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Short communication

Effects of winter food availability on the abundance of Daurian pikas (*Ochotona dauurica*) in Inner Mongolian grasslands

W. Zhong[a], G. Wang[b,*], Q. Zhou[a], X. Wan[a], G. Wang[a]

[a]*State Key Laboratory of Integrated Management of Pest Insects and Rodents, Institute of Zoology, Chinese Academy of Sciences, Datun Road, Caoyang district, Beijing 100101, China*

[b]*Department of Wildlife and Fisheries, Mississippi State University, Mail stop 9690, Mississippi State, MS 39672, USA*

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Abstract

Winter food is crucial for survival of animals in northern temperate regions where green vegetation is scarce or absent during the winters. The Daurian pika (*Ochotona dauurica* Pallas, 1776) is a steppe-dwelling, burrowing small mammal widely distributed in Inner Mongolian grasslands. Winters are severe in Inner Mongolian steppes with temperatures ranging from −40 to 5 °C. Pikas cache food plants in haypiles in late autumn. Forbs constituted over 90% of haypile biomass and were the main winter food of Daurian pikas. We conducted a haypile removal experiment during 1992 and 1993 to determine the ecological importance of haypiles. Pika densities in the spring were significantly lower on the removal plots than on the control plots. Therefore, haypiles as a food resource improve over-winter survival of Daurian pikas. Winter food availability may limit pika abundance in central Inner Mongolia.

Keywords: Food caching; Foraging behavior; Grassland; Haypile; Manipulative experiment; Winter food

1. Introduction

Green vegetation is either absent or scarce during winters in many places of northern latitudes and animals evolve a variety of ways to adapt to this predictable food shortage. Food storage is used by many over-wintering, non-hibernating animals. Stored food serves as an exclusive food supply throughout the winter or for intermittent periods of food shortages (Vander Wall, 1990). Species that typically collect and store food for overwinter consumption include small mammals such as ground squirrels (*Spermophilus* spp.; Vander Wall, 1990) and pikas (*Ochotona* spp.; Smith and Weaton, 1990). Pikas collect fresh vegetation in late autumns and cache it aboveground or in underground middens. Food caching is an energy- and time-consuming process (Conner, 1983; Dearing, 1997). North American pikas (*Ochotona princeps*) spend over 55% of their surface activity on haying, gathering, and storing plants in late autumn (Conner, 1983). Millar and Zwickel (1972) reported that the amount of plants stored in haypiles was inadequate to sustain pikas throughout the winter;

*Corresponding author. Tel.: +1 662 325 0414; fax: +1 662 325 8672.

E-mail address: gwang@cfr.msstate.edu (G. Wang).

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conversely, pikas on West Knoll, Colorado, stored 350 days of food, sufficient for an entire winter (Dearing, 1997). Although caching of food by pikas is well documented, its relative importance and contribution to overwinter survival is unknown (Dearing, 1997; Smith and Weaton, 1990).

The Daurian pika (*Ochotona dauurica* Pallas) is widely distributed in the typical steppes of central Inner Mongolia. Like North American pikas, Daurian pikas select monocots for summer food and cache herbs in the autumns; however, Daurian pikas are different with North American pikas in social behavior. Daurian pikas live in colonies year-around (Formozov, 1966; Huntly et al., 1986; Smith, 1988; Wang et al., 2001). North American pikas cache plants on an individual basis. One individual contributes to single haypiles (Millar and Zwickel, 1972) and constructs several haypiles within its territory (Conner, 1983). In contrast, Daurian pikas build haypiles communally. Moreover, the ecology of Daurian pikas has been documented to a lesser extent compared to North American pikas. The stored food appears to be an important component of the winter diet in pikas; however, its effects on overwinter survival and demography the following spring in Daurian pikas in Inner Mongolia has not been addressed. The objectives of our study were to: (1) identify plant species composition of Daurian pika haypiles and (2) determine their contribution to winter survival and subsequent population densities the following spring. To meet our objectives we conducted an experiment in which we selectively removed haypiles from some pikas and not others and then monitored subsequent densities the following spring. We also determined the composition of vegetation in the haypiles collected from the treatment area. We predicted that haypile removal would reduce the density of Daurian pikas in treatment plots.

2. Methods

Our study site (43°24′N, 116°46′E) was located in a flat, open grassland at 1100 m elevation in Hexiten Banner, Inner Mongolia and represented a typical habitat for Daurian pikas in Inner Mongolian steppes. Daurian pikas had occupied our study site for almost two decades since the site was discovered in the 1970s. The climate was continental and semi-arid with long, cold winters. The temperature ranged from −40 to 30 °C with an annual average of about—0.1 °C; the average annual precipitation was about 350 mm, mainly falling in June, July, and August. Snow cover lasted from November through March the following year. Most plant growth occurred during the summer months from April to August (Jiang, 1985). Vegetation was represented by the *Stipa krylovii*, *Artemisia frigida*, and *Aneurolepidium chinense* community.

We conducted a haypile removal experiment in 1992 and 1993 to determine the ecological importance of haypiles for Duarian pikas. We selected 10 1-ha plots as controls with no haypiles removed and 10 1-ha plots as removal treatments with all haypiles completely removed in October 1992. These plots were arranged in two rows, one row of control plots and one row of treatment plots, with 30 m intervals between two neighboring 1-ha plots. Daurian pikas are central place foragers and territorial (Personal observations). A distance of 30 m between two 1-ha plots made the plots of each row independent in a statistical sense. The distance between the two rows was about 100 m. Control and treatment plots were chosen so as to have similar pika densities prior to haypile removal. Haypiles were situated aboveground near active burrow entrances of pikas throughout winters. We excavated some burrow systems in October and observed a small amount of cached plant material in underground tunnels. Decayed, remnant haypiles were still present aboveground in April of the following year. Haypiles on the control plots were removed when the first snow fell. Pikas terminate annual haying when the first snow falls in October or early November. Pika densities were surveyed using the burrow entrance index method (Wang et al., 2003) in October before the haypile removal and in May 1993 after the removal. All burrow entrances on a plot were collapsed and filled with dirt at dusk. Daurian pikas usually reopen occupied entrances filled with dirt within a few hours. The renewal of the entrances enabled us to distinguish between active and abandoned entrances. Entrances reopened by pikas were counted as active entrances the following morning. The number of individuals in a 1-ha plot or density of pikas (D) was estimated by the number of active entrances times the entrance index, i.e., $D = I * N$, where D is density (animals/ha); I the entrance index of pikas; and N the number of active entrances in a 1-ha plot. The burrow entrance index was computed as the number of captured pikas divided by the number of active entrances of each colony, i.e., the number of pikas per active entrance, using trapping data from several Daurian pika colonies from 1989 to

1990 at the same site (Wang et al., 2003). The entrance index was calculated for spring and autumn, respectively. We used the student t test to test for difference in the natural logarithm of density between control and treatment plots before and after haypile removal, respectively.

We determined plant species composition of haypiles collected from the removal experiment. Removed haypiles were combined and well mixed. Ten samples (about $\frac{1}{3}$ of entire removed hays) were randomly taken and sorted by species. Dry weight of each plant species from each sample was measured to the nearest 0.1 g. Average proportion of plant species of the total biomass of sampled hay was computed over 10 samples.

3. Results

Pikas selected forbs for haying in late autumns. A total of 15 plant species was identified, including 12 species of dicots that comprised 98% of the total biomass of sampled hays, whereas monocots comprised only 2%. All plant species constituting more than 5% of the total biomass were forbs (Table 1).

Pika densities on the hay-removal plots were not different from that on the control plots before haypile removal experiment ($t = 0.65$, df $= 18$, $P = 0.52$) but significantly lower than that on the control plots in May of 1993 after hay removal ($t = 3.03$, df $= 18$, $P = 0.007$). The population size of pika declined over winter on both control and treatment plots in the spring. However, the population size of pikas declined more in the haypile-removal plots than on controls (Fig. 1).

Table 1
Plant species composition of *Ochotona dauurica* haypiles in Hexiten Banner, Inner Mongolia

Plant species	Percent of haypile biomass (%)
Artemisia frigida	24.8
Thermopsis lanceolata	20.1
Melissitus ruthenica	16.1
Heteropappus altaicus	15.9
Artemisia scoparia	4.8
Other dicots plant (7 species)	16.4
Monocots plants (3 species)	1.9

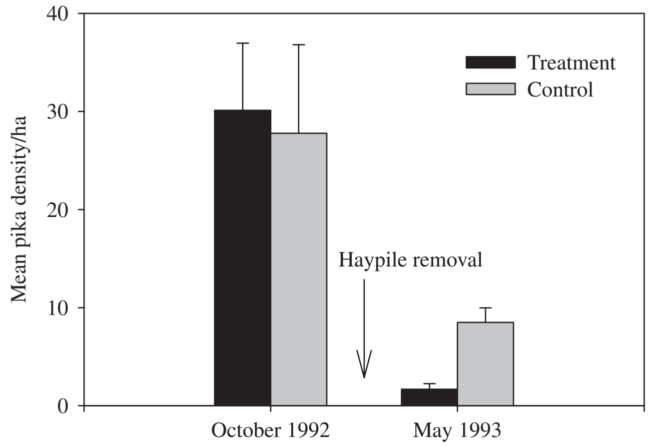

Fig. 1. Effects of haypile removal on population density of *Ochotona dauurica* in Hexiten Banner, Inner Mongolia. Vertical lines are one standard error.

4. Discussion

Pikas exhibit selective foraging behavior, choosing certain food plants in higher proportions compared to the proportions of these plants in vegetation (Gliwicz et al., 2006; Huntly et al., 1986). North American pikas feed mainly on grasses but hay predominantly forbs (>50% of biomass of haypiles; Huntly et al., 1986). Similarly, monocots are the main food of Daurian pikas during the summers and autumns (Wang et al., 2001), but Daurian pikas select forbs for haying during the autumns. Forbs constitute over 90% of hay biomass (this study; Komonen et al., 2003). Likewise, North American pikas store more forbs rich of protein and lipid (Huntly et al., 1986; Millar and Zwickel, 1972). Therefore, North American pikas and Daurian pikas share similar foraging patterns. The difference in food selection between haying and feeding suggests that forbs are a critical winter food of pikas.

All Daurian pikas of a burrow system contribute to haying (Personal observations) and build about 10 haypiles on average with an average haypile weighing 42.4 g in eastern Mongolia (Komonen et al., 2003). Pikas heavily rely on cached food during intermittent periods of food shortages in winter (Vander Wall, 1990). However, there might be a small amount of plant material cached underground in pika burrow systems. Daurian pikas may also eat standing dead plants during the winters. Overwinter mortality of Daurian pikas was high in the control plots, and about $\frac{1}{3}$ of those at the control plots survived through the winter (Fig. 1). However, hay removal resulted in additional mortality and lowered pika abundance in the spring compared to that in the control plots (Fig. 1). Therefore, haypiles play an important role in overwinter survival of Daurian pikas.

Small mammals at northern latitudes exhibit a diverse pattern of food caching to adapt to winter food shortages. Male arctic ground squirrels (*Spermophilus parryii*) store seeds and fruits of plants in underground middens for winter use; however, female arctic ground squirrels carry food for immediate use. Males enter hibernation in August, emerge in March the following year, and feed on cached food after emergence, whereas females are inactive from late July through April and do not rely on any cached food in winters (Zazula et al., 2006). Therefore, arctic ground squirrels use a combination of food caching and hibernation to adapt to winter food scarcity. North American pikas store food plants beneath or beside rocks of the talus, while Daurian pikas cache food plants aboveground close to burrow entrances. Pikas use cached food during intermittent periods of food shortages (Vander Wall, 1990). In Inner Mongolian steppes, Brandt's voles (*Lasiopodomys brandtii*), Daurian pikas, and Mongolian gerbils (*Meriones unguiculatus*) store food cooperatively by social group or colony (Agren et al., 1989; Zhong et al., 1982; Zhong et al., 2007). Mongolian gerbils store seeds of annual plants in underground caches (Agren et al., 1989). Both Brandt's voles and Daurian pikas store herbs in underground caches and aboveground haypiles, respectively. The three small mammal species in Inner Mongolian steppes belong to different taxa of mammals, but converge on similar sociality and cooperative food caching to adapt to cold winters and winter food shortage in Inner Mongolian steppes.

Availability of food resources is an important factor limiting densities of many small subterranean mammalian herbivores (Huntly and Reichman, 1994). Food resources are likely limited in arid, arctic, and alpine regions of low primary productivity and may regulate population dynamics of herbivore (Ayal, 2007; Oksanen and Oksanen, 2000). Removal of haypiles reduced Daurian pika densities the following spring. In addition, Daurian pika abundance was positively related to availability of selected forbs (Zhong et al., 1982). Population growth rates of Daurian pikas were negatively related to pika density but positively related to precipitation in central eastern Inner Mongolia (Wang and Zhong, 2006). Rainfall might enhance primary productivity and increase per capita availability of food resources for Daurian pikas in Inner Mongolia (Wang and Zhong, 2006). Therefore, availability of winter food likely limits Daurian pika abundance through either habitat selection or density-dependent regulation.

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