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# Vegetation-type effects on performance and meat quality of growing Engadine and Valaisian Black Nose sheep grazing alpine pastures

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ABSTRACT

Lambs of two Swiss mountain breeds, Engadine Sheep (ES; $n=55$) and Valaisian Black Nose Sheep (VS; $n=55$), were fattened in 2010 and 2011 on one lowland and three alpine pastures. Groups of six to seven lambs per breed were allocated to pastures of a size allowing ad libitum intake on the following four vegetation types: (i) species-poor and nutrient-rich lowland (400 m a.s.l.) ryegrass–clover ley on flat terrain ('lowland-rich'); (ii) alpine, species-rich and nutrient-rich vegetation type on a flat terrain (1950 m; 'alpine-rich'); (iii) alpine, species-rich vegetation type, moderate in nutrients on steep terrain (2150 m; 'alpine-moderate'); and (iv) alpine, species-rich and nutrient-poor vegetation type on steep terrain (2150 m; 'alpine-poor'). Lambs were slaughtered after 9 weeks of grazing in a commercial slaughterhouse. Carcasses were subjected to the Swiss CH-TAX classification grid. Meat quality was analysed on the *Musculus longissimus dorsi* (LD) in the segment of *Musculus longissimus lumborum*. Forage quality varied among vegetation types as anticipated. Across all sites, ES were superior ($P<0.001$) to VS in dressing percentage (43.9 vs. 38.4), carcass weight (18.4 vs. 16.4 kg), meat conformation and fat cover scores, even though daily gains had been lower (105 vs. 122 g/d; $P<0.05$). Meat of ES contained more dry matter, protein, total ash ($P<0.001$) and fat ($P<0.05$). Their meat was darker and more intensive red, had lower cooking losses (23.0 vs. 25.1%) but was less tender (65.6 vs. 58.1 N) compared to VS ($P<0.001$). Vegetation types offering good quality forage (lowland-rich and alpine-rich) enhanced average daily gains, dressing percentage, meat conformation and fat cover scores (mostly $P<0.05$ against alpine-moderate and -poor). Similarly, a higher vegetation quality promoted a higher intramuscular fat and lower cooking losses. Meat from lowland-rich was darkest and had the lowest shear force ($P<0.05$). Almost no breed × site interactions occurred in growth performance as well as carcass and meat quality. It was therefore concluded that both breeds are similarly well adapted to the extensive pasture production system in alpine regions. Still, ES seem to be the more efficient one of the two sheep breeds. The results also indicate that growth performance and meat quality clearly vary between vegetation types in animals grazing alpine pastures.



## 1. Introduction

Summer grazing in alpine regions without use of concentrate is a common production system for sheep in Switzerland (Baur et al., 2007). These often steep and remote grasslands can hardly be utilised other than with herbivore livestock with the purpose to produce milk or

*Abbreviations:* ADF, acid detergent fibre; ADL, acid detergent lignin; CP, crude protein; DM, dry matter; ES, Engadine Sheep; LD, *Musculus longissimus dorsi*; NDF, neutral detergent fibre; VS, Valaisian Black Nose Sheep

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meat (Alpfutur, 2011). High altitude production systems are characterised by various factors affecting the grazing animal. Climatic conditions in terms of ambient temperature, humidity and solar radiation are harsh (Bianca and Kunz, 1978; Christen et al., 1996). The lower oxygen partial pressure (Hays et al., 1978) may lead to hypoxia before an adaptation has taken place (Bianca and Puhan, 1974). Due to topographical reasons and lower biomass density in mountain regions, there is a need for a higher locomotive activity of the animals during grazing; this is associated with higher energy requirements (Clapperton, 1964; Henning, 1987; Lachica et al., 1997), energy missing for growth performance. The generally lower biomass density and poorer forage quality in alpine regions normally allow no compensatory increases in intake, which could counterbalance the higher maintenance requirements. Thus, growth performance is lower on alpine pastures than that obtained in lowland production systems. In turn, the nutrient density and the sensory meat quality of lambs grazing alpine pastures seem to be higher in comparison to that from lowland pastures (Ådnøy et al., 2005; Fisher et al., 2000). These beneficial meat quality traits may be reversed after an intensive finishing period lasting more than 4 weeks (Lind et al., 2009a). Recently, a label using the alpine origin of the meat as a selling argument was introduced in Switzerland (Alplamm, 2011) in order to compensate for the possible productivity losses by higher prices realised from the specific production quality and, potentially, physico-chemical meat quality. Another important and so far only sparsely investigated factor influencing animal productivity and product quality is the alpine vegetation type. Alpine pastures are highly biodiverse (Keller, 2006; Körner, 1995) and contain on average fewer grasses and legumes but clearly more herbs than lowland pastures (Keller, 2006; Leiber et al., 2005). Early in the alpine grazing season, most plant species are well digestible and resemble lowland species in their energy content (Jayanegara et al., 2011). Later, the forage quality of the alpine vegetation declines more rapidly than that of lowland vegetation, and the extent of this decline is dependent on climatic conditions and plant species composition (Long et al., 1999; Schubiger et al., 1998). Alpine plant species differ largely in nutritional composition (Schubiger et al., 1998) and there are various characteristic alpine vegetation types (Körner, 1995), which also have a different forage potential.

Some studies have already investigated the effect of alpine grazing on different target traits in free-ranging flocks (Steinheim et al., 2005) or in flocks gathered with sheep dogs (Ådnøy et al., 2005). However, free-ranging animals can chose between all accessible vegetation types. It can be expected that the animals' genotype is of great importance in this context as well. Contrasting responses in productive traits of different breeds (Burrow, 2012; Ekiz et al., 2009; Osoro et al., 2002) or genotypes (Williams et al., 2012) to specific site conditions have been reported for sheep and cattle. Breed performance response to alpine vegetation may thus differ due to different production types, mature body weight (Ekiz et al., 2009) and growth potential, but also because of a different ability to cope with the harsh conditions associated with grazing alpine pastures.

The hypotheses tested in the present study were (i) that there are clear differences in growth performance and meat quality between characteristic alpine vegetation types when grazed by lambs, (ii) that even different mountain sheep breeds differ in their growth response and product quality to alpine vegetation, (iii) that there are substantial interactions between alpine vegetation type and sheep breed, which indicate that different sheep breeds are differently suitable for distinct alpine vegetation types, and (iv) that there are differences between lambs grazing high altitude or lowland grasslands. For this purpose, three diverse alpine vegetation types and one species-poor lowland vegetation type were grazed with two mountain sheep breeds. The traits investigated included forage quality, growth and slaughter performance as well as meat quality of the lambs. The robustness of the effects was tested by repeating the study in a second year.

## 2. Materials and methods

### 2.1. Animals, vegetation types and climate

Lambs of two autochthonous Swiss mountain breeds, Engadine Sheep (ES, castrated males) and Valaisian Black Nose Sheep (VS, castrated males and females (4:3) in 2010, castrated males in 2011) grazed in groups of seven per breed ($n=6$ once for ES and for VS each in 2010 due to missing data) on four different vegetation types during summertime in 2010 and 2011. This resulted in eight breed × vegetation type groups tested in a total of 110 lambs. The study sites were part of the ETH research stations Alp Weissenstein (South-east Switzerland, 2000 m a.s.l.) and Chamau (central Switzerland, 400 m a.s.l.). The animals were born between December and March in 2010 and between December and January in 2011. They had been purchased from several farms located in the respective breed-specific areas. In order to diminish initial farm origin differences, lambs grazed together the same ryegrass-red and white clover ley at the research station Chamau for 1 month before the experiment started. During this adaptation period, the health status of the animals was monitored. At the start of the experiment, i.e. after the adaptation period, live weights were $32.7 \pm 3.5$ kg and $30.8 \pm 2.9$ kg for ES and VS in 2010 and $35.1 \pm 4.3$ kg and $37.5 \pm 5.0$ kg in 2011 (means ± standard deviations), respectively. The corresponding initial ages were $26 \pm 2$, $18 \pm 7$, $26 \pm 2$ and $27 \pm 3$ weeks. All animals were treated against parasites and sheared before the experiment started. Lambs were allocated to the groups after balancing for age, initial weights and gender (where applicable).

Three characteristic alpine vegetation types were selected based on the vegetation mapping of the entire grassland part of the 434 ha area of Alp Weissenstein performed by Keller (2006). The detailed species composition of the selected vegetation types is given in Table 1. The first was a herb-dominated alpine pasture, nutrient-rich (further on called 'alpine-rich'), on a flat terrain located at 1950 m a.s.l. which is occasionally fertilised with farmyard manure. The second vegetation type was