Grazing enhances immune parameters and complete blood count in calves

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Three genotypes in pasture trials. Photo: Geoffrey Mesbahi, FiBL

Summary

Seventy-two calves, distributed into three genotypes (Brown Swiss [BS], Limousin × Brown Swiss [LB] and Swiss Fleckvieh [SF]), were used in an extensive fattening trial from the fourth to the sixth month of life. Each farm included six calves of each genotype. The farm in Frick AG, where calves were kept in a barn, served as the control group, while the other three sites provided grazing access (Wülflingen ZH, Früebüel on the Zugerberg and Alp Weissenstein on the Albula Pass). Grazing time was approximately 8–9 hours per day. In the barn, all calves were fed the same hay ad libitum. The grazing calves also received 0.5 kg of alfalfa and 1.3 kg of maize pellets per animal per day, plus an additional 0.5 kg of concentrates in the last four weeks. The calves at the Frick site received 1 kg of alfalfa and 2 kg of corn pellets per animal per day, plus 1.3 kg of concentrates per day in the last 6 weeks and 4 kg of fresh grass silage per animal per day in the last month of fattening. Blood samples were taken one week before slaughter on the 180th day of life, and at slaughter. Haemoglobin, haematocrit, erythrocytes, leukocytes and other blood count parameters as well as total protein and immunoglobulins were analysed in the blood, and lactate and cortisol were analysed in the blood from the slaughter. The farm elevation positively influenced haemoglobin, haematocrit and erythrocytes. α- and γ-globulins were higher in the groups with grazing access, especially at the high-elevation extensive sites. Overall, calves of the SF breed performed better than BS; LB were in the middle of the range.

Keywords: male dairy calves, mountain pasture, immune system, red blood cells, animal health.

Introduction

The ethical and sustainable rearing of male calves from dairy herds in organic farming remains an unsolved problem. Most calves from dairy herds in Switzerland are separated from their mothers shortly after birth and start their lives in igloos with little opportunity for exercise. This form of husbandry is permitted in Switzerland until the age of eight weeks for both organic and non-organic farms (this long period of isolation mainly affects rearing calves). The reason for this is the weak immune system of young animals and the risk of disease, which could be minimised by isolation, despite the lack of scientific evidence (Lorenz, 2021). At 3–4 weeks of age, most male dairy calves – including those from organic farms – are transported to large fattening units, where they have social contact but limited opportunities for outdoor exploration. At these farms, calves require antibiotic treatment at the start of fattening, as maternal passive immunity wanes and their own immune systems remain underdeveloped. These animals also fall ill relatively frequently at later stages, requiring further antibiotic treatment (Rosignoli *et al.*, 2013; Beer *et al.*, 2015). The "Freiluftkalb" (Outdoor-Raised Calf) project, launched by the University of Bern in 2019 in collaboration with 19 IP calf fattening farms, successfully pursued an approach for raising young calves: they were kept in isolation in igloos for three weeks and then in group igloos with covered outdoor lying areas. Antibiotic use was 80 % lower and calf mortality 50 % lower on the experimental farms than on 19 other control farms with indoor housing (Meylan, 2019).

The immune system remains crucial throughout life and must be actively developed and maintained by the calf's own metabolism (Immune system development; Lopez *et al.*, 2020). Therefore, indicators of immunity are important and meaningful in terms of calf health, not only in the first weeks of life but also up to the sixth month of life (Bouda & Jagos, 1984; Brun-Hansen *et al.*, 2006). There are many prerequisites for active immunity, such as good nutrition and a sufficient supply of macronutrients, micronutrients, and antioxidants. The general vitality of the young animal is also one of the conditions for a strong immune system. This study hypothesizes that vitality is positively influenced by an appropriate and varied diet and sufficient incentives for exercise (Earley *et al.*, 2004). Grazing, especially on species-rich pastures (Leiber *et al.*, 2020), is the most obvious combination of species-appropriate, healthy feeding and exercise opportunities. In Switzerland, alpine grazing is generally cited as potentially beneficial for cattle health (Künzi *et al.*, 1988; Ruhland *et al.*, 1999; Leiber *et al.*, 2019). Elevation and species richness of pastures are often positively correlated and thus may have an overall effect. However, there is virtually no literature to date in which these relationships have been investigated and described.

Against this background, the study presented here investigated immunoglobulins and complete blood counts (CBC) in calves raised on pastures at different elevations from the fourth to the sixth month of life. Focusing on acquired immunity in the fourth to sixth months of life, the study was based on the following hypotheses:

1. Grazing has a positive effect on serum-detectable immune parameters and CBC.
2. The combination of species diversity in the pastures and elevation has a positive effect on calf health.
3. The genotype of the calves plays a role in the immune system.

Animals, sites and methods

The experiment was approved by the respective cantonal veterinary offices under number 36486.

Seventy-two calves were studied, distributed in three different genotypes (Brown Swiss [**BS**], Limousin × Brown Swiss [**LB**] and Swiss Fleckvieh [**SF**]). Six calves of each genotype were fattened in the FiBL barn in Frick (FiBL = control group) and at three grazing sites at Strickhof Zurich Wülflingen ZH (**WÜLF**), Früebüel on the Zugerberg (**FRÜE**) and Alp Weissenstein on the Albula Pass (**ALP**). All animals were purchased at 34 ± 9 days of age and initially reared together under the same conditions. At the end of their third month of life, the calves were taken to the four different sites to be fattened and slaughtered at 180 days of age. During the first month of the experiment, all animals had *ad libitum* access to hay and received an average of 2.3 litres of milk replacer per day. The pasture-raised animals also received 0.5 kg of alfalfa and 1.3 kg of corn pellets per animal per day during the three-month fattening period and 0.5 kg of concentrates per calf per day during the last four weeks of the fattening period. On average, they spent about nine hours per day on pasture. The indoor control group received slightly more intensive supplementary feeding with 1 kg of alfalfa and 2 kg of corn pellets per animal per day during the three-month fattening period, 1.3 kg of concentrated feed per calf per day during the last six weeks, and 4 kg of fresh grass silage per animal per day during the last month of fattening.

The three pasture sites differed in terms of elevation and pasture composition (Table 1).
All calves were assessed/examined every two weeks according to a health score sheet (Table 2). The results of the assessment were presented and evaluated as a percentage of abnormal scores within the examination results (Table 3).
Blood samples were taken before the calves were transferred to the test sites and one week before slaughter. The proteins and immunoglobulins were measured in the serum, while CBC was measured in the whole blood. In addition, samples were taken from the blood at slaughter. In the latter, only the cortisol and lactate levels were determined. Since almost no correlation was found between the blood values before and at the end of the grazing period for any characteristic, only the values from the end of the experimental period, shortly before slaughter, were included in the statistical model (Table 4).

Results and discussion

The calves were predominantly healthy, with only a limited nutritional status and a shaggy-dull fur being noticeable in around 20 % and 18 % of the examinations respectively (Table 3); this was significantly more common in Brown Swiss calves than in the other genotypes. Soiling in the tail area, indicating diarrhea, increased with the elevation: FiBL (around 6 %) and Alp (around 20 %) sites were significantly different. Veterinary treatment was least necessary for SF, at around 3 %. Beyond this, there were no differences between sites or genotypes.
The slightly poorer condition of the Brown Swiss calves is reflected in the complete blood count (CBC), but not in the serum immunoglobulins (Table 4). The haematocrit value was within the normal range for all animals (Bouda & Jagos, 1984; Brun-Hansen *et al.*, 2006); but calves raised at 2000 m asl in Alp Weissenstein had significantly greater values.
The haemoglobin concentration was in the lower range of the reference values (Bouda & Jagos, 1984; Brun-Hansen *et al.*, 2006; Idexx, Switzerland 2024), only calves from the Alp were within the range specified for healthy animals. Erythrocyte concentrations showed the same trend (Figure 1; Jezek *et al.*, 2011).
Leukocytes were also affected by the elevation and were generally in the upper range of reference values. Thrombocytes showed no effect of site.
The genotypes showed significant differences in CBC (Table 4): Swiss Fleckvieh calves had the greatest levels of haemoglobin, erythrocytes (Figure 1) and leukocytes, and the lowest platelet concentrations. The MCV (Mean Corpuscular Volume) and MCH (Mean Corpuscular Haemoglobin) values indicate a slightly anaemic situation and iron deficiency for all animals regardless of site (Jezek *et al.*, 2011; Idexx Switzerland, 2024), with the values for Brown Swiss calves being significantly but not decisively better.
The cortisol concentration differed significantly between sites, in the order FiBL > Früebüel > Wülflingen > Alp Weissenstein, indicating differences in the stress levels of the animals at the slaughterhouse. This result is surprising, as it is not related to the (very different) transport times. In contrast, the lactate values clearly reflect the different transport distances to the slaughterhouse.

Table 1 | Description of the pasture sites. Means and standard deviation of the three months.

Variable	WÜLF (n = 44)	FRÜE (n = 49)	ALP (n = 53)
Crude protein (g/kg DM)	159.3 ± 26.4	151.7 ± 26.3	143.7 ± 18.8
Crude ash (g/kg DM)	107 ± 9.9	84.8 ± 12.0	71.9 ± 10.1
Neutral detergent fibre NDF (g/kg DM)	468.1 ± 61.4	427.1 ± 59.2	406.4 ± 53.5
Acid detergent fibre ADF (g/kg DM)	309.3 ± 37.0	298 ± 35.0	268.9 ± 28.5
Dry matter digestibility (%)	69.6 ± 5.2	71.3 ± 4.6	74.1 ± 2.8
Net energy for growth NEV (MJ/kg)	5.5 ± 0.7	5.8 ± 0.6	6.2 ± 0.4
Grass (%)	73.6 ± 15.7	63.8 ± 16.9	62.4 ± 19.0
Legumes (%)	19.4 ± 14.1	17.1 ± 12.0	4.9 ± 4.9
Forbs (%)	7.2 ± 7.5	19.1 ± 11.1	32.8 ± 17.5
Number of species in the pasture	23	33	61
Elevation (m above sea level)	460	980	2000

FiBL: Research Institute of Organic Agriculture; WÜLF: Strickhof site Wülflingen; FRÜE: Strickhof site Früebüel; ALP: Strickhof site Alp Weissenstein; DM: Dry matter

For blood protein and α- and γ-immunoglobulins, the values of the animals fed in the barn were always the lowest (Table 4). The variation in γ-globulin concentration (Figure 2) corresponds very well with the values from a broad study of grazing young beef cattle in France (Rosignoli *et al.*, 2013) and clearly indicates a positive grazing effect. The two more extensive and higher-elevation sites, Früebüel and Alp Weissenstein, performed particularly well in this respect. It is not possible to conclude definitively whether the botanical species in the pasture may have played a role (Galvan *et al.*, 2021) or whether there were indirect effects of elevation on haemoglobin and erythrocytes (Sarkozy *et al.*, 1985); both are possible. The BS calves had an advantage in terms of β-globulin, while the SF calves had an advantage in terms of γ-globulin. In general, serum immunoglobulin concentrations were within the normal range of reference values (Bouda & Jagos, 1984; Bieber *et al.*, 2022; Idexx Switzerland, 2024).

In summary, grazing had a clearly positive effect on immunoglobulins, and the elevation improved the CBC values, which were generally poor.

In terms of genotype, there was an advantage for SF calves, both in terms of CBC values and immunoglobulins.

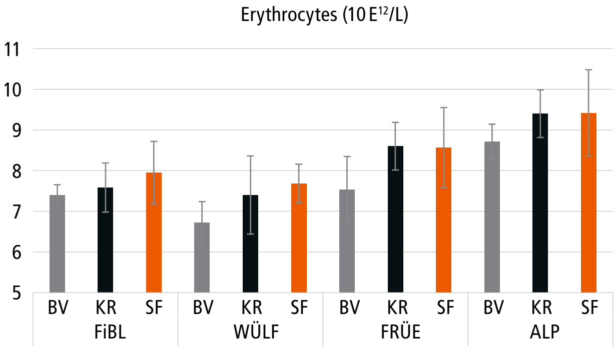

Figure 1 | Erythrocyte counts in whole blood by site and genotype.

FiBL: Research Institute of Organic Agriculture (350 m above sea level); WÜLF: Strickhof, Wülflingen site (460 m above sea level); FRÜE: Strickhof, Früebüel site (980 m above sea level); ALP: Strickhof, Alp Weissenstein site (2000 m above sea level); BS: Brown Swiss; LB: Limousin × Brown Swiss; SF: Swiss Fleckvieh

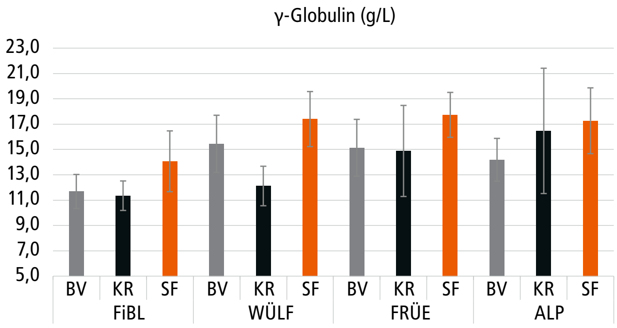

Figure 2 | γ-globulin concentration in serum by site and genotype.

FiBL: Research Institute of Organic Agriculture (350 m above sea level); WÜLF: Strickhof, Wülflingen site (460 m above sea level); FRÜE: Strickhof, Früebüel site (980 m above sea level); ALP: Strickhof, Alp Weissenstein site (2000 m above sea level); BS: Brown Swiss; LB: Limousin × Brown Swiss; SF: Swiss Fleckvieh

Table 2 | Scheme of health assessment for clinical health scores

Category	Parameter	Scores and definitions
General condition	Vitality	1 Lively, agile, alert calf 2 calf that is unresponsive or unable to stand; and/or with a curved back or clearly drooping ears
	Fur	1 Smooth, shiny 2 shaggy and dull – at least half of the thorax
Nutritional status	Body condition	1 Good to very good: ribs and spinous processes not visible and hip bones rounded. 2 Moderate to thin. **Moderate:** ribs and spinous processes visible and hip bones angular; or **thin:** sharp ribs and prominent spinous processes, weak musculature: long back muscle behind the shoulder poorly developed, additionally clearly visible tail base without fat cover, poorly developed musculature on the hindquarters
Diarrhea	Soiling around the tail	1 Area around the tail clean or slightly soiled, i.e. maximum soiling the size of a human palm. 2 Fur around the tail soiled/sticky with faeces over an area larger than the palm of a hand
Respiratory problems	Cough	1 No cough 2 Occasional or repeated coughing
	Nasal discharge	1 No nasal discharge 2 Clear, dripping discharge or any cloudy or purulent discharge
	Eye discharge	1 No eye discharge 2 Visible eye discharge (at least 1 cm long) or crusting (wet or dry, at least 0.5 cm long)
	Breathing	1 Normal 2 forced breathing

modified according to Bieber *et al.* 2022, based on assessment systems by Aly *et al.* (2014) and Buczinski *et al.* (2018)

Table 3 | Proportion of calves with abnormalities in health assessment and proportion of calves receiving antibiotic and conventional medical treatment by site and genotype (percentage of cases)

Parameters	Site[2]				Genotype[3]			*p*-values[1]			
	FiBL	WÜLF	FRÜE	ALP	BS	SF	LB	Site	Genotype	S × G	Age
Number of observations	126	126	108	108	156	156	156				
Impaired vitality [%]	0	0	0.9	2.8	1.3	0.6	0.6	n.s.[1]	n.s.	n.s.	n.s.
Shaggy-dull fur [%]	13.5	19.0	13.0	18.5	27.6^{a}	7.7^{b}	12.8^{ab}	n.s.	< 0.01	n.s.	< 0.05
Moderate nutritional status [%]	15.1	22.2	21.3	16.7	44.2^{a}	11.5^{b}	0.6^{b}	n.s.	< 0.05	n.s.	n.s.
Soiling around the tail [%]	5.6^{a}	11.9^{ab}	16.7^{ab}	20.4^{b}	12.8	10.9	16.0	< 0.05	n.s.	n.s.	< 0.01
Cough [%]	4.0	3.2	2.8	3.7	5.8	2.6	1.9	n.s.	n.s.	n.s.	n.s.
Nasal discharge [%]	18.3	33.3	18.5	24.1	25.6	18.6	26.9	n.s.	n.s.	n.s.	n.s.
Eye discharge [%]	15.1	14.3	9.3	13.9	13.5	13.5	12.8	n.s.	n.s.	n.s.	n.s.
Forced breathing [%]	0	0	0	5.6	0.6	1.9	1.3	n.s.	n.s.	n.s.	n.s.
Antibiotic treatments [%]	1.6	0	0	9.3	3.8	0.6	3.2	n.s.	n.s.	n.s.	n.s.
Veterinary treatment [%]	10.3	1.6	1.9	11.1	9.0^{a}	3.2^{b}	6.4^{ab}	n.s.	< 0.05	n.s.	< 0.05

Values with different lowercase letters within the site or genotype differ significantly from each other in the post-hoc test.
[1] n.s. = not significant
[2] FiBL: Research Institute of Organic Agriculture; WÜLF: Strickhof, site Wülflingen; FRÜE: Strickhof, site Früebüel; ALP: Strickhof, site Alp Weissenstein
[3] BS: Brown Swiss, SF: Swiss Fleckvieh; LB: Limousin × Brown Swiss

Table 4 | Red blood cell counts and immunoglobulins in the serum of male calves aged six months (N = 6 per interaction)

	Site[1]				Genotype[2]				*p*-values				
	FiBL	WÜLF	FRÜE	ALP	BS	SF	KR	S.E.M.	Site	Genotype	S × G	Age[3]	Coeff[4]
Full blood													
Haematocrit [%]	26,1^{bc}	24,7^{c}	27,5^{b}	30,9^{a}	26,8	27,5	27,6	0,96	< 0,001	n.s.	n.s.	n.s.	
Haemoglobin [mmol/L]	5,72^{b}	5,32^{c}	5,98^{b}	6,54^{a}	5,71^{b}	5,98^{a}	5,97^{ab}	0,158	< 0,001	< 0,05	n.s.	n.s.	
Erythrocytes [10^{12}/L]	7,64^{bc}	7,27^{c}	8,23^{b}	9,18^{a}	7,59^{b}	8,40^{a}	8,25^{a}	0,318	< 0,001	< 0,01	n.s.	n.s.	
Leukocytes [10^{9}/L]	9,36	9,25	10,26	10,87	9,15^{b}	11,02^{a}	9,63^{b}	0,798	< 0,05	< 0,01	n.s.	n.s.	
Thrombocytes [10^{9}/L]	668	760	783	688	736^{ab}	643^{b}	795^{a}	64,5	n.s.	< 0,01	< 0,01	< 0,01	–7,2
MCV [fL]	34,2	34,2	33,1	32,9	34,6^{a}	32,8^{b}	33,4^{ab}	0,77	n.s.	< 0,01	n.s.	n.s.	
MCH [fmol]	0,75	0,74	0,73	0,72	0,75^{a}	0,72^{b}	0,73^{ab}	0,021	n.s.	< 0,05	n.s.	n.s.	
MCHC [mmol/L]	21,9	21,5	22,1	21,8	21,8	21,8	21,9	0,26	n.s.	n.s.	n.s.	n.s.	
Cortisol [µg/dL][5]	2,06^{a}	1,08^{b}	2,64^{a}	0,54^{b}	1,70	1,71	1,38	0,356	< 0,001	n.s.	n.s.	n.s.	
Lactate [mmol/L][5]	3,82^{ab}	2,88^{b}	4,79^{a}	4,27^{a}	3,05^{b}	4,57^{a}	5,26^{a}	0,358	n.s.	< 0,001	n.s.	n.s.	
Serum													
Total protein [g/L]	55,7^{b}	59,8^{ab}	61,6^{a}	60,8^{ab}	58,0^{b}	62,8^{a}	57,6^{b}	2,36	< 0,05	< 0,01	n.s.	< 0,01	0,257
Albumin [g/L]	26,6	27,1	27,1	26,5	25,6^{b}	28,6^{a}	26,3^{b}	1,16	n.s.	< 0,01	n.s.	n.s.	
α1-globulin [g/L]	3,65^{b}	3,92^{ab}	4,25^{a}	4,23^{a}	3,93	3,93	4,18	0,230	< 0,01	n.s.	n.s.	n.s.	
α2-globulin [g/L]	5,57^{b}	6,14^{ab}	6,73^{a}	6,57^{a}	6,20	6,28	6,28	0,350	< 0,001	n.s.	n.s.	n.s.	
β-globulin [g/L]	7,76	7,67	7,78	7,57	8,24^{a}	7,73^{ab}	7,11^{b}	0,462	n.s.	< 0,01	n.s.	< 0,001	0,049
γ-globulin [g/L]	12,4^{b}	15,0^{a}	15,9^{a}	16,0^{a}	14,1^{b}	16,6^{a}	13,7^{b}	1,13	< 0,001	< 0,001	n.s.	n.s.	

[1] FiBL: Research Institute of Organic Agriculture (350 m asl); WÜLF: Strickhof, Wülflingen site (460 m asl); FRÜE: Strickhof, Früebüel site (980 m asl); ALP: Strickhof, Alp Weissenstein site (2000 m asl)
[2] BS: Brown Swiss, SF: Swiss Fleckvieh; LB: Limousin × Brown Swiss
[3] Age at slaughter
[4] Coefficient with age at slaughter in days (range 166–209). Only specified if significant.
[5] In blood samples from slaughter.

Conclusions

Grazing significantly enhances immunoglobulin concentrations in male dairy calves aged 3–6 months. Elevation also plays a positive role, though its effects are particularly pronounced in shaping key parameters of the complete blood count – such as haemoglobin, haematocrit, and red blood cell levels. Among the groups studied, SF calves consistently demonstrated superior performance across multiple blood and serum characteristics. In contrast, purebred Brown Swiss calves exhibited the greatest challenges, both in terms of overall health and blood count metrics.

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