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Abstract—The Mexican gray wolf (*Canis lupus baileyi*) was extirpated from Arizona and New Mexico in the 1970s. In 1998, Mexican gray wolves were translocated into the east-central Arizona portion of the Blue Range Wolf Recovery Area. One measure of success of the translocation is the ability of the Mexican gray wolf to capture native prey. Our objectives were to determine diet of wolves during summers 2005 and 2006, and contrast diet in areas that were grazed by livestock seasonally to areas grazed annually. We collected scats, identified contents from hair and bone fragments, and estimated diet by calculating percentage biomass of prey consumed. Elk (*Cervus elaphus*) comprised 80.3% of diet of the Mexican gray wolf. Other prey included domestic cattle (16.8%), deer (*Odocoileus*; <1%), squirrels (<1%), other rodents (2%), and lagomorphs (<1%). In areas of year-around grazing, 21% more livestock were consumed, compared to areas grazed seasonally.

Resumen—El lobo gris mexicano (*Canis lupus baileyi*) fue extirpado de Arizona y de Nuevo México en la década de 1970. En 1998, los lobos mexicanos fueron trasladados a la porción este-central de Arizona del área de recuperación del lobo ''Blue Range Wolf Recovery Area.'' Una medida del éxito del traslado es la capacidad del lobo gris mexicano de capturar las presas nativas. Nuestros objetivos fueron determinar la dieta de los lobos durante los veranos del 2005 y 2006, y compararla en áreas que fueron pastadas estacionalmente por ganado con áreas pastadas durante todo el año. Recogimos excretas, identificamos el contenido por medio de fragmentos del pelo y hueso, y estimamos la dieta calculando el porcentaje de biomasa de presa consumida. Los alces (*Cervus elaphus*) abarcaron el 80.3% de la dieta del lobo gris mexicano. Otras presas incluyeron ganado (16.8%), venados (*Odocoileus*; <1%), ardillas (<1%), otros roedores (2%), y lagomorfos (<1%). Veintiun por ciento más ganado fue consumido en áreas de pastoreo constante comparado a las áreas de pastoreo estacional.

The Mexican gray wolf (*Canis lupus baileyi*; hereafter Mexican wolf) is the smallest (Hall and Kelson, 1959), most genetically distinct (Wayne et al., 1992; Garcia-Moreno et al., 1996), and most endangered (McBride, 1980; Brown, 1983; Ginsberg and Macdonald, 1990) subspecies of gray wolf (*C. lupus*) in North America. The Mexican wolf was extirpated from its range in Arizona and New Mexico by the 1970s (Brown, 1983).

In May 1976, the Mexican wolf was listed as endangered under the Endangered Species Act. In 1998, the United States Fish and Wildlife Service began a translocation program to establish a nonessential, experimental population of Mexican wolves in the Blue Range Wolf Recovery Area (United States Fish and Wildlife Service, in litt.). One measure of success of the translocation is the ability of Mexican wolves to capture native prey.

Analysis of scats is a common method for studying diets of large, elusive predators such as wolves (Putman, 1984). Reed et al. (2006) reported that elk (*Cervus elaphus*) was the primary prey item in scats of Mexican wolves during 1998–2001. However, no study has specifically quantified diet during summer. Our objectives were to examine summer diet of Mexican wolves based on analysis of scats, and compare composition of diet between areas where seasonal or year-around livestock grazing occurs.

Our research was conducted throughout the 17,700-km^2 Blue Range Wolf Recovery Area, and included the Apache and Gila national forests in east-central Arizona and west-central New Mexico. The study area was surrounded by public, private, and tribal lands; cattle grazing is permitted on most of the recovery area (Reed et al., 2006). Elevations were 1,200 m in semidesert lowlands to 3,350 m in mixed-conifer forests. Lower elevations were characterized by rolling hills with steep canyons and sandy washes, and higher elevations consisted of rugged slopes, high mesas, and rock cliffs (United States Fish and Wildlife Service, in litt.). Long-term annual maximum and minimum temperatures in the study area were 16.4 and −3.1°C (Desert Research Institute, Western Region Climate Center, Reno, Nevada, http://www.wrcc.dri.edu), respectively. Annual precipitation was 30.5 cm in lower elevations to 127 cm in higher elevations, with an average annual rainfall of 53.3 cm (United States Fish and Wildlife Service, in litt.).

In April 1998, Mexican wolves were released into the primary recovery zone (2,600 km^2), located in the center of the Arizona portion of the Blue Range Wolf Recovery Area. However, since the first (and subsequent) release(s) of Mexican wolves, they have dispersed throughout most of the Blue Range Wolf Recovery Area (Adaptive Management Oversight Committee and Interagency Field Team, in litt).

Potential large prey of the Mexican wolf in the study area included elk, mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), pronghorn (*Antilocapra americana*), collared peccary (*Pecari tajacu*), bighorn sheep (*Ovis canadensis)*, and domestic cattle (United States Fish and Wildlife Service, in litt.). Potential medium and small prey included American beavers (*Castor canadensis*), lagomorphs (*Lepus* and *Sylvilagus*), skunks (*Mephitis*), North American porcupines (*Erethizon dorsatum*), Merriam's turkeys (*Meleagris gallopavo*), tree (*Sciurus* and *Tamiasciurus*) and ground squirrels (*Spermophilus*), chipmunks (*Tamias*), woodrats (*Neotoma*), deermice (*Peromyscus*), and voles (*Microtus*; Hoffmeister, 1986; United States Fish and Wildlife Service, in litt.).

We collected scats along roads and trails, and at den and rendezvous sites. Scats were collected on roads while driving weekly routes within territories of packs, and also opportunistically within the study area. We opportunistically hiked trails within territories of wolves and collected all scats of wolves that were found. Lastly, we used radiotelemetry to track wolves and identify locations of den and rendezvous sites. We then hiked to these locations and opportunistically collected scats within 0.4 km of the site.

We collected scats ≥30 mm in diameter to minimize collection of scats of coyotes (*Canis latrans*) and other canids (i.e., domestic dog; Weaver and Fritts, 1979; Arjo et al., 2002; Reed et al., 2004). We also collected scats ≥22 mm in diameter if fresh wolf tracks and no evidence of coyotes were present, or if they were <0.4 km of a known den or rendezvous site of wolves. Although scats of coyotes may have been collected inadvertently, their collection probability was small (or maybe zero) and did not impact results appreciably. We deposited scats into individually labeled paper bags. We assigned each scat a number and recorded date collected, relative age of scat (i.e., old, recent, or fresh based upon appearance, exposure to sun, and weather conditions; Ciucci et al., 1996), location (Universal Transverse Mercator coordinates), probable pack responsible for the scat, and search technique used to locate the scat.

Scats were air dried to keep mold from growing during storage, washed in a sieve to separate bone fragments and hairs, then allowed to air dry before analysis (Arjo et al., 2002). We compared hairs to a reference collection to identify prey (Moore et al., 1974). We used patterns in the medulla to determine if the hair was from deer, elk, cattle, squirrels, other rodents, or lagomorphs (Moore et al., 1974). We calculated biomass of prey consumed using Weaver's (1993) regression equation ($y = 0.439 + 0.008x$) from the frequency of occurrence (number of occurrences of each prey item found) of contents found in scats (Spaulding et al., 1997). This equation describes the linear relationship between mass of prey and amount of prey present in each collectable scat, but does not include variation in age and weight of prey (Weaver, 1993). We used masses of adult prey from Reed et al. (2006) for calculations, and

TABLE 1—Name of each pack is provided above the sample size and percentage biomass of prey items in scats of Mexican gray wolves (*Canis lupus baileyi*) studied in Arizona and New Mexico, summer 2005 and 2006. Packs with small samples ($n < 15$) were not included.

	2005			2006			
Prey	Blue Stem ($n = 33$)	Saddle ($n = 30$)	Luna ($n = 36$)	San Mateo ($n = 35$)	Rim ($n = 45$)	Saddle ($n = 29$)	Luna ($n = 50$)
Elk	84.6	94.5	45.9	98.3	96.0	91.5	75.1
Cattle	12.4	4.3	52.7	—	—	4.9	24.1
Deer	—	—	—	—	1.7	—	—
Squirrel	1.0	—	—	—	0.5	—	—
Lagomorph	—	—	—	—	0.5	0.7	—
Other rodent	2.0	1.3	1.5	1.7	1.4	2.9	1.7

were not concerned with biases due to variation in mass of consumed prey. Because one species of ungulate was the main source of food, adjusting average mass of consumed individuals would not have altered results significantly.

Home ranges for packs in 2005 and 2006 were based on aerial locations during April–August and 95% Minimum Convex Polygon (White and Garrott, 1990) estimators of home range using the animal-movement extension in ArcView 3.2 (Hooge et al., 1999; Environmental Systems Research Institute, Redlands, California). All allotments of the United States Department of Agriculture Forest Service that overlapped home ranges were classified by their grazing system (i.e., seasonal or year around). We compared diet among packs, grazing systems, and years based on percentage biomass of each category of prey using a chi-squared likelihood-ratio contingency-table analysis (*G*-test; Ott, 1988) corrected for continuity (Williams, 1976).

We collected 139 scats 25 May–14 August 2005, and 165 scats 23 May–20 August 2006. Nine different packs (Bluestem, Francisco, Hawks Nest, Luna, Rim, Ring, Saddle, San Mateo, and unknown) were sampled in 2005 and eight packs (Granite, Hawks Nest, Luna, Nantac, Rim, Saddle, San Mateo, and unknown) were sampled in 2006 (Table 1). We collected 165 scats at den sites, 109 on roads, 17 on trails, 7 at rendezvous sites, and 6 at other locations.

Scats from both summers contained 347 different prey items. Remains of elk (80.3%) comprised most of the biomass consumed. Cattle (16.8%), other rodents (2%), squirrels (<1%), deer (<1%), and rabbits (<1%) made up the rest of the diet (Table 2). Juniper (*Juniperus*) berries and feathers were present in nine and two of the scats, respectively, but were not quantified as part of the diet because they were <5% of the scat in which they were found.

TABLE 2—Percentage frequency of occurrence and percentage biomass of prey items consumed by Mexican gray wolves (*Canis lupus baileyi*) studied in Arizona and New Mexico, summer 2005 and 2006.

Prey	Mass of prey (kg)[a]	kg/scat[b]	Number of items	Frequency of occurrence (%)	Biomass (kg)	Biomass (%)
Elk	250.0	2.44	245	73.4	597.8	80.3
Cattle	318.0	2.98	42	12.6	125.2	16.8
Deer	50.5	0.84	2	0.6	1.7	0.2
Squirrel	0.2	0.44	5	1.5	2.2	0.3
Lagomorph	0.9	0.45	3	0.9	1.4	0.2
Other rodent	0.2	0.44	37	11.1	16.3	2.2
Total			334[c]	100.0	744.5	100.0

[a] Mass of prey from Reed et al. (2006).

[b] Calculated by equation $y = 0.439 + 0.008x$ (Weaver, 1993).

[c] Excludes 11 juniper berries, 2 feathers, 1 invertebrate, and 1 unknown prey item.

In 2005, there was only one pack that was different among packs relative to biomass of prey. Luna was different from Bluestem (G_{adj} = 31.579, *df* = 3, $P < 0.001$) and Saddle (G_{adj} = 51.271, *df* = 2, $P < 0.001$). The Luna pack consumed 40–48% more cattle and 39–49% less elk than these packs (Table 2). Samples for San Mateo, Rim, Hawks Nest, Ring, Francisco, and unknown packs were too small ($n < 30$) to compare to Luna. In 2006, the Luna pack was different from Rim (G_{adj} = 40.788, *df* = 5, $P < 0.001$), Saddle (G_{adj} = 13.377, *df* = 3, $P < 0.01$), and San Mateo (G_{adj} = 32.848, *df* = 2, $P < 0.001$). The Luna pack consumed 19–24% more cattle and 16–23% less elk than these packs (Table 1). Samples during 2006 for Granite, Nantec, Hawks Nest, and unknown packs were too small ($n < 30$) to compare to Luna pack. There was a change in diet between years for Luna (G_{adj} = 19.485, *df* = 2, $P < 0.001$), but not Saddle. The Luna pack consumed 29% more cattle and 29% less elk in 2005 than in 2006 (Table 1). There was a difference in total diet between years among pooled packs (G_{adj} = 18.199, *df* = 5, $P < 0.01$). However, when diet of the Luna pack was excluded from the analysis, there was no difference in diet between years.

The Bluestem, Rim, Hawks Nest, and San Mateo packs resided in areas where >98% of grazing allotments support seasonal or no grazing. The Saddle, Luna, Ring, Granite, and Francisco packs resided in areas where >84% of grazing allotments support year-around grazing. Packs from areas of seasonal grazing consumed 18% more elk and 21% less cattle than packs from areas of year-around grazing (G_{adj} = 71.936, *df* = 5, $P < 0.001$). However, this difference was determined by the contribution of the diet of Luna pack, because there was no difference when the diet of Luna pack was removed from the analysis.

Historical determinations of diets of Mexican wolves were based on field observations and stomach analysis (Young and Goldman, 1944), and may have been confounded by a shift in prey base. Before Mexican wolves were extirpated, most researchers hypothesized that Mexican wolves preyed primarily on deer (Leopold, 1959; McBride, 1980; Parsons, 1996). Native elk (*C. e. merriami*) were extinct from our study area by 1890 (Nelson, 1902) and Rocky Mountain elk (*C. e. nelsoni*) were not introduced until 1925. This shift in prey base may account for the speculations on diet of Mexican wolves during the late 1800s and early 1900s.

Our results agree with the majority of studies of scats conducted on summer diets of gray wolves in North America; ungulates are the predominant prey (Mech, 1970; Ballard et al., 1987; Thurber and Peterson, 1993; Spaulding et al., 1998; Reed et al., 2006). Our results also are similar to the only other study of scats conducted on the Mexican wolf (Reed et al., 2006). We determined that Mexican wolves primarily preyed upon native ungulates (80.3 versus 90.4% reported by Reed et al., 2006) and to a lesser extent cattle (16.8 versus 8.0% reported by Reed et al., 2006). The difference in biomass consumed between the two studies may be temporal. Reed et al. (2006) collected scats throughout the year and over multiple years. Our study collected scats only during summers 2005 and 2006. Calving by cattle takes place year around, but peaks during spring and summer, and parts of the Blue Range Wolf Recovery Area do not support cattle in winter. These grazing dynamics may account for the increase in biomass of cattle in scats in our study relative to results reported by Reed et al. (2006).

All territories of packs of Mexican wolves overlapped active cattle-grazing allotments during our collection period (i.e., summer). However, grazing takes place seasonally or year around throughout the Blue Range Wolf Recovery Area due to a climate gradient. We detected a difference in diet between grazing areas, but the difference was driven by one pack. The Luna pack consumed a significantly higher amount of cattle than all other packs in the study area. One potential hypothesis for the observed diet of the Luna pack is decreased predation on cattle in areas where they were not consistently exposed to cattle as a potential prey item. Younger calves (i.e., more vulnerable cattle; Oakleaf et al., 2003; Chavez and Gese, 2005) are likely more consistently present on year-around grazing allotments relative to seasonal grazing patterns, possibly subsidizing diet of the Luna pack. These results suggest that significant wolf-livestock issues may be pack specific, and that further research is needed. Studies addressing the following questions may elucidate impacts of different cattle-grazing regimes on diet of the Mexican wolf. Are there a higher proportion of cows with young calves on grazing allotments occupied by packs that consume livestock? Does a higher proportion of calving take place on territories of wolves that consume more livestock compared to other territories of wolves? Finally, what are the ages of cattle stocked on allotments occupied by territories of wolves that consume more livestock compared to other territories of wolves? With a better understanding of predation by wolves and grazing dynamics of livestock, improved management decisions regarding successful conservation of Mexican wolves can be made.

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