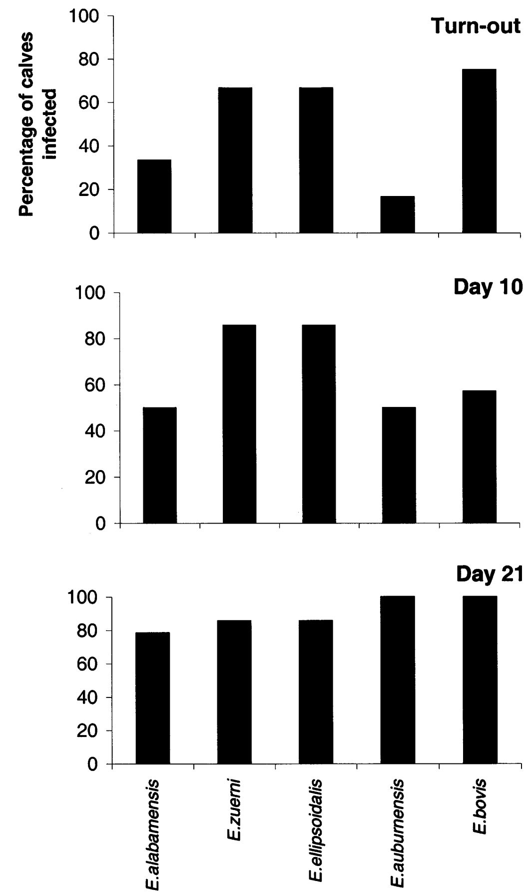

Fig. 5. Eimeria species identified in calves at turn-out, day 10 and day 21 following turn-out irrespective of treatment (4–5 samples per day per group) (Farm II).

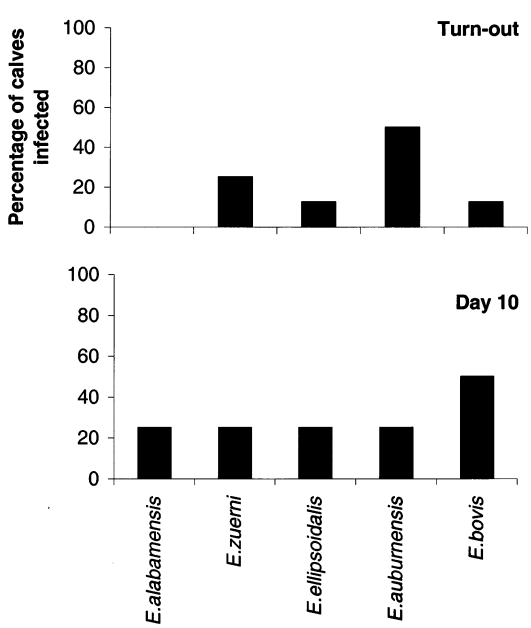

Fig. 6. Eimeria species identified in calves at turn-out and day 10 following turn-out irrespective of treatment (Farm I) (4 samples per day per group).

On Farm II a correlation between oocyst counts and daily gain (week 0–8) was found. Calves with oocyst counts above 5000 opg at least once during the period with supplemental feeding had reduced daily gain of 222 g/day ($P < 0.05$) (707 g/day) compared to calves with an opg below 5000 (929 g/day) during the whole period with supplemental feeding. On Farm II, 19 calves had above 5000 opg during the period. Additionally, low FDM ($< 11\%$) at least once in the period was associated with reduced daily gain of 40 g/day (885 and 845 g/day (lsmeans)) ($P < 0.05$). On Farm I there was no correlation between FDM or opg and daily gain.

Discussion

Effect of energy and protein on weight gain

Supplementation of calves on clover grass pasture with commercial concentrates (2% DM of LW and 18% CP of DM) resulted in an increase in daily gain of 1% and 49% compared to supplementation with barley (10–11% CP of DM) alone on Farm I and II respectively. The effect on increased weight gain could be attributed to improved protein and/or energy supply. The commercial concentrate had slightly higher energy content than barley, resulting in an increased energy intake in group EP. This increase in energy intake would, according to AFRC (1993) give an extra daily gain of 243 g/day on Farm I, slightly more than the measured difference between groups of 174 g/day. In the present experiment, it was not possible to decide whether differences in energy or the combination of energy and protein are the reasons for the improved weight gain. Other feeding experiments with somewhat heavier implanted calves (anabolic steroids) (about 200 kg liveweight) on pasture supplemented with slowly degraded protein based on blood meal demonstrated an improvement of weight gain of 17–25% compared to supplementation with energy or protein alone (Goetsch et al., 1990). These results are not, however, directly applicable to an organic farming context, as protein supplementation often gives greater responses with implanted cattle than with unimplanted cattle (Goetsch et al., 1990).

As with Farm I, differences in weight gain between group EP and E on Farm II can be partly explained by differences in energy intake, but on Farm II feed intake was lower for group E. There is no explanation for this low feed intake, and feed analysis of barley on Farm II was comparable with barley on Farm I. The commercial concentrates were added sugar beet molasses to ensure a high palatability, and high feed intake was observed on both farms.

There was no significant difference in daily gain between group E and Eres on Farm II, suggesting that energy requirements were met from pasture. However, it seemed that group E had a lower daily gain than group Eres that might be due to negative influence on fiber digestion when feeding high amounts of grain to grazing cattle (Galloway et al., 1993). Supplementation of barley in group E exceeded 30% of total diet (DM) but not in group Eres.

Effect of liveweight at turn-out on weight gain

The effect of initial liveweight on daily gain in the grazing season is in agreement with other experiments, where 18 g increase in daily gain was found for a 10 kg increase in initial liveweight (Fox et al., 1991). The response was higher in the present experiment (50 g on Farm I per 10 kg increase in initial liveweight), probably due to a lower weight of the calves. However, daily gain in relation to metabolic liveweight ($LW^{0.75}$) was similar between groups. This is in agreement with the findings from Fox et al. (1991). Supplementing protein and energy in the period following turn-out increases daily gain and reduces the effect of liveweight at turn-out on daily gain for calves with low liveweight at turn-out (< 130 kg) during the whole grazing season (Table 4) (Fig. 2). However, no such interactions were found on Farm II. This is surprising, as daily gain on Farm II was generally lower.

No major weight losses were observed following turn-out to pasture in contrast to what is typically observed about 7–14 days after turn-out (Wright et al., 1986). Supplementation with only small amounts of energy ($\frac{1}{2}$–1 kg/animal/day) may have reduced or avoided weight losses following turn-out in the present experiment. Weight losses following turn-out may generally be small in calves, as the few existing experiments concerning weight loss at this time, show greater relative weight loss with increasing liveweight (Wright et al., 1986; Cazcarra & Petit, 1995).

Farm effect on weight gain

The effect of energy and protein supplementation on weight gain was higher on Farm II compared to Farm I, although the protein content in the herbage was higher on Farm II. In general, daily gain was much lower on Farm II compared to Farm I. Several factors may explain the low daily gain on Farm II, such as low sward height, castration of the calves prior to turn-out, and subclinical coccidia infections. Sward height on Farm II from mid May to the beginning of June was 5–7 cm lower compared to Farm I, and the last 2 weeks of the experimental period, sward height was below 6 cm (Fig. 1). Sward heights below 7 cm are often associated with reduced weight gain and good effects of energy supplementation in older cattle (Steen, 1994). Castration reduces daily gain and protein anabolism, due to a reduction of testosterone production. However, this effect is expected after the onset of puberty at an age of about 6 months (Robelin & Tulloh, 1992). Thus during the experimental period the performance of most of the calves should not have been affected by reduced testosterone caused by castration. It is possible, though, that the imposition of the surgical procedure directly before turn-out could have adversely affected performance. The generally low gain of the calves on Farm II may explain the higher effect of the energy and protein supplementation.

Subclinical coccidiosis

The excretion of oocysts in the present experiment was very low compared to studies in Sweden with 850 000 to several millions opg in clinical infections (Svensson, 1994). In the present experiment, no differences in mean opg between groups were found. However, it is obvious that the calves on Farm II on the pasture grazed by calves the previous year, had a higher infection rate and lower FDM compared to Farm I. Additionally, supplementation with protein and energy had a larger effect on daily gain on Farm II than on Farm I, probably due to subclinical coccidiosis on Farm II. In general, infection with gastrointestinal parasites reduces the nutrient availability to the host, a key feature being an increased endogenous loss of protein (Coop & Holmes, 1996). Protein synthesis is diverted away from the production processes into responses essential for maintenance of homeostasis and repair of the gastrointestinal tract (Coop & Kyriazakis, 1999). These findings are related to helminth infections, and the question arises whether nutrition and coccidie infection interactions are comparable. Sporozoites are released from coccidia oocysts and these invade and develop in the intestine epithelium resulting in damaged cells, and thus it seems probable that protein will be directed to the repair of the intestinal tract and restricted from the production process in the same way as described from helminth infections. The high effect of supplementation with energy and protein on weight gains on Farm II compared to Farm I may be explained by reduced protein availability due to subclinical coccidiosis.

The coccidia oocyst excretion comprised several species and peaked 3–4 weeks following turn-out. During a typical coccidial infection with E. alabamensis observed following turn-out, oocyst counts peaked at day 10 of turn-out (Svensson, 1994). The late peak in the present experiment could be caused by the mixed infection with emphasis on the pathogen species *E. bovis* and *E. zuerni* with a prepatent period of 15–20 days (Marshall et al., 1998). Furthermore, reinfection of the calves with *E. alabamensis* excreted by themselves during their first days on pasture may have caused the infection observed 3 weeks following turn-out.

Optimization at farm level

There was a strong effect of the commercial concentrate on weight gain. The economics of feeding supplements depends primarily on the price of the supplement, the value of the additional gain and the cost of labour to feed the supplement. At present, the supply of organic supplements is low and thus prices are high. In this experiment, there was an additional expenditure of about 0.39 Euro/day for the 3 kg commercial concentrates used compared to feeding with barley, assuming additional expenditures of 2 and 1 Euro/kg gain (Farm I and II respectively). In comparison with present beef prices in Europe of about 2 Euro/kg slaughter weight for EUROPE-classification 4, the typical classification for beef from Holstein Friesian steers, supplementation with commercial concentrates seemed not to be economic.

Secondly, the compensatory effect has to be considered. In the period after supplementation, compensatory growth was observed in the groups supplemented with energy, resulting in a similar liveweight at housing. Whereas the difference between groups was reduced from 9 to 7 kg on Farm I, on Farm II a difference of 17 kg was compensated for at housing. However, on both farms daily gain during the whole grazing period was highest for the calves fed energy and protein following turn-out. Thus although commercial concentrates result in increased weight gain, at the end of the grazing season and in relation to the additional expenditure, the overall benefit from supplementation with commercial concentrates compared to barley seem to be small. In the present experiment, the calves on the two farms irrespective of group had acceptable daily gains, but farms having calves with low daily gain or turning out at light weights may gain more benefit from using commercial concentrates.

Protein utilization in organic farming

As discussed previously, the use of local organic concentrates and protein sources such as rape seed cake and peas and only small amounts of soybean and fishmeal seem to have similar effects on weight gain as supplementation with conventional protein sources. Although protein degradability is higher in rape seed cake and peas, the high daily gain of the calves suggest a high protein supply and improved protein utilization. The high level of roughage in the feed ration on organic dairy farms probably has positive effects on rumen metabolism. Turn-out of dairy calves at an age of 3 months may have similar positive effects on microbial growth. Although ryegrass/clover pastures have a high content of degradable protein, excessive ammonia absorption and urinary loss may be smaller than expected due to improved protein utilization. This area is insufficiently examined, and more focus should given to protein supply and utilization of ryegrass/clover pastures in organic dairy production.

Conclusion

Supplementation with organic commercial concentrates rich in energy and protein primarily based on local protein sources to young calves grazing ryegrass/clover pastures increased liveweight gain by 17–49% compared to supplementation with barley alone. However, the overall gain at the end of the grazing season seems to be limited and differences in liveweight up to 17 kg at the end of the supplementation period were compensated for at housing. On organic farms, more focus should be on subclinical coccidiosis, and the repeated use of pastures for calves in consecutive seasons should be avoided.

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