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# USE OF MULTI-OPENING BURROW SYSTEMS BY BLACK-FOOTED FERRETS

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ABSTRACT.—Multi-opening burrow systems constructed by prairie dogs (*Cynomys*) ostensibly provide escape routes when prairie dogs are pursued by predators capable of entering the burrows, such as black-footed ferrets (*Mustela nigripes*), or by predators that can rapidly dig into the tunnels, such as American badgers (*Taxidea taxus*). Because badgers also prey on ferrets, ferrets might similarly benefit from multi-opening burrow systems. Using an air blower, white-tailed prairie dog (*Cynomys leucurus*) burrow openings were tested for connectivity on plots occupied by black-footed ferrets and on randomly selected plots in Wyoming. Significantly more connected openings were found on ferret-occupied plots than on random plots. Connected openings might be due to modifications by ferrets in response to plugging by prairie dogs, due to selection by ferrets for complex systems with multiple openings that are already unobstructed, or simply due to ferrets lingering at kill sites that were multi-opening systems selected by their prairie dog prey.

RESUMEN.—Los sistemas de madrigueras con entradas múltiples construidos por perros llaneros (*Cynomys*) aparentemente sirven como rutas de escape para cuando los persiguen depredadores que caben en las madrigueras, tal como el hurón de patas negras (*Mustela nigripes*), o para cuando hay depredadores que pueden cavar rápidamente hacia los túneles, tal como el tejón (*Taxidea taxus*). Debido a que los tejones también matan hurones, estos últimos podrían beneficiarse de forma similar de los sistemas de madrigueras con entradas múltiples. Se utilizó un ventilador en las entradas de las madrigueras de los perros llaneros de cola blanca (*Cynomys leucurus*) para probar su conectividad en los cuadrantes ocupados por los hurones de patas negras y en otros cuadrantes seleccionados al azar en Wyoming. Se encontró un aumento significativo en el número de entradas conectadas en los cuadrantes ocupados por hurones con relación a los que se escogieron al azar. La conexión en las entradas podría deberse a un cambio hecho por los hurones como respuesta al taponamiento de los perros llaneros, a la selección por parte de los hurones de sistemas complejos con entradas múltiples que se encuentran libres de obstrucciones, o simplemente a que los hurones se quedan un tiempo en donde matan a su presa y estos son lugares con sistemas de entradas múltiples que su presa, el perro llanero, había seleccionado.

Prairie dogs (*Cynomys*) often construct burrow systems with multiple openings to the surface (Stromberg 1978, Hoogland 1995, Verdolin et al. 2008). These complex systems provide potential benefits of ventilation (Vogel et al. 1973) and routes of escape for prairie dogs when they are pursued underground by predators, such as American badgers (*Taxidea taxus*), long-tailed weasels (*Mustela frenata*), and black-footed ferrets (*Mustela nigripes*). Black-footed ferrets ("ferrets" henceforth) also might be expected to benefit from multi-opening burrow systems because they, too, use prairie dog burrows as refuge and are killed by badgers (Biggins et al. 2006a, 2011). Although other predators (chiefly coyotes, *Canis latrans*) have killed many more radio-tagged ferrets at reintroduction sites than have badgers (Biggins et al. 2006a), predation by badgers might be substantially underestimated because much of it likely occurs belowground where radio signals are difficult to detect (Biggins et al. 2011). Stromberg (1975) stated that ferrets appeared to select complex multi-opening burrow systems. This statement was based on excavations of burrow systems by Sheets et al. (1971), but Stromberg (1975) did not speculate about a cause for such selection.

Ferrets were extirpated from the wild by 1987, when the remnants of a population living on a complex of white-tailed prairie dog (*Cynomys leucurus*) colonies near Meeteetse, Wyoming, were captured for a captive breeding program (Biggins et al. 2006c). Reintroduction of ferrets on white-tailed prairie dog colonies in Shirley Basin, Wyoming, in 1992 afforded an opportunity to investigate the use of multi-opening burrow systems by ferrets. It is difficult to study this phenomenon on black-tailed prairie dog (*Cynomys ludovcianus*) habitats because black-tailed prairie dogs tend to plug burrows used by ferrets (Hillman and

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Linder 1973, Biggins et al. 2012a) and tend to remain active throughout the year (Hoogland 1995).

To test the hypothesis that ferrets favor use of multi-opening burrow systems, counts of connected burrow openings were compared for plots centered on burrow openings used by ferrets and on randomly selected burrow openings on colonies. The study was conducted in October–November, after most white-tailed prairie dogs had entered hibernation; thus, observed burrow connectivity reflected connectivity as prairie dogs entered hibernation or reflected modification of burrow connectivity by ferrets via digging.

## METHODS

Radio-tracking for a separate study documenting movements and survival of ferrets released into Shirley Basin (see detailed description and map of study site in Biggins et al. 1999) enabled immediate calculation of real-time ferret locations with program TRITEL (Biggins et al. 2006b). These locations were visited on the ground by use of handheld radio-tracking equipment to identify underground positions of radio-tagged ferrets, and locations were marked with pin flags for sampling of the burrow systems after departure of the ferrets.

In some cases, more than one burrow system occupied by an individual ferret was sampled. For a burrow to qualify for sampling, a ferret that was free-ranging for at least 3 days had to use the burrow system for at least one day. Some burrow systems were occupied for up to 3 days. Sampling was conducted during 29 October–17 November 1992 on burrows used by ferrets during 10 October–11 November 1992, after most white-tailed prairie dogs had entered hibernation. Few prairie dogs were observed during the study. On similar white-tailed prairie dog habitat, 80% of radio-monitored prairie dogs became inactive by 22 October, and 96% were inactive by 2 November (Biggins et al. 2012a). Lack of prairie dog activity was advantageous because prairie dogs tend to plug the openings of burrow systems occupied by ferrets (Biggins et al. 2012a). Thirteen ferret-occupied burrow openings were sampled for 7 different ferrets (all young-of-year: 4 females, 3 males). These openings were compared to 13 randomly selected burrow openings that were within 200 m of the ferret-occupied burrow and on the same colonies.

Smoke has been used to test connectivity of prairie dog burrows (e.g., Stromberg 1978) but was not used in this study due to the potential hazards to burrow occupants. Instead, a 37.7 cc gasoline-powered backpack air blower (Craftsman® Model 636796912) was used to pressurize the burrow systems, and feathers were used to detect air flow. The 5.1 cm (inside diameter) blower tube was inserted ~25 cm into the focal burrow opening closest to where a ferret had been located underground. The tube was first encircled in plastic bags near the distal end to hold it in place, and soil was packed (above the plastic bags) between the walls of the burrow and the tube to create a seal. A search was then conducted to find all other burrow openings within 17 m of the focal burrow opening. It was noted if any of these openings had excavations of soil with sign characteristic of ferret deposits (Clark et al. 1984) or if any openings were reamed to large diameters with soil deposits characteristic of badgers (Eldridge 2004). The 17-m radius resulted in a burrow-centered circular plot of 0.091 ha, a plot size that would have included >90% of the connected burrows detected by Sheets (1970) in his study of prairie dog burrow systems. The blower was started and the burrow opening closest to the focal opening was checked for airflow by placing feathers 10 cm into it and watching for feather movement. Detection of feather movement was enhanced by working on days without wind. Feather movement was not subtle in most cases involving connectivity; there was usually sufficient air flow to blow the feathers back out of the opening into which they were placed. Openings were sequentially tested at increasing distances from the focal opening, and those with airflow were plugged with bags and soil to increase air flow to openings subsequently tested.

Distances between burrow openings connected by subsurface tunnels were recorded. These measurements underestimate lengths of connecting tunnels for 2 reasons. First, prairie dog burrow tunnels are 3-dimensional features that often follow circuitous routes in both vertical and lateral dimensions, descending at times to >2 m deep (Sheets et al. 1971). Second, distances were measured from each

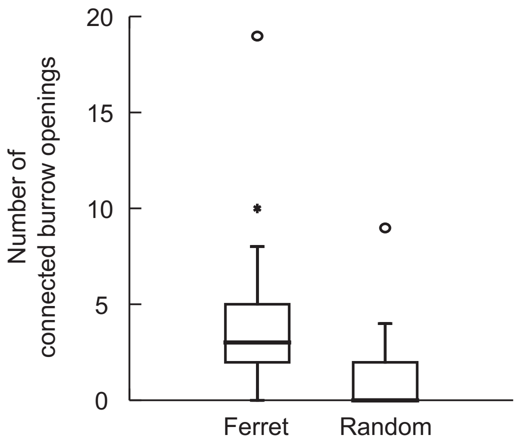


Fig. 1. Number of burrow openings connected by subsurface passages within 0.091-ha plots centered on burrows occupied by radio-tagged black-footed ferrets (*Mustela nigripes*) and randomly selected burrow openings on white-tailed prairie dog (*Cynomys leucurus*) colonies in Shirley Basin, Wyoming, October–November 1992.

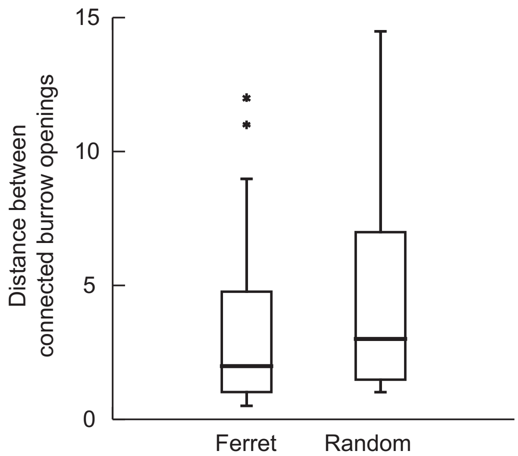


Fig. 2. Distances between burrow openings connected by subsurface passages within 0.091-ha plots centered on burrows occupied by radio-tagged black-footed ferrets (*Mustela nigripes*) and randomly selected burrow openings on white-tailed prairie dog (*Cynomys leucurus*) colonies in Shirley Basin, Wyoming, October–November, 1992.

connected opening to the nearest opening that exhibited airflow. When >2 openings were connected, the actual routes of subsurface connection may not have been between nearest-neighbor openings. Burrow openings were sketched and labeled with the distances separating them and with descriptive notes on connections and other features (e.g., evidence of badger and ferret excavation, tracks). After sampling was completed, all bags and soil plugs were removed from the burrow openings. Using Mann–Whitney *U* tests, statistical comparisons among ferret-occupied plots and random plots were made of (1) numbers of connected burrow openings, (2) total numbers of burrow openings, and (3) distances between connected burrow openings.

## RESULTS

Radio-tagged ferrets that used the burrow systems in the sample had various types of prerelease experience (see Biggins et al. 1999), but only one had occupied prairie dog burrows (in a preconditioning pen) before release. The sampled burrow systems were used by ferrets that had been free-ranging for 3 to 38 days ($\bar{x}$ = 11.86 days, SD = 8.91). Ferret-occupied burrow systems had 0–19 connected openings and random burrow systems had 0–9 connected openings, with distributions that resulted in a significant difference between their ranked values (Fig. 1; Mann–Whitney test: $\chi^2_1 = 5.949$, $P = 0.015$). The difference could not be explained by total numbers of burrow openings in plots, as these values were similar for ferret-occupied and random plots (Mann–Whitney test: $\chi^2_1 = 0.259$, $P = 0.611$); moreover, there was a trend for slightly lower density of openings in the ferret-occupied plots than in the random plots. The focal opening nearest the underground ferret location was connected to at least one additional opening on 11 of 13 occasions (84.6%), compared to 5 connections of 13 random openings tested (38.5%). Overall, these 0.091-ha plots had a mean density of 105.9 burrow openings per ha (SD = 43.8), an estimate that is likely biased high because plots were centered on burrow openings. Mean distance between 83 connected burrow openings ($n = 66$ distances) was 3.5 m (range 0.5–14.5 m) and was similar for both ferret-occupied plots and random plots (Fig. 2; Mann–Whitney test: $\chi^2_1 = 0.647$, $P = 0.421$).

Three badger-reamed burrows were encountered in ferret-occupied plots and one in a random plot. Two ferret diggings were found in ferret-occupied plots compared to none in random plots. Both ferret diggings were at burrow openings that were not connected to other openings.

## DISCUSSION

The hypothesis that ferrets would favor use of burrow systems with multiple openings was supported despite 3 phenomena that might have reduced the power to detect differences. First, these captive-born ferrets were naïve, and their experiences in captivity coupled with the stresses of transport, release, and sudden exposure to a novel environment might have deterred rapid expression of predisposed behaviors. Second, the few prairie dogs that might have remained active during the study could have plugged burrow systems occupied by ferrets. Third, some burrow openings randomly selected for sampling might have been used by ferrets. The relative frequency of connections for randomly selected burrow openings (34.5%) was much higher than that reported by Stromberg (1978) for white-tailed prairie dog burrow systems (2.1%) on a colony without ferrets, suggesting that ferrets might have modified burrows that were randomly selected on Shirley Basin colonies (e.g. via digging; Eads et al. 2012), or that the Stromberg smoke method was less sensitive than the leaf-blower method at detecting connections.

Estimates of overall density of burrow openings for the present study, although perhaps inflated by the burrow-centered plot technique, were within the range typical for white-tailed prairie dogs in Shirley Basin (Orabona-Cerovski 1991) and at other Wyoming sites (Menkens 1987); however, they were about 2 orders of magnitude greater than those reported by Stromberg (1978). The white-tailed prairie dog colonies studied by Stromberg (1978) and Menkens (1987) were in the same area (near Laramie, WY) and would not be expected to have such disparate attributes.

At least some of the winter excavation by ferrets is thought to be related to hunting of hibernating prairie dogs (Clark et al. 1984). Hibernating prairie dogs probably sequester themselves into hibernation chambers by plugging underground openings to these chambers, but we cannot be certain that main connecting tunnels are also plugged. Considering the large volume of soil excavated by ferrets (Clark 1989, Biggins et al. 2012a), however, some plugs on white-tailed prairie dog colonies might be rather long, suggesting plugging of main tunnels. In the present study, distances separating connected burrow openings were similar for ferret-occupied plots and random plots, suggesting that ferrets were not selectively clearing plugs from short tunnels that connected multiple openings within a single mound. There were no large diggings present, however, implying that these ferrets were not excavating tunnels with long plugs.

Badgers have been observed to kill radio-tagged ferrets (Biggins et al. 2006a, Biggins et al. 2011). Presence of badger diggings in ferret-occupied plots provides additional evidence of the hazards they pose to ferrets. Supplemental provisioning of experimentally released Siberian polecats (*Mustela eversmanii*) with dead prairie dogs appeared to attract badgers (Biggins 2000), and remains of prairie dogs killed by ferrets may be similarly attractive. Although there was more badger sign encountered in plots occupied by ferrets than in random plots, sample sizes in this study were too small to adequately assess attraction of badgers to ferrets or the ferrets' prey remains.

During winter, it would not seem adaptive for ferrets to linger in burrows from which they excavate hibernating prairie dogs, because those burrows likely do not have escape routes (due to plugs made by the prairie dogs). Nevertheless, ferret dens in winter have been associated with presence of ferret diggings (Richardson et al. 1987). Perhaps the risk to ferrets of occupying prairie dog hibernation burrows without multiple openings is reduced in midwinter due to inactivity of badgers during that season (Harlow 1981, Messick and Hornocker 1981), or perhaps some of the excavations by ferrets in winter are to modify den sites to create multiple escape routes rather than to excavate hibernating prairie dogs.

The proximate causes for multi-opening burrow systems occupied by ferrets in the present study are similarly unclear. The connected openings might be due to modifications by ferrets in response to plugging by prairie dogs (Eads et al. 2012, Biggins et al. 2012a) or due simply to selection by ferrets for complex systems with burrows that are already open; a combination of the 2 seems plausible. Also, ferrets might be associated with such systems because their prairie dog prey might prefer such systems (Biggins et al. 2012b) and the ferrets might remain with their kills. Regardless of proximate cause, it seems that availability of escape routes for ferrets pursued by badgers provides a selective advantage to ferrets that use burrow systems with connected openings.


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