Ecological Indicators 72 (2017) 667–674

Contents lists available at ScienceDirect

Ecological Indicators

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

Response of moths (Lepidoptera: Heterocera) to livestock grazing in Mongolian rangelands

Khishigdelger Enkhtur[a], Martin Pfeiffer[a,b,*], Ariuntsetseg Lkhagva[a], Bazartseren Boldgiv[a,*]

[a] National University of Mongolia, School of Arts and Sciences, Department of Biology, Graduate Group in Ecology, Baga toiruu 47, P.O. Box 377, Ulaanbaatar 14201, Mongolia
[b] University of Bayreuth, Department of Biogeography, Universitätsstrasse 30, D-95440 Bayreuth, Germany

ARTICLE INFO

Article history:
Received 25 April 2016
Received in revised form 9 August 2016
Accepted 29 August 2016
Available online 12 September 2016

Keywords:
Indicator species
Grazing effect
Rangeland
Herbivory
Mongolian steppe

ABSTRACT

Overgrazing has become an ecological problem in the wide steppes of Mongolia due to rapid livestock growth in the last two decades. Species diversity and productivity of biological communities, along with information on the presence and absence of certain species, can be indicators of environmental health to assess the state of pasture. Moths have been used as indicator species in various studies as they are abundant in many different habitats and sensitive to environmental changes. We used moths as indicators for pasture degradation in the Mongolian steppe for the first time. In this study, we investigated how overgrazing affected moth species diversity, identified indicator species for degraded pasture and collected baseline data to study distribution and migration of moths under future climate change. To accomplish these objectives, we compared moth diversity in plots with different grazing intensity in two locations in central Mongolia. Species diversity of moths was two times higher in lightly grazed plots than in medium-grazed and heavily grazed plots. Thus we conclude that pasture degradation affected moth diversity negatively. As a result of indicator species analysis we identified four indicator species for heavily grazed plots (*Leucoma salicis, Autographa buraetica, Mythimna impura* and *Pelochrista arabescana*) and seven indicator species for lightly grazed plots (*Panchrysia dives, Gastropacha quercifolia, Selagia argyrella, Lymantria dispar, Mythimna conigera, Stigmatophora micans* and *Perconia strigillaria*). The meadow moth *Loxostege sticticalis* was most abundant in all plots. In this study we collected a total of 115 species from Ikhtamir and Undurshireet as baseline data in order to study distribution and migration of moths under future climate change.

1. Introduction

Although Mongolia's wide steppe area is one of the largest pasture resources existing in the Asian temperate region, overgrazing has become a major ecological problem (Hilker et al., 2014), since herding is a major economic support of this country. Pasture degradation is intensifying due to recent years' rapid growth of livestock and loss of traditional methods of pasture use (Green Gold Project, 2015). As a result of transition from the centralized socialist system to a market economy in the 1990s, livestock were privatized and herd sizes increased, especially goats for production of cashmere, which is one of Mongolia's major agricultural products. Cashmere goats, which are more detrimental to the vegetation than other species of livestock, have tripled in numbers since 1990 (Lkhagvadorj et al., 2013). In 2005 the overall number of animals exceeded the carrying capacity of pastureland by 32.5% or 16 million sheep units at a national level (Jigjidsuren, 2005). Latest figures from November 2015 show that the number of livestock in Mongolia has reached almost 56 million head with an increase of 7.6% from 2014 (Monthly Bulletin of Statistics, 2015). Especially concerning is overgrazing in forest steppe and steppe zones where the number of livestock is 2–3 times higher than the estimated carrying capacity of those areas (Mongolian Society for Range Management, 2009). Pasture degradation is not only negatively affecting soil and vegetation (Wang and Wesche, 2016) and thus animal breeding, but also impacting other living organisms and their environment. Thus there is a need for sustainable pasture

Abbreviations: HG, heavily grazed; MG, medium grazed; LG, lightly grazed; IKH, Ikhtamir; UN, Undurshireet; NMDS, Non Metric Multidimensional Scaling.

* Corresponding authors.
E-mail addresses: khishigdelger@num.edu.mn (K. Enkhtur), martin.pfeiffer@uni-bayreuth.de (M. Pfeiffer), ariuntsetseg@num.edu.mn (A. Lkhagva), boldgiv@num.edu.mn (B. Boldgiv).

http://dx.doi.org/10.1016/j.ecolind.2016.08.053
1470-160X/

management and objective evaluation of pasture conditions (Pöyry et al., 2005).

Species diversity and productivity of biological communities are important indicators of environmental health (Rapport et al., 1998; Gerlach et al., 2013) that can be used to assess the state of pasture (Lawton and Gaston, 2001). For example, epiphytic lichens have been successfully used as indicators of overgrazing in Mongolian forest steppes (Hauck and Lkhagvadorj, 2013). Dayflying Lepidoptera (butterflies and moths) are indicators of the state of semi-natural grasslands for conservation in Europe (Lawton and Gaston, 2001; Rákosy and Schmitt, 2011), while ants (Hoffmann, 2010; Williams et al., 2012), dung beetles (Verdú et al., 2007), carabid beetles (Kaltsas et al., 2013) and plants (Best and Bork, 2003) have been successfully used as indicators of grazing pressure in Mediteranean and arid ecosystems. Compared to lichens (Walser et al., 2005), arthropod life span and generation times are short. As demonstrated by Niemelä et al. (1993), species with shorter generation times will respond to disturbance events faster than those with longer generation times and are therefore better indicator species. The higher mobility of invertebrates compared to plants and lichens allows for rapid adaptation to habitat changes, even at the community level. However, this goes hand in hand with a high variability in abundance due to weather conditions, a clear drawback of animal-bioindicators compared with stationary taxa like plants and lichens.

How grazing pressure affects plant diversity, cover and production has been widely studied in Mongolian steppes (e.g., Lkhagva et al., 2013), northern China (Wang and Wesche, 2016) and elsewhere (e.g. Manier and Hobbs, 2006), but there is not enough information about how pasture degradation affects herbivores other than pasture livestock (Pöyry et al., 2005) and what kind of organisms can be used as indicators for it. In the vast true steppes of central Mongolia trees are extremely rare so epiphytic lichens can not serve as indicators for overgrazing as they have further northern distribution and thus other bioindicators are needed.

To study the effects of pasture degradation on herbivores and to assess different pasture patterns, we chose to use moth species occurrence and diversity. As moths are abundant, mobile, and widespread in many different habitats and sensitive to environmental changes, they are particularly useful as indicator species (Maleque et al., 2009). Monitoring their numbers and ranges can give us vital clues to changes in our own environment, such as the effects of new farming practices, pesticides, air pollution, pasture degradation, ecosystem condition and climate change (Bachand et al., 2014; Folcher et al., 2012; Summerville et al., 2004; Kitching et al., 2000; Kroupa et al., 1990). Moths also can be indicators of diversity for other animal species (Lund and Rahbek, 2002). They live in close interaction with vegetation, as caterpillars and adult moths of many species depend on plants as food and nectar source, while moths in return act as important pollinators (Choi and Chun, 2009; Axmacher et al., 2011). As grasses and herbs are the prevailing vegetation in Mongolian steppe zone, herbivore caterpillars are directly competing with livestock for food and should be especially suited as indicator species, while bioindicators from other trophic groups are only in indirect competition. Compared with beetles and ants, moth offspring are less protected, as caterpillars are much more exposed to other direct effects of overgrazing, e.g. trampling, destruction of shelter and loss of individuals by (unintended) predation of livestock, and thus in some aspects similar to plants. Moreover, information on abundance, distribution and species diversity of moths are useful baseline data to study effects of climate change in the future (Itämies et al., 2011).

In this study we (1) investigated how pasture degradation affects moth diversity; (2) revealed indicator species of intensively grazed and less grazed pasture, and (3) collected baseline data of species richness and distribution of moths in the face of climate change.

We investigated the following detailed hypotheses: (1) Pasture degradation impacts moth diversity negatively, so species richness and diversity measures will be higher in less grazed areas; (2) Grazing pressure by large herbivores changes habitat conditions for insect herbivores, so indicator species of moths in lightly grazed and heavily grazed plots will be different; (3) Mongolian steppe is a diverse habitat, so moth and vegetation communities will be different at different sample sites.

2. Materials and methods

2.1. Study area

Mongolia is a landlocked country situated in Central Asia between Russia and China. It has a vast territory of 1.56 million square km. Mongolia is located in the transition zone between the deserts of Central Asia and the boreal taiga of southern Siberia and belongs to the temperate region (Tsegmid, 1969). About 72% of the territory (112.8 million hectares) is categorized as rangeland, which supports about 170,000 herder families. The rangeland is divided into six ecological zones: high mountain, taiga, forest steppe, steppe, desert steppe and desert. These ecological zones differ from each other by topography, climate, flora and fauna (Yunatov, 1976).

Our study sites were selected in the area around Undurshireet soum (subdistrict) (N 47°27′11.82″ E 105°03′19.11″) in Tuv Aimag (district) and in the Ikhtamir soum (N 47°25′01.86″ E 100°44′45.54″) of Arkhangai Aimag, which are located 180 km and 570 km from Ulaanbaatar, respectively (Fig. 1). Both areas have been monitored during recent years with help of the Green Gold Project funded and implemented by Swiss Development Agency at Mongolia, which also gave financial support to our study. In terms of vegetation and responses to livestock grazing, the sites were different (Fernandez-Gimenez and Allen-Diaz, 1999). Plots at Ikhtamir were placed in mountain steppe, while the plots at Undurshireet lay in dry steppe (Appendix Fig. A1 in Supplementary material). Annual precipitation at Undurshireet is 200–250 mm, with flat to undulating topography at altitude of up to 1700 m a.s.l. Annual precipitation at Ikhtamir is 300–400 mm, also with undulating topography at elevations up to 1700 m a.s.l. (Tsegmid, 1969).

In each study site we chose two plots for characterization of vegetation for grazing regime based on vegetation cover and structure. Pasture degradation was broken into the following categories according to Chognii (1978):

Lightly grazed pasture: The main vegetation community of steppe dominates (*Poa attenuata*, *Koeleria cristata*, *Agropyron cristatum, Stipa* spp.), forbs are less dominant and plants which tolerate grazing such as *Artemisia frigida, Potentilla acaulis, Convolvulus ammanii, Leymus chinensis, Cleistogenes squarrosa* are slightly increased in abundance. Plant species richness is decreased due to grazing pressure.

Medium grazed pasture: The plants of the main steppe vegetation community are decreased in abundance and grazing resistant plants such as *Artemisia frigida, A. adamsii, Potentilla acaulis, Convolvulus ammanii*, and *Leymus chinensis* dominate.

Heavily grazed pasture: Plant species from the main steppe vegetation community become very scarce and plants that tolerate grazing are dominant. For example, *A. frigida, A. adamsii, P. acaulis, Carex duriuscula*, and *L. chinensis*.

We sampled moths and plants from “Lightly grazed” (LG), “Medium grazed” (MG) and “Heavily grazed” (HG) plots depending on local situation. Completely ungrazed plots did not occur in either site, as fencing was damaged during the investigation period at the