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Clonal growth buffers the effect of grazing management on the population growth rate of a perennial grassland herb

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ABSTRACT

Grazing is an important management action to conserve biodiversity in semi-natural grasslands but it is important to understand how grazing influences the life-history components and population dynamics of plant species. In this study, we analysed effects of grazing intensity and abandonment on population dynamics of the semi-natural grassland species *Knautia arvensis* which is an important nectar source for pollinating species and an indicator of biodiversity in agricultural landscapes. We recorded life-history stage, survival, establishment of seedlings and ramets, number of inflorescences and grazing marks on permanently marked individuals in eight populations in mid-Norway for three consecutive years. Matrix modelling was used to estimate population growth rates and elasticities, and life Table response experiments (LTREs) were used to assess the contribution of different life-history components to the observed variation in population growth rates between different management treatments. Generalized linear mixed effects models (GLMMs) were used to investigate the effect of management on vital rates and number of inflorescences as well as damage to *K. arvensis* individuals. Populations in abandoned grasslands had more inflorescences, a lower proportion of seedlings and a higher proportion of flowering ramets compared to populations in grasslands under high grazing intensity. There were no differences in population growth rates between different grazing intensities. Fecundity however, contributed more to the growth rate in grazed grasslands compared to abandoned grasslands where clonal regeneration contributed the most. Survival of non-flowering rosettes made the largest impact to overall growth rates. Our results indicate that a long life-span and clonal growth buffer the effect of environmental change in abandoned grasslands and that there is a trade-off between fertility and clonal regeneration in *K. arvensis* populations.

1. Introduction

Semi-natural grasslands harbour a high diversity of plant species (Marini et al., 2008). However, the area of semi-natural grasslands in Europe has decreased due to agricultural intensification, changed management practices and abandonment (Hodgson et al., 2005; Poschlod and WallisDeVries, 2002). Semi-natural grasslands that have been abandoned or managed at too low intensity to halt successional change will gradually be invaded by shrubs and trees (Wehn, 2009). As a result, growth conditions become less favourable for light-demanding species in particular (Pykala et al., 2005), and populations of such species may rapidly decline once grasslands have been abandoned (Endels et al., 2007b; Hamre et al., 2010).

Extensive grazing is recommended as a management tool to maintain or improve plant population viability in semi-natural grasslands (Metera et al., 2010; Wrage et al., 2011). Herbivory affects plant abundance and distribution as well as plant traits (Louault et al., 2005; Maron and Crone, 2006). Effects of grazing on plant performance are both direct and indirect; indirect through changing the habitat quality by trampling, reducing competition, addition of nutrient and litter accumulation (Brys et al., 2004; Ehrlen et al., 2005) and direct by damaging the plant or reducing flowering and seed set (Knight, 2004). Hence, different levels of grazing intensity can have disparate effects on vital rates and the demographic behaviour of plant populations (Brys et al., 2004; Lennartsson and Oostermeijer, 2001). Vital rates may even differ between populations of a single species, depending on grazing intensity and the time since abandonment (Brys et al., 2004; Jacquemyn and Brys, 2008). The life span of a species may correlate

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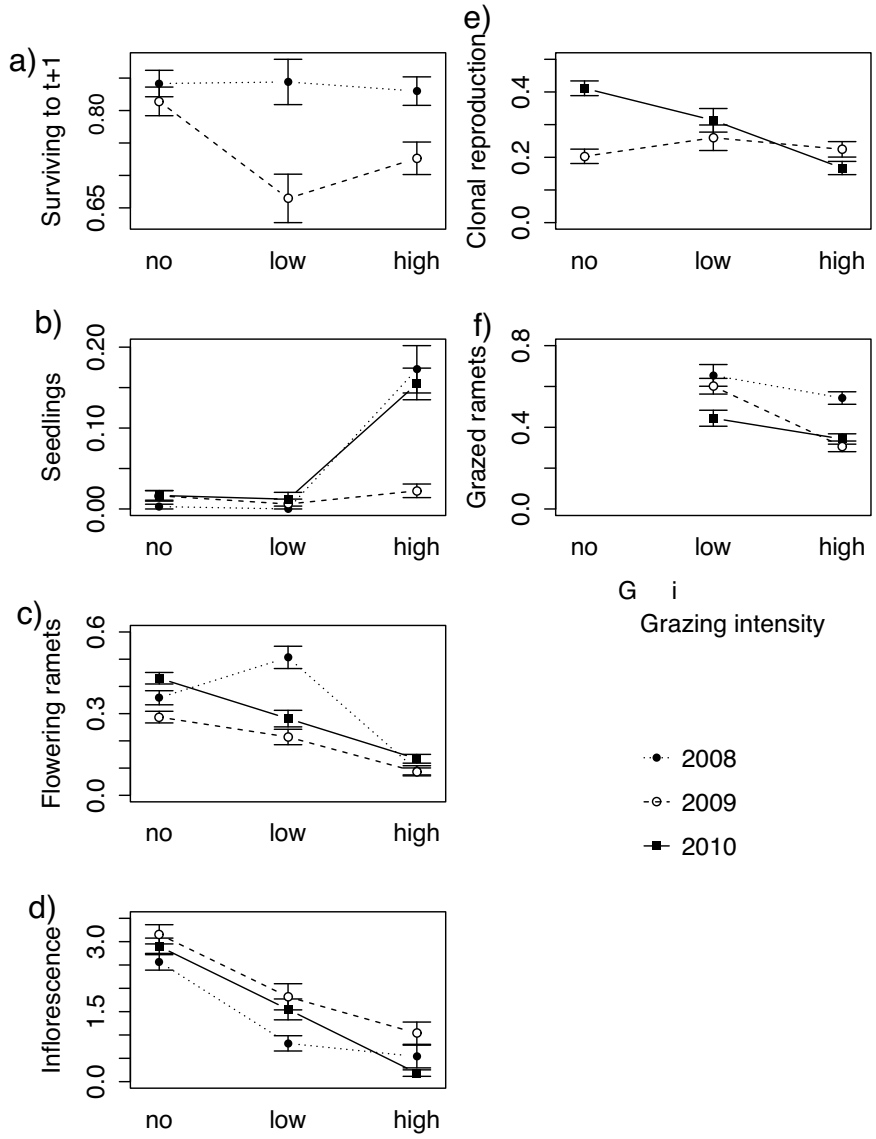

Fig. 1. Mean and standard error of (a) survival to the next year (t+1), (b) proportion of seedlings, (c) proportion of flowering ramets, (d) number of inflorescences per ramet, (e) proportion of clonal reproduction, and (f) proportion of grazed ramets in *Knautia arvensis* populations in 2008, 2009 and 2010 in semi-natural grasslands with no (abandoned), low and high grazing intensity.

with its population dynamics, and longevity can buffer changing environmental conditions (Morris et al., 2008). Long-lived perennial plants are known to have more stable population sizes than short-lived plants, because in general survival has less variability than fecundity, and fecundity is relatively more important for population dynamics of short-lived plant species (Garcia et al., 2008). Because grazing affects different life-history stages simultaneously, it is essential to integrate multiple vital rates within a single analysis to fully understand the population dynamics and viability of a species. In stage-structured populations this can be achieved using matrix models (Caswell, 2001).

The objective of this study is to analyse the effect of grazing intensity and abandonment on population dynamics of the clonal species *Knautia arvensis*. We want to estimate how its life-history components contribute to its population growth rate in semi-natural grasslands under different land-use regimes. In Norway, *K. arvensis* can be regarded as a keystone species upholding species richness in semi-natural grasslands as it is an important nectar source for many species of butterflies, bumblebees, solitary bees and other groups of pollinating insects, e.g. the Norwegian red listed mining bee *Andrena hattorfiana* (Cahenzli and Erhardt, 2012; Clausen et al., 2001; Franzen and Nilsson, 2008; Kålås et al., 2010; Totland et al., 2013). Models were developed to assess how abandonment and different levels of grazing intensity by cattle influence plant traits, vital rates, life-history components and growth rate. The contribution of vital rates to the growth rate for each level of grazing intensity was determined to see whether *K. arvensis* had different reproduction strategies when exposed to different levels of herbivory.

2. Methods

2.1. Study species

Knautia arvensis (L.) Coult. is a perennial, clonal herb with a generalist pollination system that grows in grasslands, open woods, on road verges and ruderal sites. The species is widely distributed in Europe, west Asia and north-west Africa (Lid and Lid, 2005). It has a sympodial, branched stock with leaf rosettes and flowering stems, a taproot and usually lateral underground rhizomes (Tutin