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Goat pasturing—A biological solution to counteract shrub encroachment on abandoned dry grasslands in Central Europe?

Daniel Elias*, Sabine Tischew

Anhalt University of Applied Sciences, Department for Nature Conservation and Landscape Planning, Strenzfelder Allee 28, D-06406 Bernburg, Germany

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ABSTRACT

Shrub encroachment is one of the main causes of dry grassland loss in Central Europe. Abandoned semi-natural grasslands are often overgrown by thorny or spiny shrubs. Such unpalatable shrubs have frequently established by selective foraging during periods with low grazing pressure, particularly if sheep herding was performed. Feeding behaviour and diet selection vary between different livestock species and especially browsing goats are increasingly recognized for preventing woody encroachment. However, little is known about the appropriate timing of the grazing regime and the selection of woody species on abandoned dry grasslands already dominated by thorny and spiny shrubs.

We quantified the foraging behaviour of Boer goats by direct observation on three encroached paddocks in the lower Saale River valley (Central Germany), which were grazed yearly from spring to autumn with a high stocking rate (0.6–0.8 LU/ha/yr). Feeding activities, the proportion of browsed woody species and identity of the browsed species were recorded in five minute intervals during a total of 30 days in spring and 30 days in summer/autumn. Dry grassland vegetation and woody coverage were observed on grazed and ungrazed 25-m² plots for seven years.

Contrary to other studies on grazing animals, we found that goats frequently browsed on spiny or thorny shrub species, if these species exhibited a high share of the shrub coverage. Altogether we detected a significant relationship between the abundance of woody species and browsing time on the respective species. The goats tended to spend more time browsing in spring than in summer/autumn. As a result of the browsing activity, we observed a significant decrease of woody coverage within pastures from 69.8% to 37.4% over seven years, which was positively related to the frequency of typical and endangered dry grassland species. An opposite trend was recorded on ungrazed plots.

Therefore, goat pasturing with high-stocking rates and an early start in spring can be an efficient method for improving shrub-encroached dry grasslands during the restoration phase.

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1. Introduction

In Central Europe, dry grasslands are predominantly semi-natural communities originating from different types of land-use since the beginning of the Neolithic period (Poschlod and WallisDeVries, 2002; Poschlod et al., 2009; Hejman et al., 2013). Commonly, they have been used as pastures with sheep and goats. Dry grasslands are one of the most species-rich communities (Van Swaay et al., 2006; Wilson et al., 2012; Dengler et al., 2014) and contain a large number of rare and endangered species (Korneck et al., 1998; Van Swaay et al., 2006), but also some

of the most threatened habitat types (Veen et al., 2009; WallisDeVries et al., 2002). Pasture abandonment and subsequent shrub encroachment are the main causes of dry grassland loss in Central Europe, especially on isolated marginal sites (WallisDeVries et al., 2002; European Commission, 2008; Hegedušová and Senko, 2011). Therefore, improving dry grassland management and the restoration of already encroached grasslands are central issues in nature conservation in Europe. In addition to grazing, brush-cutting and prescribed burning have been studied as possible management options for effectively controlling shrub encroachment (see Redhead et al., 2012; Valkó et al., 2014).

Abandoned semi-natural dry grasslands are often overgrown by woody species having defence mechanisms against mammalian herbivores, especially thorny and spiny shrubs (e.g. *Berberis vulgaris*, *Crataegus* spp., *Rosa* spp.). Some of these species can also

* Corresponding author.

E-mail address: d.elias@loel.hs-anhalt.de (D. Elias).

rapidly proliferate clonally (e.g. *Prunus spinosa*). Locally, invasive neophytic species considerably accelerate the encroachment (e.g. *Robinia pseudoacacia*). Spinescent shrubs often have established by selective foraging during periods with low grazing pressure, particularly if sheep herding was performed (Rahmann, 2000).

Woody species exhibit a wide variety of chemical (e.g. condensed tannins, lignin) and physical properties (e.g. spines, thorns) that are considered to reduce forage quality and protect against browsing animals such as sheep and goats (Papachristou et al., 2005). Borchard et al. (2011) developed an indicator value that quantifies the defence mechanisms of Central European woody plants. According to this indicator value, woody plants displaying defence mechanisms are usually less heavily browsed than undefended species.

Goats are commonly used to control bush encroachment (e.g. Strang, 1973 [South-central Africa]; Haumann, 1999 [Germany]; Holst et al., 2004 [Australia]; Smart et al., 2006 [USA]; Aharon et al., 2007 [Israel]; Celaya et al., 2010 [Spain]; Ascoli et al., 2013 [Italy]). They are mixed feeders with a preference for browsing (e.g. Aharon et al., 2007; El Aich et al., 2007; Osoro et al., 2013). In addition, goats can strip bark from woody plants which can effectively damage trees (Fajemisin et al., 1996; Rahmann, 2000; Holst et al., 2004). Frequently, they stand up on their hind legs to maximize available forage (El Aich et al., 2007; Rahmann, 2000). Furthermore, goats are able to climb rocks (Dolek and Geyer, 2002) or trees when branch structures permit (El Aich et al., 2007).

However, it is not known to what extent goats browse on thorny and spiny shrub species on already encroached dry grasslands and if goat grazing is a suitable management tool to restore these grasslands without additional mechanical shrub clearance in Central Europe. Furthermore, it is important to decide on the timing and the intensity of the goat grazing. One could argue that beginning of the grazing in spring will foster browsing on defended shrubs, because of the more tender structure of the thorns and spines as well as a lower content of lignin and fibre in the leaves and branches compared to those beginning in mid summer. But the common general management recommendation for dry grassland management refers to mid/late summer grazing, when many target plants (e.g. orchids or *Astragalus* spp.) and animals (e.g. invertebrates, birds) have completed their life cycles undisturbed by grazing animals (discussed by European Commission (2008) for habitat type 6210 Semi-natural dry grasslands). Crofts and Jefferson (1999) assumed that heavy or repeated spring grazing on sites with early flowering plants such as *Orchis morio* can cause local extinctions or eliminate a significant range of invertebrates. That knowledge was obviously derived from practical experience on less encroached sites. But many nature conservationists are confident of the general advantages provided by a later grazing period often making early grazing out of the question, even on encroached sites, as they are reluctant to implement grazing with a high-stocking rate, even for a time-limited restoration phase. The often recommended stocking rate for dry grassland is 0.25 LU/ha/yr (see also European Commission, 2008). On the other hand, starting with heavy grazing already in spring, in addition to more effective browsing, may also better prevent competitive grass species (e.g. *Brachypodium pinnatum*, Crofts and Jefferson, 1999; Rahmann, 2000) from establishing dense stands in abandoned dry grasslands. Besides shrub encroachment, dense grass stands also result in the loss of species diversity in dry grassland communities (Bobbink and Willems, 1987).

Up to now, studies are lacking on the effects of more intensive grazing with an early start in spring in still species-rich, but heavily encroached dry grasslands and how such a grazing regime affects the selection of woody species. To better support decisions on the most effective grazing management of encroached dry grassland sites during the restoration phase, more scientific studies are

necessary. In our study, we focused on the following specific questions:

- 1) How does the abundance and defence mechanisms of woody species affect the browsing activity of goats?
- 2) Can shrub encroachment on abandoned dry grasslands be considerably reduced by browsing goats?
- 3) How does heavy goat grazing with an early start in spring affect the frequency of typical and endangered dry grassland species?

2. Materials and methods

2.1. Study area and grazing management

The study was carried out in the lower Saale River valley between Halle and Könnern, in the south of the German federal state of Saxony-Anhalt in Central Germany. The area is characterized by a subcontinental climate due to the rain shadow of the Harz mountains. The average annual precipitation is 473 mm and the mean annual temperature 9.6°C (climatic stations: Rothenburg, Halle-Kröllwitz, period 1981–2010; DWD, 2015). Furthermore, the lower Saale River valley is characterized by greatly varying geological and edaphic conditions (e.g. carboniferous sandstone, loess, new red conglomerate, rhyolitic bedrocks, upper permian). Elevations range from 70 to 150 m above sea level.

Sheep and goats as livestock have been present since Neolithic times in Central Germany (Benecke, 1994). The tradition of migratory herding of sheep and goats in combination with varying geomorphology and edaphic conditions resulted in attractive mosaics of different dry grassland habitat types. Some of the characteristic plant communities are listed as natural habitat types in Annex I of the Habitats directive (e.g. 6210 Semi-natural dry grasslands on calcareous substrates, 6240* Sub-pannonic steppic grasslands).

Socio-economic changes after the German reunification in 1990 led to an abandonment of sheep grazing or reduced intensity of grazing (Richter et al., 2003), whereas goat breeding decreased already in the middle of the last century. Since that time, species-rich dry grasslands have declined tremendously. Currently, the species-rich dry grasslands are heavily endangered by shrub encroachment. However, remnants of dry grassland habitats as well as even some red list plants are still present, particularly on steep slopes with shallow soils. Therefore, in cooperation with local farmers, a pilot project for goat grazing was initiated in 2006. The restoration of the encroached pastures appeared to be economically feasible only by using permanent fencing allowing continuous grazing without permanent care for the goats. Therefore, in contrast to migratory herding, labour costs for this grazing management are much lower. In order to hinder the goats from breaking out of the pastures, electric fences with four to five strands proved to be useful.

This study was conducted from 2007 to 2014 at three paddocks (Nelbener Grund [Nel], Dobis [Dob], Mueheln [Mue]), located mainly on steep slopes with shallow soils. Before grazing started, they were characterized by intense woody plant encroachment due to long-term abandonment. The level of woody encroachment differed between grazing sites (see Table 1). The woody vegetation was dominated by thermophilic shrub communities (Berberidion), which include many different thorny and spiny deciduous shrub species (e.g. *Berberis vulgaris*, *Crataegus* spp., *Prunus spinosa*, *Robinia pseudoacacia*, *Rosa* spp.). These species are typical for abandoned pastures in the whole region. The shrubbery was surrounded by deciduous forests, meadow orchards (Mue) and dry grassland fragments. Despite the heavy encroachment, the following dry grassland plant communities were still identifiable,

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