

The Management of Brandt's Vole in Mongolia: Toward an Ecologically Based Means of Control

Peter Zahler¹, L. Dolgormaa², Lyn A. Hinds³ and Andrew T. Smith⁴

¹ Wildlife Conservation Society, P.O. Box 485, Ulaanbaatar 211238, Mongolia e-mail: pzahler@wcs.org

² WWF-Mongolia, Hydrometeorological and Environmental Monitoring Agency, Building Room 303, Ulaanbaatar-46, Mongolia e-mail: mpo-toxic@wwf.mn

³ CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2601, Australia e-mail: Lyn.Hinds@csiro.au

⁴ School of Life Sciences, Box 874501, Arizona State University, Tempe, AZ 85287-4501, USA e-mail: a.smith@asu.edu

Introduction

The Brandt's vole (*Lasiopodomys* [= *Microtus brandti*]) inhabits much of the Mongolian steppe and adjacent grasslands in China and Russia. This small rodent has a high reproductive capacity, and local populations may increase in numbers and reach periodic peaks, or outbreaks, that occur in cycles of between 3-14 years. Brandt's voles live in family groups, store plant material for over-winter consumption, and show an annual cycle of abundance. The density and height of vegetation influence their habitat selection, with their preference being for areas where the grass is short, between 30-130 mm (Zhong *et al.* 1999). There is an over-winter decline in numbers of voles that is density-dependent, i.e., populations at a high autumn density decrease at a faster rate over winter than populations at low autumn density. During the breeding season, the rate of increase in the population is not density dependent; the rate of increase is a non-linear response to the height and cover of grass. Population growth rates are lowest in conditions of very short, sparse grass that provides insufficient food, and in tall, dense grass that probably disrupts social interactions and interferes with detection of predators (Zhang *et al.*, 2003).

Brandt's voles are an eruptive species with outbreaks occurring episodically – for example there have been 17 severe outbreaks in Inner Mongolia in the last 50 years (Zhang *et al.* 2003). They have been considered a pest species because they compete with livestock, contribute to soil disturbance through their burrowing activities (and can therefore potentially influence grassland desertification), and are reservoirs for diseases such as bubonic plague.

At high population densities, voles can negatively affect grasslands through their grazing. However, recent scientific studies have shown that Brandt's voles are short-grass specialists, and that vole outbreaks are more likely if areas are overgrazed. The frequency of outbreaks has increased in the last 20 years compared to the previous 20 years, and this has coincided with an approximate 5-fold increase in livestock numbers (Zhang *et al.* 2003). At the same time, Brandt's voles are a critical part of the steppe ecosystem, and may qualify as a "keystone species" – e.g., their occurrence may have a greater effect on ecosystem processes and general biodiversity than their numbers alone might suggest (Kotliar *et al.*, 1999; Smith and Foggin, 1999; Lai and Smith, 2003). Brandt's voles cycle and aerate soil through their burrowing efforts, and they affect vegetation around their colonies that can (during non-outbreak years) encourage a landscape mosaic of successional plant diversity (Samjaa *et al.*, 2000). Brandt's voles are also an important prey species for a wide range of carnivores, from foxes, polecats and Pallas' cats to saker falcons, upland buzzards, and steppe eagles (Samjaa *et al.*, 2000).

Management Issues: Bromadiolone

In recent years the Mongolian Government has been spending between about US\$300,000-\$800,000 each year on poisoning campaigns against Brandt's voles. The main rodenticide used in this campaign over the last few years is Bromadiolone. Unfortunately, this poisoning campaign has had little long-term effect on the target species, but it has had a serious negative effect on mammalian predators, raptors, cranes, various passerines, livestock, and even human health (Tsevenmyadag & Batbayar 2002). According to a report from the Ministry for Food and Agriculture in 2002, at least

one person has died from this poison, and others have been hospitalized because of it. Additionally many livestock have died as well as significant numbers of birds and wildlife, including those that are the natural predators on voles. Also, current control efforts are often implemented during the height of outbreaks. This is inefficient as usually in the following winter, vole populations decrease naturally and without the need for control efforts. At the same time, poor safety methods involving processing and distribution of the poison have threatened the health of workers and community members involved in the poisoning campaign.

There are three main classes of rodenticide in use today; acute poisons, first generation anticoagulants (e.g., warfarin) and second generation anticoagulants. Zinc phosphide, an acute poison, was used in Mongolia until 2000, when it was replaced by Bromadiolone. Bromadiolone is one of the 'second-generation' anti-coagulant rodenticides. The following are some facts related to Bromadiolone (WHO 1995):

- Bromadiolone is a vitamin K antagonist. The main site of its action is the liver. It functions as an anticoagulant and causes haemorrhaging. Bromadiolone may be absorbed from the gastrointestinal tract, from the skin, or from the lung. This means that it will act as a poison through ingestion, from contact with the hand or other body part, or through breathing in the material. Bromadiolone may accumulate in the liver and reach toxic levels over time with repeated exposure.
- In the case of humans, the main features of Bromadiolone poisoning are excessive bruising, nose and gum bleeding, and blood in urine and faeces in the less severe cases. Bleeding from several organs within the body can lead to shock and possibly death in the more severe cases. The onset of the signs of poisoning may not be evident until a few days after ingestion.
- Poor placement of Bromadiolone may allow poisoning of non-target species, primary poisoning through consumption of bait and secondary poisoning through consumption of poisoned rodents. This may negatively affect the natural predators of Brandt's voles, as well as endangered wildlife, livestock, and children and other people who may not be aware of the danger.
- At the present time, Mongolia is still using fixed-wing aircraft for aerial application. However,

because of the highly toxic nature of Bromadiolone and its ability to poison a wide class of animals including humans, the World Health Organization (WHO 1995) strongly recommends against aerial application.

Alternative Control Methods

Integrated pest management (IPM) was first developed for managing insect pests and plant diseases (Smith and van den Bosch, 1967). IPM focuses on the integration of a range of control practices to provide more effective management of the pest than any individual technique could achieve on its own. The approach has been applied to control of rodents but has revolved around standard monitoring of numbers, followed by decisions to undertake a control campaign using chemical rodenticides (Buckle and Smith, 1994). It has not been a cost effective and environmentally sound approach for pest rodents because the chemical use affects non-target species. More importantly, the approach has not focused sufficiently on an understanding of the biology and ecology of the species and its interactions in the environment – that is, demographic processes or ecological compensation mechanisms have been largely ignored. Ecologically-based rodent management (EBRM) has emerged from the principles of IPM and focuses on having a broad understanding of the biology and ecology of the species of interest (Singleton *et al.*, 1999). Factors that are the main drivers of population dynamics are identified, manipulated and then management strategies are devised which are economic, sustainable, socially acceptable, and environmentally safe.

Based on current knowledge, an increased prevalence of short-grass conditions is the most likely cause of the recent higher frequency in outbreaks of Brandt's vole (Shi *et al.* 2002). The increase in the number of livestock over the last few decades, with a possible contribution from climate change, has resulted in more years when the balance between grass production and grass off-take by herbivores causes conditions that are likely to produce outbreaks. There appears to have been a transition from tall grasslands to generally short-grass conditions maintained by high grazing pressure. Ecologically-based management will require a combination of herd management and carefully-targeted pest control to reverse this trend.

Recently, research efforts have focused on determining the feasibility of fertility control for

Brandt's vole. Fertility control is being investigated as an alternative to lethal control because it has potential to be species-specific, humane, environmentally acceptable and cost effective (Hinds *et al.*, 2003). Researchers have been assessing the use of proteins which surround the egg and which are important for the first steps in fertilization. Initial studies assessed the effects of immunization with two heterologous reproductive proteins, zona pellucida (ZP) proteins (whole porcine ZP and baculovirus-expressed mouse ZPC). While good immune responses were generated, no effects on the fertility of captive adult female voles were observed. Researchers have now cloned the gene for vole ZP3. Immunization with the vole ZP3 peptide (conjugated to Keyhole Limpet Haemocyanin) generated high antibody titres and decreased fertility in a high proportion (72%) of females after 4 booster treatments. Antibodies from infertile females cross-reacted with the egg coat surrounding oocytes in ovarian sections from untreated voles. No pathology of ovarian tissue was observed in immunized animals (L.A. Hinds *et al.*, unpublished observations). These results indicate that fertility control for Brandt's vole is feasible and further studies are warranted.

Models of the population dynamics of Brandt's voles have been developed and used to simulate the application of fertility control or lethal control (Shi *et al.*, 2002, Zhang *et al.*, 2003). Fertility control of voles would be effective if applied at the end of the preceding breeding season or twice at the start of an outbreak year and is equivalent to the effects of lethal control. A capacity to forecast outbreaks of Brandt's voles would also be essential for implementation of efficient control. Researchers are currently exploring various systems for delivery of this vole-specific peptide on a broad scale – however, this method is still a number of years from use in the field. A capacity to forecast outbreaks of Brandt's voles would also be essential for implementation of efficient control.

Workshop and Recommendations

As the present poisoning campaign in Mongolia threatens human health, livelihoods, and the natural balance of the steppe ecosystem without solving the problem of vole outbreaks, an international workshop was held 27-28 September, 2004 to develop specific solutions to the problems involved in Brandt's vole management. Topics included alternative, integrated, and ecologically-based means of vole management, experimental methods

and monitoring, training and education, environmental impact assessment, and rangeland management issues. At the workshop, international experts in integrated pest management and small mammal biology from the USA, UK and Australia gave talks on international best practice while Mongolian biologists and managers described the situation in Mongolia to the public. The second day focused on developing policy recommendations for the phase-out of the poison currently used; regulatory recommendations including proper environmental impact assessments, alternative management methods, testing and monitoring methodologies; and improving rangeland management to control vole populations. Members of Parliament, the Ministry of Nature and Environment, the Ministry of Food and Agriculture, the Ministry of Health, the Academy of Sciences, the National University of Mongolia, and a range of NGOs, concerned citizens and the media were involved in the workshop.

Outputs for this workshop were a set of recommendations to the Mongolian Government for ecologically-based management of Brandt's vole based on international best practice. The workshop also created a forum for an International Working Group to investigate issues and disseminate information on the extremely important conservation issue of small mammal management (Brandt's vole, pikas, etc.) across the grasslands of Mongolia and throughout Central and Eastern Asia.

Specific workshop recommendations included the following:

1. Stop Bromadiolone use in pastures by 2005

Stop using Bromadiolone for eradication of Brandt's vole in open pastureland by the end of 2005.

2. Use Bromadiolone based only on WHO Guidelines

After 2005, use Bromadiolone only in enclosed spaces and only based on requirements of the World Health Organization (WHO 1995).

3. Re-allocate government funds for the development and implementation of non-chemical control methods

Spend the government budget presently used for purchase and application of Bromadiolone for a non-chemical control program to control Brandt's voles. These government funds should be spent in the following manner:

a) Pilot field projects: Organize contracted work and provide financial support to

- i. Field-test various non-chemical methods of control of Brandt's voles,
- ii. Field-test combined herd management and pest control to create grassland conditions that minimize outbreaks of Brandt's voles, and
- iii. Apply the most successful combination of herd management and non-chemical methods for Brandt's vole control over broader areas.

b) Identify appropriate sites for control

Use non-chemical methods for Brandt's vole management only at locations identified by local government inspectors as potential problem areas, such as populated locations or water sources.

c) Identify appropriate timing of control

Use non-chemical methods of Brandt's vole management only during relevant in proper seasons, *before* the increase in population growth, rather than at peak periods, as shortly after peak periods (during winter) voles die off by themselves with no need of management action.

4. Raise awareness of the problems with use of Bromadiolone

Advertise widely to the public the dangers related to and reasons for not using Bromadiolone and other toxic chemicals in the pasture.

5. Train local people

Using researchers and professionals, organize training for local people in efficient and effective use of non-chemical management methods for Brandt's voles.

6. Encourage natural controls

Actively encourage natural controls including wildlife and birds that feed on Brandt's voles to maintain the natural balance of the steppe, including:

- a) Stop hunting of carnivore species including foxes, falcons, etc. and use methods that minimize the impact of rodent control on non-target species.
- b) Plant trees and bushes or construct artificial nests for raptor species that feed on Brandt's voles; monitor these sites and perform experimental studies to determine if they are successful in controlling Brandt's voles.

7. Develop a grassland management plan

Create an organized grassland use and management plan by identifying livestock carrying capacity but maintaining flexibility in herd management to maintain grassland biomass and species composition, taking into account between-year variability in climate (and perhaps climate shifts); alternating, saving and restoring grassland areas; and by identifying potential areas to grow animal feed.

8. Work with local herders

Train and work with local herders to assist them in implementing sustainable grassland management plans; consider creating herder cooperatives to collectively manage grasslands.

9. Create soum grassland managers

Create full time-grassland managers at soum levels to ensure reasonable numbers of productive livestock and avoid overgrazing.

10. Create yearly soum Grassland Survey and Management Plan

Ensure that each soum performs a yearly survey and assessment of grassland in their region and plans grazing schemes according to an agreed schedule.

11. Restore degraded grasslands

Restore degraded land into grassland, re-grow unused roads for grassland use, and restore and re-grow the post mining sites.

The workshop also developed a suite of recommendations for Mongolian research agencies and non-government and international organizations:

12. Initiate field research program

Support government actions against Brandt's voles through the study of international methods of prevention of Brandt's vole's population outbreaks and implement those methods as pilot field projects at specific locations.

13. Create long-term monitoring program

Organize a long-term monitoring program to identify locations with increased Brandt's vole populations and develop a method to predict years of vole outbreaks.

14. Study alternative vole uses

Study ways and technologies to use Brandt's vole biomass productively.

15. Organize management and training

Increase grassland management activities and organize educational training workshops on how to manage Brandt's vole populations.

16. Increase awareness

Publish booklets and information brochures to educate the public on prevention of Brandt's vole population outbreaks.

17. Promote results

Promote, organize and implement practical results of pilot projects and research studies.

Acknowledgements

The International Brandt's Vole Workshop was

funded by the Wildlife Conservation Society, WWF-Mongolia, the United States Agency for International Development, the UNDP-GEF Sustainable Grassland Management Project, and the UNDP-GEF Eastern Steppe Biodiversity Project. Special thanks must go to the Mongolian Ministry of Agriculture and the Mongolian Ministry of Nature and Environment for their participation and encouragement. We would also like to express our gratitude to A. Laurie, J. Chimeg, D. Negue, T. Damdin, B. Battur, D. Galbadrakh, Borgil, N. Batsaikhan, B. Lhagvasuren, R. Risebrough and the many other workshop participants for providing their expertise and enthusiasm in developing these recommendations.

References

- Buckle, A.P. & Smith, R. H. (ed.) (1994). *Rodent pests and their control*. Wallingford, UK. CAB International, 405p.
- Hinds, L.A., Hardy, C.M., Lawson, M.A. & Singleton, G.R. 2003. Developments in fertility control for pest animal management. Pp. 31-36 in: *Rats, Mice and People: Rodent Biology and Management* (eds. Singleton, G.R., Hinds, L.A., Krebs, C.J. & Spratt, D.M.). ACIAR Monograph 96.
- Kotliar, N.B., Baker B.W., Whicker A.D. & Plumb G. 1999. A critical review of assumptions about the prairie dog as a keystone species. *Environmental Management*, 24(2): 177-192.
- Lai C.H. & Smith A.T. 2003. Keystone status of plateau pikas (*Ochotona curzoniae*): effect of control on biodiversity of native birds. *Biodiversity and Conservation*, 12: 1901-1912.
- Samjaa, R., Zophel, U. & Peterson, J. 2000. The impact of the vole *Microtus brandti* on Mongolian steppe ecosystems. *Marburger Geographische Schriften*, 135: 346-360.
- Shi, D. Wan, X., Davis, S.A., Pech, R.P. & Zhang, Z. 2002. Simulation of lethal control and fertility control in a demographic model for Brandt's vole (*Microtus brandti*). *Journal of Applied Ecology*, 39: 337-348.
- Singleton, G.R. 1997. Integrated management of rodents: A Southeast Asian and Australian perspective. *Belgian Journal of Zoology* 127: 157-169.
- Singleton, G.R., Leirs, H., Hinds, L.A. and Zhang, Z. (1999). Ecologically-based management of rodents – re-evaluating our approach to an old problem. Pp.17-29 in: *Ecologically-based Rodent Management* (Eds Singleton, G.R., Hinds, L.A., Leirs, H. and Zhang Z.), ACIAR, Canberra.
- Smith, A.T. & Foggin, J.M. 1999. The plateau pika (*Ochotona curzoniae*) is a keystone species for biodiversity on the Tibetan plateau. *Animal Conservation*, 2: 235-240.
- Smith, R.F. & van den Bosch, R. 1967. Integrated control. pp 295-340 in: *Pest control: biological, physical, and selected chemical methods*. (Eds Kilgore, W.W. and Doutt, R.T.), Academic Press, New York.
- Tsevenmyadag, N. & Nyambayar, B. 2002. The impact of a rodenticide used to control rodents on demoiselle crane (*Anthropoides virgo*) and other animals in Mongolia. *Report to the International Crane Workshop, Beijing, China*. Ornithology Laboratory, Institute of Biology, Academy of Science of Mongolia.
- WHO. 1995. Bromadiolone. *Data Sheets on Pesticides No. 88*. World Health Organization, United Nations Environment Programme, and International Labour Organisation, Geneva.
- Zhang, Z., Pech, R., Davis, S., Shi, D., Wan, X. & Zhong, W. 2003. Extrinsic and intrinsic factors determine the eruptive dynamics of Brandt's voles *Microtus brandti* in Inner Mongolia, China. *Oikos*, 100: 299-310.
- Zhong, W., Wang, M. & Wan, X. 1999. Ecological management of Brandt's vole (*Microtus brandti*) in Inner Mongolia, China. Pp. 199-214 in: *Ecologically-based management of rodent pests*. (eds. Singleton, G. R., Hinds, L.A., Leirs, H. & Zhang, Z.), Australian Centre for International Agricultural Research, Canberra.