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Regeneration of willows and herbaceous vegetation on river banks after grazing by small ruminants

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ABSTRACT

Willow bushes (*Salix*) in a biosphere reserve cause build up of water when the river is in flood. In order to avoid flood disaster as well as for nature conservation reasons we studied whether small ruminants might suppress the willows without causing long-lasting damage both to the reeds and the vegetation of the banks. Comparing the effects of single (one time) and repeated grazing in a two-year trial, 109 sheep and 10 goats grazed up to 13 days on 8000 m^2 plots with direct access to the river. A single grazing resulted in extensive reduction of the herbaceous vegetation, but its complete regeneration within three months. This is due to a variety of strategies for survival in a dynamic bank habitat in which grazing imitates natural disturbance by changing water levels; 77.3% of the 128 species persisted under a single grazing, 10.2% were new, 12.5% were not found afterwards. Heavily reducing the biomass stimulated less competitive herbaceous species. Death of willow stems occurred only where the bark had been completely removed. The proportion that died rose from 21.7% after first grazing to 36.3% after first penning and up to 44.1% after second penning. Early grazing in the season is much more efficient (58.6%) than late (23.1%) in controlling willow growth. Insufficient damage to the bark of old multi-branched willows also reduced the proportion that died. Sustainable bark reduction of willow growth depends on damaging them severely by single grazing and then penning once early in the year, and to avoid their full regeneration by repeating this treatment every second year. Over the long-term a cyclic grazing treatment will weaken the willows and enable the herbaceous life forms to take and over reinvigorate sufficiently, suggesting it as an option for flood protection in the biosphere reserve.

Introduction

The UNESCO biosphere reserve "Niedersächsische Elbtalaue" in Germany, Lower Saxony, includes on its 100 km of streams (Anonymous 2006) the banks, meadows and dikes of the River Elbe. According to the European Flora–Fauna–Habitat (FFH) guidelines, the zones of low and middle high-water level should receive full protection (Anonymous 1979; Scholz et al. 2005). Willow bushes (Genus *Salix*), a natural part of the zone of middle high-water level, however, lead to a build up of the river when it is in flood. This situation could lead to disasters when the water starts to flood the dike (Anonymous 2007). For that reason, the willows have been sawn off in some areas. However, such an enterprise is both expensive and goes against FFH-guidelines (Anonymous 1979). Various experiments with large herbivores have proven that grazing keeps landscapes open, particularly along rivers (Bunzel-Drüke et al. 2008; Mährlein 2005; Rieken 2004). In former times the whole area between the River Elbe and its dikes was used as pastures for cattle (Anonymous 2007), but data about the effects on the vegetation at this site are lacking since FFH-conditions did not allow any grazing in the reserve. However, a LEADER+ Project was initiated (Gude 2008), that allowed us to check whether grazing with small ruminants, sheep and goats, lessened the number of willows without long-lasting damage to the herbaceous vegetation.

Methods

The study was carried out in Lower Saxony in the biosphere reserve Elbtalaue (large-scale map # 2730/2/1-3, 2730/2/9; Anonymous 1993). The area is part of the 920 ha nature reserve called "Elbvordeichgelände zwischen Sassendorf und Walmsburg"[1] (Pohl 1992). There are four zones of vegetation involved: (1) groynes and banks with pioneer plants and sedges (*Xanthio albini-Chenopodietum rubri* = "banks"); (2) a zone of low high-water

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[1] Translation: Sites in front of the River Elbe dike between the villages Sassendorf and Walmsburg.

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level with dominant *Phragmites australis* (*Phalaridetum arundinaceae* = "reeds"); (3) a zone of middle high-water level with bushes of *Salix* sp. (*Salicietea purpureae* = "willows" = *S. triandra* L. ssp. *triandra, Salix alba* L., *S. x rubens* Schrank and *S. viminalis* L.); and (4) a zone of top high-water where ruderal vegetation with *Calamagrostis epigejos*, *Tanacetum vulgare* and *Urtica dioica* ssp. *galeopsifolia* occurs (*Tanaceto-Artemisietum* = "ruderal vegetation"). At Sassendorf (River Elbe km 560, 568, 569) the willow trees and tall bushes had been cut several years ago, while at Alt Garge (km 546) the natural area was unaltered.

Two grazing areas (referred to as km 546, 568) of some 8000 m^2 for a flock of 109 domestic sheep and 10 goats were partitioned off by mobile fences in the first year. Animals grazed from May to July with direct access to river. They stayed inside the pen between 11 and 13 days till their need for both satiation and feed selection could no longer be fulfilled (single grazing). The experiment was varied at two further grazing plots from June to September (km 569), and from August to October (km 560) in the second year (Table 1). When the point of poor feed supply was reached, the animals were penned up within the willow zone for 1–3 days. Grazing and penning in the second year were repeated once (recurring grazing).

During each year the presence/absence of vascular plants was recorded at three times: 3–13 days before the grazing period (first record); and 8–10 days after grazing (second record), as well as 2–3 months afterwards (third record). This took place on five 10 m × 10 m plots within each of the zones of vegetation, except for the willows where 1 m^2 were used. At the second record it was possible to include early germinating species that might have disappeared by the third record. In addition, all kind of plant remnants, organs that were not eaten by the animals, and thus still present after grazing, were documented for each species. Adjacent to the grazing area control plots were set up, and checked at the same times.

Species were grouped according to the final grazing result. "Persistent" when a species occurs both before and at any time after grazing; "missing", when it fails to be found again at any time after grazing, and "new", when it appears after grazing for the first time, either shortly after grazing or 2–3 months afterwards. Presence in at least one plot was sufficient for a species to be classed as present. Plant species on both grazing spots (km 546, 568) are treated as one data pool. In the few cases, where species display different responses at the two sites, the overall response was taken as that plot in which the species showed highest frequency. Four groups of life forms were used to describe the vegetation: (1) perennials with rhizome; (2) perennials without rhizome; (3) annuals; and (4) others (bushes, tree-seedlings, climbing plants, 2-year-cycle (hapaxanthic) life forms). The strategies of surviving grazing were obtained from the species-specific comparison between plant organs that had been left after single grazing and those appearing again.

In order to estimate the extent of regeneration (secondary growth) of the willows (genus *Salix*) we documented which plant organs were eaten by the animals during single grazing (*cf.* Table 1: prior estimation of interaction animals–willows). Counting the dead and living branches at the beginning of the second year shows the extent to which the willows regenerated after a single grazing. Based on these findings the share of completely peeled off stems was recorded at 15 randomly selected willow individuals in plots 560 and 569, respectively. There were four classes of stem diameters (<1, >1, >3, >6 cm) under recurrent grazing. In terms of data analysis the proportion of stems completely stripped of bark is related to the total sum of stems in each class of 30 willows on both spots. Individuals were defined as any vertical stem independently rooted in the soil.

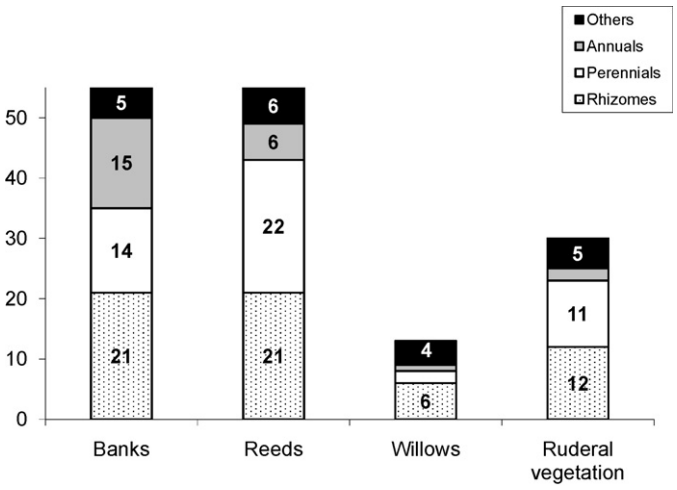

Fig. 1. Persistent species.

Nomenclature of plant species follows Wisskirchen and Haeupler (1998), and the status of endangered species is according to Garve (2004).

Results

Herbaceous vegetation

Most species were either eaten completely, leaving unpalatable organs only, or trampled down leading to major destruction of vegetation and reduction of biomass at all zones after a single grazing. Of the 128 plant species 99 (77.3%) were persistent (Table 2). The reed as well as bank zones were most species-rich (72 species), while willows and ruderal vegetation had only half as many species (Fig. 1). Thirteen of 128 species (10.2%) appeared following grazing whereas 16 (12.5%) were lost afterwards (Table 3). On balance more species were lost than gained on the banks, while the reverse was true for the willows (Fig. 2). Turnover was high (17 species), but balanced in the reed zone, whereas little turnover occurred in the ruderal zone though with a notable difference in the total of 17 (reeds) versus 5 (ruderal vegetation) species. Little turnover was true also for the 13 endangered species (Table 4).

Despite the extent of damage, fast and nearly complete regeneration takes place. On the banks only one sedge tussock out of 10 failed to recover. In the reeds, secondary growth of less competitive perennials without rhizome such as the Red List species *Thalictrum flavum* L., *Pseudolysimachion longifolium* (L.) Opiz, *Sanguisorba officinalis* L. and other subdominate species typical for the site as *Euphorbia esula* L., and *Persicaria lapathifolia* (Opiz) ssp. *brittingeri* were seen shortly after grazing as new shoots or seedlings. One culm and rhizome out of 10 of *Phragmites* failed to regenerate, leaving only small gaps in the former dense vegetation structure. In comparison to the control, there was a more flowering of the reeds in the grazing treatment. Under the defoliated willows an extensive lawn of seedlings developed shortly after grazing. New species were *Chenopodium rubrum* L. and *Corrigiola littoralis* L. but this zone was mainly composed of species that were already recorded in the grazing plot.[2] At least some of these species produced flowers and seeds, though the willows regenerated their leaves shortly after

[2] These 14 species are *Artemisia annua* L., *Atriplex prostrata* Boucher ex DC, *Barbarea stricta* Andrz., *Chenopodium album* L., *Equisetum arvense* L., *Erysimum cheiranthoides* L., *Lysimachia vulgaris* L., *Lythrum salicaria* L., *Persicaria lapathifolia* ssp. *brittingeri* (Opiz) Soják, *Plantago major* (Gilib.) Lange ssp. *intermedia*, *Rorippa palustris* (L.) Besser, *R. sylvestris* (L.) Besser, *Rumex acetosa* L., *R. crispus* L.