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MULE DEER AND PRONGHORN USE OF WASTEWATER PONDS IN A COLD DESERT

Karen L. Cieminski 1,2 and Lester D. Flake 1

ABSTRACT—Pronghorn (Antilocapra americana) and mule deer (Odocoileus hemionus) were counted at wastewater ponds at the Idaho National Engineering and Environmental Laboratory (INEEL) in southeastern Idaho 4 to 8 times per month from August 1989 through July 1991. Mule deer used wastewater ponds (n = 15) from June through December and were most commonly observed August through November. Pronghorn frequented wastewater ponds from May through November and were most common from July through September, the driest and warmest months; ponds were also used heavily in November 1990. Diel activity was studied from July through October. Mule deer use of ponds varied in relation to 8 diel time periods in August (P = 0.02) and September (P = 0.01) while pronghorn use varied by time period (P < 0.01) in all 4 months. Mule deer were more active at ponds during nocturnal than diurnal counts from July through September (P < 0.01). Pronghorn diurnal activity exceeded nocturnal activity (P < 0.01) August through October. Mule deer and pronghorn use of ponds was not related to distance from site facilities (groups of buildings used for research and other purposes). Pronghorn made greater use of individual ponds lacking additional nearby watering sites, and both pronghorn and mule deer were attracted to ponds with grass/forb and shrub cover around the upland periphery.

Key words: pronghorn, mule deer, desert, Idaho, diel activity, ponds, wastewater

During warmer and drier periods of the year, mule deer (Odocoileus hemionus) and pronghorn (Antilocapra americana) in desert habitats may seek free water (Beale and Smith 1970, Yoakum 1978, Hervert and Krausman 1986). Diel temperature patterns during warm and dry conditions may influence watering and activity patterns of mule deer (Eberhardt et al. 1984, Hervert and Krausman 1986) and potentially pronghorn (Deblinger and Allredge 1991). Mule deer and pronghorn are found sympatrically on the Idaho National Engineering and Environmental Laboratory (INEEL), a Department of Energy research area located in the upper Snake River plain. In this semiarid environment ephemeral water sources are often available in the spring. Permanent watering sites on the 231,600-ha INEEL, however, are limited to a few game-watering cisterns, and sanitary, industrial, and radioactive wastewater ponds.

Concerns about mammal use of wastewater ponds stem from possible effects to the mammals (Halford and Markham 1978, Kuoz et al. 1978) and possible transport of contaminants to hunters (Reynolds and Rose 1978, Hoskinson and Tester 1980) if game mammals leave the INEEL. Studies thus far have shown that radiation does not pose a hazard to animals that directly use the ponds (Halford et al. 1982, Millard et al. 1990) or to secondary consumers (Markham and Autenrieth 1976, Arthur and Markham 1982).

Artificial systems such as INEEL wastewater ponds are becoming increasingly common in North America and many other regions of the world. The degree to which such ponds are used by large mammals and their potential influences, either negative or positive, have been largely overlooked. Our objectives were to evaluate wastewater ponds to (1) determine monthly and diel patterns of pond use by mule deer and pronghorn, and (2) determine characteristics associated with use or nonuse of ponds by mule deer and pronghorn.

STUDY AREA

The INEEL is located in southeastern Idaho and has an average elevation of 1485 m (Fig. 1). Temperatures range from -44°C to 39°C, with July normally the warmest month. Average daily temperatures range from -11°C to 21°C. Average annual precipitation is 21 cm. Typically,
precipitation levels are highest in May and June and lowest in October. Relative humidity is commonly at its yearly minimum (daily average approximately 30%) in July and maximum (69%) from December through February (Clawson et al. 1989).

Most plant communities on the INEEL are dominated by desert shrubs, particularly Wyoming big sagebrush (Artemisia tridentata wyomingensis; Anderson et al. 1996). Other common shrubs are green rabbitbrush (Chrysothamnus viscidiflorus), gray rabbitbrush (C. nauseosus), winterfat (Krasheninnikovia lanata), and spiny hopsage (Grayia spinosa); assemblages dominated by shadscale (Atriplex confertifolia), Nuttall saltbush (Atriplex falcata), and winterfat, similar to salt-desert shrub communities, may occur on old lakebed sediment (Anderson et al. 1996). The primary native grasses include thick-spiked wheatgrass (Elymus lanceolatus), bottlebrush squirreltail (E. elymoides), Indian ricegrass (Oryzopsis hymenoides), needle-and-thread grass (Stipa comata), and Nevada bluegrass (Poa secunda; Anderson et al. 1996).

Wastewater ponds at which mule deer and pronghorn were studied contained sanitary waste, industrial waste, radioactive waste, or a combination of waste types. Ponds were located on the periphery of groups of buildings (site facilities) being used for research, maintenance, operations management, and other purposes (Fig. 1). We eliminated 2 INEEL ponds from analysis because they were surrounded by a 3-m-high chain-link fence that excluded pronghorn and mule deer. Fifteen ponds were readily

Fig. 1. Location of facilities at the Idaho National Engineering and Environmental Laboratory (INEEL) where wastewater ponds were surveyed for mule deer and pronghorn, August 1989–July 1991.
accessible to mule deer and 13 to pronghorn. Most ponds were rectangular and ranged in size from 0.02 to 2.21 ha. One additional wastewater source was a waste ditch that we included only in the monthly use and diel activity studies. Shorelines were gravel and subsoil, plastic-lined, or cobbles over plastic-lined. Only 3 ponds contained emergent vegetation, and 1 other had abundant submerged vegetation. Ponds were partially to completely ice covered from late November through early March. Ponds are described in further detail by Cieminski (1993).

Birch Creek and Little Lost River at one time terminated in playas on and at the edge of the INEEL, respectively (Fig. 1). Most flow is now diverted for upstream irrigation of crops. Big Lost River flows onto the INEEL only in years following heavy snowfall, the last of which prior to our study was 1987. The ponds may, in small part, compensate for wetland habitat lost since surface water no longer flows regularly onto the INEEL.

**METHODS**

**Counts of Mule Deer and Pronghorn**

We conducted monthly diurnal and nocturnal counts on each pond, August 1989 through July 1991. The period from August 1989 through July 1990 was defined as year 1 when year was used in analyses; August 1990 through July 1991 was defined as year 2. Mule deer and pronghorn were considered to be at the pond site if they were within 100 m of a pond. We used a spotlight for nocturnal counts, which lasted about 15 min and were not conducted during inclement weather.

Five diurnal (sunrise through sunset) and 3 nocturnal (dusk through dawn) time periods, each 2 h long, were established during which counts were conducted from July through October. Time periods were sunrise (centered 0.5 h after sunrise), mid-morning, midday, mid-afternoon, sunset (centered 0.5 h before sunset), dusk (centered 1.5 h after sunset), midnight (centered around 2400 military time), and dawn (centered 1.5 h before sunrise). Diurnal and nocturnal counts from March through October were conducted in a manner that assured sampling of all ponds in all time periods. We attempted to visit a pond no more than once per 24-h period.

Due to shortened daylight hours and decreased activity around the frozen ponds, we reduced monthly surveys to 3 diurnal (sunrise, midday, and sunset) and 2 nocturnal (dusk and dawn) counts per month in November and December. In January and February 1990, counts were conducted as in November and December except only 1 nocturnal count (either dusk or dawn) was conducted. Ponds were not surveyed in January and February 1991 due to lack of target species observations during these months in 1990. Diurnal and nocturnal counts were rotated from November through February to assure sampling of all ponds during all time periods used in those months.

We attempted to initiate monthly diurnal and nocturnal counts about 30 d after initiation of counts in the preceding month. Ponds were scheduled to be counted only once per day because observer presence at the ponds could influence later pond counts. Monthly counts were conducted on consecutive days unless interrupted by inclement weather.

**Monthly and Diel Use Analysis**

"Observations" were used as an indication of pond use. For example, 2 pronghorn seen once or 1 pronghorn seen twice would both equal 2 observations. For monthly use for the entire year, we made data comparable between months by summing the number of observations in a month for year 1 and year 2 (at all ponds combined) and dividing by the number of counts conducted during that month (for both years combined). For example, the total number of pronghorn observed during diurnal periods at ponds in July of year 1 plus year 2 would be divided by the following denominator: 5 count periods per pond x number of ponds surveyed x 2 yr. Monthly data were then presented as the average number of pronghorn or mule deer observed per diurnal or nocturnal count.

For analysis of diel use patterns, we summed the number of target species observations in each year, month, and time period (8 diel time periods) over all study ponds. Using log-linear analysis under Categorical Data Modeling procedures (CATMOD; SAS Institute Inc. 1989a), we examined differences (P < 0.05) in diel use patterns. Diel activity was analyzed for differences due to diel time period and month for the period from July through October for year 1 and year 2. In a second analysis we compared
diurnal use of ponds with nocturnal use, including month and time (diurnal or nocturnal) as explanatory variables in the logistic regression; in this analysis we also used the period from July through October. The sum of observations over the 5 diurnal time periods was compared with an adjusted sum of observations for the 3 nocturnal time periods. Nocturnal counts were adjusted to make them comparable with diurnal counts as follows: adjusted sum = mean observations per nocturnal count × 5.

Pond Characteristics

The number of ponds or ditches within a 1-km circle of a surveyed pond (from the pond center) was obtained from maps and aerial photos, as was the distance to site facilities. Shoreline distance (meters of shoreline/pond) was determined by superimposing sketches of water surface area and shoreline interface on blueprints of ponds or drawings made from direct measurements. Shoreline distance was remeasured whenever fluctuating water levels appeared to influence this measurement. During summer 1991 we determined percent cover of shrubs and grasses/forbs (combined) around the ponds by running six 20-m line-intercepts (evenly spaced and perpendicular to the shoreline) at each pond; plant coverage around ponds appeared to have changed little from 1989 through 1991. The method used was that described by Canfield (1941) except only 1 intercept line, placed 1 m off the ground, was used for both shrubs and grasses/forbs. Because of restricted access, we visually estimated vegetation coverage inside the fences around radioactive ponds (n = 2). Percentage of shoreline (from the water to 1 m onto the shore) lacking vegetation or with vegetation <15 cm tall was estimated and defined as bare shoreline. The vertical distance from the water surface to the top of the surrounding berm was defined as pond relief. We obtained weather data from a National Oceanic and Atmospheric Administration weather station located in the south central portion of the INEEL.

Mule deer and pronghorn occurrences at ponds were compared to pond characteristics from July through November. Each month ponds were grouped by target species into those with no pronghorn or mule deer observations and those where these target species were observed; months were then combined for the analysis. Thus, in the analysis a particular pond and its characteristics could fall into a different category each month, depending on target species observation data. We assumed that the target species were selecting ponds based on pond characteristics and location in relation to facilities and other ponds. Logistic regression (SAS Institute Inc. 1989b) was used to identify possible pond characteristics associated with use of ponds by target species. Logistic regression models were developed with a stepwise procedure at an alpha level of 0.05.

RESULTS AND DISCUSSION

Monthly Use

Mule deer first appeared at study ponds in June after a January through May absence (Fig. 2). In the intermountain region, June is the beginning of mule deer fawning season, which runs through mid-July (Robinette and Olsen 1944). Juveniles were first seen at the ponds in July but were not commonly seen until mid-August. Pond use by juveniles increased through the summer and fall to a peak (diurnal plus nocturnal) in November. Observations of adults steadily increased through the summer and early fall, then remained constant through November. Mule deer were not reported by age in December because we had increasing difficulty distinguishing between adults and juveniles under survey conditions.

Many mule deer are year-round residents on the INEEL but apparently are not dependent on ponds in the spring. Swank (1958) and Hervert and Krausman (1986) reported movements to water by mule deer in Arizona associated with increased temperatures; these movements may be associated with changing needs for water as metabolic rates increase and, at higher ambient temperatures (38°C), as evaporative cooling increases (Hervert and Krausman 1986). During these hot, dry periods, mule deer normally remain in their home range even if regular excursions are necessary to seek water (Hervert and Krausman 1986, Boroński and Mossman 1996). In our study the peak in mule deer observations in September lagged 2 months behind the temperature peak in July. July follows the 2 wettest months of the year on the INEEL; July through November is the driest series of months (Clawson et al. 1989). During our study precipitation in July was lower than in any other month (INEEL,
Fig. 2. Monthly use of wastewater ponds in southeastern Idaho by mule deer. Monthly use was calculated as the mean number of mule deer (observations) seen per visit to a pond (count), August 1989–July 1991; dotted line represents mean observations per visit for all 8 diel time periods.

National Oceanic and Atmospheric Administration unpublished data). This precipitation pattern and availability of forbs around pond edges may influence pond visitation patterns by mule deer on the INEEL.

Beale and Smith (1970) reported that highest water consumption by pronghorn in Utah varied from July to September, depending upon forage succulence (moisture content), which was dependent on precipitation. Pronghorn pond visitation in our study (Fig. 3) peaked in November. However, the November peak in adult and juvenile numbers was caused by several observations of large herds in November 1990; no pronghorn were seen in November 1989. Excluding November, adult pronghorn observations peaked in July through September and then declined in October (Fig. 3). Juvenile pronghorn were first seen at study ponds in June. Use by juvenile pronghorn then remained low through October with the same November peak (due to large herds in 1990) as in adults.

During colder months resident pronghorn on or near the INEEL are joined by pronghorn moving to lower altitudes (Hoskinson and Tester 1980). With the exception of November (from herds observed in 1990), pronghorn use of INEEL ponds during 1989 and 1990 generally declined after August or September. Lack
of heat stress and availability of snow may have reduced or eliminated the need for drinking water during the cooler months. We cannot explain the later seasonal peak in pond observations of mule deer compared with pronghorn.

Although ponds were ice free by mid-March, we observed no pronghorn at ponds until May. During May and June, pronghorn dependence on INEEL ponds was also low because air temperatures were low, plant moisture content was high (Beale and Smith 1970), and temporary rain pools were plentiful. Pronghorn in Wyoming's Red Desert were attracted to free water during summer but did not move from an area when the water source was no longer available (Deblinger and All dredge 1991); these authors note that moisture content of vegetation was high throughout the summers of their study and that these results may not apply to an unusually hot, dry summer.

Diel Use

Observations from the 8 diel time periods were used in analysis of diel pond use by target species from July through October of year 1 and year 2 (Figs. 4, 5). Both time period and
month influenced ($P = 0.01$) numbers of mule deer observed at ponds (Fig. 4); there was a time period × month interaction ($P = 0.01$). When months were analyzed individually, time period had a significant influence on mule deer observations only in August ($P = 0.02$) and September ($P = 0.01$).

Log-linear analysis indicated that mule deer use of ponds was greater ($P = 0.01$) during the nocturnal (dusk to dawn) than diurnal (sunrise to sunset) portion of the diel cycle (Fig. 4); the analysis also indicated that months ($P = 0.01$) influenced our counts and that there was a month × time (nocturnal and diurnal) interaction ($P = 0.01$). When we examined months individually, mule deer were more likely ($P < 0.05$) to be at ponds during nocturnal periods in all months except October. In October of year 1, we observed mule deer only during daylight hours (Fig. 4).

Due to the small sample size, we did not separate antlered mule deer from adult females. The percentages of antlered adults were similar between diurnal (16.7% antlered) and nocturnal (17.3% antlered) surveys from July through October.

Among black-tailed deer (O. h. columbianus), Miller (1970) found differences in diurnal activity due to time in all months; morning and twilight peaks occurred June through September, early morning and midday peaks in October and November, and high use mid-morning till twilight in December. We observed considerable midday or mid-afternoon occurrence of mule deer at ponds in September and October but no strong sunrise or sunset peaks in activity during the diurnal cycle (Fig. 4). Interestingly, within the nocturnal period, deer were as active at ponds during midnight as during dusk and dawn. Hervert and Krausman (1986) suggested that desert mule deer does, during the warmer, drier months in Arizona, may have remained less active during the diurnal period to avoid water loss and to conserve energy. In general, diurnal activity in midsummer in our Idaho study was greater than that observed by Hervert and Krausman (1986), probably a result of milder daytime temperatures.

Numbers of pronghorn observed at ponds during the 8 diel time periods were related to time period ($P = 0.01$) and month ($P = 0.01$); there was a time period × month interaction ($P = 0.01$). Analysis by individual months indicated that time period had an effect ($P < 0.01$) on numbers of pronghorn observed at ponds in all 4 months; they were observed at ponds in all time periods except dawn (Fig. 5).

Pronghorn used ponds at different rates ($P = 0.01$) during the diurnal and nocturnal portions of the diel cycle; there was also a month effect ($P = 0.01$) and a time × month interaction ($P = 0.01$). When months were analyzed separately, pronghorn use of ponds was greater ($P < 0.01$) during daylight hours from August through October. Change in use due to time (diurnal and nocturnal) was not statistically significant ($P > 0.05$) in July. Greater diurnal use of ponds from August through October at the INEEL is similar to observations in Wyoming by Amstrup (1978). Nocturnal activity is consistent with observations that daytime activities are also engaged in at night, albeit generally at a lower frequency (Buechner 1950, Kitchen 1974, Amstrup 1978).

Amstrup (1978) observed crepuscular daily peaks of pronghorn activity July through November; Reynolds (1984) observed similar patterns in summer on the INEEL. Taylor (1972) recorded a midday peak June through August in Wyoming in pronghorn activity, in addition to crepuscular peaks. Peaks in activity from September through November were at 0600, 0900, and 1300 h (Taylor 1972). Our observations related to occurrence of pronghorn at ponds and not to general increases in activity. Still, pronghorn at ponds were actively feeding and watering and would have been rated as active by other authors. Pronghorn use of wastewater ponds was irregular for diel time periods from July through October in our study (Fig. 5); there was no strong trend of increased use of ponds in crepuscular hours.

Use in Relation to
Pond Characteristics

Fifteen ponds were accessible to mule deer on the INEEL and 13 to pronghorn. The 2 ponds used by mule deer but not by pronghorn lacked an open gate and were surrounded by mesh wire plus barbed wire on the top that mule deer readily jumped. In addition to wastewater ponds, mule deer and pronghorn frequently used a wastewater ditch that extended for over 1000 m across the shrub desert. During the period from July through November, mule deer were observed at 12 of 15 available study ponds. Pronghorn were observed at 10 of 13 ponds accessible to them.
Differences in habitat variables between observation categories (mule deer observed or not observed) were found only for percent bare shoreline and percent grass/forb cover within 20 m of the pond (log-linear analysis; Table 1). Buildings and other physical facilities had no apparent influence on mule deer use of ponds. Logistic regression, using these 2 variables, identified percent grass/forb within 20 m of the ponds as the only significant variable separating observation categories ($P = 0.01$). Concordant pairs (61.9%) indicated that this is not a particularly strong logistic regression model.

We suspect that greater amounts of vegetation in the upland periphery next to the pond (percent shrubs was nearly significant) attracted mule deer to ponds either because of forage value or increased concealment. Ponds surrounded by bare soil (or subsoil) and gravel on the uplands looked much less natural and were apparently less attractive to mule deer.

For pronghorn, log-linear analysis using single variables indicated that all habitat variables other than distance to facilities were significantly different ($P < 0.05$) between pond observation categories (Table 1). When these variables
were evaluated as a group in logistic regression, only number of ponds within 1 km entered the equation ($P = 0.01$); as with mule deer, concordant pairs (63.0%) indicated that the model separating observation categories was not strong.

Increased isolation of ponds (fewer ponds within 1 km) was apparently associated with concentration of pronghorn use at a single pond. Other variables such as shoreline distance and percent shrub cover could also be used to develop a logistic regression model. Larger ponds were associated with increased chances of observing pronghorn. Both percent shrub cover and percent grass/shrub cover were associated with increased use of ponds by pronghorn.

We commonly observed pronghorn drinking water from some (usually larger) ponds. At smaller ponds pronghorn were flushed by observers' arrival, and we rarely saw them actually drinking. Pronghorn were also observed drinking from sources such as parking lot runoff catchments, guzzlers, road construction ponds, and leaks in piping to construction or maintenance work areas. These temporary water sources, quickly discovered by pronghorn, were
probably selected over ponds if they were nearer the pronghorn’s center of activity. However, none of these aforementioned water sources were permanent, and some lasted little more than a day.

Beale and Smith (1970) observed that pronghorn did not drink available water when moisture content of forbs was >75%; when moisture content in forage plants was insufficient, pronghorn regularly drank water. Reynolds (1984) found open water was within only 1 of the 5 home ranges of pronghorn bands studied at the INEEL. Pronghorn probably drink water if available and otherwise depend on moisture from vegetation consumed (Emerson 1948).

It was not unusual to see pronghorn feeding in the vicinity of a pond for a few minutes after drinking, probably an attraction to herbaceous vegetation around some of the INEEL ponds. Several authors have found that pronghorn use was greater in areas of higher soil moisture (Good and Crawford 1978), or that pronghorn selection of forage was influenced by succulence (Beale and Smith 1970). Forbs common at some study ponds that can be important in pronghorn diets were prostrate knotweed (Polygonum aviculare), dock (Rumex spp.), and poverty sumpweed (Iva axillaris; Ferrel and Leach 1950, Bruns 1977, Good and Crawford 1978). Of the 5 INEEL ponds with well-vegetated shorelines, 3 had the highest pronghorn use of all ponds, and 1 had intermediate pronghorn use. Vegetation around these ponds included willow-leaved dock (R. salicifolius; at all 5 well-vegetated ponds), prostrate knotweed (at 1 of the highest use ponds), and poverty sumpweed (at another of the highest use ponds).

Mule deer and pronghorn readily use wastewater ponds at the INEEL, perhaps as much for the surrounding succulent vegetation as the drinking water. The presence of drinking water may be important to both species during the warmest and driest months of the year, particularly during unusually hot and dry years. Where ponds are determined to be safe for wildlife use, designs that include grass, forb, and shrub cover around wetlands would likely improve use by mule deer and pronghorn.

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