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Original Article

Effects of Food Availability on Time Budget and Home Range of Siberian Marmots in Mongolia

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Abstract

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The Siberian marmot (*Marmota sibirica*) is a common rodent species that ranges widely throughout northern Asia. However, due to overharvesting for fur and meats its population in Mongolia declined steeply and they are now categorized as an endangered. They are considered a keystone species because they can have a great impact on the landscape heterogeneity and its burrows serve as a refuge for a variety of taxa. Despite the important roles in the ecosystem and endangered status of the Siberian marmots, there is no study quantified behavioral ecology of this species in Mongolia. We studied effects of food availability on home range and time budget of the Siberian marmot in Hustai National Park, Mongolian, during 16-29 June, 2007. We conducted direct observations and vegetation surveys at one livestock grazed and one ungrazed site. Vegetation biomass, percent cover, plant height, and number of plant species were lower in the grazed site than in the ungrazed site. Marmots in the grazed site used larger home ranges, spent more time foraging, and spent less time vigilant compared to marmots in the ungrazed site.

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Introduction

A central question in ecology is how observed patterns in the spatial distribution of individuals within populations are determined by the interactions between individuals and their environment (Turchin, 1998; Matthiopoulos, 2003). A useful approach to address this question is to understand the dynamics of animal movements in relation to state-dependent social and ecological factors (Whitehead & Rendell, 2004). Most animals use the same areas repeatedly over time (Darwin, 1861); hence animal movements are often defined using the home range concept (Crook, 2004; Jetz *et al.*, 2004). The use of home ranges and territoriality is an essential characteristic of many birds and mammals (Ostfeld, 1990; Adams, 2001). The main purpose of maintaining a home range or territory is the acquisition of resources, basically food, but also shelter or mates (Brown & Orians, 1970).

The allocation of time to various activities is of special importance to hibernating sciurids that have a short active season (Armitage *et al*., 1996). Because time is limited, time spent in one activity decreases the time available for some other activities. Generally time available for foraging is considered to be critical; sufficient time must be allocated to foraging to meet the energy demands of growth, maintenance, and reproduction (Altmann, 1974). Time spent in other activities reduces the time available for foraging. However, time must be allocated to activities such as mating and reproduction, predator defense, defense of resources against conspecifics, and self-maintenance (Armitage *et al*., 1996). The time allocation for each activity generally varies with environment quality or food availability.

The Siberian marmot (*Marmota sibirica*) is a social and colonial-living rodent that ranges across the steppe and mountain ecosystems of Russia, China, and Mongolia (Bannikov, 1954; Adiya, 2000; Clark *et al*., 2006). Marmots play an important role in the overall structure and health of the steppe and mountain ecosystem (Yoshihara *et al.,* 2010a, b), and they can have a great impact on the landscape by modifying vegetation structure and composition (Van Staalduinen & Werger, 2007; Yoshihara *et al*., 2009; Yoshihara *et al.,* 2010c). In addition, marmots are essential prey for predators and their burrows can serve as refuges for a variety of mammals and birds (Adiya, 2000).

The total population number of Siberian marmots in Mongolia has sharply declined in recent years from a high of 40 million in the 1940s (Eregdendagva, 1972) to 10 million during 1990s (Demberel & Batbold, 1997), primarily due to overexploitation for fur and meats (Wingard and Zahler, 2006). Although the Siberian marmot is recognized globally as a species of least concern, it was recently regionally classified as endangered in Mongolia by IUCN Red List criteria (Clark *et al*., 2006). Despite the important roles in the ecosystem and endangered status of Siberian marmots, there is no scientific study available on the behavioral ecology of marmots in Mongolia.

In this study, we examined effects of food availability on the daily home range patterns and time budget of Siberian marmots in Hustai National Park, Mongolia. We predicted that the home range of marmots is smaller in areas with greater food availability. We also expected marmots in areas of low food availability spend more time foraging to meet daily energy requirements. Our overarching goal was to estimate and compare the home range and time budget of marmots in areas with different food availability using direct observation and vegetation survey.

Materials and Methods

Study area. Hustai National Park (HNP; $47^0 35'$- $47^0 52$, N, $105^0 40'$-$106^0 37$, E) is located ~100 km west of Ulaanbaatar, Mongolia. Elevation ranges from 1100 to 1840 m. HNP receives an average of 296 mm of precipitation annually. About 88% of the Park's 60,000 ha is covered by grassland and shrub land steppe and ca 5% is covered by birch (*Betula plathyphylla)* dominated forest (Fig. 1). The vegetation is dominated by grasses such as *Stipa* spp., *Agropyron* spp. and *Leymus* spp.; forbs, particularly *Artemisia* and *Allium* spp.; and sedges such as *Carex* spp. Gray wolves (*Canis lupus)* and raptors such as steppe eagles (*Aquila rapax)* and golden eagles (*Aquila chrysaetos)* prey on marmots. During late 1990s, over 24,000 marmots occupy about 25% of the HNP (Hustai National Park, 1999).

Methods. Livestock have been excluded from the park since its establishment in 1992; therefore no livestock grazing exists within the park boundaries. We established one study site inside (ungrazed) and one study site outside (grazed) of the park boundaries (Fig. 1). Two marmots (> 100 m between focal animals) were observed separately for each site (in total 4 marmots were observed in this study). Observations were carried out by binoculars and spotting scopes from 16 to 29 June, 2007. Due to weather constraints such as rain we collected data for 10 full days for each animal. The observers remained alone at fixed positions on top of a hill located 50-100 m from the focal animals. Easily recognized focal marmots (distinctive molt pattern and body size) were chosen for the observations. Due to extreme afternoon heat causing the marmots to remain in their burrows during mid-day (Melcher *et al*., 1990), we made 2 four-hour observations during two periods of the day: early morning (6:00 to

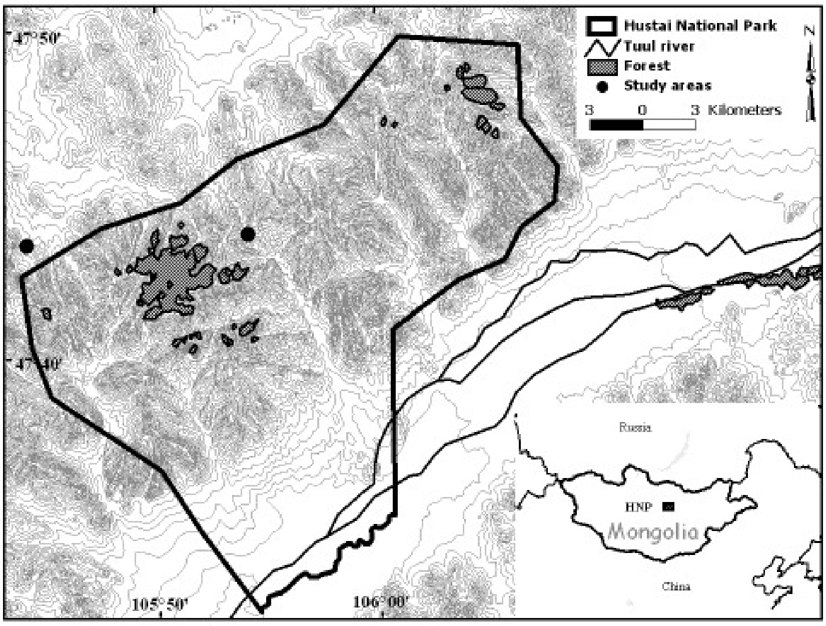

Figure 1. Study area (Hustai National Park, Mongolia).

10:00) and late evening (16:00 to 20:00). Focal animals were observed for 10-minute sessions with 5 minute interval (a total of 32 10-minute sessions per day) and recorded the time spent for different behavioral categories. For simplicity, marmot behaviors were classified as below ground; foraging (including brief instances of looking up, < 10 seconds); and vigilance (any instance of looking up >10 seconds, typically while sitting or lying at the burrow entrance or on a rock). Two observers alternated observations between the two focal animals at each study site on daily basis to reduce bias.

We assessed food availability by measuring plant percent cover, above-ground biomass, and plant height from 15 randomly located 1-m2 quadrats (with 2 m spacing between them, e.g. along 45 m lines) from a burrow of the focal animals. Plant percent cover (including grasses, forbs, and shrubs) visually estimated for each quadrat. The height of the tallest plant species was averaged to calculate overall vegetation height. Above-ground biomass of vegetation (grasses, forbs, and leaves of shrubs) clipped and dried from each $1m^2$ was weighed to the nearest 0.1 g.

In order to determine the home range of each study marmot, we made a schematic map for each site including presence of burrows and habitat characteristics prior to marmot observation. ArcView (version 3.2, ESRI) was used to create the schematic maps. During the observation period, the locations of the focal marmot were precisely drawn on the schematic map. After each observation period we used GPS (Global Positioning System) to locate edge points (> 30 locations) of the focal marmot's home range. We plotted location points into ArcView GIS 3.2 software and we used Minimum Convex Polygon extension to calculate marmot home range.

To estimate daily home range and time budget, we pooled observations made during early morning and late evening for each animal. We further combined time budget and home range data for each animal within the study site and compared results between the ungrazed and grazed sites. The number of plant species, average above ground biomass, plant height and percent cover between the areas were compared using a two-sample *t*-test. Time budget (average number of times in each activity category per observation session) and home range size was log transformed prior to statistical analysis to meet assumptions of a normal distribution. The time budget and home range variables between grazed and ungrazed areas of the park were also compared using a two-sample *t*-test. Means are reported with standard deviations.

Results

We recorded a total of 40 and 28 species of plants in non-grazed and grazed areas,

Table 1. Vegetation characteristics of ungrazed and grazed study areas in Hustai National Park, Mongolia (results are reported as means with standard deviations).

Vegetation variables	Ungrazed	Grazed
Vegetation cover, %	50.87 ± 11.84	29.61 ± 7.36
Plant height, cm	11.33 ± 3.87	5.05 ± 1.52
Above ground biomass, g	51.58 ± 16.75	35.35 ± 9.65
Number of plant species	40	28
Number of forbs	25	16
Number of grasses	10	9
Number of shrubs	5	3

respectively (Table 1). The average number of plant species recorded in $1m^2$ was higher in the ungrazed area than in the grazed area ($t = -6.7$, $df = 58$; $p < 0.01$). Vegetation biomass was significantly higher in the non-grazed area compared to the grazed area ($t = -5.8$, $df = 58$; $p < 0.01$; Table 1). The ungrazed area also showed higher percentage cover ($t = -11.07$; $df = 58$; $p < 0.01$) and the average height of plants ($t = -7.9$; $df = 58$; $p < 0.01$).

The daily home range size averaged 0.65 ± 0.39 ha (range = 0.29–1.69 ha) for marmots in the grazed area and 0.44 ± 0.33 ha (range = 0.27–0.81 ha) in the ungrazed area. The marmots in the grazed site had significantly larger home ranges than marmots in the ungrazed site ($t = 2.24$, $df = 38$, $p = 0.03$). No significant difference was found in home range size between morning and evening periods in both areas (*t*-test; non-grazed: $p = 0.12$; grazed: $p = 0.45$).

Among the three behavior categories recorded, marmots spent more time in burrows for grazed (38.1%) and ungrazed areas (45.4%), and there was no significant difference between the two areas ($t = 1.40$; $df = 38$; $p = 0.08$, Fig. 2). The average time spent foraging was higher ($t = 1.82$; $df = 38$; $p = 0.04$) in the grazed area (160.01 ± 44.13 min) than in the ungrazed area (114.21 ± 61.09 min). In contrast, the average time spent vigilant was higher (170.95 ± 77.61 min; $t = -8.61$; $df = 38$; $p < 0.01$) in the ungrazed area than the grazed one (88.30 ± 74.28 min; Fig. 2).

Discussion

We found the overall mean marmot home-range of 0.55 ha (range = 0.27–1.69 ha) in HNP.

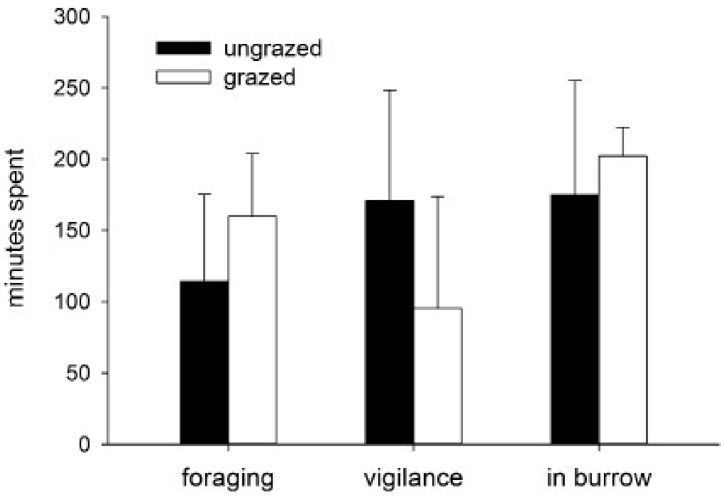

Figure 2. Time budgets of Siberian marmots studied in grazed and ungrazed areas at Hustai National Park, Mongolia (mean ± SD).

The home-range area estimates of Siberian marmots were similar to yellow bellied marmots, *M. flaviventris* (0.13–1.98 ha; Armitage, 1975), but were much smaller than golden marmots, *M. caudata aurea* (2.9–3.1 ha; Blumstein & Arnold, 1998) and woodchuck, *M. monax* (3.0 ha; Swihart, 1992). However, a direct comparison of home ranges among marmot species has a drawback, since there are a number of inter-species differences in habitat and ecology among marmot species. Our results suggesting that marmots in areas with higher food availability have smaller home range sizes is consistent with similar studies of yellow bellied marmots (*M. flaviventris*; Armitage 1974; Salsbury & Armitage, 1994), woodchuck (*M. monax*; Ferron & Quellet, 1989), and hoary marmots (*M. caligata*; Homes, 1984). Further research necessitates replication of study site with larger sample size to better understand changes in the home range of Siberian marmots in relation to different age-sex classes, seasons, habitats, and/or years.

Visibility is essential for detecting approaching predators and is related to habitat features, which is important for persistence of yellow-bellied marmots (Blumstein *et al*., 2006). In accordance with this, the habitat preference of Alpine marmots was rocky grassland, and they avoided using dense grasslands (Herrero *et al.*, 1997). In HNP, where they are protected from hunting, many of them fall prey to wolves, eagles, and other predators (Adiya, 2000). Dense vegetation within the park may, in part, be responsible for the marmots to be grazed within less home range to mitigate predation.

If marmots fail to gain critical mass before entering hibernation, they may not survive the winter (Armitage, 1975). Availability and quality of food are therefore, important factors affecting marmot body mass upon hibernation (Lenihan & Van Vuren, 1996). It is possible that livestock prevalent competition may lead to potential risk for the Siberian marmot in heavily grazed areas as lowering fitness prior to hibernation. In this study, marmots in the low food availability areas had a larger home range and spent more time on foraging suggests marmots in poor habitat spend more effort to meet their nutritional demand to survive during the hibernation. Alternatively, Armitage *et al*. (1996) suggested the foraging time of marmots does not necessarily measure weight gain, but possibly the quality and quantity of food. The number of plant species and the above ground biomass were greater in ungrazed areas, thus spending less time for foraging within smaller home ranges in high food availability area, may be sufficient in gaining the required amount of food.

Weather is an important factor affecting time budgets (Melcher *et al*., 1990; Loughry, 1993), yellow-bellied marmots having reduced activity at midday is primarily a consequence of thermal stress (Melcher *et al*., 1990). The observations we made at both grazed and ungrazed sites of marmots spending the more time in borrows may be related to this constraint, although we did not measure climate variables.

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References

Adams, E. S. 2001. Approaches to the study of territory size and shape. *Annual Review of Ecology and Systematics*, 32: 277–303.

Adiya, Y. 2000. Mongolian *Marmots: Biology, Ecology, Conservation and Use.* Institute of Biology, Mongolian Academy of Sciences, Ulaanbaatar. (in Mongolian)

Altmann, J. 1974. Observational study of behavior: Sampling methods. *Behaviour,* 49: 227–266.

Armitage, K. B. 1974. Male behaviour and territoriality in the yellow-bellied marmot. *Journal of Zoology*, 172: 233–265.

Armitage, K. B. 1975. Social behavior and population dynamics of marmots. *Oikos,* 26: 341-54.

Armitage, K. B., Salsbury, C. M., Barthelmess, E. L., Gray, R. C. & Kovach, A. 1996. Population time budget for the yellow-bellied marmot. *Ethology Ecology & Evolution*, 8: 67–95.

Bannikov, A. G. 1954. *Mammals of the Mongolian Peoples` Republic*. USSR Academy of Sciences Press, Moscow. (in

Russian).

Blumstein, D. T. & Arnold, W. 1998. Ecology and social behavior of Golden marmots (*Marmota caudate aurea*). *Journal of Mammalogy*, 79: 873–886.

Blumstein, D.T., Ozgul, A., Yovovich, V., Van Vure, D.H. & Armitage, K. B. 2006. Effect of predation risk on the presence and persistence of yellow-bellied marmot (*Marmota flaviventris*) colonies. *Journal of Zoology*, 270: 132–138.

Brown, J. L. & Orians, G. H. 1970. Spacing patterns in mobile animals. *Annual Review of Ecology and Systematics,* 1: 239–262.

Clark, E. L., Javzansuren, M., Dulamtseren, S., Baillie, J., Batsaikhan, N., Samiya, R. & Stubbe, M. (eds.). 2006. *Mongolian Red List of Mammals*. Zoological Society of London, London, pp. 64-66.

Crook, D. A. 2004. Is the home range concept compatible with the movements of two species of lowland river fish? *Journal of Animal Ecology,* 73: 353–366.

Darwin, C. 1861. *On the Origin of Species by Means of Natural Selection, 3rd edn*. Murray, London.

Demberel, J. & Batbold J. 1997. Distribution and resources of Mongolian marmot in Mongolia. In: *Epidemiological Survey of the Plague Natural Foci in the Central Asian Region*. Institute of Biology, Mongolian Academy of Sciences, Ulaanbaatar. (in Mongolian).

Eregdendagva, D. 1972. Altai marmot. *Science and Life Magazine*, 3: 72-73. (in Mongolian)

Ferron, J. & Quellet, J. P. 1989. Temporal and intersexual variations in the use of space with regard to social organization in the woodchuck (*Marmota monax*). *Canadian Journal of Zoology,* 67: 1642–1646.

Herrero, J., Garcia-Gonzalez, R. G. & Garcia-Serrano, A. 1997: Research on alpine marmot (*Marmota marmota*) in the Spanish Pyrenees. In V. Y. Rumiantsev, A. A. Nikol'skii, & O. V. Brandler (eds.): *Holarctic Marmots as a Factor of Biodiversity.* Abstracts of the 3rd International Conference on Marmots. ABF, Moscow, pp. 150–151.

Holmes, W. G. 1984. The ecological basis of monogamy in Alaskan hoary marmots. In J. O. Murie & G. R. Michener (eds.): *The Biology of Ground-dwelling Squirrels*. University of Nebraska Press, Lincoln, pp. 250–274.

Jetz, W., Carbone, C., Fulford, J. & Brown, J. H. 2004. The scaling of animal space use. *Science*, 306: 266–268.

Lenihan, C. & Van Vuren, D.1996. Growth and survival of juvenile yellow-bellied marmots (*Marmota flaviventris*). *Canadian Journal of Zoology,* 74: 297–302.

Loughry, W. J. 1993. Determinants of time allocation by adult and yearling black-tailed prairie dogs. *Behaviour*, 124: 23–43.

Matthiopoulos, J. 2003. The use of space by animals as a function of accessibility and preference. *Ecological Modelling,* 159: 239–268.

Melcher, J. C., Armitage, K. B. & Porter, W. P. 1990. Thermal influences on the activity and energetics of yellow-bellied marmots (*Marmota flaviventris*). *Physiological Zoology,* 63: 803–820.

Ostfeld, R. S. 1990. The ecology of territoriality in small mammals. *Trends in Ecology and Evolution*, 5: 411–415.

Salsbury, C. M. & Armitage, K. B. 1994. Home range size exploratory excursions of adult, male yellow-bellied marmots. *Journal of Mammalogy*, 75: 648–656.

Swihart, R. K. 1992. Home-range attributes and spatial structure of woodchuck populations. *Journal of Mammalogy,* 73: 604–618.

Turchin, P. 1998. *Quantitative Analysis of Movement: Measuring and Modeling Population Redistribution in Animals and Plants*. Sinauer Associates, Sunderland, Massachusetts.

Van Staalduinen, M. A. & Werger, M. J. A. 2007. Marmot disturbances in a Mongolian steppe vegetation. *Journal of Arid Environments*, 69: 344–351.

Whitehead, H. & Rendell, L. 2004. Movements, habitat use and feeding success of cultural clans of South Pacific sperm whales. *Journal of Animal Ecology*, 73: 190–196.

Wingard, J. R. & Zahler, P. 2006. *Silent Steppe: the Illegal Wildlife Trade Crisis in Mongolia: Mongolia Discussion Papers*. East Asia and Pacific Environment and Social Development Department. World Bank.

Yoshihara, Y., Ohkuro, T., Buuveibaatar, B. & Takeuchi, K. 2009. Effects of disturbance by Siberian marmots (*Marmota sibirica*) on spatial heterogeneity of vegetation at multiple spatial scales. *Grassland Science,* 55: 89–95.

Yoshihara, Y., Ohkuro, T., Buuveibaatar, B., Undarmaa, J. & Takeuchi, K. 2010a. Spatial pattern of grazing affects influence of herbivores on spatial heterogeneity of plants and soils. *Oecologia,* 162: 427–434.

Yoshihara, Y., Ohkuro, T., Buuveibaatar, B., Undarmaa, J. & Takeuchi, K. 2010b. Pollinators are attracted to mounds created by burrowing animals (marmots) in a Mongolian grassland. *Journal of Arid Environments*, 74: 159–163.

Yoshihara, Y., Ohkuro, T., Buuveibaatar, B., Undarmaa, J. & Takeuchi, K. 2010c. Clustered animal burrows yield higher spatial heterogeneity. *Plant Ecology,* 206: 211–224.

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