Agriculture, Ecosystems and Environment 128 (2008) 59–67

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Vegetation dynamics and livestock performance in system-scale studies of sheep and cattle grazing on degraded upland wet heath

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ARTICLE INFO

Article history:
Received 8 January 2008
Received in revised form 30 April 2008
Accepted 5 May 2008
Available online 12 June 2008

Keywords:
Calluna vulgaris
Habitat restoration
Liveweight gain
Molinia caerulea
Rangeland

ABSTRACT

Upland wet heaths in the UK are of international conservation significance but high grazing pressure by sheep has caused widespread degradation. Restoration by reducing sheep numbers is not always successful if competitive grasses such as *Molinia caerulea* become dominant. Cattle can reduce grass biomass but their utility as a conservation tool is also dependent on economic viability. This study assessed the effect of two sheep-only and two mixed cattle-plus-sheep grazing regimes on vegetation and livestock performance over 4 years at a system scale on a 103 ha heterogeneous degraded wet heath. Grazing regimes were sheep all year at 1.5 or 0.66 ewes ha^{-1} with 25% removed in winter, with or without dry Continental cross suckler cows at 0.75 cows ha^{-1} for up to 10 weeks in summer. In mixed grazing paddocks, *M. caerulea* cover declined substantially in vegetation types where it was abundant. *Calluna vulgaris* declined slightly in the mixed grazing paddocks, primarily because of localised trampling. *M. caerulea* increased in the sheep-only paddocks and *C. vulgaris* declined slightly despite low grazing indices. Other changes in plant community composition were minor. Cow daily liveweight gains were adequate to regain body condition prior to calving, but these and ewe mating weights and lamb weaning weights were lower in paddocks with 1.5 than 0.66 ewes ha^{-1}. Ewe and lamb performance were similar in mixed and sheep-only paddocks at each ewe stocking rate. Cows can be grazed with sheep to remove *M. caerulea* biomass without detriment to livestock performance, although the stocking levels used in this study would not be sustainable every year. Despite reduction of *M. caerulea* biomass, there was no evidence that heathland vegetation was being restored after 4 years. Restoration by grazing alone probably requires longer timescales and agri-environment schemes should avoid prescribing stocking levels regardless of livestock species.

1. Introduction

Domestic herbivores have a profound influence on grazed ecosystems (Gordon and Prins, 2008), which in turn are economically important for supporting extensive livestock systems (Gordon et al., 2004). For example, upland heaths in the UK are of international conservation significance (Usher and Thompson, 1993; Thompson et al., 1995). These heaths are traditionally managed by extensive grazing systems that maintain the semi-natural plant communities and provide income to farms in the hills and uplands (Usher and Thompson, 1993). Wet heaths occur on peat up to 0.5 m deep at 250–600 m above sea level and usually contain a mosaic of plant communities characterised by dwarf shrubs, grasses, sedges and bog-mosses (Rodwell, 1991). High grazing pressure due to increasing numbers of sheep in the second half of the 20th century resulted in degradation of upland heaths, with dwarf shrubs and bog-mosses being replaced by competitive grasses (Bardgett et al., 1995).

To counteract these trends, agri-environment schemes were introduced in the UK in the late 1980s to encourage farmers to reduce sheep numbers. Where dwarf shrubs such as *Calluna vulgaris* are still present, their biomass can increase if grazing pressure is reduced (Hulme et al., 2002; Pakeman et al., 2003). However, if the dwarf shrub component is scarce or has been lost completely, reduced stocking results in an increase in competitive grasses such as *Molinia caerulea*, which prevent recolonisation or spread of dwarf shrubs (Adamson et al., 2001; Marrs et al., 2004).

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0167-8809/$ – see front matter
doi:10.1016/j.agee.2008.05.002

Therefore, simply reducing grazing pressure on severely degraded heath is unlikely to result in successful restoration (El Aich and Waterhouse, 1999).

Heavy summer grazing can reduce *M. caerulea* (Grant et al., 1963; Hulme et al., 2002). Since cattle will selectively graze *M. caerulea* in summer (Grant et al., 1996; Mandaluniz et al., 2005), they could aid restoration of degraded wet heath by reducing competition from grasses. Cattle grazing can also increase diversity of species (Pykala, 2005; Scimone et al., 2007) and structure (Pavlů et al., 2007) and cause more disturbance from trampling than sheep, potentially creating bare patches and enhancing seedling germination.

Alteration of grazing regimes for heathland restoration will only be acceptable to farmers if livestock productivity and welfare are not compromised. Managed grazing of *M. caerulea* can potentially provide adequate forage for cattle in summer (Common et al., 1997). However, selective grazing and ranging behaviour of livestock results in spatial variation in grazing pressure at heterogeneous sites (Clarke et al., 1995; Hester and Baillie, 1998; Palmer et al., 2003; Albon et al., 2007; Dumont et al., 2007). Vegetation response to altered grazing regimes also varies amongst locations and vegetation types (Hope et al., 1996; Virtanen et al., 2002; Gordon et al., 2004; Marrs et al., 2004; Vandvik et al., 2005). At a farm system scale therefore, uncontrolled grazing by cattle and sheep at heterogeneous sites is likely to produce varying responses amongst different heathland plant communities.

The aim of this project was to assess the effect of two sheep-only and two mixed sheep-plus-cattle grazing regimes on vegetation and livestock performance when applied to a heterogeneous degraded wet heath. The main goal for restoration was to reduce *M. caerulea* competition to facilitate spread of other heathland species, particularly *C. vulgaris*, whilst maintaining adequate livestock performance. Specifically, progress towards restoration of heathland vegetation was determined by measuring grazing levels on *M. caerulea* and *C. vulgaris* and subsequent changes to plant species cover and frequency among the different vegetation types present.

2. Methods

2.1. Study site and grazing regimes

The study was carried out on 103 ha of degraded wet heath on a gently sloping site at 260–350 m above sea level, on amorphous peat and silty clay loam with impeded drainage over silty or sandy clay loam at the ADAS Redesdale Research Centre, Northumberland, UK (grid. ref. NY 831950). The vegetation most closely resembled the *Scirpus cespitosus–Erica tetralix* (M15) community (Rodwell, 1991), with small scale variation in the relative abundance of species such as *C. vulgaris*, *M. caerulea*, *Juncus* spp., *Nardus stricta*, *Eriophorum vaginatum*, *Carex nigra*, *Deschampsia flexuosa*, *Polytrichum commune*, *Festuca ovina* and *Agrostis capillaris*. The heathland had been degraded in the past by heavy sheep grazing, which increased the local dominance of graminoids such as *M. caerulea* and *Juncus* spp. at the expense of other species.

Table 1
Grazing regimes in the four paddocks

Paddock	Grazing regime (animals ha^{-1})	Area (ha)
Low sheep (LS)	0.66 ewes	26.7
Low sheep plus cows (LSC)	0.66 ewes + 0.75 cows (summer only)	28.6
High sheep (HS)	1.5 ewes	25.5
High sheep plus cows (HSC)	1.5 ewes + 0.75 cows (summer only)	22.0

The area was split (running down- to upslope) into four paddocks each with a different stocking regime. The fenceline between paddocks was adjusted to ensure there were approximately equal areas of the different vegetation types (see below) in each paddock. The low sheep (LS) paddock was grazed by Scottish Blackface sheep at 0.66 ewes ha^{-1}, minus 25% from 1 October to 28 February, and with all ewes removed for 3 weeks in November for mating and April for lambing (Table 1). The low sheep plus cows (LSC) paddock had the LS regime plus non-lactating, autumn calving Simmental × Holstein and Belgium Blue × Holstein mature cows at 0.75 cows ha^{-1} from mid-June each year. The same regimes were applied in the high sheep (HS) and high sheep plus cows (HSC) paddocks respectively, except that sheep were stocked at 1.5 instead of 0.66 ewes ha^{-1}.

The sheep grazing regimes had been applied since 1995 and cows were introduced in 2003. After cows were released in the paddocks the vegetation was checked weekly and cows were removed from both paddocks after the first signs of grazing of *C. vulgaris* by cows in either paddock in mid-summer. This was intended to minimise damage to *C. vulgaris*, since cows remove more of the shoot than sheep. It also mirrored livestock husbandry decisions based on productivity and welfare grounds, since cows only graze *C. vulgaris* when more palatable species are no longer available (Grant et al., 1987). Cows were grazed for 9–10 weeks in the first 2 years but this was truncated to 4 weeks by the fourth year as they started grazing *C. vulgaris* earlier in the season (Table 2). Immediately after removal of cows, the vegetation condition was checked by measuring the length of five randomly selected laminae of *M. caerulea* at each of thirty randomly located points in each paddock.

2.2. Vegetation

A rectangular grid of 196 points at 75 m spacing was superimposed on the site and vegetation recorded at each point from a fixed 1 m × 1 m quadrat subdivided into 100 cells of 10 cm × 10 cm. Percentage top cover was estimated using a sighter with cross-wires in the centre of each cell and recording the plant species, plant litter, bare ground or dung present at the cross-wire intersection. Local frequencies of *M. caerulea* and *C. vulgaris* were calculated as the number of cells per quadrat in which they were present. A grazing index was calculated for both species as the proportion of occupied cells in which grazed shoots

Table 2
Cow grazing periods and mean (standard error in parentheses) *M. caerulea* lamina lengths (cm) at removal date with one-way ANOVA results

Year	On	Off	Weeks	LS	LSC	HS	HSC
2003	10 June	13 August	9	25.4 (1.61)	10.1 (0.81)	23.7 (1.38)	8.1 (0.59)
2004	10 June	17 August	10	25.3 (1.68)	11.1 (1.29)	24.5 (1.87)	11.6 (1.34)
2005	14 June	26 July	6	34.9 (1.47)	8.6 (0.84)	26.3 (1.50)	7.3 (0.56)
2006	14 June	12 July	4	31.2 (1.22)	10.9 (1.06)	25.4 (1.57)	8.3 (0.65)
		$F_{3,116}$		9.75^{***}	1.19ns	0.51ns	5.10^{**}

Paddock codes as Table 1.