

Counteracting green alder shrub expansion by low-input grazing

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Abstract

In the past decades, the decline of traditional agriculture has caused an abandonment of marginal pastures in many mountain areas of Europe. In the Swiss Alps, green alder (*Alnus viridis*) is the most abundant successional shrub. A survey of 24 pasture-shrub gradients showed that the encroachment by green alder, in contrast to other shrubs, is associated with a substantial decline in plant species richness. The understorey of alder is primarily populated by very few, broad-leaved herbaceous species benefitting from the atmospheric nitrogen fixed by actinomycetes in symbiosis with green alder. However, the understorey vegetation also provides an underestimated forage, rich in protein and comparable in productivity and digestibility to nearby open pastures. A two-year grazing experiment with cattle (Dexter), sheep (local Engadine sheep) and mixed-breed goats in the Eastern Swiss Alps demonstrated that robust breeds were able to exploit these resources as they readily penetrated the thickets. The Engadine sheep and the goats consumed green alder bark and thus actively counteracted shrub encroachment. Dexter cattle did not forage on alder bark but on leaves and opened the thickets by their movement through them. Since goats preferred other woody species to green alder and depleted them before the alder, they may impair the regeneration of late-successional forest. Dexter heifers and Engadine lambs performed equally well on pastures with high shrub cover and on open pastures in terms of average daily weight gain, carcass and meat quality. This was facilitated by the comparatively low productivity of these breeds. In this way, low-input grazing systems utilizing adapted breeds, especially sheep, can add to conservation goals and sustain a viable meat production in marginal areas.

Introduction

Farming in European mountain regions has considerably changed during recent decades. Emigration and increased employment outside the agricultural sector have strongly decreased labour availability. Consequently, land use was intensified on fertile land accessible by machinery, while low-productive and remote areas were increasingly abandoned (Strebel and Bühler 2013). In addition, there were shifts in livestock systems from intensive milk to extensive meat production, for example from dairy cows to suckler beef cattle or from dairy goats to sheep lambs (Herzog and Seidl 2018). Reduction of farming activities has led to an increase in reforestation and shrub encroachment, primarily in abandoned pastures. In the Swiss Alps, the shrubland area increased by 18% between 1995 and 2017 (Brändli *et al.*, 2020). In the Alps, 70% of all shrublands are dominated by green alder (*Alnus viridis* (Chaix) DC.), a pioneer species which takes advantage

of atmospheric nitrogen fixed by the symbiotic actinomycete *Frankia alnii*. The fixed nitrogen is eventually released into nutrient-poor ecosystems, eutrophication surrounding soils and streams (Bühlmann *et al.*, 2016). Due to the high nitrogen availability, the understorey vegetation of green alder is dominated by a few broad-leaved herbs such as *Adenostyles alliariae* L. and *Peucedanum ostruthium* L. (Zehnder *et al.*, 2020). Hence, the encroachment with green alder threatens the rich biodiversity and the aesthetic value of mountain pastures. Moreover, the shrub impairs animal movement and the utilisation of the remaining open areas. We therefore aimed to develop and test strategies to stop or even reverse alder encroachment on species-rich mountain pastures while maintaining a viable meat production.

Materials and Methods

A grazing experiment was set up using Dexter cattle, Engadine sheep and mixed-breed goats

on two neighbouring areas on both sides of the Albula pass (Canton of Grisons, Switzerland, 46° 34' N, 9° 50' E) at an elevation of 1900-2200 m a.s.l. All chosen breeds were of low productivity and adapted to roam steep terrain and to feed on low-quality forage. Dexter cattle (heifers of 1-2 years) and local Engadine sheep (ewes and their lambs) were evenly split into four groups each. The groups were assigned to pastures with different degrees of shrub encroachment ranging from 0% to 80% cover of green alder. In addition, a group of mixed-breed goats grazed paddocks with the highest alder cover. Each group grazed three different paddocks with similar shrub cover twice. To assess the interaction of grazing animals and the pasture, we measured various parameters: (1) Forage biomass was sampled from grazing exclusion cages (1.2 × 1.2 m) placed in different vegetation types classified according to Dietl *et al.*, (2002). Digestibility of organic matter was analysed *in vitro* according to Tilley and Terry (1963). (2) Movement of selected animals was monitored by GPS trackers at a frequency of 10s using the methodology of Homburger *et al.*, (2015). (3) After each rotation, areas encroached by green alder were systematically searched for signs of bark removal. The proportion of damaged branches was quantified and their location recorded. (4) Before the experiment and after each rotation the animals were weighed to quantify daily gains in body weight. (5) After grazing the experimental pastures for eight weeks, the animals were slaughtered and their carcass and meat quality was assessed. Significance of differences was tested by pairwise comparison with Tukey contrasts.

Results and discussion

Green alder stands are an underestimated forage resource

Because of the high elevation, annual biomass yield was low, but differed significantly among vegetation types (Table 1). The highest mean yields of 2.3 t/ha were measured in fertile pastures and nitrophilous areas, and these were higher ($P < 0.05$) than the average of 0.9 t/ha in the nutrient-poor pastures. The understorey vegetation of green alder produced 1.5 t/ha on average. In addition, measurements by Wiedmer and Senn-Irlet (2006) indicated an annual production of around 3.8 t of alder leaves and 1 t/ha of bark. There was no significant difference in *in vitro* digestibility between the understorey vegetation of green alder and the vegetation of open pastures. The digestibility of alder leaves was slightly lower ($P < 0.05$) than for nutrient-poor pastures and understorey vegetation. The bark, however, was substantially less ($P < 0.05$) digestible than herbs and alder leaves. The crude protein content was higher ($P < 0.05$) in the understorey vegetation of green alder and in alder leaves than in the other vegetation types and in the bark. This is explained by the additional input of symbiotically fixed nitrogen provided by green alder (Bühlmann *et al.*, 2016). Commonly, green alder and its associated vegetation are assumed to be of low forage quality. However, the high digestibility and protein content combined with the relatively high productivity of the understorey show that this vegetation type provides an underestimated forage resource for adapted low-productive ruminants.

Table 1: Annual biomass yield, *in vitro* digestibility of organic matter and crude protein content in the dry matter of different vegetation types and plant parts of green alder (*Alnus viridis*). Shown are mean values \pm one standard deviation. Different letters indicate significant differences of pairwise comparison with Tukey contrasts at 5% level

Vegetation type	Annual yield (t/ha)	Digestibility (g/kg DM)	Crude protein (g/kg DM)
Fertile and nitrophilous pastures	2.25 \pm 0.89 b	487 \pm 114 bc	117 \pm 37 a
Nutrient-poor pastures and wetlands	0.93 \pm 0.52 a	531 \pm 60 c	133 \pm 34 a
Green alder understorey vegetation	1.53 \pm 0.89 ab	559 \pm 75 c	190 \pm 39 b
Green alder leaves	3.8 *	439 \pm 54 b	211 \pm 21 b
Green alder bark	1.04 *	163 \pm 12 a	78.1 \pm 8.8 a

* Estimates measured and published in Wiedmer and Senn-Irlet (2006)

Ruminant species differ in feeding behaviour

All three ruminant species exploited the areas encroached by green alder. Dexter cattle were not hindered in movement by the shrubs but they showed a clear preference for open pastures (Figure 1a). They were observed foraging on understorey vegetation as well as browsing alder leaves and buds. In contrast, Engadine sheep only slightly preferred open pastures to areas encroached by alder (Figure 1b) and frequently foraged some of the plants abundantly available in the alder understorey. In addition to leaves and buds, Engadine sheep also stripped the bark at the basis of green alder branches and consumed

it, especially at the edge of the stand, where the sheep could access the shrubs more easily than in the centre. This resulted in partial damage to many alder plants, since debarked branches lose their transport capacity for assimilates and thus, die back. The goats showed almost no preference for open pastures over closed stands of green alder (Figure 1c). They consumed alder leaves and buds but very rarely alder bark. In contrast, the bark of the few elderberry trees (*Sorbus aucuparia* L.) growing in the alder stands was almost completely stripped. Goats consumed the bark of elderberry immediately when released to the paddocks, whereas they debarked green alder only when very little elderberry was left over.

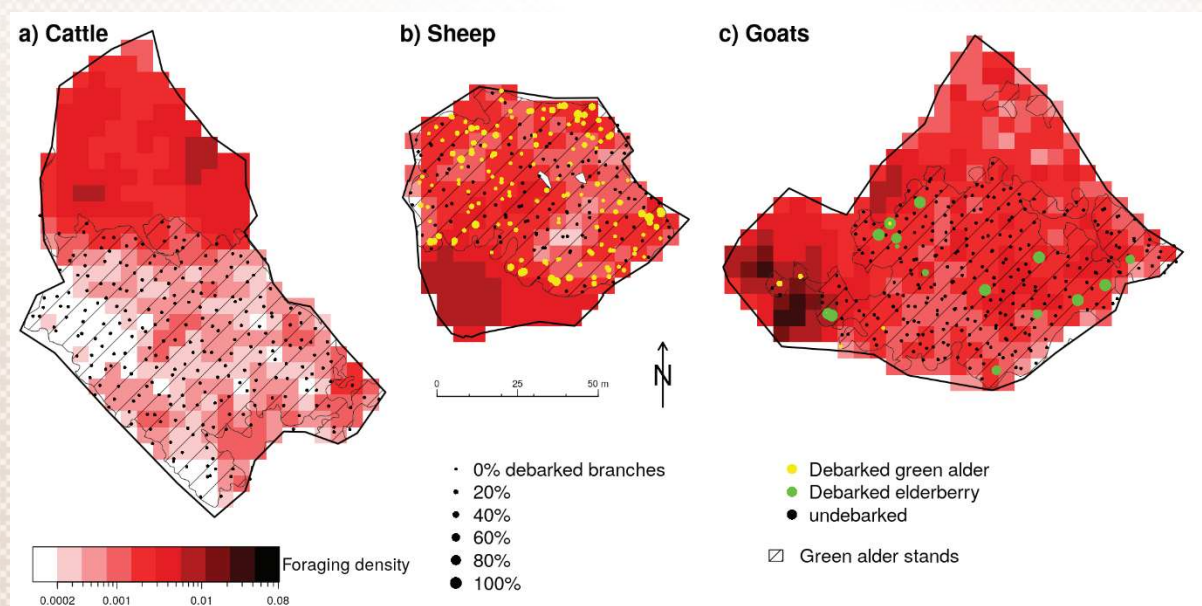


Figure 1: Foraging density (i.e. the relative number of GPS locations classified as foraging per grid cell) and proportion of debarked branches in exemplarily selected paddocks grazed by Dexter cattle (a), Engadine sheep (b) and mixed-breed goats (c). Hatched polygons are areas covered by green alder (*Alnus viridis*). Dots show debarked plants of green alder or elderberry (*Sorbus aucuparia*) as well as unbarked plants. Dot size is scaled by the proportion of branches with removed bark

Grazing of green alder areas did not impair animal performance

The cover of green alder on pastures did not affect the average daily weight gain of the Dexter heifers and Engadine lambs (Table 2). Weight gain was positive in all groups and there were no significant differences attributable to shrub cover. For Dexter cattle, the lowest weight gains were observed in the group grazing pastures with a cover of green alder of around 80%. In contrast, the weight gain of Engadine lambs increased with the areal share covered by green alder. This may be due to a higher preference of this sheep breed for alder leaves and understorey vegetation.

Likewise, the dressing percentage of the animals (i.e., proportion of carcass after removal of blood, viscera, skin, head and feet to live weight) did not decrease with increasing cover of green alder (Zehnder *et al.*, 2016). Engadine sheep even had a higher dressing percentage in pastures with medium and high covers of green alder than on open grassland. Pasture type did also not have an influence on the shear force of the meat, a measure of tenderness (Zehnder *et al.*, 2016). Hence, the substantial biomass available in the alder stands and the high digestibility and protein content of the understorey vegetation and of the alder leaves (Table 1) provided an adequate nutrient supply for the investigated robust livestock breeds.

Table 2: Average daily weight gain (g/d) \pm standard error of Dexter cattle and Engadine lambs grazing areas with different degrees of green alder cover. No significant differences at $P < 0.05$ were found

Cover of green alder	Dexter cattle	Engadine lambs
None (0%)	186 \pm 42 a	104 \pm 14 a
Low (20%)	242 \pm 42 a	92 \pm 12 a
Medium (60%)	201 \pm 40 a	132 \pm 15 a
High (80%)	127 \pm 39 a	131 \pm 15 a

Conclusions and implications

The forage provided by green alder stands is generally underrated in the nutrition of adapted low-productive ruminants. The present study demonstrated that the abundant understorey vegetation as well as alder leaves have relatively high yields with high estimated digestibility and crude protein content. Consequently, all investigated breeds of different ruminant species exploited green alder stands, as revealed by GPS tracking. However, the breeds differed in their preference of understorey vegetation and alder parts. This has important implications for practical use: Dexter cattle have the smallest direct impact on alder, but they exploit the understorey vegetation and can open up green alder areas for

other types of animals. Engadine sheep actively counteract alder expansion by consuming its bark. Hence, they provide an attractive option for regaining open pastures, but they mainly stay within the edge of dense alder stands. Since goats prefer other woody species to green alder and deplete them first, they must be kept under high grazing pressure to drive back alder shrubs. Otherwise, they may only hinder the regeneration of late-successional forest. Finally, the study demonstrated that growth performance, carcass and meat quality are not impaired in animals grazing green alder pastures.

In contrast to previous assumptions by practitioners and scientists, green alder stands are a forage resource in marginal mountain areas, at least when exploited by low-productive breeds. Therefore, using green alder and its understorey as forage for robust livestock breeds has a double positive effect: The grazing animals sustainably produce organic meat on areas otherwise abandoned and, in this way, maintain or restore valuable species-rich grassland.

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