Journal of Arid Environments 75 (2011) 132–137

Contents lists available at ScienceDirect

Journal of Arid Environments

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

Home-range sizes of social groups of Mongolian gerbils *Meriones unguiculatus*

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ARTICLE INFO

Article history:
Received 20 January 2010
Received in revised form
21 August 2010
Accepted 31 August 2010
Available online 13 October 2010

Keywords:
Food availability
Group size
Inner Mongolia
Seasonal change
Social organization
Space use

ABSTRACT

Spacing behavior is important to the population regulation and social organization of rodents. However, little is known regarding the factors influencing space use by rodent social groups. We tested the hypotheses that food resources in the typical steppe would be so abundant that food availability would not be a limiting factor of home-range sizes of social groups of Mongolian gerbils (*Meriones unguiculatus*). We also assessed the effects of social organization on the home-range size of social groups of gerbils, using capture–recapture methods. Home ranges of social groups of Mongolian gerbils did not differ in size between the breeding and non-breeding periods; however, home ranges overlapped more during the breeding period than during the non-breeding period. Overlap of home ranges might allow male gerbils to access female mates of neighboring colonies during the breeding period. Home-range sizes of social groups were positively related to number of males during the breeding period, but positively related to group size and number of females during the non-breeding period. Therefore, social organization influenced home-range sizes of social groups. Our hypothesis that food availability is not a limiting factor of space use by social groups of Mongolian gerbils from spring through autumn was supported.

1. Introduction

A suite of extrinsic factors (e.g., the availability of food and space, predation and habitat structure) and intrinsic factors (such as animal abundance and reproductive condition) influences animal space use and home-range size (Hayes et al., 2007 and references therein). Understanding the effects of ecological factors on space use of animals is critical to elucidating ecological mechanisms underlying the social organization of animals (Emlen and Oring, 1977; Hayes et al., 2007). Increased food availability is hypothesized to reduce home-range sizes needed to meet the food requirement of rodents and consequently reduce the space needed (Travis and Slobodchikoff, 1993). For instance, supplemental food reduces the home-range size of Arctic ground squirrels (*Spermophilus parryii*; Hubbs and Boonstra, 1998). However, the home-range size of *Octodon degus* is not related to food biomass (Hayes et al., 2007). Supplemental food does not affect social group sizes of Mongolian gerbils (*Meriones unguiculatus* Milne-Edwards, 1867) during the breeding period (Liu et al., 2009a). Thus, we hypothesize that home-range size of social groups of Mongolian gerbils is not limited by food in a typical steppe where green plants are abundant and renewable during the growing season. However, few studies have tested the hypothesis.

Rodent spacing behavior may change seasonally as the reproductive condition of rodents and resource availability vary from season to season (Madison and McShea, 1987; Ostfeld, 1990). Rodents may expand home ranges during the breeding period to meet increased demands for energy and resources, but reduce home ranges during the non-breeding period (Hoset et al., 2008; Urayama, 1995). Home-range sizes of female pampas mice *Akodon azarae* are larger during the breeding period than during the non-breeding period (Bilenca and Kravetz, 1998). Social organization can also affect rodent space use (Branch, 1993; Burton and Krebs, 2003; Rayor, 1988) and demography (Blumstein and Armitage, 1998; McGuire et al., 2002). The size of the home range of a social group (combining the locations of all individuals living in a group) may vary with the size of the social group. For Mongolian gerbils, the home-range size of a social group is positively related to social group size and body mass of the largest male (Ågren et al. 1989a,b). The social organization of rodents can vary seasonally due to differences in reproductive activity between

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doi:10.1016/j.jaridenv.2010.08.008

seasons. Although recent studies have improved our understanding of seasonal variation in the home-range size of solitary rodents (Bond and Wolff, 1999; Hoset et al., 2008; Ostfeld, 1990; Schradin and Pillay, 2006), few studies have investigated the factors influencing seasonal changes in the home-range size of rodent social groups.

The Mongolian gerbil (*M. unguiculatus*) is widely distributed in the dry and desert grasslands of the southeast Bakal area in Russia, Mongolia and northern China (Luo et al., 2000; Mallon, 1985). Mongolian gerbils live in social groups or burrow systems year-round. Group sizes vary from 2 to 18 animals (Ågren et al., 1989a; Liu et al., 2004, 2009b). Mongolian gerbils reproduce mainly during spring and summer. In late autumn, reproduction ceases and all members of a group hoard food for winter (Ågren et al., 1989b; Liu et al., 2001). *M. unguiculatus* is also a model species for studies of rodent social behavior conducted in a laboratory (Clark and Galef, 2000; Prates and Guerra, 2005) and under semi-natural conditions (Ågren, 1976; Roper and Polioudakis, 1977); however, under semi-natural conditions, studies of social behavior and spacing behavior are affected by limited space and restricted movement (Ågren, 1976; Roper and Polioudakis, 1977). Recent work has helped to elucidate the ecology and the population ecology of wild Mongolian gerbils (Ågren et al., 1989a,b; Liu et al., 2009b; Wang and Zhong, 2006; Xia et al., 1982). Ågren et al. (1989a) studied the spacing behavior of Mongolian gerbils during the breeding period and found that home-range size of social groups was related to group size. However, little is known regarding seasonal changes in the spacing behavior of Mongolian gerbils. The main objectives of this study were to: (1) test our hypothesis that the home-range size of Mongolian gerbils is limited by social organization (group size, the number of males, the number of females and body mass), but not by food availability in the typical steppe; and (2) investigate seasonal variation in the home-range size of gerbil social groups. We predicted that home-range size of social groups of gerbils is not related to the height and cover of food plants within their home ranges, but is correlated with the complexity of social groups, such as group sizes, numbers of males and numbers of females of a social group.

2. Methods

2.1. Study area

Our study was conducted at Xima Gou (village; 42°07′N, 115°22′E; the elevation of 1450 m), about 30 km north of Baochang, Taipusi Qi (county), Inner Mongolia, China. The area was situated in a typical region where steppes were intermixed with croplands. The climate was semiarid and continental with relatively hot summers and cold winters. Average monthly temperatures ranged from −19 to 21.1 °C. Mean annual total precipitation was about 350 mm, ranging from 258 to 550 mm; more than 70% of the total precipitation fell in June, July and August. Snow cover lasted for about 90 days, from mid- or late October to early April, with the average monthly depth of 50 mm (Liu et al., 2007). June, July and August were the warmest months, with average monthly temperatures from 16.0 to 18.0 °C, and average monthly temperatures ranged from −14.0 to −4.0 °C during the coldest period from November to the following March in 2006. The total precipitation was 415 mm in 2006. The soil of the area was sandy and loamy Chestnut soil (Scheibler et al., 2006).

Our study site was situated on a 9-ha grassland (300 × 300 m) surrounded by wheat (*Triticum* spp.) and cabbage (*Brassica* spp.) croplands. The vegetation was dominated by the grass *Leymus chinense* and the herb *Corispermum mongolicum* with a mixture of grasses such as *Cleistogenes squarrosa* and *Setaria viridis*, herbs *Artemisia sieversiama*, *Artemisia scoparia* and *Heteropappus altaicus* and small shrubs *Caragana microphylla* and *Caragana korshinskii*. No livestock grazed on the study site during our study.

2.2. Trapping procedures

We established a 2-ha (200 × 100 m) trapping plot in the center of our 9-ha study site in early April of 2006. The trapping plot exhibited a higher density of gerbil burrows compared to the rest of our study site, encompassing 15 (65%) gerbil colonies at the beginning of our study. To enhance the probability of captures, we used a concentric circle trapping method (Liu et al., 2007). Trap stations were arranged in 3–4 concentric circles, with equal spacing, at each burrow system, which was adjusted based on the area occupied by a burrow system. The radius was about 1–2, 2–3, 4–5 and 6–8 m for the inner, second, third, and outer circle, respectively. The four trap circles had 4–6, 8–10, 12–14, and 15–16 trap stations, respectively, with an average distance of 1–2 m between trap stations. One wire-mesh live trap (28 × 13 × 10 cm) was placed at each station with the trap door opening facing a burrow entrance or gerbil runway to maximize the probability of capture (Liu et al., 2007). In the concentric trapping, traps were clustered only at burrow systems, with no traps placed between the two outer trap circles; therefore, we used a trap grid to supplement gerbil location data on space use between burrow systems. Between two concentric circle trapping periods, a 29 × 14 trap grid with a total of 406 trap stations, at 7-m spacing, was set within our trapping plot. Therefore, we combined data from our grid trapping and the concentric circle trapping to estimate home-range sizes of gerbil social groups. Each trapping period lasted for 3 consecutive days and we checked traps at the same times throughout the study.

Mongolian gerbils were live trapped from 28 April to 21 October in 2006 at a 2-week interval (Liu et al., 2009b). The gerbils remain active mainly under the snow during winter and move on the surface of the snow only on calm, sunny days (Wei Liu, personal observation). Therefore, we did not trap during winter to avoid trap mortality due to low temperatures. Traps were set at 0500 h–0600 h, and checked every 1–2 h until about 1100 h. Traps were closed from 1100 h to 1500 h to avoid trap mortality from heat stress; trapping was resumed at 1600 h and continued until 1900 h. In April, September and October, traps were set at 0630 h and 0730 h and monitored until 1730 h. Since Mongolian gerbils are diurnal, we did not trap during the night (Ågren et al., 1989a; Liu et al., 2007).

All captured gerbils were toe-clipped at the first capture for permanent identification (ID). We clipped only one toe per foot, removing one-half of a toe at the joint with a pair of sharp thin-bladed scissors; no more than three toes were removed from a gerbil. Captured gerbils were sexed and weighed to the nearest 0.1 g. Reproductive condition, trap location, and ID number were recorded for each capture. Males were considered in reproductive condition if they had scrotal testes and visible ventral scent glands with either clear contour or large, visible pores surrounded by secreted substance. Female gerbils were considered in reproductive condition if they had a bulging abdomen, enlarged nipples surrounded by white mammary tissue, or opened pubic symphysis (Liu et al., 2007; Payman and Swanson, 1980). Captured animals were immediately released at the same trap station of their capture. Our trapping and handling of Mongolian gerbils followed the guidelines of the Animal Care and Use Committee of the American Society of Mammalogists (Gannon and Sikes, 2007) and was approved by the Institutional Animal Use and Care Committee of the Institute of Zoology, the Chinese Academy of Sciences.