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Post-dispersal impact on seed fate by livestock trampling – A gap of knowledge

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Abstract

Sheep grazing is an important management tool in threatened sandy grassland of the temperate zone. Besides direct grazing effects, previous studies have shown benefits of seed dispersal, but little is known about post-dispersal processes. We studied the role of sheep trampling for the post-dispersal fate of seeds embedded in sheep and rabbit dung and hypothesized a positive impact for the development of seedlings as a consequence of cracking the dung pellets. Sheep and rabbit dung samples were collected from species-rich sandy grasslands, and their seed potential was assessed in a climate room. In a factorial field experiment we tested the effects of trampling and dung type on seedling emergence and fruiting success.

Seedling emergence in the field was only 5% (sheep dung) or 7% (rabbit dung) of the potential without trampling but 18 or 14% with trampling. Plots with trampled sheep or rabbit dung both showed significantly more seedlings (3.6- or 2.1-fold), more species (2.4- or 1.9-fold), more fruiting individuals (3.9- or 2.6-fold) and more fruiting species (2.1- or 1.9-fold) compared to non-trampled dung plots. Both target as well as non-target species profited from trampling, but the proportion of target species is clearly increased by trampling and graminoid competitors did not reach fruiting stage.

Sheep play a multifaceted role in dispersal processes: after endozoochoric transport they act as a sort of 'gardener' not only for sheep-dispersed seeds, but also for those dispersed by rabbits.

Zusammenfassung

Schafbeweidung ist ein wichtiger Beitrag zum Management bedrohter Sandrasen der gemäßigten Zone. Abgesehen von direkten Beweidungseffekten, wie z. B. die Entstehung von Lücken durch extensive Viehbeweidung, konnten vorangegangene Studien die Bedeutung von Schafen für die Samenausbreitung (Endo-, Epizoochorie) zeigen, aber dennoch ist wenig über Prozesse nach der Ausbreitung bekannt wie beispielsweise Effekte durch Trampeln. Wir untersuchten die Rolle der Hufeinwirkung („trampling") von Schafen auf das Schicksal von Samen, die in Schaf- und Kaninchendung eingeschlossenen waren, nach deren Ausbreitung und stellten die Hypothese auf, dass die Etablierung von Keimlingen begünstigt wird als Folge des Aufbrechens der Dungpellets durch Schafhufe. Schaf- und Kaninchendung wurde in gefährdeten Sandrasen gesammelt und deren Samenpotential in einer Klimakammer getestet. In einem faktoriellen Freilandexperiment wurden die Effekte des Trampelns (mittels Schafhuf-Replikaten) und des Dungtyps auf das Keimlingsaufkommen und den Fruchterfolg festgestellt.

Das Keimlingsaufkommen im Freiland entsprach für beide Dungtypen zu nur 5 (Schafdung) bzw. 7% (Kaninchendung) dem Potential ohne Trampeln, mit Trampeln lagen die Werte bei 18 bzw. 14%. Flächen mit Trampel-Wirkung auf Schaf- oder

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Kaninchendung zeigten signifikant mehr Keimlinge (3,6- oder 2,1-fach), mehr Arten (2,4- oder 1,9-fach) und mehr fruchtende Individuen (3,9- oder 2,6-fach) und fruchtende Arten (2,1- oder 1,9-fach) verglichen mit den Flächen ohne diesen Effekt. Es profitierten nicht nur Zielarten durch das Trampeln, auch Nicht-Zielarten, aber der Anteil der Zielarten erhöhte sich deutlich, und konkurrenzstarke Graminoide erreichten nicht das Fruchtstadium.

Schafe spielen eine facettenreiche Rolle in Ausbreitungsprozessen: nach dem endozoochoren Transport haben sie eine Art "Gärtnerfunktion" nicht nur für Schaf-ausgebreitete Samen, sondern auch für die Samen, die durch Kaninchen ausgebreitet werden.

Keywords: Dung; Endozoochory; Facilitation; Fragmentation; Nutrient-poor grassland; Rabbit; Sheep; Seedling emergence; Target species

Introduction

Seed dispersal and re-colonization processes of plant individuals are decisive factors for population dynamics in grassland communities (Foster & Tilman 2003). In many open grazed habitats, herbivorous mammals transport large quantities of seeds (e.g., Malo & Suárez 1995a, 1995b; Cosyns, Claerbout, Lamoot, & Hoffman 2005; Eichberg, Storm, & Schwabe 2007; Bakker, Galvez Bravo, & Mouissie 2008). A growing number of studies have focused on the role of herbivores to overcome seed limitations in a conservation and restoration context (e.g., Couvreur, Christiaen, Verheyen, & Hermy 2004; Mouissie 2004; Wessels-de Wit & Schwabe 2010). By dispersing seeds over long distances, moving livestock provides survival opportunities for small plant populations in fragmented landscapes (e.g., Cosyns et al. 2005; Mouissie, Vos, Verhagen, & Bakker 2005; Ozinga et al. 2009), but to assess the effectiveness of seed dispersal it is crucial to study post-dispersal processes (Eichberg, Storm, & Schwabe 2005; Ramos, Robles, & Castro 2006).

As a model to study post-dispersal processes we used livestock dung with an endozoochorously dispersed seed potential. Our hypothesis is that on pastures one important factor for the post-dispersal fate of dung-embedded seeds is trampling, which has a high-frequency disturbance impact on pastures (Hobbs 2006). Previous studies on trampling effects in pastures mainly focused on the gap-creating effect of hooves (e.g., Stammel & Kiehl 2004). It seemed likely that trampling also affects the germination and establishment of dung-embedded seeds, but evidence for this is still lacking. We hypothesized that the post-dispersal fate of endozoochorous seeds could be improved by cracking the dung pellets. Sheep dung pellets which are deposited in dry grasslands during the spring–summer season (main grazing period) dry out quickly and can persist over years without disintegrating (Eichberg et al. 2007). Hooves of ungulates also crack dung deposited by other herbivore species, such as rabbits, as was observed in our area (Faust, Süss, Storm, & Schwabe 2011). Especially in the case of sheep it is likely that trampling of dung has a significant impact on the grazed system, for the following reasons: first, sheep are kept in large flocks, generating a high trampling density. Second, besides concentrating their dung unintentionally in special areas (e.g., resting places) sheep scatter it while grazing. Consequently the grazed area will be affected to a large extent. As an example of a grazed semi-natural grassland type, we studied threatened sheep-grazed inland sand ecosystems in a temperate region. The high phytodiversity of these systems depends on continuous disturbance dynamics (Süss, Storm, Zehm, & Schwabe 2004; Eichberg et al. 2007). Previous studies have shown a high endozoochorous potential of sheep and rabbits (Pakeman, Engelen, & Attwood 1999; Eichberg et al. 2007; Wessels & Schwabe 2008).

We focused on the following questions: (1) Which endozoochorously dispersed plant species are contained in what quantities in sheep and rabbit dung collected from sandy grasslands? (2) What proportion of this seed potential is able to establish itself in the field after 1 or 2 years? (3) Is sheep trampling on dung pellets of sheep and rabbits a facilitative post-dispersal process for dung-embedded seeds? (4) What is the proportion of target species contained in the dung and among the emerging/fruiting individuals?

Methods

Study sites

Our study was conducted on two sites of inland sand ecosystems in the northern upper Rhine valley (Hesse, Germany), which were part of one large area ca. 70 years ago. Both sites are characterised by a mainly calcareous and nutrient-poor soil and protected by the EU 92/43 Habitat Directive. The area 'Griesheimer Düne' (8°39′E, 49°53′N; 45 ha; hereafter 'GD') served as a source area for the dung. The area 'Ehemaliger August-Euler-Flugplatz' (8°35′E, 49°51′N; 71 ha; 'AEF') was used for the installation of experimental plots. The studied vegetation of GD consisted of a well-developed species-rich grassland (*Allio-Stipetum capillatae*), whereas the vegetation of AEF was made up of species-poor grasslands (consolidated *Armerio-Festucetum trachyphyllae* stands) which were dominated by competitive grasses (*Cynodon dactylon*, *Poa angustifolia*). The topsoil of AEF is mainly slightly acidic but in the case of disturbances, e.g., by burrowing rabbits, calcareous material is transferred to the topsoil. The study region is managed by an extensive sheep grazing regime: short but intensive grazing periods are followed by long periods for re-growth of plants (pad-