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# Choosy grazers and plant communities – Interactions between cattle breeds and vegetation in semi-natural pastures

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**Key words:** cattle breeds; plant diversity; forage selection; trampling impact

## Abstract

It is well recognized that domesticated and wild ruminant grazers have an important impact on the composition of grassland vegetation, mainly by forage selection, trampling and defaecation. However, little is known on the effects of genetic diversity, for example differences among breeds of cattle. Cattle breeds differ in terms of robustness, growth rate, weight and probably also in movement and forage selection behaviour, which all could impact vegetation composition. Our study therefore aimed at identifying breed-specific differences in forage selection and behaviour and its consequences for vegetation. In a controlled experiment on semi-natural pastures in the Swiss Alps, suckler cows of three cattle breeds (high-yielding Angus×Holstein crossbreeds, dual-purpose Original Braunvieh and slow-growing Highland cattle) grazed a series of adjacent paddocks. Plant species selection of the cattle was quantified by assessing biomass proportions of all plant species in vegetation subplots before and after pasturing. Movement behaviour was monitored using GPS sensors and pedometers. To assess long-term effects of cattle breeds on vegetation, we recorded vegetation composition in 50 paired pastures in mountain areas of Switzerland and in southern Germany, which were either grazed by Highland cattle or a production-oriented cattle breed. Low-productive Highland cattle selected plant species less strictly than the two higher-yielding breeds. They also exerted less physical pressure on the vegetation, because they were substantially lighter, but had relatively large claws. Highland cattle moved less actively, likely because of less selective foraging. These differences showed a strong correlation with differences in pasture vegetation, namely a smaller number of indicator plants for grazing and trampling tolerance on pastures of Highland cattle. Moreover, plant species richness was significantly increased by pasturing with Highland cattle, suggesting a high potential of robust breeds for sustaining or even increasing the diversity of species-rich pastures.

## Introduction

The species richness of semi-natural pastures in European mountain areas, formed by grazing livestock over centuries, is endangered by structural changes in agriculture: Mountain farms have changed from subsistence smallholder farming to professional, specialised dairy or meat producers. Increased mobility and diverse job opportunities strongly reduced the number of employees in agriculture. At the same time, human artificial selection formed cattle breeds with increased milk or meat production and these high-productive breeds account for a majority of cattle today. However, elevated productivity came along with increased requirements, for example high nutritive demands. As a consequence of these agricultural changes, high-productive cattle are reared on the agriculturally best pastures, whereas nutrient-poor, marginal grasslands are underused. Both intensification and abandonment reduce the biodiversity of marginal pastures (Peter et al., 2009; Strebel and Bühler, 2015; Zehnder et al., 2020). However, besides high-productive modern cattle, there are traditional breeds almost untouched by output-oriented breeding and, thus, less productive and less demanding. Apart from breeding aims easy to quantify, such as milk and meat yield, little attention was paid to breed characteristics which possibly co-evolved unnoticed during the breeding process, such as anatomy, movement and foraging behaviour. Such unnoticed traits could have a lasting effect on plant species composition of pasture vegetation as they could modify the specific interaction of grazers and vegetation.

We therefore aimed at estimating differences between low- and high-productive cattle breeds, quantifying their long-term impact on pasture vegetation and analysing their suitability for the maintenance of species-rich, marginal grasslands by combining two scientific approaches: (1) a controlled grazing experiment and (2) an observational field study.

## Methods and Study Site

In a controlled grazing experiment, we investigated three cattle breeds, representing different levels of productivity: (i) low-productive Highland cattle, (ii) traditional, dual-purpose Original Braunvieh and (iii) high-productive Angus×Holstein crossbreed (Pauler et al., 2020a, 2020b). The cattle simultaneously grazed three types of heterogeneous subalpine pastures in the Swiss Alps (2026 m asl.) in a Latin-square design. Individual body weight and claw base area of nine cows per breed were measured. To analyse movement behaviour, we recorded movement intensity and space use evenness using GPS tracking and pedometers. In addition, we visually observed foraging behaviour by recording plant consumption at species level during foraging and changes in plant species' biomass proportions before and after grazing. Finally, we calculated the forage preference for different plant species and plant traits (Kattge et al., 2020), the quality of the diet selected (Briemle et al., 2002) by each cow using indicator values as well as the evenness of forage selection (Pielou index) and space use (Camargo index).

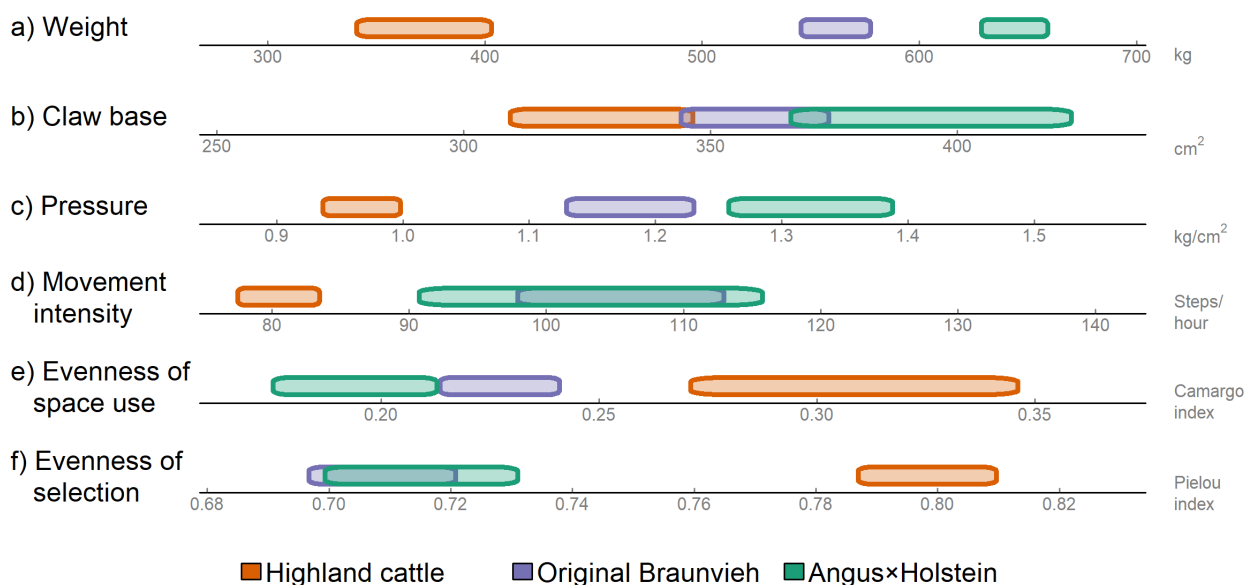
To analyse the long-term effect of grazing with high- or low-productive breeds, we conducted an observational vegetation study along a broad environmental gradient from Southern Germany to the Swiss Alps (Pauler et al., 2019). Thereby, we examined the vegetation composition of highly comparable paired pastures, either grazed low-productive Highland cattle or high-productive breeds for at least five years.

## Results and Discussion

### *Breeds differ in weight, claw size and movement behaviour*

There were consistent differences among breeds in anatomy, movement and foraging behaviour (Figs. 1 and 2). Especially Highland cattle significantly differed from the two more productive breeds, whereas there was only little divergence between Original Braunvieh and Angus×Holstein cattle (Pauler et al., 2020a).

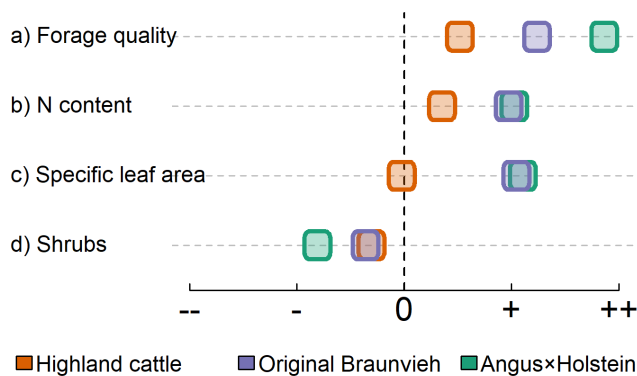
Highland cattle were significantly lighter than the other two breeds (Fig. 1a). On average, Highland cattle weight 358 kg, Original Braunvieh 582 kg and Angus×Holstein 679 kg. Claw base was also smaller in Highland cattle (Fig. 1b); yet, it was relatively large normalized to body weight: On each square centimetre claw base of a Highland cow burdened about one third less body weight than of an Angus×Holstein cow (Fig. 1c). The light body weight on relatively large claws of Highland cattle reduces physical pressure to the vegetation. Moreover, GPS and pedometers indicated that Highland cattle moved least (Fig. 1d), but used the space and the available forage plants most evenly (Figs. 1e and f).



**Figure 1:** Differences of three cattle breeds in pasture-relevant traits: a) body weight in kg, b) base area of all four claws in cm<sup>2</sup>, c) pressure burdening the ground in kg/cm<sup>2</sup>, d) movement intensity in steps per hour, e) evenness of space use calculated as Camargo Index, and g) the evenness of forage selection as Pielou index. Except for movement intensity (6 cows per breed), data are given for 9 cows per breed. Boxes represent the interquartile range covering half the values.

### Breeds differ in forage selection

A closer look on selection evenness reveals that low-productive Highland cattle not only select the forage plant *species* less strictly, but that their choice depends less on forage quality and other plant traits (Fig. 2; Pauler et al., 2020b): Among the three breeds, highland cattle chose the diet of lowest quality. The less productive a breed was, the lower the quality of the selected forage (Fig. 2a). Highland cattle consumed nutrient-poor plant species more frequently than the more productive breeds (Fig. 2b). Moreover, they cared less about the specific leaf area (i.e. a measure of digestibility; Fig. 2c) and avoided shrubs (Fig. 2d) and other unattractive plants least. On the contrary, Original Braunvieh and Angus×Holstein foraged more broad-leafed grasses and legumes. Most importantly, however, Highland cattle were the only breed gaining weight on the low-quality forage of the alpine pastures in the study area, suggesting lower energy demands (less movement, warmer fur) and a more efficient conversion of fibre-rich fodder.

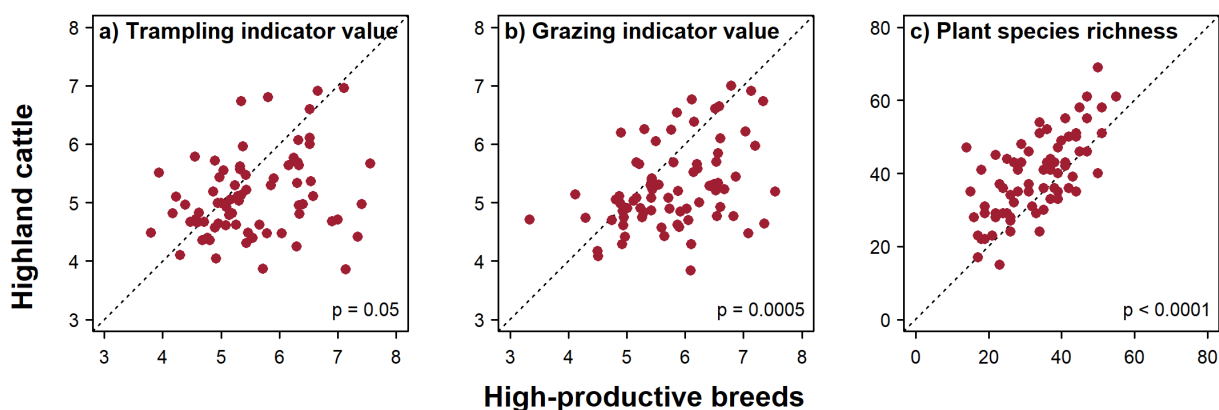


**Figure 2:** Impact of plant traits on the forage selection by three cattle breeds. Boxes indicate the average response of cattle breed's forage decision to the four traits a) forage quality, b) nitrogen content, c) specific leaf area and d) woodiness: Strong (++) or moderate (+) preference, if trait value is elevated; strong (--) or moderate (-) avoidance, if trait value is lower. The central zero-line indicates no influence of a plant trait on forage decision. Analysed were the biomass proportion of all plant species within 165 vegetation sub-plots (3×3 m) before and after grazing by the three cattle breeds.

### Vegetation adapts to differences among breeds

In long-term, pasture vegetation adapts to breed-specific competitive conditions (Fig. 3). Light and broad-footed Highland cattle exert less pressure to the ground. Consequently, there were significantly less trampling-adapted plant species on pastures of Highland cattle. On the pastures of high-productive, heavy breeds, these were more frequent because of a higher competitive advantage (Fig. 3a). Moreover, since Highland cattle were least choosy while foraging, they needed to walk shortest distances, as they just fed on what was in close proximity of their mouth. Thereby, they additionally reduced trampling pressure.

Likewise, differences in forage selection among breeds have a long-term impact on pasture vegetation. The vegetation of pastures grazed over a long period by high-productive breeds showed significantly higher grazing-indicator values than vegetation grazed by Highland cattle (Fig. 3b). Plants adapted to defoliation (e.g. by low forage quality, low specific leaf area, woodiness) were found more frequently on the pastures of high-productive and high-selective cattle. Grazing-adapted plant species benefit from the strict selectivity of high-productive breeds and become dominant.



### ***Low-productive cattle enhance species-richness***

Moreover, the high trampling pressure and selectivity of high-productive breeds decreased plant species richness on pastures (Fig. 3 c; Pauler et al., 2019), because species well adapted to trampling or grazing outcompete less resistant plants. Consequently, the species richness was lower on pastures of high-productive cattle breeds. The longer the pastures of a pair had already been grazed by the respective breeds, the clearer was the contrast. Additionally, vegetation grazed over extended periods by low-productive Highland cattle had a higher share of epizoochoric and a lower abundance of woody species. Both contributed positively to plant species richness.

### **Conclusions**

Besides desired characteristics, modern breeding unintentionally changed hidden traits of cattle anatomy, movement and foraging behaviour. Thereby, breeding modified not only the cattle themselves, but also the vegetation grazed by these animals. The differences found in the vegetation grazed by either low- or high-productive cattle can consistently be explained by the differences in cattle traits.

Today, semi-natural low-input pastures are endangered, but low-productive cattle contribute to maintain or even promote the biodiversity of these habitats. Low-productive breeds can be a worthwhile addition to more intensive livestock, e.g., for using and managing ecologically valuable land. However, desirable traits of low-productive cattle breeds may be lost when breeding is geared towards higher output. It is thus recommended to preserve their low productivity as a specific trait.

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