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Causes of low pronghorn fawn:doe ratios on the Sheldon National Wildlife Refuge Nevada

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CAUSES OF LOW PRONGHORN FAWN:DOE RATIOS ON THE SHELDON NATIONAL WILDLIFE REFUGE, NEVADA

By

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B.S., University of Montana, 1977

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Causes of Low Pronghorn Fawn:Doe Ratios on the Sheldon National Wildlife Refuge, Nevada (128 pp.)

Director: Bart W. O'Gara

Thirty-four pronghorn (Antilocapra americana Ord) fawns were fitted with radio collars during 1978 and 1979. Mortality of monitored fawns was 63%. Predation accounted for 80% of the mortality, and coyotes (Canis latrans) were involved in 15 of the 16 deaths attributed to predation. A Golden Eagle (Aquila chrysaetos) killed 1 fawn. Severe spring weather and poor maternal condition were implicated as contributing factors to the high neonatal mortality in 1978. A significant positive correlation ($r = 0.84$, $p < 0.05$) was found between fawn recruitment and the amount of precipitation during the previous late summer and fall.

Whole blood and serum chemistry was compared with similar data from Alberta; several significant differences existed, indicating that energy intake in the Sheldon fawns was lower than in the Alberta fawns.

Compared to other areas, Sheldon bedsites had low vegetative cover and volume values. Bedsite cover appeared suboptimal on the Sheldon, but the sites had a consistent, characteristic vegetative structure. Fawn home range sizes on the Sheldon were significantly greater than those determined in a Texas study, indicating a low density of preferred forage items on the Sheldon.

Pre- and post-parturient does avoided cattle, but bucks and yearling females did not. Cattle disturbance may have caused an observed shift in fawning areas between 1978 and 1979. Diet overlap was minimal between the 2 species in mid-May (2.9%), early June (2.3%), and late June (7.3%). Range transects run concurrently with fecal sampling indicated that forage species commonly used by pronghorns in other studies were available and often abundant on the Sheldon, but many were not found in the fecal analysis.

A territorial breeding system was documented in 1978. However, the appearance of succulent forage on playas just before the rut caused concentration of the pronghorns, followed by an apparent collapse of the territorial system. The effect of the fall hunting season on breeding activities was discussed.

ACKNOWLEDGEMENTS

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YACC crews from the Hart Mountain and Modoc National Wildlife Refuges assisted during the fawning periods; I am grateful for their help.

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CHAPTER I

INTRODUCTION

At the beginning of this century, the future of the pronghorn was uncertain. Their numbers had declined from an estimated 35 million prior to the arrival of Europeans, to approximately 20,000 by 1900 (Yoakum 1968). Citizens of northwestern Nevada were concerned with the rapid and continuing decline. Together with the Boone and Crockett Club and the National Audubon Society, they raised funds and purchased 12,000 ha of pronghorn range in 1918 (U.S. Fish and Wildlife Service 1980). A series of executive orders expanded the original purchase, and the Sheldon National Wildlife Refuge is now under the jurisdiction of the U.S. Fish and Wildlife Service.

The Refuge has a recent history of low pronghorn fawn:doe ratios. Aerial classification counts made by Refuge personnel in the summers of 1955 through 1967 averaged 61 fawns per 100 does. During that time, predator control was practiced by aerial gunning, poisoning, trapping, and denning. Since predator control was discontinued in 1967, pronghorn fawn recruitment has averaged 25 fawns per 100 does (data from U.S. Fish and Wildlife Service files, Lakeview, OR).

Early investigators studying the causes of pronghorn fawn mortality regarded predation as a relatively minor mortality factor (Einarsen 1948, Buechner 1950). More recently, predation has been recognized as a major cause of fawn mortality in some populations of pronghorns throughout their range (Webb 1972, Beale and Smith 1973, Barrett 1978, VonGunten 1978, Tucker 1979). Yet, the conclusion that predation is universally responsible for low pronghorn recruitment is not warranted. Other studies have indicated starvation-disease (Trueblood and Post 1959, Bodie 1979) and precipitation (Haley 1965, Hockley 1968, Beale and Smith 1970) may be significant in limiting fawn recruitment.

Low fawn production could also be responsible for poor fawn recruitment. In white-tailed deer (*Odocoileus virginianus*), doe fertility was reduced by poor dam condition and production suffered (Cheatum and Servinghaus 1950). In Alberta, several cases of fetal resorption or abortion were found in pronghorn does that died from malnutrition during a severe winter (Barrett 1978).

The question of pronghorn-cattle compatibility has been a source of debate. Kindschy et al. (1978) indicated that cattle and pronghorns were compatible because cattle were the ecological equivalent of bison (*Bison bison*), which were sympatric and obviously compatible with the pronghorn in pristine times. However, the bison-pronghorn association in the Great Basin was probably not as strong as it was on the Great Plains. Butler (1978) believed bison were present in the sagebrush-grass region of the West, but their "distribution was not uniform over the region or through time." Riddell (1952) reported, "the buffalo did not occur in large enough numbers to be of economic importance to the Indians of the region," and "the buffalo was a comparatively recent addition to the fauna of modern, northeastern California."

Cattle grazing may reduce the quality of vegetation on fawn bedsites. Bromley (1977) hypothesized that bedsite selection evolved in response to selective pressures applied by predators, and that fawns selected beds that provided concealment from both mammalian and avian predators. Fawn bedsite measurements in other areas have been consistent with Bromley's hypothesis, because fawns selected cover that, on the average, was higher and more dense than surrounding vegetation (Pyrah 1974, Autenreith 1976). In addition, Tucker (1979) reported that plant species most often found at Texas bedsites were also preferred livestock forage. Therefore, livestock grazing could reduce the concealment of a bedded pronghorn fawn, and increase the fawn's susceptibility to predation. Livestock have grazed the sagebrush-grasslands of Nevada since the 1840's and grazing allotments are currently issued on the Sheldon. Therefore, I hypothesized that cattle grazing could have an effect on pronghorn fawn survival.

My research was conducted from April through September of 1978 and 1979. Objectives were to:

1) examine the causes and degree of pronghorn fawn mortality;
2) evaluate the condition of newborn fawns as an indicator of their dams' nutritional status, and thus, indirectly, the adequacy of the range for pronghorns; and
3) evaluate the adequacy of fawn bedding sites and the impact of cattle on those sites.

CHAPTER II

STUDY AREA

General Description

The Sheldon National Wildlife Refuge is located in Humboldt and Washoe counties of northwestern Nevada and contains approximately 233,200 ha of high sagebrush desert. Geologically, it lies in a transition zone, with large plateaus of flat-lying volcanic rock characteristic of the Columbia Plateau interrupted by wide valleys characteristic of the Great Basin (Willden 1964). The plateaus have shallow soils underlain by basalt that flowed from volcanic fissures during the late Tertiary, capping underlying layers of Canon Rhyolite and volcanic tuff.

Plant communities on the Sheldon vary with elevation. Volcanic buttes and mountains rise to 2300 m and support curl leaf mountain mahogany (Cercocarpus ledifolius), western juniper (Juniperus occidentalis), big sagebrush (Artemisia tridentata), and bitterbrush (Purshia tridentata). Elevations on the eastern portion of the Refuge are as low as 1280 m where the flat bottoms of old lake basins are dominated by greasewood (Sarcobatus vermiculatus), horsebrush (Tetradymia spp.), and rabbitbrush (Chrysothamnus spp.).

Pronghorn use, especially during fawning, is concentrated on the large expanses of flat to rolling tablelands at elevations between 1800 and 1900 m where plant communities are dominated by low sagebrush (Artemesia arbuscula). Common grasses on the tablelands include Sandberg bluegrass (Poa sandbergii), squirreltail (Sitanion hystrix), needlegrass (Stipa spp.), prairie junegrass (Koleria cristata), and cheatgrass (Bromus tectorum). A variety of forbs common in the spring include: buttercups (Ranunculus spp.), lava aster (Aster scopulorum), balsamroot (Balsamorhiza spp.), buckwheat (Eriogonum spp.), clover (Trifolium spp.), bluetip collinsia (Collinsia parviflora), phlox (Phlox spp.), onion (Allium spp.), daggerpod (Phoenicaulis chieranthoides), fleabane (Erigeron spp.), hawksbeard (Crepis spp.), larkspur (Delphinium andersonii), milkvetch (Astragalus spp.), desert paintbrush (Castilleja chromosa), sandwort (Arenaria spp.), groundsel (Senecio spp.), and low penstemon (Penstemon humilis). Meadows associated with springs contain basin wildrye (Elymus cinerus), rocky mountain iris (Iris missouriensis), flax (Linum lewisii), streambank wheatgrass (Agropyron riparium), bullrush (Scirpus spp.), and Nebraska sedge (Carex nebraskensis).

Average precipitation on the Refuge varies with elevation, and generally declines from west to east. Nine-year (1961-1969) precipitation values on the area averaged 34 cm annually at the Sheldon Sub-headquarters near the western boundary, and 16 cm at the

Dufferena Sub-headquarters near the eastern boundary (U.S. Fish and Wildlife Service Files, Lakeview, OR). Approximately 75% of the precipitation falls between 1 November and 31 May, mostly as snow. Lack of precipitation and high temperatures during the summer months result in a scarcity of surface water during late summer.

Large daily temperature fluctuations are characteristic of the high desert during spring and summer. The frost-free season averages only 20 days at the Sheldon Sub-headquarters and 75 days at Dufferena (U.S. Dept. of Commerce 1978). Mean monthly temperatures and precipitation amounts are given in Table 1.

Fawning Areas

Fawn mortality was investigated on 3 low sage sites at elevations near 1800 m (Fig. 1). All 3 differed in past use, current use, and range condition. Range condition as used here is an index of the ecological state of the plant communities. "To rate an area in Poor ecological condition, less than 25% of the make-up of the current plant community (kind and amount of species) is still like the original for the site. In Fair condition, 25-50% is still like the original. Good is 50-75%, and Excellent is 75% or more like the original" (U.S. Fish and Wildlife Service 1980). Within a given area on the Sheldon, range conditions are variable, and condition in many areas has not been determined. The range conditions listed for each fawning area

Table 1. Nine-year mean monthly temperature and precipitation values at the Sheldon and Dufferena sub-headquarters (1961-1969) (Data from U.S. Fish and Wildlife Service files, Lakeview, OR).

	Precipitation (cm)		Temperature (°C)	
Month	Sheldon	Dufferena	Sheldon	Dufferena
Jan	4.2	1.5	-2.8	-2.9
Feb	2.2	1.1	-1.6	0.4
Mar	2.5	0.6	-0.8	1.4
Apr	2.7	0.7	2.8	5.3
May	3.3	1.9	7.7	10.5
Jun	4.3	3.3	11.7	14.8
Jul	0.9	0.6	16.2	19.1
Aug	2.2	1.4	15.9	18.2
Sep	1.2	0.6	12.4	13.5
Oct	2.7	1.2	7.7	7.7
Nov	3.4	1.7	1.6	1.8
Dec	4.2	1.5	-2.2	-2.1
Total[a] or Annual mean[b]	33.8[a]	16.1[a]	5.7[b]	7.3[b]

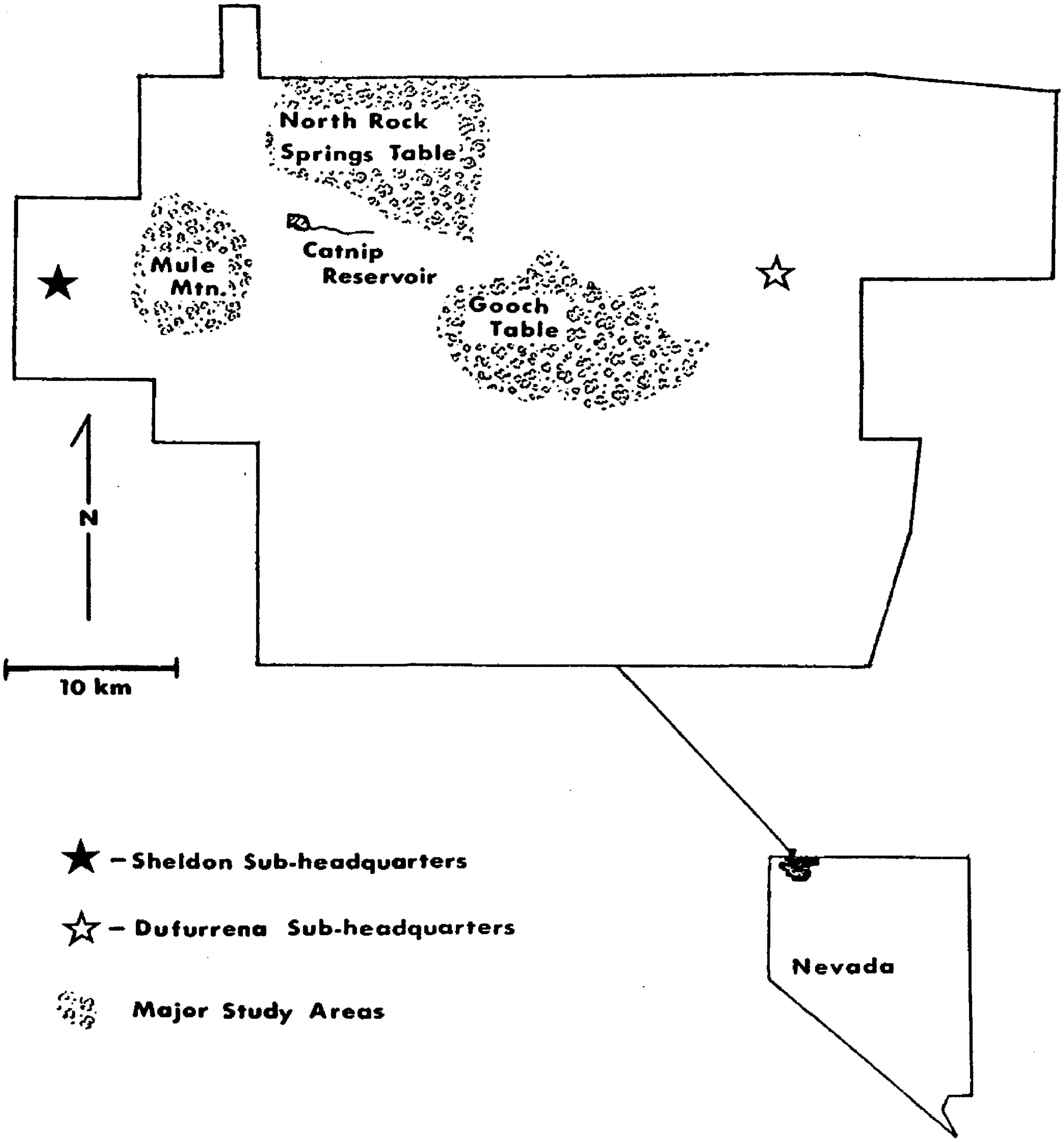


Fig. 1. The Sheldon National Wildlife Refuge.

therefore, are both generalizations and indications of the relative condition between areas.

Gooch Table

Located near the center of the Refuge, Gooch Table is a flat sage-grassland of approximately 8100 ha. Soils on the area are shallow and stony to a root-restricting layer of clay or hardpan (Anderson 1978). The range is in Poor-to-Fair condition (Franzen, USFWS Range Conservationist, pers. comm.). Permanent water is available in Gooch Lake.

This area has historically supported 100-200 feral horses and has received year-round use by 100-150 pronghorns. In addition, as many as 40 cattle grazed the area during the summers of 1978 and 1979, although no grazing leases were prescribed.

North Rock Springs Table

Located along the northern boundary of the Refuge and covering approximately 8100 ha, North Rock Springs Table is a flat to rolling sagebrush-grassland. Soils are gravelly and loamy on the surface with clayey subsoils underlain by cemented hardpan at a depth of 38-46 cm (Anderson 1978). The range is in Poor-to-Fair condition (Franzen pers. comm.). Water was available throughout the summers of 1978 and 1979 in a man-improved pond located near the southeast corner of the area.

North Rock Springs Table has historically been a favored summer range of feral horses. It was the location of a horse-pronghorn interaction study during 1977 and 1978 (Meeker 1979). At that time, 85-100 pronghorns and 115-195 feral horses were present during summer. Six hundred cattle grazed North Rock Springs Table and adjacent areas during parts of the May through October grazing seasons of 1978 and 1979. Fences presently under construction will provide a better means of managing livestock by 1980.

Mule Mountain

Investigation of fawn mortality on the western end of the Refuge was concentrated on 3600 ha of shrub-grassland near Mule Mountain. Over much of the area, the range is in Fair-Good condition and grass cover is greater than on North Rock Springs or Gooch tables (Franzen pers. comm.). The soils are very stony and shallow over a root-restricting layer of clay or tuffaceous hardpan (Anderson 1978).

Drainage patterns near Mule Mountain have created several large, shallow basins. Some basins provide an adequate source of water through the driest months; others become devoid of surface water late in the summer and produce succulent forage used by pronghorns and livestock.

Mule Mountain was part of the original Sheldon National Antelope Refuge established in 1931. Historically, cattle use near

Mule Mountain was less than on adjacent areas that were jointly administered by the Bureau of Land Management and the U.S. Fish and Wildlife Service until 1976 (U.S. Fish and Wildlife Service 1980). Approximately 150 cattle grazed the area from 1 August through 31 October in 1978 and from 1 May through 21 June in 1979. Feral horses did not use this area.

CHAPTER III

METHODS AND MATERIALS

Fawns

Capture

At vantage points, observers used telescopes and binoculars to scan fawning areas for lone does. When a doe was sighted, the observers watched for signs of impending parturition (Reichel 1976, VonGunten 1978, Bodie 1979), or in post-parturient does, for behavior indicating the doe was preparing to nurse her fawns. A doe signaled her intentions to feed her fawns by movement away from a doe herd; movement toward the bedded fawns in a more or less direct line; alertness, including frequent periods of staring in a particular direction; and when in the vicinity of the fawns, a prolonged period of standing while surveying the surrounding area.

When a fawn was sighted and it had selected a bed, a capture crew moved toward the fawn, receiving directions from the observer with a hand-held radio transceiver. When a birth was observed, no capture attempt was made for at least 4 hours to allow the completion of doe-fawn imprinting. Fawns less than 3 days old were captured by hand; older fawns were captured using a long-handled salmon net.

Coyotes respond readily to distress vocalizations of potential prey. To reduce the chance of "calling" a coyote, I held the mouth of captured fawns closed until the fawn could be blindfolded. Blindfolding captured fawns and avoiding sudden movements and loud noises reduced their tendency to struggle. Plastic gloves worn during the capture and handling of fawns minimized the transfer of human scent to the fawns.

For each fawn, weight, rectal temperature, age, sex, and length and girth measurements were determined. Age estimates were made using the behavioral criteria described by Bromley (1977). An evaluation of each fawn's condition was made, noting abnormalities in behavior, pelage, and physical structure. Indications of internal disorders such as congested breathing and rectal or oral bleeding were also recorded.

Rectal and throat bacterial cultures were collected from fawns captured in 1979. Culturettes, manufactured by the Marion Scientific Corporation, were used to collect and store samples. Within 48 hours of collection, samples were taken to the Lake District Hospital, Lakeview, Oregon, for analysis.

Blood samples from 17 fawns were collected in 1979. Blood was taken from the jugular vein with a syringe or vacutainer after a small patch of hair had been clipped to expose the vein. Whole blood samples of 5-7 cc, collected in hepranized tubes, were refrigerated for 24-48 hours before being taken to the Lake District Hospital for analysis. Blood smears for white blood cell and differential counts were prepared in the field and analyzed in Lakeview. Approximately 10 cc of blood was collected in plain vacutainers and refrigerated for 24-36 hours. The serum was then drawn off with a pipet, placed in capped vials, and frozen. Serum samples were mailed to the Treasure Valley Laboratory, Boise, Idaho, for analysis.

Captured fawns were equipped with L2B5 radio transmitter units manufactured by Telonics Inc., Mesa, Arizona. Each unit contained a transmitter and lithium battery hermetically sealed in a nickel-steel canister measuring 3.75 x 2.5 x 3.5 cm. Transmitter units had an expected life of 7-10 months and an average ground range of 2.4-4.8 km. Transmitters came equipped with a motion-sensitive mortality-sensing device that increased the signal pulse rate after a specified period of no movement. In 1978, transmitter mortality signals were set to activate after 2 hours of no movement, in 1979 after 1 hour of no movement.

Transmitter units were riveted between strips of 2.5 cm nylon belting; strips of 2.5 cm elastic were sewn to the nylon belt with heavy nylon thread, brought together at the top, and sewn with light cotton thread to form an expandable neck collar. The cotton thread was expected to disintegrate over a period of 2-4 months so the collar would expand as the fawn grew and then drop off, allowing retrival of the transmitter. The silver-colored transmitter units were wrapped with black plastic electrical tape and the entire radio collar was rubbed with sagebrush leaves, masking the unnatural appearance and odor. The completed radio collar weighed 113 g.

Relocations

Collared fawns were located using a hand-held "H" antenna and a TR-2 receiver manufactured by Telonics Inc. An attempt was made to receive transmitter signals from each fawn every day for the first 4 weeks. After that period, functioning transmitters were monitored at least twice a week until mid-August. Fawns were visually located as often as possible during the first 4 weeks, generally every 2nd day in 1978 and every 3rd day in 1979.

When a mortality signal was received, the transmitter was located immediately. I then searched the area for evidence of predation or scavenging, noting tracks and drag marks, and collecting droppings, feathers, guard hairs, and fawn remains; care was taken to avoid trampling evidence around the site.

Necropsy

Partial and complete carcasses were skinned and the locations of any subcutaneous hemorrhaging and puncture wounds were noted. Skulls were examined for fractures and the condition of internal organs was recorded. Identification of predator kills and feeding patterns was made using criteria described by O'Gara (1978a). When the typical wounds from predation were not present, the carcass was frozen and later examined by O'Gara.

Bedsites

When a fawn was located, the orientation of the fawn in its bed was recorded and a sketch was drawn showing the major physical and vegetative features of the bed. The location of the bedsite was plotted on a topographic map and marked on the ground with a stake approximately 20 m from the bed. Care was taken not to flush the fawn. Within 3 days, the marked bedsites were revisited and vegetative measurements were made. Beds were precisely relocated using drawings, compass bearings from marker stakes, and other notes made at the time of the original location.

Vegetation on, immediately surrounding, and within a 4 m radius of the bed was sampled with 33, 30 x 60 cm quadrats. One quadrat was placed directly over the bed (Bed Plot), 4 quadrats were placed adjacent to the bed (Near-bed Plot), 1 along each side of the Bed Plot. Cover and volume values from those 4 quadrats were averaged to yield a cover and a volume value for the Near-bed Plot.

Next, a 4 m string was stretched from the center of the Bed Plot and 4 quadrats were read at fixed points along the string. The points represented midpoints of 4 concentric rings of equal area. The string was then rotated through a 51° arc (Fig. 2). Seven lines were read in this manner and the values from these 28 quadrats were averaged to yield a cover and a volume value for the Circular Plot.

For each bedsite, an associated, control site was measured. Located 20 paces from the bedsite in a random direction, the control site measurements corresponded to Bed Plot and Near-bed Plot measurements.

Within each quadrat, the percent coverage of each plant species was recorded using cover classes similar to those described by Daubenmire (1959). Each species was also assigned to 1 of 5, 15 cm height classes. The tallest plant of a given species within a quadrat was used for height classification. Volume was determined by multiplying the canopy coverage of a species by the height class midpoint (Pyrah 1973). Volume was expressed as cubic decimeters of vegetation per 100 square decimeters of area ($dm^3/100\,dm^2$). Total cover and volume were determined by summing the cover and volume values for all species within the quadrat.

Movements

When twins were captured or relocated, the locations of both were plotted, but only the twin with the most locations was used in movement and home range calculations. Kill sites were not used in movement or home range calculations because determining how far the

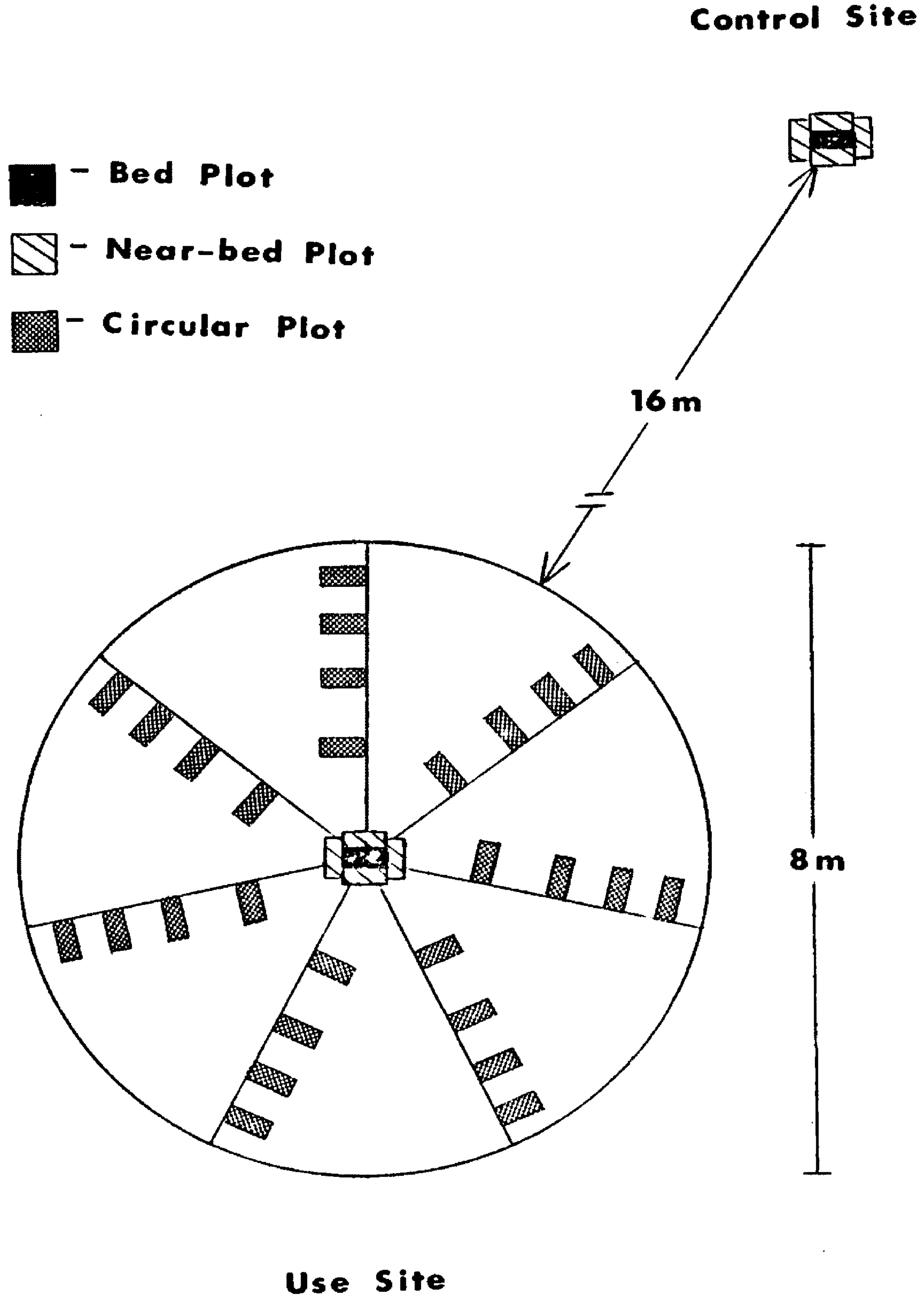


Fig. 2. Diagram showing the relationship between the different plots at use and control bedsites.

fawn was chased, or the carcass moved after the kill, was impossible.

Home ranges of fawns less than 3 weeks old were determined using the minimum home range method (Dalke 1942, Mohr 1947). Only fawns with 4 or more locations were used in home range calculations. Distances between plotted locations were measured on a topographic map to the nearest millimeter and then converted to kilometers.

Relation to Horses

Approximately 200 feral horses grazed the North Rock Springs fawning area during the spring of 1978. I did not make detailed observations of horse activities, but a general pattern of horse movement was provided by Meeker (pers. comm.) who was conducting a pronghorn-horse interactions study on Horse Heaven. In the fall of 1978, most of the horses were trapped and removed by the U.S. Fish and Wildlife Service and less than 10 horses were present on North Rock Springs Table during the spring of 1979. The location of fawn activity during 1978 was compared with plotted locations from 1979.

Adult Pronghorns

Doe Censuses

During early May 1979, pronghorn does on the 3 fawning areas were classified according to their reproductive status. Observations were made with the aid of telescopes and binoculars from a vehicle or from vantage points overlooking fawning grounds. Does were classified as pregnant, not pregnant, yearling, or unknown. Pregnant does showed pronounced swelling forward of the flanks, a distinct convex belly surface, and dark skin on the udder due to spreading of the hair as the udder enlarged. Yearlings characteristically have a smaller body size than adults, and the length of the rostrum is less than in adults, giving the face a "shortened" appearance. When the status of an animal was doubtful, it was listed as unknown.

On a given day, in a given area, does were classified only once. On subsequent days, no attempt was made to distinguish between does previously unclassified and those classified on preceding days. The observations for each day on a given area were treated as independent samples. The average proportion of animals in each category was calculated as:

$$\bar{P}_x = \frac{\Sigma(P_{ix})}{N_x}; \quad \bar{B}_x = \frac{\Sigma(B_{ix})}{N_x}; \quad \bar{Y}_x = \frac{\Sigma(Y_{ix})}{N_x}$$

where P_{ix} is the number of pregnant does on day i in area x, B_{ix} is the number of nonpregnant adult does on day i in area x, Y_{ix} is the number of female yearlings on day i in area x, and N_x is the total number of doe classifications made on area x summed over all the days of observation.

A ratio of yearling:nonpregnant:100 pregnant does was calculated for each area and for all 3 areas combined. From those ratios, the 1978 fawn:doe ratios were estimated. Adult doe estimates included 3 components: 1) female fawn recruitment from 1977, 2) non-pregnant adult does counted during 1979, and 3) adult pregnant does counted during 1979. Fawn recruitment figures from 1977 were needed to make my calculations comparable to the 1978 aerial census because adult and yearling does cannot be distinguished during an aerial census. Female fawn recruitment from 1977 represents the yearling component of the 1978 aerial census. Two assumptions were made for my calculations: 1) the number of yearling does in 1978 equaled the adult doe mortality between the 1978 aerial census and the 1979 doe census, and 2) the number of female fawns recruited into the population in 1977 equaled half of the total fawn recruitment. This calculation should have yielded a conservative estimate of the fawn:doe ratios. If, in fact, the number of yearling does exceeded the adult doe mortality, my calculations yielded a low fawn:doe estimate.

Breeding Buck Behavior

The activities of an adult buck (buck no. 1) were monitored from 5 through 31 August 1978. Observations were made from a blind or vehicle overlooking the western half of North Rock Springs Table. Detailed observations were made with the aid of a telescope. Written descriptions and sketches illustrating the conformation and coloration of the buck's horns and face helped me identify him during subsequent observations. Similarly, a buck occupying an adjacent territory (buck no. 2) was described.

After a generalized pattern of movement was plotted for buck no. 1, a series of parallel north-south and east-west lines were drawn on a topographic map. This grid delineated 64, 200 x 200 m blocks of land that included all of the initial observations. To improve the precision of plotted locations, I pounded 1 or 2 black, wooden stakes into the ground at 20 locations. Each stake location corresponded to a selected intersection of the grid lines on the map. Coded white stripes on each stake facilitated the identification of staked locations through the telescope.

For each observation period, a clean acetate overlay was placed over the map. The location of the bucks' scent markings, buck-buck encounters, and bedsites were plotted on the map, then transferred to a 2 mm grid. The outermost scent marking locations of buck no. 1 were connected to approximate the buck's territorial boundaries. Territory size was then determined by estimating the number of grid squares within the delineated boundary.

Scent markings do not necessarily mark a specific boundary (O'Gara 1978b), but are concentrated within the territory (Bromley 1967). Therefore, I considered the outermost scent marking locations as point estimates for the territorial perimeter. This method of territory size determination included 100% of the scent marking locations.

From 1 through 3 September 1978, pronghorn activities were observed on the Bald Mountain Lake playa. Observations were made using binoculars and a 20X telescope and recorded in a field notebook.

Hunting Season

Since 1967, a limited number of pronghorn, buck-only permits have been issued each year on the Sheldon. Hunters have been required to attend pre-hunt orientation meetings where trophy heads were displayed and trophy hunting emphasized. Each successful hunter was required to report to a checking station where Boone and Crockett measurements were taken and the age of the buck determined. In addition, kidney indices were determined from hunter-killed bucks during 1978 and 1979.

Cattle-Pronghorn Interactions

Spatial Interactions

Adult pronghorns. From 29 April through 8 May 1979, pronghorns were observed from 2 points on the road south of Mule Mountain near the center of the 6900 ha Mule Mountain Management Unit (Fig. 3). Approximately 150 ha were observable from each point. On 1 May, 150 cattle were herded into the vicinity of the observation areas in accordance with a grazing contract between the Refuge and a

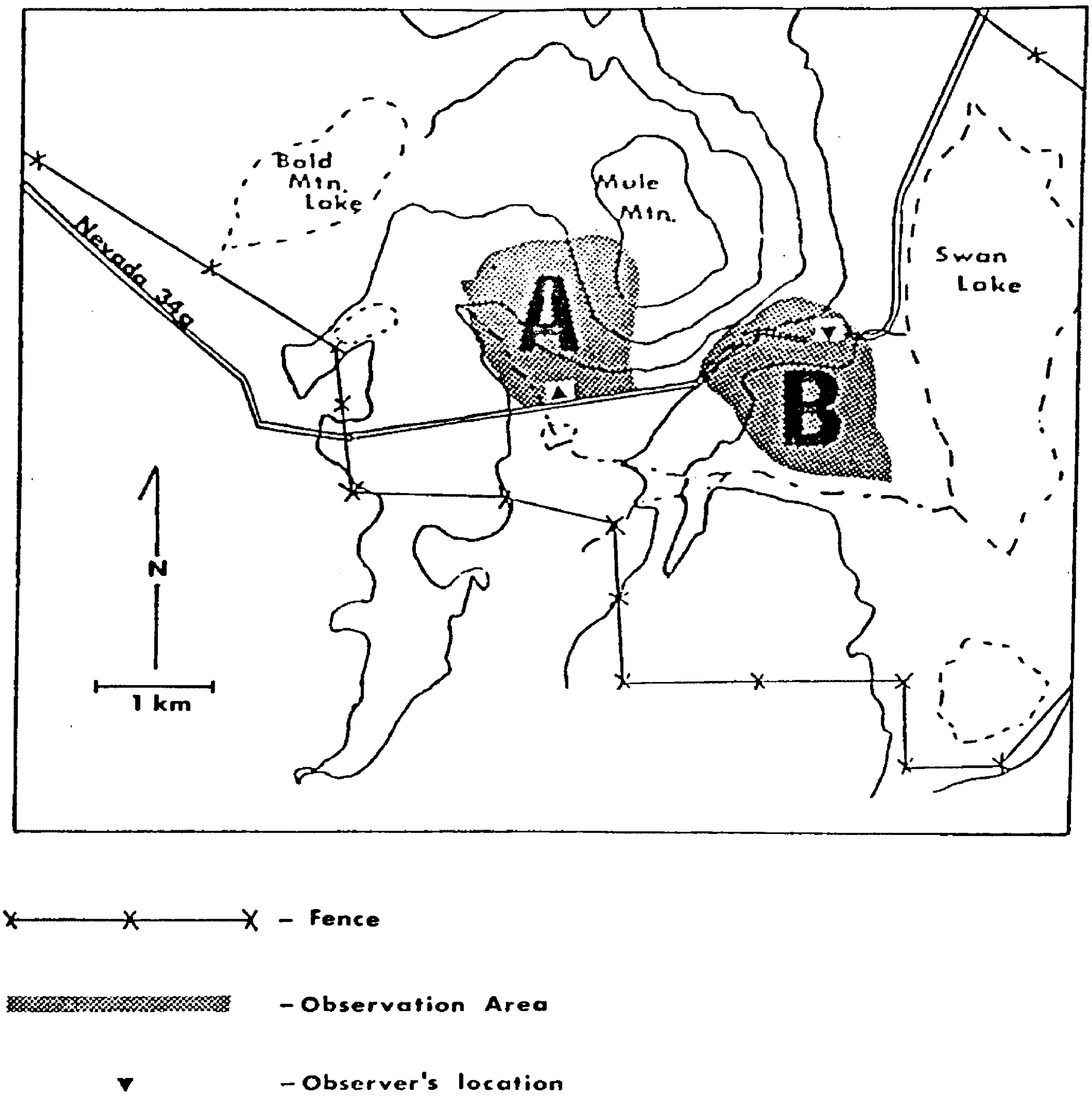


Fig. 3. Observation areas used in the study of pronghorn-cattle spatial interactions.

local rancher.

Observations on area A were conducted for equal time before and after cattle grazing began. Temporal use of the area by pronghorns was converted to pronghorn activity hours with 1 pregnant doe present for 1 hour equal to 1 pronghorn activity hour.

Observation of area B began after cattle had been using the area for 5 days. Numbers and locations of cattle and pronghorns were recorded at 20-minute intervals during morning and afternoon observation periods in area B.

Fawns. In 1978, cattle began grazing Mule Mountain on 1 June, after the major fawning period had ended. In 1979, cattle began grazing on 1 May, before the fawning period started. The earlier starting date in 1979 provided the opportunity to study the effects of cattle on pronghorn fawning activities.

An area of cattle use was delineated on a topographic map, based on my daily observations of cattle movements during May of 1979. Locations of fawn activities (birth sites, capture sites, and bedsites) for both years were then plotted on the map. Kill sites and locations of fawns greater than 3 weeks old were not plotted.

The proportion of fawn activity locations within the cattle use area in 1978 was compared with the proportion of locations in the cattle use area in 1979. Statistical analysis was accomplished by arranging the data in a 2 x 2 contingency table and applying the chi-square test of independence.

Dietary Overlap

During the spring of 1979, grazing by cattle and pronghorns overlapped on the Mule Mountain Management Unit. In each of 3 periods, 2 areas of overlap were sampled; each area represented a different vegetation type. In mid-May and early June, low sage sites and grassland sites were sampled. In late June, wet and dry sites on the Bald Mountain Lake playa were sampled. For each sampling period, the canopy coverage and frequency values were averaged for the 2 sites.

Vegetative and fecal sampling were done on 1-ha plots in areas of overlap. Vegetation on each plot was sampled along 5 parallel, 50-m lines that were 50 m apart. Fifty 30 x 60-cm quadrats were placed at 1-m intervals along each line. Canopy coverage for all plant species encountered was estimated using the canopy coverage frequency method (Daubenmire 1959) to provide an indication of the composition and frequency of forage species.

Fecal samples from both pronghorns and cattle were collected in and around each of the 6 plots. Two pellets of pronghorn feces from each of 20 fresh pellet groups and an equal volume of fresh cattle feces were collected from each plot. Samples were preserved with salt (NaCl) and sent to the Composition Analysis Laboratory in Fort Collins, Colorado, for analysis.

An index used by Meeker (1979) to measure diet overlap between pronghorns and horses was used in this study to determine overlap between the diets of pronghorns and cattle. Kulcyzenski's (Oosting 1956) similarity index gives SI, the percent overlap in 2 diets as:

$$SI = \frac{\Sigma\, 2W_i}{\Sigma(W_i + Y_i)} \times 100$$

where W_i is the percentage of plant species i in the diet containing the least percentage of species i, Y_i is the percentage of plant species i in the other diet.

CHAPTER IV

RESULTS

Fawns

Fawning Period

Radio collars were attached to 34 fawns, 20 males and 14 females, during the 1978 and 1979 fawning seasons (Table 2). The estimated fawning periods extended from 12 through 24 May. During both years, fawns appeared first on Gooch Table, then on Mule Mountain, and last on Horse Heaven. Estimated mean birth dates for captured fawns on each of the study areas were Gooch Table, 15 May; Mule Mountain, 17 May; and Horse Heaven, 21 May.

Table 2. Distribution of captured fawns.

	1978	1979	Total
North Rock Springs Table	6	7	13
Mule Mountain	3	10	13
Gooch Table	3	4	7
Fish Creek Table	1	0	1
Total	13	21	34

During both years, maximum and minimum temperatures, wind velocities, and general weather conditions were recorded daily at Catnip Creek, 1.6 km east of Catnip Reservoir (Fig. 1). Environmental conditions were more severe in 1978 during and for 2 weeks after the fawning period than in 1979. In 1978, snow fell on 5 days and rain on 4 days during the 30-day period. During the same period in 1979, precipitation was recorded only twice, as rain. Mean temperatures were higher and mean estimated wind velocities lower in 1979 (Fig. 4).

Weights and Measurements

Mean weights and all measurements were greater, but not significantly different, in fawns 1 day old or less in 1979 than in 1978 (Table 3). Rectal temperatures were significantly higher in fawns captured during 1979 than 1978 (2-sided t-test, $p < 0.01$). Weights, measurements, and rectal temperatures are given in Appendix A. The secondary sex ratio of captured fawns was 142♂:100♀.

Observed Births

Six births were observed, 3 in 1978 and 3 in 1979. All were twins except a single fawn birth observed on Horse Heaven in 1978. Normal doe-fawn imprinting was observed in all 6 cases and fetal membranes at the birth site were consumed by the doe in all cases except the single birth.

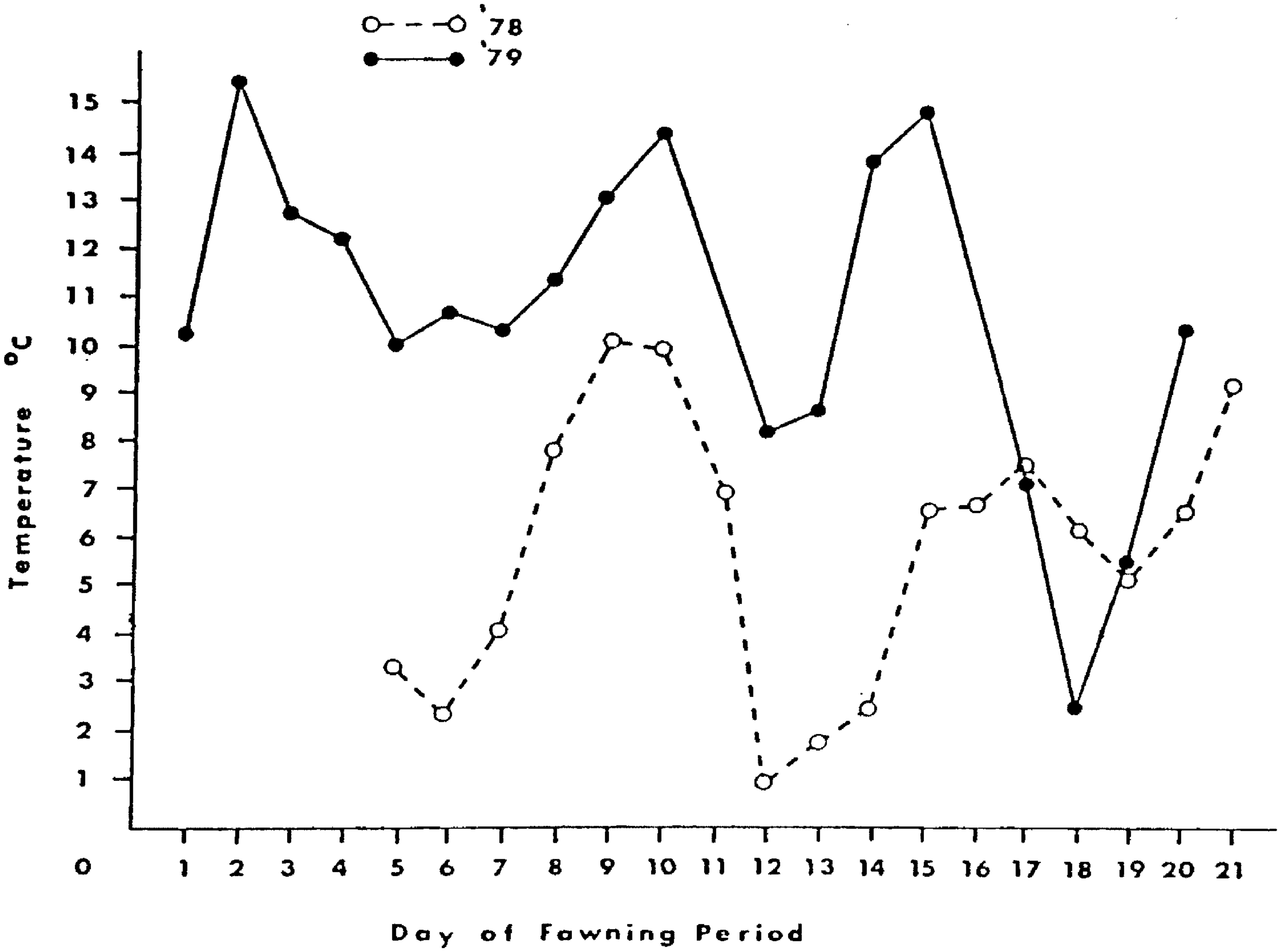


Fig. 4. Mean daily temperatures during the fawning periods of 1978 and 1979.

Table 3. Means and standard errors of measurements of fawns ≤ 1 day old.

Measurement	1978 n = 7 ($\bar{x}$ ± 1 SE)	Significance level°	1979 n = 11 ($\bar{x}$ ± 1 SE)
Weight (kg)	3.6 ± 0.11	$0.30 < p < 0.40$	3.8 ± 0.15
Length (cm)	62.1 ± 0.79	$0.05 < p < 0.10$	65.4 ± 1.22
Girth (cm)	37.9 ± 0.87	$0.30 < p < 0.40$	39.0 ± 0.70
Neck (cm)	16.8 ± 0.46	$0.30 < p < 0.40$	17.4 ± 0.40
Rectal temp. (°C)	38.6 ± 0.43	$0.02 < p < 0.05$	39.7 ± 0.25

°Two-sided probability, t-test.

Condition

In 1978, 11 of the 13 captured fawns appeared normal. Respiratory congestion and rectal bleeding were noted in 1 fawn and the condition of 1 fawn was not recorded.

In 1979, 17 of the 21 captured fawns appeared normal. Two fawns had labored, congested breathing; 1 of those fawns also suffered from rectal bleeding. The pelage of another fawn was shorter and less dense than in other captured fawns, giving the fawn a gaunt appearance. The throat swab from that fawn was spotted with blood, but the fawn did not have noticeable congestion or breathing problems. Another fawn was noticeably weaker than its twin and had an abnormal appearing, reddish tongue.

Abnormal behavior was noted in 2 fawns, 1 each year. In each case, the fawn ran toward us as we approached to capture it. Apparently, doe-fawn imprinting was incomplete, although in each case at least 4 hours had passed since parturition, the fawn had nursed and selected its own bedsite, the doe had moved away to feed, and the fawn's twin remained in a hiding position as we approached.

The proportion of unhealthy fawns surviving (80%) was more than twice the proportion of healthy fawns surviving (29%) (Table 4). Fisher's exact test (Daniel 1978) was used to test the difference in the proportion of normal and abnormal fawns surviving ($p = 0.094$, 2-sided).

Table 4. The fate of fawns classified at capture as healthy or unhealthy.

Fate	Healthy	Unhealthy
Coyote involved	8	1
Coyote kill	3	0
Eagle kill	1	0
Accidental	1	0
Undetermined	3	0
Missing	2	0
Survived	8	4
Research influenced	1	0
Total	28	5

Ten rectal and throat bacterial samples collected in 1979 included 3 samples from unhealthy fawns and 7 samples from healthy fawns. Pathogens were isolated in 2 of the abnormal samples and in 3 of the normal samples (Table 5).

Blood Analysis

Whole blood samples from 15 fawns and serum samples from 17 fawns were collected during 1979 (Appendix B). No significant differences were noted in whole blood or serum parameters between surviving fawns and those suffering fatalities, but red blood cell counts were greater in surviving fawns (t-test, 2-sided, $0.05 < p < 0.10$). Whole blood and serum parameters from the 4 fawns classified at capture as unhealthy did not reflect any abnormality, and were not significantly different than values from healthy fawns.

The only other available data on blood parameters of newly captured wild pronghorn neonates were collected in Alberta (Barrett and Chalmers 1976). A comparison of whole blood values between Sheldon and Alberta fawns revealed a number of significant differences (Table 6). Fawns captured on the Sheldon had lower average red cell counts (RBC) than Alberta fawns, but higher average mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) values. Average hemoglobin (Hb) values were not significantly different, but average hematocrit (Ht) values were lower in the Nevada fawns ($p < 0.001$).

Table 5. Results of bacterial cultures, and the condition and fate of sampled fawns.

Fawn no.	Rectal	Throat	Physical condition	Fate
15	Negative	Negative	Unhealthy	Survived
17	*Pseudomonas* spp.	Negative	Unhealthy	Survived
18	*Pseudomonas* spp.	Negative	Healthy	Predation
19	*Enterobacter agglomerans*	Alpha Streptococci	Healthy	Unknown
20	Negative	*Pseudomonas* spp.	Unhealthy	Survived
24	Negative	Negative	Healthy	Survived
25	Negative	Negative	Healthy	Predation
26	Alpha Streptococci	Alpha Streptococci	Healthy	Accidental
30	Negative	Negative	Healthy	Abandoned
31	Negative	Negative	Healthy	Predation

Table 6. A comparison of whole blood parameters from Alberta and Nevada fawns.

Blood parameter	Alberta[a]		Significance level[b]	Nevada	
	N	$\bar{X} \pm 1$ S.E.		N	$\bar{X} \pm 1$ S.E.
Red blood cells ($10^6/mm^3$)	122	9.68 ± 0.09	$p < .001$	17	5.68 ± 0.16
White blood cells ($10^3/mm^3$)	122	3.97 ± 0.17	$p < .001$	17	2.34 ± 0.23
Neutrophils (%)	120	59.86 ± 1.32	$p < .05$	15	67.80 ± 3.36
Lymphocytes (%)	120	33.94 ± 1.30	$.1 < p < .2$	15	27.66 ± 3.56
Mean corpuscular volume (u^3)	[c]	41.01		17	55.28 ± 0.55
Mean corpuscular hemoglobin (uug)	[c]	15.04		16	24.38 ± 0.50
Mean corpuscular hemoglobin concentration (%)	[c]	36.67		16	44.10 ± 1.15
Hemoglobin (g/100 ml)	116	14.56 ± 0.16	$.1 < p < .2$	16	13.85 ± 0.34
Hematocrit (%)	110	39.70 ± 0.38	$p < .001$	17	31.40 ± 1.14

[a] From Barrett and Chalmers 1976.

[b] Two sample t-test, 2-sided probability level.

[c] Sample size not available; values were calculated from RBC, Hb, or Ht values.

A comparison of serum values between Nevada and Alberta fawns also revealed significant differences (Table 7). Sodium values were significantly lower in the Sheldon fawns. Blood urea nitrogen, cholesterol, total protein, phosphorus, and glucose values were not significantly different.

Mortality

Natural mortality of monitored fawns was 69% during 1978 and 53% during 1979. These figures include 3 fawns that were under observation by capture crews when killed by coyotes, 2 in 1978 and 1 in 1979.

During both years, 90% of the fawn mortality occurred in the first 3 weeks of life. During that period, the estimated mean age at death for monitored fawns was 7.5 days in 1978 and 11.1 days in 1979. However, in 1978, 2 fawns died at 30 days of age and in 1979, 1 fawn died when it was 45 days old.

Predation was the main source of natural mortality, accounting for 89% of the natural mortality during 1978 and 73% during 1979. Accidental death and death from undetermined causes accounted for the remainder of the natural mortality. Three of the 37 fawns (8%) apparently died as an indirect result of capture and handling. The fate of the 37 fawns is given in Table 8.

Table 7. A comparison of serum parameters from Alberta and Nevada fawns.

Blood parameter	Alberta[a] N	Alberta[a] $\bar{X} \pm 1$ S.E.	Significance level[b]	Nevada N	Nevada $\bar{X} \pm 1$ S.E.
Calcium (mg/100 ml)	49	12.35 ± 0.19	$p < 0.001$	15	10.64 ± 0.15
Sodium (mEq/L)	49	137.53 ± 2.00	$p < 0.001$	15	151.60 ± 0.86
Potassium (mEq/L)	49	6.11 ± 0.13	$p < 0.01$	15	5.35 ± 0.23
Phosphorus (mg/100 ml)	49	9.11 ± 0.29	$p = 0.20$	15	9.82 ± 0.21
Cholesterol (mg/100 ml)	56	69.30 ± 5.52	$p = 0.30$	14	57.35 ± 7.01
Glucose (mg/100 ml)	26	157.26 ± 19.00	$0.6 < p < 0.7$	14	169.42 ± 15.01
Blood urea nitrogen (mg/100 ml)	27	16.22 ± 1.09	$p = 0.5$	15	14.90 ± 1.79
Total protein (g/100 ml)	46	4.78 ± 0.08	$0.3 < p < 0.4$	15	4.64 ± 0.13
Albumin (g/100 ml)	46	2.36 ± 0.05	$p < 0.001$	15	1.96 ± 0.07
SGOT (U/L)	57	157.02 ± 11.56	$0.6 < p < 0.7$	15	147.46 ± 11.00

[a] From Barrett and Chalmers 1976.

[b] t-test, 2-sided probability level.

Table 8. Fate of monitored fawns.

Fate	1978	1979
Coyote involved	6	3
Coyote kill[a]	2	4
Eagle kill	0	1
Accidental	0	1
Missing	1	1
Undetermined	1	2
Survived	3	9
Research influenced	2	1
Total	15	22

[a] Includes 3 fawns killed by coyotes while under observation, before attempts to capture the fawns were made.

Coyotes. Coyotes (Canis latrans) were involved in 15 of the 16 deaths (94%) attributed to predation. In several instances, tracks, scats, and guard hairs on brush indicated that coyotes were involved in the death or consumption of the fawn, but only remnants of the carcass were found. In those cases, mortality was classified as coyote-involved.

Coyotes were seen hunting in fawning areas singly or in pairs, and 3 coyotes were seen attacking and killing a fawn on Gooch Table in 1978. In one case, a coyote used a fenceline to its advantage in attacking and killing a fawn. Worden (U.S. Fish and Wildlife Service Biologist) and I observed the incident and recorded the events on a tape recorder. A summary of that account follows:

Shortly after noon on 18 May 1978, a postparturient doe was sighted in a sage flat south of Mule Mountain. Fetal membranes hanging from the doe indicated parturition had occurred a short time prior to our arrival. A yearling doe and a yearling buck accompanied the doe. The 2 newly born fawns were sighted and doe-fawn interactions were observed until 1315.

At 1315 a large, light-colored coyote was seen trotting along a fenceline approximately 100 m south of the pronghorn group. The fawns were bedded and the doe was aware of the coyote's presence. When directly opposite the pronghorns, the coyote began a slow stalk toward the area where the fawns were bedded, breaking into a run when approximately 50 m from the group. The doe immediately charged the coyote and a series of circular chases began in which the aggressiveness of the doe seemed matched by the aggressiveness of the coyote. Breaking away from the encounter, the coyote ran toward the fawns, briefly gaining a hold on one as he passed over it at a run. With the doe in pursuit, the coyote continued past the fawns, turned, and ran a zig-zag pattern to the fenceline. Immediately after passing under the fence, the coyote stopped, turned, and sat. Stopping short of the fence, the doe stared at the coyote but did not attempt further pursuit. During this incident, the yearling doe and buck stood by and did not pursue the coyote.

Returning to her fawns, the doe moved northeast across the sage flat. At 1330, the coyote moved under the fence and began stalking the pronghorns again. The doe met the coyote, again the coyote broke the encounter and grabbed one of the fawns, this time dragging it a few feet before the doe drove him off. Again the coyote ran for the fenceline where the pursuit ended as before. This second attack crippled the fawn, and it was then unable to keep up with the doe and the second fawn, creating a distance of up to 100 m between the fawns.

Within the next 40 minutes, the coyote made 4 more passes at the crippled fawn. Each encounter ended at the fenceline, a refuge for the coyote and apparent barricade to the doe. The coyote finished the kill during the 6th attempt at 1415, but was driven off by the doe and yearling buck. At 1426 a final stalk was made, but the fawn was apparently dead and was not defended.

The coyote rushed the doe and fawn a total of 6 times, but concentrated its efforts on 1 fawn. The coyote contacted the fawn on the 1st, 2nd, 4th, 5th, and 6th attempts. After passively standing by during the first 3 encounters, the yearling buck joined the pursuit during the 4th encounter and led the chase during the 5th and 6th encounters. Throughout the time of observation, the yearling buck periodically attempted to mount the doe, possibly a response to odors produced during parturition.

Necropsy of the fawn showed that it had been in good condition. Bruises, but no puncture wounds, were evident on the back; the fatal wounds were in the throat and head.

Eagles. Although Golden Eagles (Aquila chrysaetos) were often seen west of the Refuge, they were rarely seen in the vicinity of fawning areas. This scarcity of eagles may have resulted from the distribution of jackrabbits (Lepus californicus). Although very abundant in the big sage areas west of the Refuge, jackrabbits were rarely seen on the low sage flats of North Rock Springs or Gooch tables, or on Mule Mountain.

Feathers, droppings, and feeding patterns characteristic of eagle predation were associated with the carcass of a 21-day-old fawn in 1979, and an unsuccessful eagle attack was witnessed by Levesque (field assistant). The fawn took refuge under its dam during the attack and both doe and fawn remained relatively immobile until the eagle left the area.

Abandonment-starvation. Two fawns were abandoned and subsequently died of starvation, 1 in 1978 and 1 in 1979. The abandonment of the 1978 fawn was probably caused by the capture crew who inadvertently flushed the fawn from its bed when it was only a few hours old, interrupting doe-fawn imprinting. The other fawn was captured approximately 6 hours after its birth was observed. Although its twin was accepted by the doe, this fawn was abandoned. The deaths of those 2 fawns were classified as research influenced and were not used in predation or natural mortality calculations.

Accidental. The death of 1 fawn was classified as accidental when its remains were found at the base of a cliff on the south edge of Gooch Table. Necropsy of the fawn did not reveal any puncture wounds, the trachea was intact, there were no apparent fractures in the skull or in other bones, but subcutaneous hemorrhaging was evident over a large portion of the left side. The hoofs had been eaten away by rodents, but no sign of predator feeding was evident. It may, however, have been chased over the cliff by a predator.

Movements

Combined for both years, fawn activities were inferred from 94 locations--19 on Gooch Table, 33 on Mule Mountain, and 42 on North Rock Springs Table. Movements from the birthsite to the first bedsite were measured for 5 fawns. The distances ranged from 0.1 to 0.8 km and averaged 0.4 km. Measurements from beds selected on consecutive days were made for 13 movements of fawns less than 9 days old. The greatest distance moved, 2.0 km, was made by a 2- to 3-day-old fawn. The closest consecutive beds, also selected by a 2- to 3-day-old fawn, were 0.2 km apart. The average distance between consecutive beds was 0.7 km.

The relative position of consecutive locations varied from nearly linear to nearly circular. One fawn was last located 9.5 km from its capture site; another was last located only 0.3 km from its capture site. The average distance between fawn capture sites and final locations was 3.5 km ($n = 12$).

Home range sizes varied from 29 ha to 1150 ha and averaged 438 ha for 12 fawns less than 3 weeks old (Table 9). Home ranges of females were smaller than those for males. The mean home range size on the Sheldon was significantly different than the 127 ha mean home range size reported by Tucker (1979) for Texas fawns (Fisher-Behrens test $p < 0.05$, Campbell 1974).

Table 9. Home range sizes for fawns less than 3 weeks old for which 4 or more locations were made.

Fawn no.	Sex	Area°	Number of locations	Home range size (ha)
1	♀	NRST	8	181
8	♀	NRST	4	102
10	♂	NRST	6	967
11	♀	NRST	5	102
14	♂	NRST	8	596
17	♀	NRST	4	540
5	♂	MM	4	50
13	♂	MM	7	1150
16	♂	MM	4	277
28	♂	MM	4	995
32	♂	MM	4	29
3	♂	GT	10	264

°NRST - North Rock Springs Table
MM - Mule Mountain
GT - Gooch Table

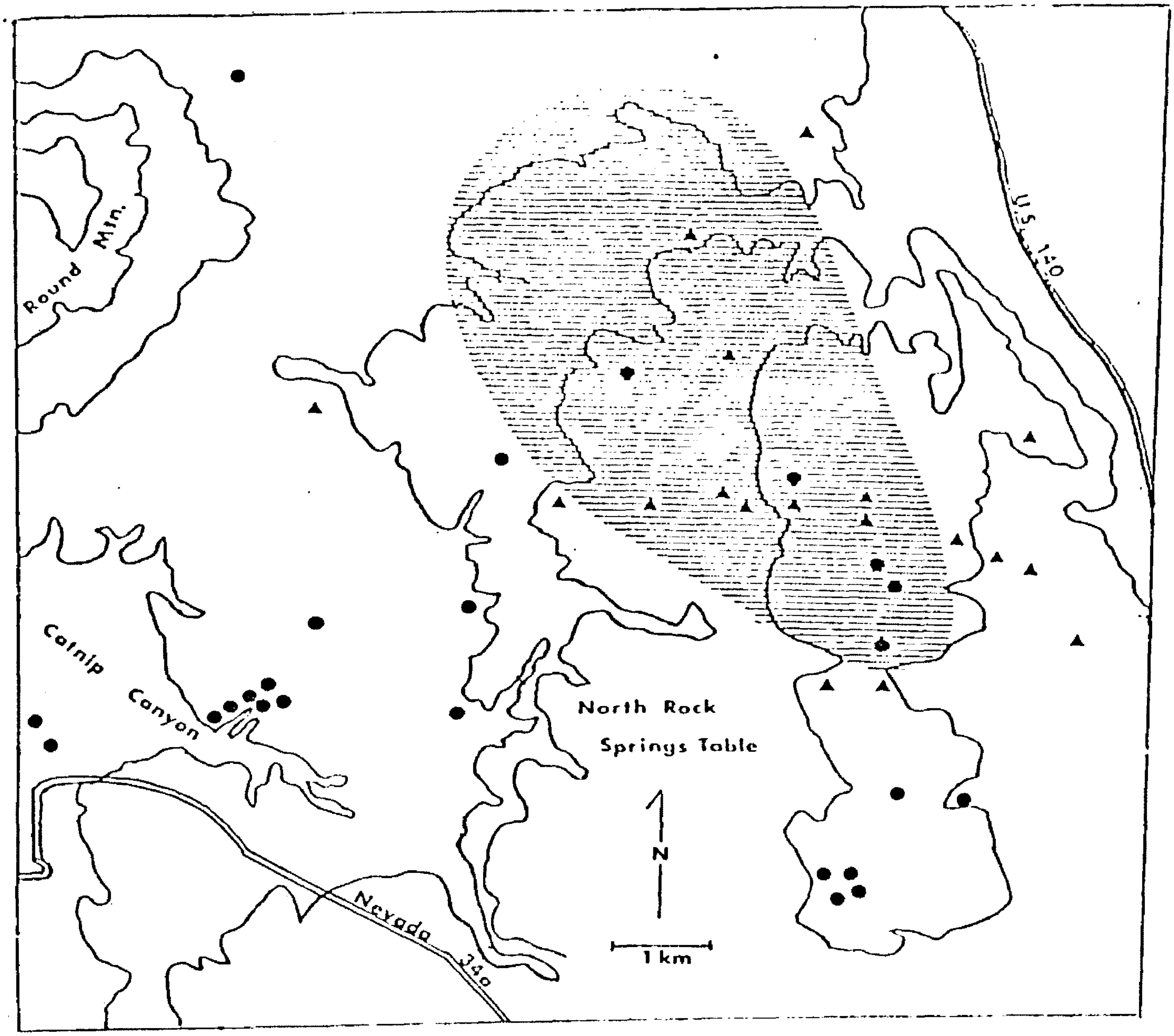
In relation to horses. Although the uncertainty over exact horse movements precluded statistical testing, plotted locations of fawns indicated a shift in fawn activity from 1978 to 1979 on North Rock Springs Table. Locations from 1978 indicated fawn activity was peripheral to feral horse concentrations, but fawn locations during 1979, in the absence of horses, were centered in the area delineated for 1978 horse activity (Fig. 5). During 1979, 44% of the fawn locations on North Rock Springs Table were within the delineated spring horse range, but only 21% were within the delineated area during 1978 when approximately 200 horses were present.

Bedsites

General Characteristics

During 1979, 50 bedsites were measured within 3 days after fawn use (Table 10). Vegetation within a 0.3 m radius of the bed (Near-bed Plot) had greater cover and volume than vegetation directly on the bed (Bed Plot). Vegetative values within a 1- to 4-m radius of the bed (Circular Plot) were intermediate between the Near-bed and Bed Plot values, and cover values on the Near-bed Plot were significantly greater than those on the Circular and Bed Plots (Wilcoxon's matched-pairs, signed-ranks test, 2-sided, $p < .002$).

Control plots were measured for 39 of the 50 bedsites (Table 11). Total vegetative cover and volume values on used Bed Plots were



● Fawn locations (birth, capture, and relocation sites) during 1978.

▲ Fawn locations (birth, capture, and relocation sites) during 1979.

▨ Approximation of feral horse movements during the spring of 1978.

Fig. 5. Fawn activity and its relationship to feral horse movements during late May and early June 1978 and 1979 on North Rock Springs Table.

Table 10. Average vegetative cover and volume characteristics of 50 fawn bedsites.

	Bed Plot		Near-bed Plot		Circular Plot	
	% cover	Volume°	% cover	Volume°	% cover	Volume°
Total vegetation						
$\bar{x}$	23	21.6	54	83.6	46	46.1
SE	1.8	2.2	1.8	5.6	1.0	1.6
Shrub						
$\bar{x}$	9	11.0	32	64.1	18	24.1
SE	1.4	2.1	2.0	5.9	1.0	1.7
Grass						
$\bar{x}$	7	5.5	11	10.4	12	10.1
SE	0.9	0.7	0.8	1.1	0.9	1.2
Forb						
$\bar{x}$	7	5.2	11	9.1	16	11.9
SE	1.1	0.9	1.1	1.0	1.1	0.8
Bare/Rock						
$\bar{x}$	81	---	46	---	57	---
SE	2.0	---	2.0	---	1.3	---

°$dm^3/100\ dm^2$ ($1\ ft^3/100\ ft^2 = 3.05\ dm^3/100\ dm^2$).

Table 11. A comparison of use and control Bed Plot and Near-bed Plot values.

	Use n = 39		Control n = 39	
	% cover (R.C.)[b]	Volume[a] (R.V.)[c]	% cover (R.C.)[b]	Volume[a] (R.V.)[c]
Bed Plot				
Total vegetation	25	25.3	41	37.2
Shrub	9	11.6	13	16.5
	(36)	(46)	(32)	(44)
Grass	7	6.1	11	8.2
	(28)	(24)	(27)	(22)
Forb	9	7.6	17	12.5
	(36)	(30)	(41)	(34)
Bare/Rock	80	---	56	---
Near-bed Plot				
Total vegetation	55	84.2	44	42.7
Shrub	33	65.9	18	22.0
	(60)	(78)	(41)	(51)
Grass	11	10.1	11	8.8
	(20)	(12)	(25)	(21)
Forb	11	8.2	15	11.9
	(20)	(10)	(34)	(28)
Bare/Rock	45	---	53	---

[a] dm^3/100 dm^2 (1 ft^3/100 ft^2 = 3.05 dm^3/100 dm^2).

[b] Relative cover = % of total.

[c] Relative volume = % of total.

significantly lower than the corresponding control plot values (cover: $p < 0.002$, volume: $p = 0.05$), and bare and rock cover values on used Bed Plots were significantly greater than those on control plots ($p < 0.002$). Near-bed total vegetative cover and volume values were higher than the corresponding values on control plots (cover: $p = 0.002$, volume: $p < 0.002$). The average relationship between control plots and used plots is shown in Fig. 6.

Relationship to Range Condition

The Horse Heaven and Gooch Table fawning areas were in poor to fair range condition. Range condition on Mule Mountain was fair to good; the different conditions were reflected in the relative bedsite cover and volume values for shrubs, grasses, and forbs (Table 12). Mean relative shrub values were highest on the areas in Poor-to-Fair condition. Mean relative grass values were highest on the areas in Fair-to-Good condition. However, the characteristic relationship of low Bed Plot cover and volume, high Near-bed Plot cover and volume, and intermediate Circular Plot cover and volume, held for both range conditions.

Bedsites of Predator-killed Fawns

Nine bedsites of predator-killed fawns and 24 bedsites of surviving fawns were measured (Table 13). Bed Plot, Near-bed Plot, and Circular Plot mean cover or mean volume values from bedsites of

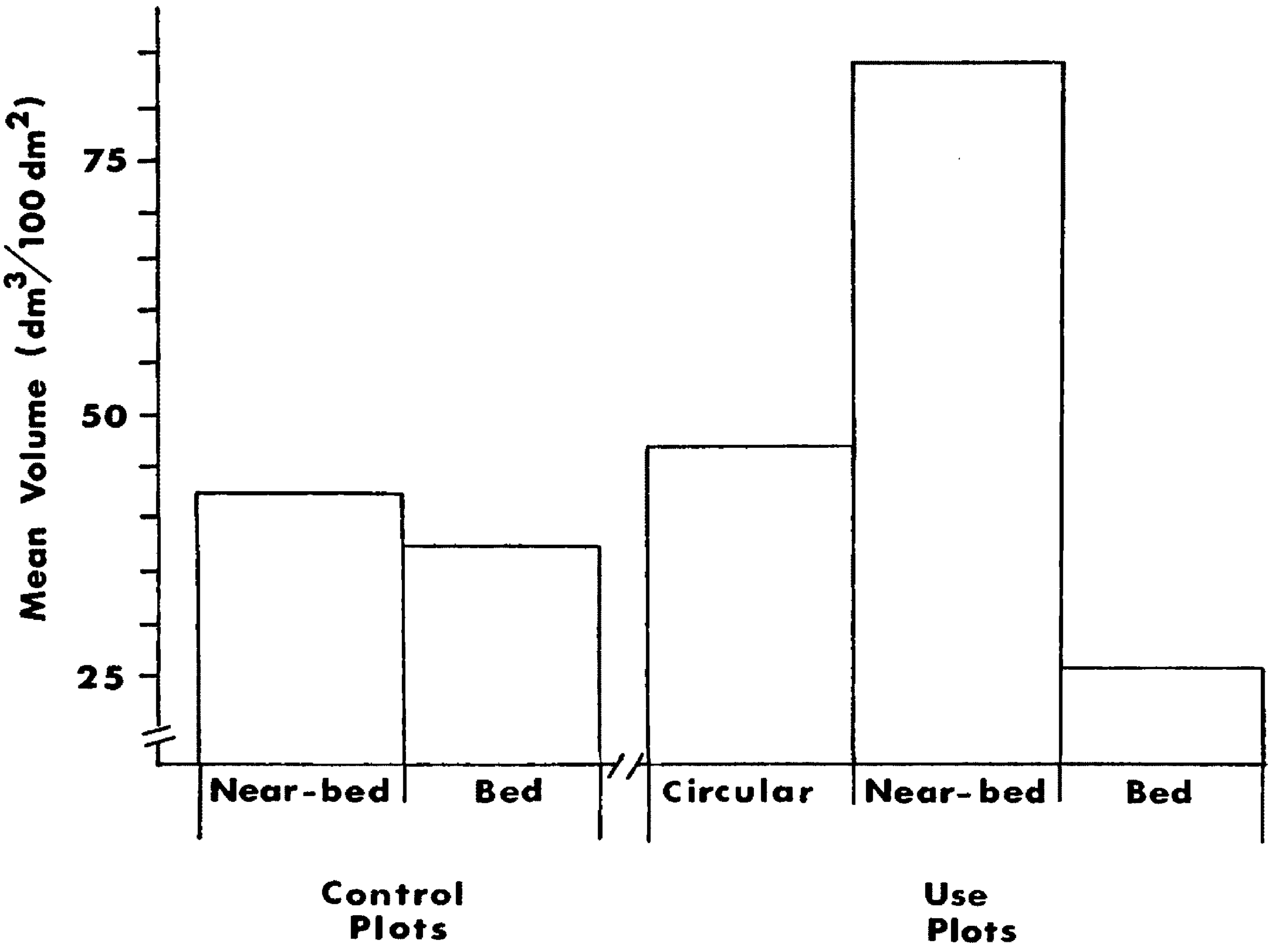


Fig. 6. Average relationship between vegetative volume at use and control bedsites.

Table 12. Average bedsite cover and volume values for 2 range conditions.

	Poor-to-Fair condition n = 33		Fair-to-Good condition n = 17	
	% cover (R.C.)[b]	Volume[a] (R.V.)[c]	% cover (R.C.)[b]	Volume[a] (R.V.)[c]
Circular Plot				
Total vegetation	45	44.8	45	47.9
Shrub	19	24.7	17	22.9
	(42)	(55)	(38)	(48)
Grass	10	7.6	15	14.3
	(22)	(17)	(33)	(30)
Forb	16	12.5	13	10.7
	(36)	(28)	(29)	(22)
Bare/Rock	57	---	57	---
Near-Bed Plot				
Total vegetation	56	93.3	49	62.8
Shrub	35	74.7	26	42.4
	(63)	(80)	(52)	(67)
Grass	10	9.1	13	12.2
	(18)	(10)	(26)	(22)
Forb	11	9.5	10	8.2
	(19)	(10)	(22)	(13)
Bare/Rock	43	---	51	---
Bed Plot				
Total vegetation	25	24.4	21	16.8
Shrub	11	14.0	7	5.8
	(44)	(57)	(32)	(35)
Grass	6	4.6	9	7.0
	(24)	(18)	(44)	(42)
Forb	8	5.8	5	4.0
	(32)	(25)	(24)	(23)
Bare/Rock	79	---	84	---

[a] dm^3/100 dm^2 (1 ft^3/100 ft^2 = 3.05 dm^3/100 dm^2).

[b] Relative cover = % of total.

[c] Relative volume = % of total.

predator-killed fawns were not significantly different from the corresponding values from bedsites of surviving fawns. The proportion of fawns killed by predators on North Rock Springs and Gooch tables (5 of 9) was not significantly different than the proportion killed by predators on Mule Mountain (4 of 9).

Table 13. A comparison of mean cover and volume values between bedsites of predator-killed fawns and bedsites of surviving fawns.

	Bedsites of fawns killed by predators (n = 9)		Bedsites of surviving fawns (n = 24)	
	% cover	Volume[a]	% cover	Volume[a]
Circular Plot				
$\bar{x}$	46	54.3	45	47.6
SE	2.4	9.6	1.4	2.8
Near-bed Plot				
$\bar{x}$	55	69.5	51	76.3
SE	3.6	5.0	2.8	7.0
Bed Plot				
$\bar{x}$	22	18.6	21	20.1
SE	3.6	2.5	2.7	3.8

[a] $dm^3/100\ dm^2$ ($1\ ft^3/100\ ft^2 = 3.05\ dm^3/100\ dm^2$).

Adult Pronghorns

Doe Censuses

During early May 1979, 140 doe classifications were made; 31 yearlings, 8 nonpregnant does, and 101 pregnant does were counted (Table 14). Of the adult does counted, 93% were pregnant. However, the obvious external signs of pregnancy became more pronounced as parturition approached and some does classified as nonpregnant may have given birth late in the fawning season.

Fawn:doe ratios calculated from the 1979 ground census were much higher than those calculated from the aerial census flown in July 1978. That discrepancy may be a function of incorrect classification of adult does as yearlings in the 1979 doe census, an error in the aerial count, movement of new animals into the area, or a combination of those factors.

Breeding Buck Behavior

Buck no. 1 was observed for 31 hours between 5 and 31 August 1978. A territorial boundary drawn to include 100% of his plotted scent markings encompassed 130 ha. On several occasions, buck no. 1 was seen herding does within his territory, becoming more aggressive when does strayed into adjacent areas.

The virtually complete segregation of scent markings by bucks nos. 1 and 2, and the location of buck-buck encounters,

Table 14. Fawn:doe ratios calculated from ground doe censuses in 1979 compared with aerial censuses.

		Ratios from 1979 ground census			
Area	n	Yrlg. does : non-pregnant does : 100 pregnant does	% pregnant	1978 fawn:doe ratios calculated from 1979 ground census data	1978 fawn:doe ratios calculated from 1978 aerial census
North Rock Springs Table	48	21.4:9.5:100	91	36:100	15:100
Mule Mountain	36	75.7:5.0:100	95	133:100	14:100
Gooch Table	56	15.2:6.5:100	94	26:100	25:100
Total	140	30.5:8.0:100	93	52:100	21:100

substantiated the hypothesis of a territorial breeding system on North Rock Springs Table (Fig. 7). All of the buck-buck encounters included some of the ritualized behaviors described by Bromley and Kitchen (1974). In every case, the ritualized displays of buck no. 1, often followed by a short chase, were sufficient to defend the territorial boundary. I did not observe any fighting between bucks.

Ten hours of observations were logged on the Bald Mountain Lake playa. As many as 97 pronghorns foraged on the playa simultaneously, attracted to the dried lake bed by an abundance of newly sprouted forage. In contrast to the orderly territorial system observed on North Rock Springs Table, the breeding behavior on the playa was chaotic. Two bucks were observed herding does toward a rock escarpment on the south edge of the playa, but interference from other bucks and the unwillingness of does to be held in a small area made the bucks' attempts unsuccessful. One buck displayed his cheek patch to a doe near the center of the playa, and attempted to mount her several times, but was not accepted by the doe. Fighting broke out between 2 bucks less than 100 m from the displaying buck and lasted for approximately 10 minutes, after which each buck returned to separate, nearby doe herds. Other bucks hooked at passing does with their horns, apparently trying to herd the does. All this activity resulted in the constant movement of virtually all of the pronghorns on the playa. Grazing was necessarily sporadic and of short duration, and none of the bucks

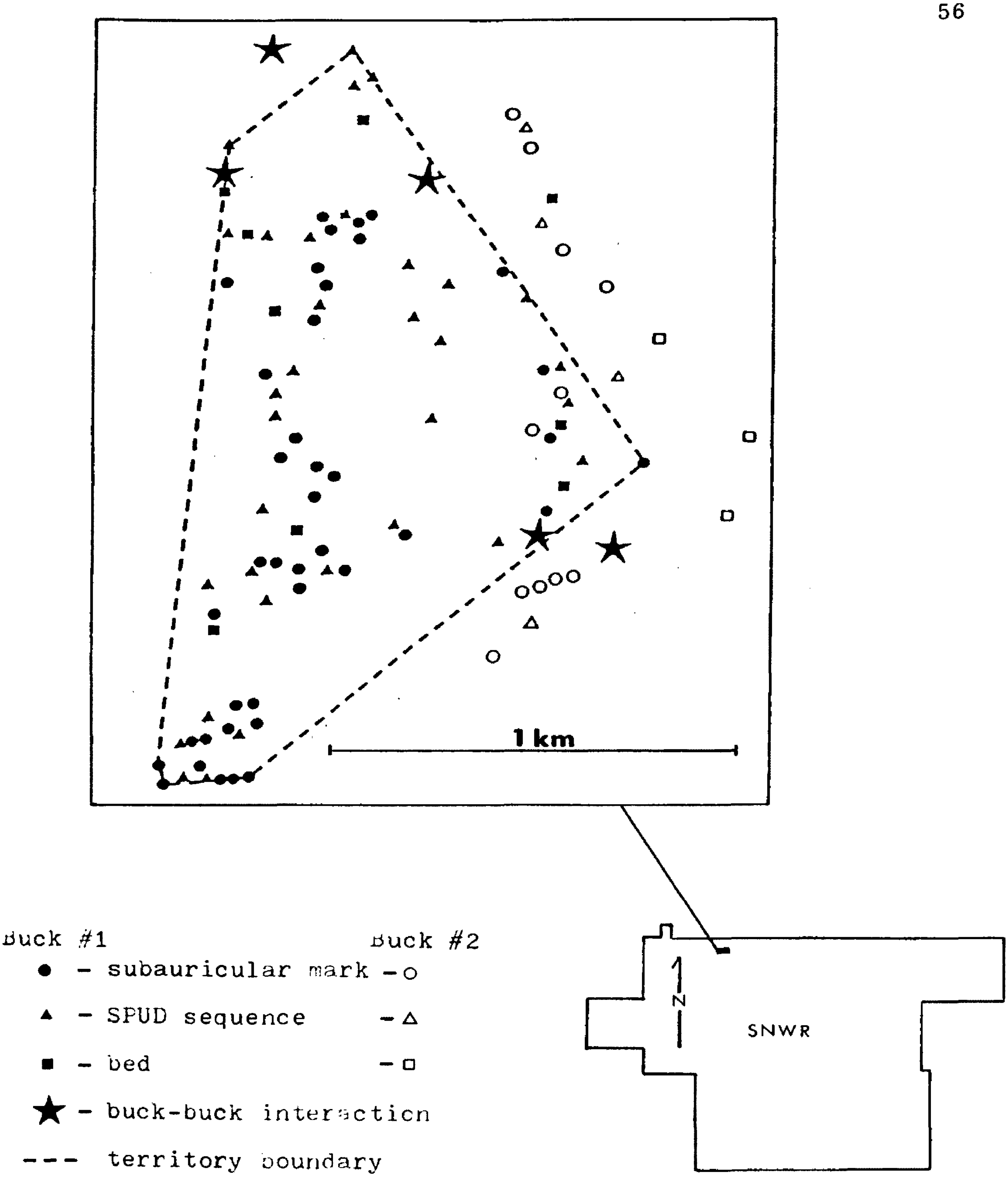


Fig. 7. Distribution of scent markings, beds, and buck-buck encounters for 2 territorial bucks on North Rock Springs Table.

successfully courted or herded does for more than a few minutes.

Cattle moved onto the playa on 3 September, displacing the concentration of pronghorns. Only a few scattered pronghorns were seen on the playa after that date.

Hunting Season

During the 2-week hunting season on the Sheldon in 1978 and 1979, 25 bucks were taken by 30 permit holders each year for an 83% hunter success. The mean Boone and Crockett score of bucks taken in 1978 was 71.6, less than the 1979 mean of 75.2, but not significantly different from the 1967-1977 mean of 72.4. During the 1979 hunt, 4 bucks were shot that scored over 82, the minimum score for the record book. None of the 1978 bucks made the record book. Since 1967, hunters have killed 240 bucks on the Sheldon during the late August-early September hunts. Five percent of those bucks unofficially scored above the minimum record book score, and an additional 8% scored within 2 points of the minimum score. Does were not legal game during any of those hunts.

Cattle-Pronghorn Interactions

Spatial Interactions

During 1979, observation on area A totaled 19 hours. Pronghorn use averaged 1.8 pregnant does per hour before cattle use, and 1.3 pregnant does per hour after cattle use began. Although cattle use was observed along the creek that bisected the observation area, most use was concentrated in the southeast corner, near a small reservoir. Pronghorn use, both before and after cattle use began, was concentrated in low sage flats on the perimeter of the observation area. Those spatial preferences by both species reduced direct cattle-pronghorn confrontations.

Sixteen hours of observation were logged on area B. The numbers of cattle and pronghorns present at each 20-minute interval were recorded. Analysis of observations taken on the hour indicated a significant negative correlation between cattle and pronghorn use ($r = -0.81$, $p < 0.01$; Fig. 8).

Cattle-pronghorn confrontations were observed during the 35 hours of observation near Mule Mountain. The reactions to cattle of bucks and yearling females differed from those of pregnant females. Bucks and yearling females were often seen bedded or feeding near cattle, but adult does avoided cattle. The following observations illustrate the consistently observed patterns of pronghorn behavior in the presence of cattle.

1) On 4 May, 42 cattle moving east along Bald Mountain Creek in area B encountered a lone buck feeding along the creek. When the cattle were 50 m from the buck, he stopped feeding, stared at the cattle, and began walking northwest away from the creek and the cattle. After moving approximately 200 m, the buck performed the Sniff-Paw-

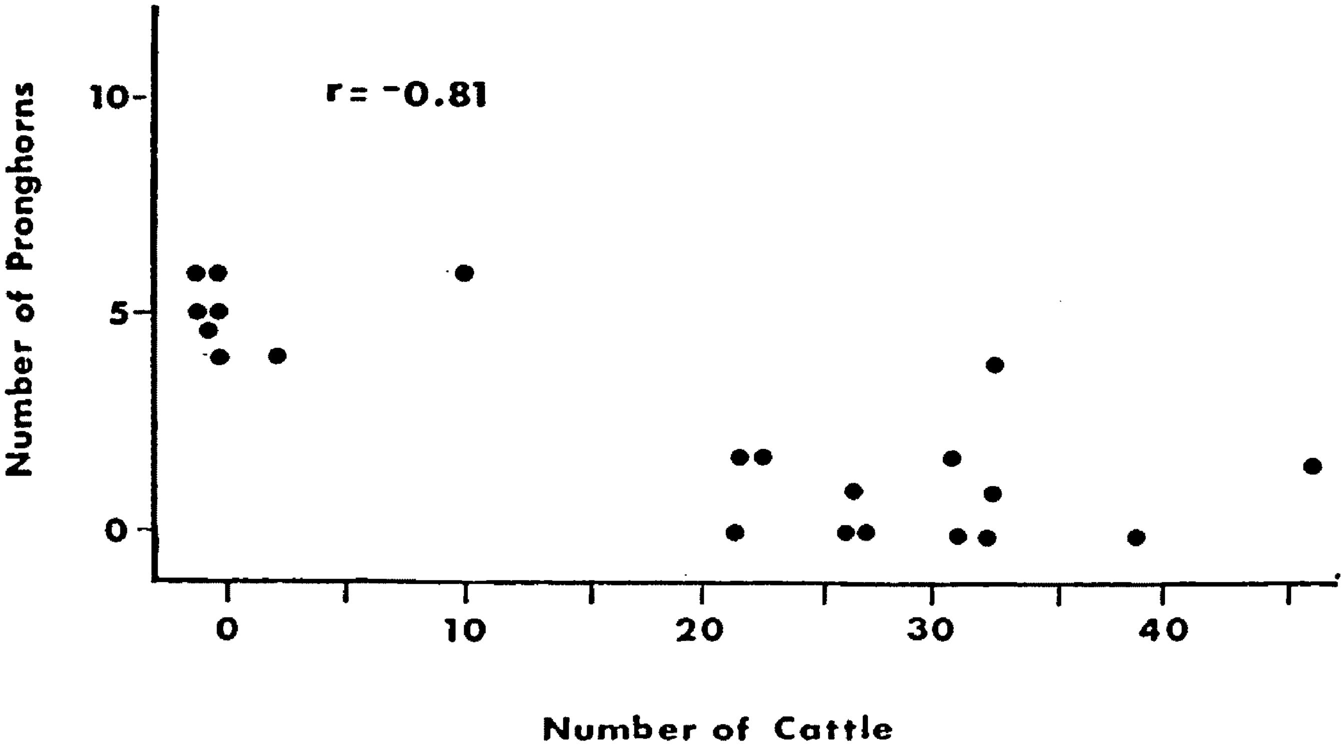


Fig. 8. The relationship of numbers of cattle and pronghorns at hourly intervals on Observation Area B in early May 1979.

Urinate-Defecate (SPUD) sequence and resumed feeding. Five minutes later the buck performed the SPUD sequence a 2nd time and continued feeding. The cattle continued moving east toward Swan Lake Reservoir.

2) On 5 May, 60 cattle were observed in area B, 20 (group I) standing near a salt block in the northwest corner of the area, and 40 (group II) grazing near the center of the area. A pronghorn buck was bedded approximately 100 m west of group I. A pregnant doe was feeding near Bald Mountain Creek and moving northeast. The rolling topography of the area apparently prevented her from seeing either group of cattle. Her direction of movement took her to a point directly between the groups. Eventually, group II came over a small rise and into full view of the doe at 150 m. The doe stopped feeding, stared at them, then turned and trotted to the west. When approximately 100 m from the salt blocks, the doe saw group I. She stopped, turned her head several times, and began moving southwest at a trot-gallop. She passed between the cattle groups and continued out of my view. The buck remained bedded in full view of the cattle, 100 m west of group I.

3) After the fawning period, cattle-pronghorn interactions were observed at a man-improved water catchment on the Bald Mountain Lake playa. At 1800 on 15 June, 16 cattle moved south off the playa into an area of tall sage. Five pronghorn, 3 does and 2 bucks, walked onto the playa; the bucks passed within 20 m of the cattle, but the does took a circular route to the water, staying 200-300 m from the cattle.

At 1930, the cattle moved back to the playa. When the cattle were approximately 300 m from the waterhole, the does raised their heads, stared at the approaching cattle, and trotted off the playa. They went over the rim surrounding the lake basin and out of sight. The 2 bucks moved away from the water, but remained on the playa and returned to drink when the cattle moved off at 1950. Later, when a single cow returned to the waterhole, the 2 bucks trotted approximately 100 m and began feeding.

Effects on Fawn Activities

Fawn activity during 1978, when cattle were not present, was centered in the basin south and west of Mule Mountain; 7 of 13 locations were within the delineated cattle use area. When cattle were present during 1979, most of the fawn locations were northeast of Mule Mountain; only 3 of 20 fawn locations were within the boundaries of the cattle use area. The proportion of fawn locations within the cattle use area was significantly greater in 1978 than in 1979 ($X^2 = 5.63$, 1 df., $P < 0.025$; Fig. 9).

Dietary Overlap

Little overlap existed between the diets of pronghorns and cattle during the mid-May, early June, and late June sampling periods (Fig. 10). Diet overlaps determined from shrub-grassland pellet samples collected in mid-May and early June were 2.9% and 2.3%,

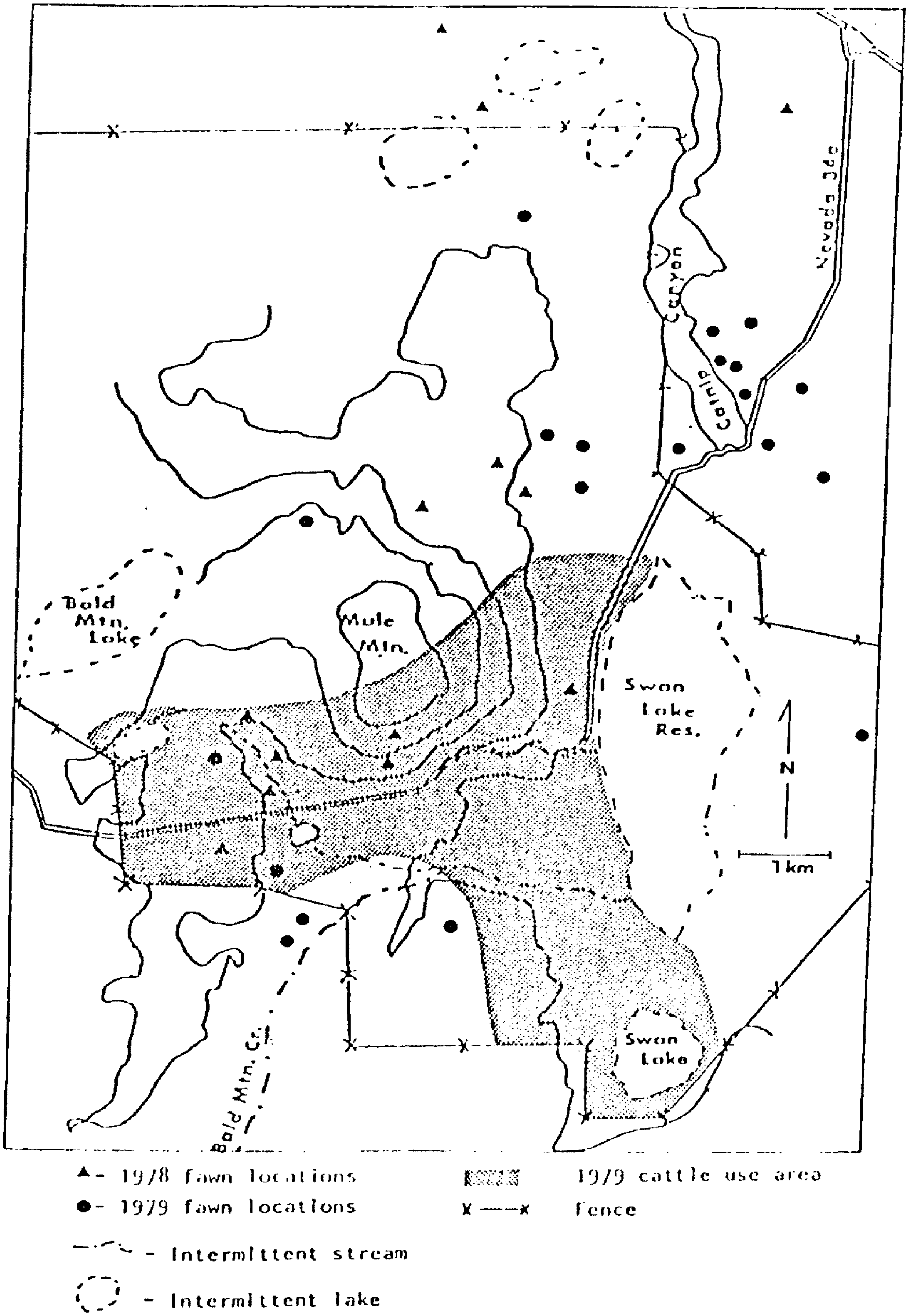


Fig. 9. Fawn locations near Mule Mountain during late May and early June 1978 and 1979. Shows shift in fawning area between years.

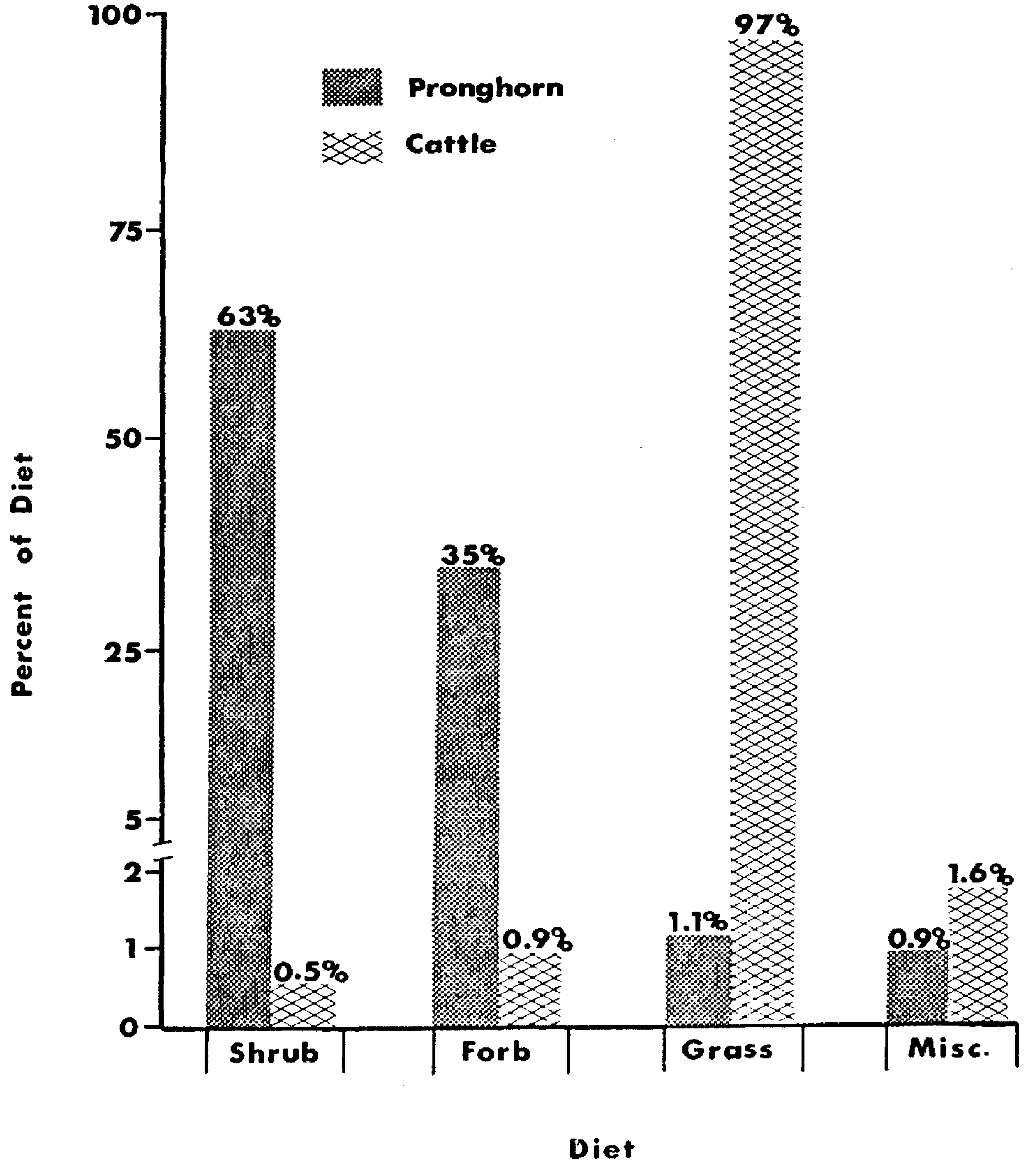


Fig. 10. A comparison of spring pronghorn and cattle diets determined by fecal analysis.

respectively. Diet overlap determined from the playa pellet samples collected during late June was 7.3%. Combined for all 3 periods, the cattle diet consisted almost entirely of grasses, sedges, and rushes (97% of the total diet), but pronghorns selected shrubs and forbs (98% of the total diet).

Thirteen species of grasses, sedges, and rushes were found in the cattle feces. The most common species, Sandberg bluegrass (Poa sandbergii) averaged 32% of the total cattle diet. Four shrub species occurred in the pronghorns' diet; sagebrush (Artemisia spp.) was the most common, averaging 58% of the total. Tansymustard (Descurainia sp.) was the most common of the 18 forbs in the pronghorns' diet, averaging 27%.

The analysis of pronghorn and cattle feces revealed 33 plant species in their combined diets, but only 14 of those were found in the vegetation transects. Complete lists of the plant species found in the vegetation transects and in the fecal analysis are given in Appendix C.

CHAPTER V

DISCUSSION

Factors Affecting Fawn Mortality

Timing of the Fawning Period

"Severe spring weather may make late fawning advantageous to pronghorns on high-altitude ranges" (Bodie 1979). However, despite the high altitudes on the Sheldon fawning areas, the fawning period, 12-24 May, was earlier than those reported in other parts of the pronghorn's range. Von Gunten (1978) reported a mean fawning date of 25 May on the National Bison Range in Montana, with some fawns born after 1 June. In Idaho, a mean fawning date of 31 May was reported (Bodie 1979), and in Colorado, fawns were born as late as 23 June with the majority of fawns being born between 1 and 12 June (Hoover et al. 1959). Fawns were not seen until July in Chihuahua, Mexico (Trevino 1978), but Tucker (1979) reported that the peak of fawning was between 3 and 13 May in the Trans-pecos region of Texas. In New Mexico, the fawning peak was reported as 23 May (Larsen 1964).

The highly variable, potentially severe weather on the Sheldon in mid-May could have a significant impact on fawn survival. In Wyoming, severe mortality in young pronghorns may be caused by freezing temperatures and precipitation (Kindschy et al. 1978), and spring storms in the Pahsimeroi Valley of Idaho were thought to increase losses to starvation and disease (Bodie 1978). Hypothermia has been reported as a major mortality factor for caribou (Rangifer tarandus) calves in some areas (Kelsall 1968).

Information is lacking on the specific conditions that cause hypothermia in pronghorn fawns, but mean daily temperatures of 1.5°C, accompanied by rain and wind, caused hypothermic death in caribou calves after 5.5 hours of exposure (Hart et al. 1961). Alexander (1962) demonstrated increased susceptibility to hypothermia in small, neonatal domestic lambs that experienced poor prenatal nutrition.

Climatic conditions on the Sheldon were more severe during the 1978 fawning period than during 1979. That difference was reflected in the low mean rectal temperatures of fawns captured during 1978 ($p < 0.01$). The mean ambient temperature from 15 through 31 May 1978 was 5°C, and 5 days had a mean temperature less than 3°C. From 23 through 25 May, mean daily temperatures varied from 1 to 2.5°C, snow fell and accumulated up to 7.6 cm, and winds varied from 16 to 40 kph, creating conditions that could have induced hypothermia in caribou calves. A pronghorn fawn, weighing approximately 64% of the weight of a caribou calf, and with relatively longer extremities, could not be expected to maintain a thermoregulatory balance under those conditions.

Pronghorns normally give birth to twins (O'Gara 1978b). Hoover et al. (1959) examined 42 does during pregnancy in Colorado; 3 had 1 fetus and 39 had 2 fetuses for a fetus:doe ratio of 193:100. However, at fawning 159 does produced 1.6 fawns per doe. Larsen (1964) reported that 93% of the mature does examined in a New Mexico study were pregnant and fetal rates in yearling does were similar to those for older does. In Utah, fawn:doe ratios at birth averaged 153:100 over 8 years, but varied from 1 to 1.81 fawns per doe (Beale and Smith 1970).

On the Sheldon, 1 single birth was observed, but of the remaining 12 fawns captured in 1978, 7 were single fawns when captured. Therefore, the disappearance of up to 35% of the potential fawn sample was unexplained. Severe weather undoubtedly contributed to this unexplained, but apparently high, early mortality on the Sheldon in 1978.

Condition

Mean weights and measurements of fawns captured during 1978 were less than those for fawns captured in 1979. The differences were not statistically significant between years, and weights and measurements were similar to those reported by other workers (Hoover et al. 1959, Mitchell 1971, Von Gunten 1978, Bodie 1979). However, the differences between years may have been biologically significant. Working with white-tailed deer fawns, Verme (1977) constructed a model showing, "a curvilinear relationship between natal body weights and mortality risk; that is, a slight reduction in a fawn's size disproportionately increases its chances of dying." Reduced birth weights were associated with maternal malnutrition (Verme 1963) and the relative severity of the preceding winter (Verme 1977). Thorne et al. (1976) found a similar relationship between elk calf survival and birth weights. The nutritional state of the dam during the last half of gestation determined calf birth weights. In experiments with domestic animals, poor nutrition of the dam during gestation reduced maternal care and milk production, resulting in low survival of neonates (Thomson and Thomson 1953).

In deer, secondary sex ratios and behavioral changes in the doe may accompany nutritional stress. Robinette et al. (1973) reported a higher proportion of female fawns were born to nutritionally stressed mule deer (Odocoileus hemionus) does than to does on a high nutritional plane. Similar experiments with penned white-tailed deer did not reveal nutritional effects on secondary sex ratios, but malnourished does often rejected their fawns, refused to lick and nurse the fawns, and failed to eat the afterbirth (Langenau and Lerg 1976).

Secondary sex ratios of captured fawns on the Sheldon indicated that a higher proportion of female fawns were born in 1978 than in 1979, but because the sample size was small, the 1978 ratio of 116♂:100♀ was not significantly different from the 1979 ratio of 163♂:100♀.

Weather records from the Dufferena Sub-headquarters showed that the severe winter of 1977-1978 was preceded by a late summer-fall drought, while the relatively mild winter of 1978-1979 was preceded by near average late summer-fall precipitation. Although the nutritional state of the Sheldon does could not be determined, the greater weights, measurements, and survival of fawns in 1979 possibly reflected the relative condition of parturient does during the 2 fawning periods.

Blood parameters. Mean whole blood and serum values collected from captured fawns in 1979 did not reveal significant differences between surviving fawns and those suffering fatalities, or between healthy and unhealthy fawns. Blood samples were not collected from fawns in 1978, so no blood-based evaluation of the relative condition of fawns between years could be made.

Differences in blood parameters between Nevada and Alberta fawns probably reflected dietary differences between the 2 populations. Seal et al. (1978a) reported that white-tailed deer fawns on low energy diets had reduced red blood cell (RBC) and calcium values and increased phosphorus, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH) values. Higher calcium/phosphorus ratios indicated higher energy diets. Sodium values were reduced by low energy diets, but low protein intake increased sodium concentrations regardless of the energy intake. Increased hemoglobin (Hb) and mean corpuscular hemoglobin concentration (MCHC) values were also related to low energy diets, but were more directly affected by reduced protein intake.

In wild, free-ranging deer (Seal et al. 1978b) and pronghorn (Seal and Hoskinson 1978) populations the effects of different diets were sufficient to allow identification of separate populations based on blood parameters. Blood urea nitrogen (BUN) was implicated as a good indicator of protein intake in both species. Stress from capture and handling increased lactate dehydrogenase and serum glutamic oxalacetic transaminase levels, but did not seem to have a significant impact on parameters valuable as indicators of protein or energy intake. However, the number of circulating red blood cells may increase during handling because of splenic contraction.

Although total protein and BUN values were slightly lower in the Nevada fawns than in the Alberta fawns, the differences were not significant, suggesting protein intake in the 2 populations was similar. However, the significantly greater sodium values in the Sheldon fawns seemed inconsistent with that conclusion. Lower energy intake in the Nevada fawns was implied by the significantly lower RBC and calcium values and by the higher MCV, MCH, and MCHC values. In addition, the calcium to phosphorus ratio was higher in the Alberta fawns (1.35) than in the Sheldon fawns (1.08).

The investigations into metabolic indicators of protein and energy intake cited above were based on either adult animals or weaned fawns greater than 2 months old. The validity of those indicators in neonates has not been established. However, fetal nutrition is hemotrophic, derived directly from the maternal circulatory system (Nalbandov 1976). Therefore, nutritional deficiencies in the doe should be reflected in the fawn.

The literature was inconsistent concerning the effects of various dietary protein and energy levels on ungulate production and survival of neonates. Protein intake has been positively associated with production in domestic sheep (Torrell et al. 1974), and with fawn survival in white-tailed deer (Murphy and Coates 1966). However, kid production by domestic goats was related to energy intake and independent of protein intake (Sachdeva et al. 1973). Rates of ovulation have been positively associated with energy intake in white-tailed deer (Abler et al. 1976) and domestic pigs (Nalbandov 1976), but lower ovulation rates were accompanied by higher embryonal survival in pigs. Reduced ovulation rates probably would not affect numbers of fawns produced by pronghorns because that species produces 2-3 times more ova than can find implantation sites (O'Gara 1969).

In addition to protein and energy deficiencies, other deficiencies such as vitamins B and E (Nalbandov 1976) and various trace elements (Stoszek et al. 1978) are important determinants of ungulate production and neonatal survival. Reduced energy intake, therefore, does not by itself indicate a potential production problem. Although dietary energy appears to be lower in Sheldon fawns than in Alberta fawns, the level of energy intake seems adequate in the Sheldon animals.

Starvation-disease. The death of 2 fawns on the Sheldon was attributed to starvation, 1 in 1978 and 1 in 1979. In each case, the carcass was emaciated and necropsy revealed a lack of milk in the stomach, serous atrophy of fat, and edema in the leg joints. Handling-caused abandonment was thought to be responsible for both starvation deaths.

Generally, starvation is a minor mortality factor in pronghorn fawns over much of their range. Bodie (1979) reported a starvation loss of 7% in Idaho, VonGunten (1978) reported a 10% loss in Montana, and a 3% starvation loss was reported in Utah (Beale and Smith 1973). Barrett (1978) reported a higher starvation/unknown loss in Alberta (19%). In the Idaho study, human harassment, presence of livestock, predator attacks, disease, and severe weather appeared to increase the frequency of abandonment and subsequent starvation. As discussed earlier, maternal malnutrition has also been shown to induce fawn abandonment in white-tailed deer (Langenau and Lerg 1976).

The incidence of disease in pronghorns is low relative to other ungulates (Yoakum 1978), and only rarely has widespread disease been demonstrated in pronghorn fawns. Yet, many of the diseases that afflict livestock are potentially pathogenic to pronghorns. Vibriosis, an abortive bacterial disease of sheep and cattle, "apparently causes either abortion late in gestation or increased neonatal mortality" (Howe 1970). It was found in pronghorns using ranges concurrently with sheep and was implicated as the cause for low production in that population (Trueblood and Post 1959). Weak calf syndrome was suspected as a cause of pronghorn fawn mortality in Idaho and Montana (Reichel 1976, Bodie 1979), and pneumonia and salmonellosis were reported to have caused the death of 5 fawns in Utah (Beale and Smith 1973).

Representatives of 3 genera of bacteria were cultured from throat and rectal swabs taken from captured fawns on the Sheldon. Pseudomonas spp. were present in 3 fawns, 2 of those were classified as unhealthy at capture. Although over 30 species of Pseudomonas have been described, only 1, P. aeruginosa, is pathogenic in man and animals (Merchant 1940). It is found in soil and water and occurs commonly in many mammals. In domestic animals, it is frequently demonstrated in pneumonic tissue and may be involved in a number of other maladies including gall stones, inflammation of the urinary tract, inflammation of testicular tissue, inflammation of the udder, and in any purulent inflammation (Smith et al. 1972). Rarely, P. aeruginosa is associated with abortion in cattle.

Alpha streptococci were cultured from 2 fawns classified at capture as healthy. Many of the streptococci are pathogenic, but as with Pseudomonas spp., the potential danger to a fawn cannot be evaluated unless the specific organism is identified. Enterobacter agglomerans was isolated from the rectal swab of 1 healthy fawn, but I could find no reference indicating it was pathogenic.

No evidence was found that disease was a major mortality factor. However, the existence of Pseudomonas spp. in 2 of the unhealthy fawns suggested that infection from this pathogen may be common.

Predation

Predation was the major proximate cause of mortality, claiming 50% of the monitored fawns. It was responsible for 89% of the natural mortality in 1978 and 73% in 1979. Coyotes were involved in all but 1 of those deaths and a Golden Eagle killed 1 fawn. Similar predator-involved mortality has been reported in other areas of the pronghorn's range. On the National Bison Range in Montana, predator-involved mortality was 67% before and 37% after coyote control (VonGunten 1978, Corneli 1980). In Utah, predator-involved mortality was 49% (Beale 1978) and in Texas, 60% (Tucker 1979). However, those studies involved pronghorn populations restricted by fences. Unrestricted populations in Idaho (Bodie 1979) and Alberta (Barrett 1978) had predator-involved mortality rates of 36% and 55%, respectively.

Barrett (1978) noted that predation was greatest on fawns between 11 and 20 days of age, and that mortality of younger fawns accounted for only 22% of the losses to predation during his study in Alberta. On the Sheldon, 62% of the losses to predation were fawns 1 to 3 weeks old, and 23% of the predation losses were fawns less than 1 week old. The higher rate of predation on 1- to 3-week fawns corresponds to the period when fawns are becoming more active. Fawns that were less than 1 week old generally remained in the head-down hiding position when I approached; older fawns more often remained head up and watched me as I approached and often flushed at 20 m or more.

The health of the fawn may also affect its susceptibility to predation. Beale and Smith (1973) noted that the largest, most active twin was the 1 selected by a Golden Eagle in Utah. In domestic lambs, "Siblings that were killed by coyotes consistently lay down less than their littermates" (Gleusing 1977). Jackson et al. (1972) stated that more active white-tailed deer fawns were more susceptible to predation, and Bodie (1979) thought, "The increased movement of healthy fawns may increase a predator's ability to locate them." Those reports are consistent with my observations on the Sheldon where the mortality of healthy fawns (71%) was higher than the mortality of sick or weakened fawns (20%).

The inactivity of weakened fawns was demonstrated by 1 fawn caught in 1978. The radio transmitter was sending a mortality signal, but when I located the fawn it was alive and in a head-down, hiding position. As I approached, the fawn slowly raised its head, deactivating the motion-sensitive mortality signal. Apparently, the fawn had been motionless for over 2.5 hours. When captured 2 days earlier, that fawn suffered from rectal bleeding and labored, congested breathing. Its twin was vigorous and healthy at capture, but was killed by a coyote when 4 days old. The health of the sick fawn then improved, and it was killed by a coyote on its 18th day. Possibly, in areas where predation is high, selection favors less active fawns.

Fences. Fences can be a contributing mortality factor increasing losses of pronghorn fawns to predators. As reported by Knowlton (1968), "it [is] reasonable to assume that fences would facilitate the capture of antelope by coyotes. Coyotes have an uncanny ability to learn and will take advantage of fences." One coyote was observed taking advantage of a fenceline when it killed a fawn during this study near Mule Mountain. In the absence of the fence it appeared the doe would have successfully defended the fawn. Buechner (1950) and Corneli (1980) also postulated that fences could increase fawn mortality, especially in older fawns that were following does. They observed fawns wandering along fencelines apparently attempting to join does on the other side. Of 6 fawns observed, only 1 was able to cross the fence; the others could not, and the does crawled back under the fences to join the fawns. Fence entanglement also was reported as a source of fawn mortality in Utah pronghorns (Udy 1953).

Although fences contribute to fawn mortality, the degree is unknown. Recent fence construction on the Sheldon near and across fawning areas should, therefore, be expected to proportionately increase fawn mortality from predation in those areas.

Predator control. Between 1955 and 1967, an average of 160 coyote and 53 bobcat carcasses were recovered annually from predator control efforts on the Sheldon (Table 15). Primarily, those figures represented trapping or aerial gunning efforts, and the additional, and probably significant, effect of 1080 (sodium monofluroacetate) use was unknown. During 1967, aerial gunning on the fawning grounds during late May and early June was the only predator control applied. No predator control has been practiced since 1967.

The effectiveness of predator control, aside from economic limitations, can be confounded by several factors. In the presence of adequate food supplies, coyotes respond to high mortality by increasing

Table 15. Summary of predator control success on the Sheldon between 1955 and 1967.[a]

Year	Coyotes	Bobcats	Control methods
1955	60	19	1080, trapping
1956	121	34	1080, trapping
1957	95	75	1080, trapping
1958	120	72	1080, trapping
1959	140	61	1080, trapping
1960	179	88	1080, trapping, denning
1961	203	86	1080, trapping, aerial
1962	136	18	1080, trapping, aerial
1963	190	39	1080, trapping, aerial
1964	245	46	1080, trapping, aerial, denning
1965	283	59	1080, trapping, aerial
1966	146	33	1080, trapping, aerial
1967	67	6	aerial
1968-77	0	0	no control

[a] Compiled from the Sheldon National Wildlife Refuge narrative reports by Rod Flynn, graduate student, University of Montana.

litter sizes and decreasing the age at first reproduction (Connolly and Longhurst 1975). Also, some predators are more effective than others. A few individual predators have often been locally responsible for a disproportionate number of losses (Robinette and Olsen 1944, Beale and Smith 1973, Corneli 1980).

Connolly (1978) pointed out that, "The only remedy for excessive predation on big game animals is wholesale reduction of predator populations in the problem area." In Arizona (Arrington and Edwards 1951) intensive coyote control was associated with an increase in pronghorn fawn survival, but Johnson (1972) could find no correlation between pronghorn fawn survival and either the degree of predator control or the estimated coyote population in New Mexico. On the National Bison Range in Montana, coyote control virtually eliminated the resident coyote population, but in some areas bobcat and eagle predation compensated for the absence of coyotes, and fawn mortality remained high (Corneli 1980).

A large degree of the success during the period of predator control on the Sheldon was undoubtedly due to 1080 bait stations. Presently, the use of 1080 is not authorized on public lands, and aerial gunning is considered the most practical, authorized method of control (Connolly 1978). By itself, aerial gunning may prove ineffective on the Sheldon where heavily vegetated hillsides and rocky canyons surround and bisect the major fawning areas. In 1967, when aerial gunning on the fawning grounds was the only form of predator control, the fawn:doe ratio was the lowest in 12 years and was slightly below the average ratio calculated for the 12-year period of no control.

Home Ranges

Tucker (1979) determined home range sizes for 10 pronghorn fawns in Texas. Home range size increased with age and by 3 weeks fawns occupied an average home range size of 127 ha. Fawn home ranges in this study averaged 438 ha, approximately 3.5 times larger than those determined by Tucker. However, in the Texas study, pronghorns were restricted to a 6073 ha pasture. That restriction may have influenced home range size.

Pronghorns are selective feeders (Ellis and Travis 1975) and move when forage in a given area has been removed (Bromley 1977). On the National Bison Range, Swanger (1977) felt an increase in doe home range size over a 5-year period was probably related to a decrease in the density of preferred forage items. Movements by does would affect fawn home range sizes. The large home ranges of fawns on the Sheldon may, therefore, reflect the relative abundance of preferred forage. Because a large home range size implies greater movement by the fawn than a small home range, large home ranges may contribute to mortality. Long movements across the low sage flats on the Sheldon would make fawns highly visible to predators and increase the fawn's energy demand, a factor that could be significant under adverse weather conditions.

Bedsites

Bromley suggested that the characteristics of fawn bedding sites were ultimately determined as a result of selective pressure applied by predators. In addition, he hypothesized that bedsite cover was important in protecting young fawns from severe weather. Assuming those hypotheses are true, the mortality rate of pronghorn fawns may, in part, be a function of the adequacy of fawn bedsites.

Bedsites selected by fawns on the Sheldon had a characteristic structure. In general, fawns bedded on bare ground with more or less gravel and rock. Vegetation immediately around the bed had significantly greater cover and volume than vegetation in a 1-4 m radius. Bedsites were not picked at random, as evidenced by the significantly lower cover and volume values measured at control sites.

A bedded fawn lying on bare ground was essentially in a depression relative to the overall vegetative relief. Frequently, fawns bedded at the base of a sagebrush plant, but occasionally they bedded next to large rocks. Those observations are consistent with those of other workers in Idaho and South Dakota (Autenreith and Fichter 1975, Bromley 1977).

Fawn bedsite vegetative characteristics were quantified in

Idaho (Autenreith 1976) and Montana (Pyrah 1974). In both studies, fawns were using shrub-grassland habitats and big sage was the most common shrub associated with bedsites. Low sage was available to fawns in Autenreith's study, but 73% of the bedsites studied were in big sage. On the Sheldon, 94% of the bedsites I measured during 1979 were in low sage areas, although big sage communities were common peripheral to the major fawning areas.

Pyrah (1974) measured 85 bedsites in a central Montana shrub-grassland and noted that, although vegetative cover and volume values were relatively uniform between bedsites, the composition of the vegetation was variable. Total coverage on those sites averaged 66.7%, and total volume averaged 105.5 $dm^3/100\ dm^2$.

Of the Bed Plot, Near-bed Plot, and Circular Plot measurements I made on the Sheldon, the Circular Plot sample was most similar to Pyrah's sampling method. Vegetation around the Sheldon bedsites was less dense and shorter than the vegetation around central Montana sites. Total coverage on the Sheldon plots averaged 46% and volume values averaged 46.1 dm^3. Large differences existed in the shrub and grass components between the 2 areas. Mean grass cover and volume on the Montana bedsites were 32% and 43.0 dm^3, respectively, while the same values on the Sheldon sites were only 12% and 10.1 dm^3, respectively. Shrub cover was similar in both areas, but the Montana shrubs were taller, accounting for the difference in shrub volumes: 49.1 dm^3 in Montana and 24.1 dm^3 in Nevada.

Autenreith (1976) measured vegetation within a 1/100-acre circular plot around 131 fawn bedsites in Idaho. Total coverage averaged 37.4% and shrub cover 20.6%. Volume was not calculated in that study, but the average maximum height of vegetation within the plot was 41.9 cm, considerably higher than the average maximum height of 25.4 cm I recorded in circular plots at the Sheldon bedsites.

Increased vegetation height around bedsites may be a disadvantage in some areas. Bodie (1979) felt that fawns bedded in tall sage areas were more vulnerable to predation because the high cover aided in concealing approaching predators. However, that study area was open to coyote hunting, and coyotes avoided low sage flats during the day. In addition, tall sage was generally on, or at the bottoms of, slopes where updrafts facilitated hunting by Golden Eagles. Eagle aeries and coyote dens were also located in the steep areas. Therefore, tall sage sites probably had increased densities of predators and bedded fawns were more vulnerable to predation in those sites simply because the probability of a chance predator encounter was increased. Beale and Smith (1973) also reported high fawn mortality due to predation in higher cover. They also concluded that the highest densities of predators occurred in the heavier cover, thereby increasing the chance of predator encounters for fawns bedded in those areas.

While tall cover may increase the chance of a predator encounter in areas where predators are hunted, predators on the Sheldon are protected and I frequently saw coyotes hunting low sage flats during the day. Given that situation, fawns are probably more vulnerable to predation in low sage areas where any movement could be detected by a predator from a distance. A pronghorn fawn has little scent, and predators probably depend more on sight than smell to locate fawns. In addition, fawns on the low sage flats of the Sheldon were completely exposed when they were with the doe nursing or playing, and I often observed fawns from a distance of up to 2 km. Therefore, an increase in the average vegetative height on the Sheldon fawning areas would aid in concealing the fawn during those periods when the fawn is active and more vulnerable to detection by a predator.

With the limited amount of quantitative data available for comparison, assessing the adequacy of the Sheldon bedsites is difficult. However, fawns in other areas apparently select bedsite cover that is more concealing than that selected by the Sheldon fawns. Therefore, while I can not state that cover on the Sheldon is inadequate for fawn bedsites, it seems suboptimal. The present, relatively poor range condition of the Sheldon fawning areas is due to past abuse by livestock (USFWS 1980). Management that would encourage an increase in the overall vegetative height and plant diversity on fawning areas would provide better cover for fawns.

Factors Related to Fawn Production

Fertility

Pronghorns normally breed first as yearlings. From 4 to 7 ova are fertilized, but intrauterine mortality reduces the number of embryos and normally 2 fawns are born (O'Gara 1969, 1978a). The effect that poor nutritional condition of the dam has on decreasing the litter size still further is not well known for pronghorns. In white-tailed deer, malnutrition may decrease ovulation rates (Cheatum and Servinghaus 1950) and result in low fetal vitality and fawn birth weights (Verme 1979). Larsen (1970) found no evidence of reduced conception or fetal rates in 8 emaciated pronghorns collected in New Mexico, but Bodie (1979) felt condition during the breeding season may have contributed to conception problems in some Idaho pronghorns.

Does are not hunted on the Sheldon so female reproductive tracts were not available for study, but 93% of the does censused in early May 1979 showed obvious signs of pregnancy. Fawns of 14 does were captured during 1979 and 9 of those does had twins at the time of capture. Three births were observed in 1979; all were twins. Unfortunately, does were not censused before the fawning period in 1978. Of 3 births observed in 1978, 1 was a single birth. Fawns from 11 does were captured during 1978 and 3 of those does had twins at the time of capture. Therefore, production may have been low in 1978, but with the available data no conclusions can be made, and the relative fertility of the Sheldon does remains unknown.

Breeding System

Three different breeding systems have been described for pronghorns: harem; territorial; and intermediate, the latter includes characteristics of both the harem and territorial systems (Deblinger and Ellis 1976). Kitchen (1974) studied the territorial system and found that most of the breeding was done by territorial bucks. Two bucks in that study bred most of the does. The quality of the buck's territory was a determinant of breeding success, and more does were bred by bucks that defended territories rich in forage resources than were bred by bucks defending resource-poor territories.

The size and shape of a buck's territory is, in part, determined by the energy he has available to use in territorial defense (Bromley 1977). Obviously, a long territorial boundary would require more energy to defend than a shorter boundary. Therefore, territory size may be determined by the need to defend an appealing resource (to estrous does) while not overdrawing the energy budget. Although the occurrence of the harem and intermediate systems has not been related to forage availability, they may be the result of local conditions where forage resources are insufficient to allow a defendable territory size, thereby indicating suboptimal pronghorn range.

With the above hypothesis in mind, I observed the breeding behavior of pronghorn bucks on North Rock Springs Table and Mule

Mountain during August and September of 1978. The buck on North Rock Springs Table defended a distinct territory of a size comparable to that described by Bromley (1967) on the National Bison Range in Montana, and he herded does within that territory. However, near Mule Mountain the territorial system apparently broke down, at least temporarily, when succulent forage became available on Bald Mountain Lake in late August. Large numbers of pronghorns were then concentrated on the lake bed, and I observed a chaotic sequence of rutting activity. Therefore, in years when playas become available to pronghorns during the breeding season, the well-ordered territorial system could collapse. The effect this has on breeding success is unknown, but the advantages offered by the territorial system (a majority of the breeding being done by the most vigorous, well-adapted bucks) would be lost.

Precipitation

A number of researchers have presented evidence for, and speculated upon, the relationship between fawn recruitment and precipitation. In Arizona, October through April precipitation was correlated with spring forage production and, in turn, mule deer fawn survival (Smith and LeCount 1979). Similar results were reported for Texas pronghorns (Haley 1965), and high precipitation in the ecological year, September through August, was associated with high pronghorn fawn survival in Wyoming (Hockley 1968). Conversely, Halloran and Glass (1959) suspected an inverse relationship between May precipitation and pronghorn fawn survival in Oklahoma. On the National Bison Range in Montana, only a weak correlation between fawn survival and precipitation was demonstrated (Von Gunten 1978).

Analysis of precipitation and fawn recruitment from the Sheldon for 1955 through 1966 showed that October through April precipitation and fawn recruitment were independent ($r = 0.16$). However, July through October precipitation was highly correlated with fawn recruitment ($r = 0.84$, $p < 0.05$) (Fig. 11). Beale and Smith (1970) hypothesized, "the condition of forage during late summer and fall, which on the desert responds to above-normal precipitation, could influence both breeding activity and successful gestation of the does and size of the fawn crop the following spring." That hypothesis may apply on the Sheldon where dry conditions in late summer may disrupt breeding activities as pronghorns congregate on the playas. It is also consistent with the low recruitment observed on the Sheldon in 1978 following the dry summer of 1977 and high fawn recruitment in 1979 following good September precipitation in 1978.

Analysis of more recent precipitation fawn recruitment data could not be accomplished because of 1) closure of the Sheldon weather station in 1972, and 2) changes in predator control practices in 1967 and 1968 that affected fawn recruitment.

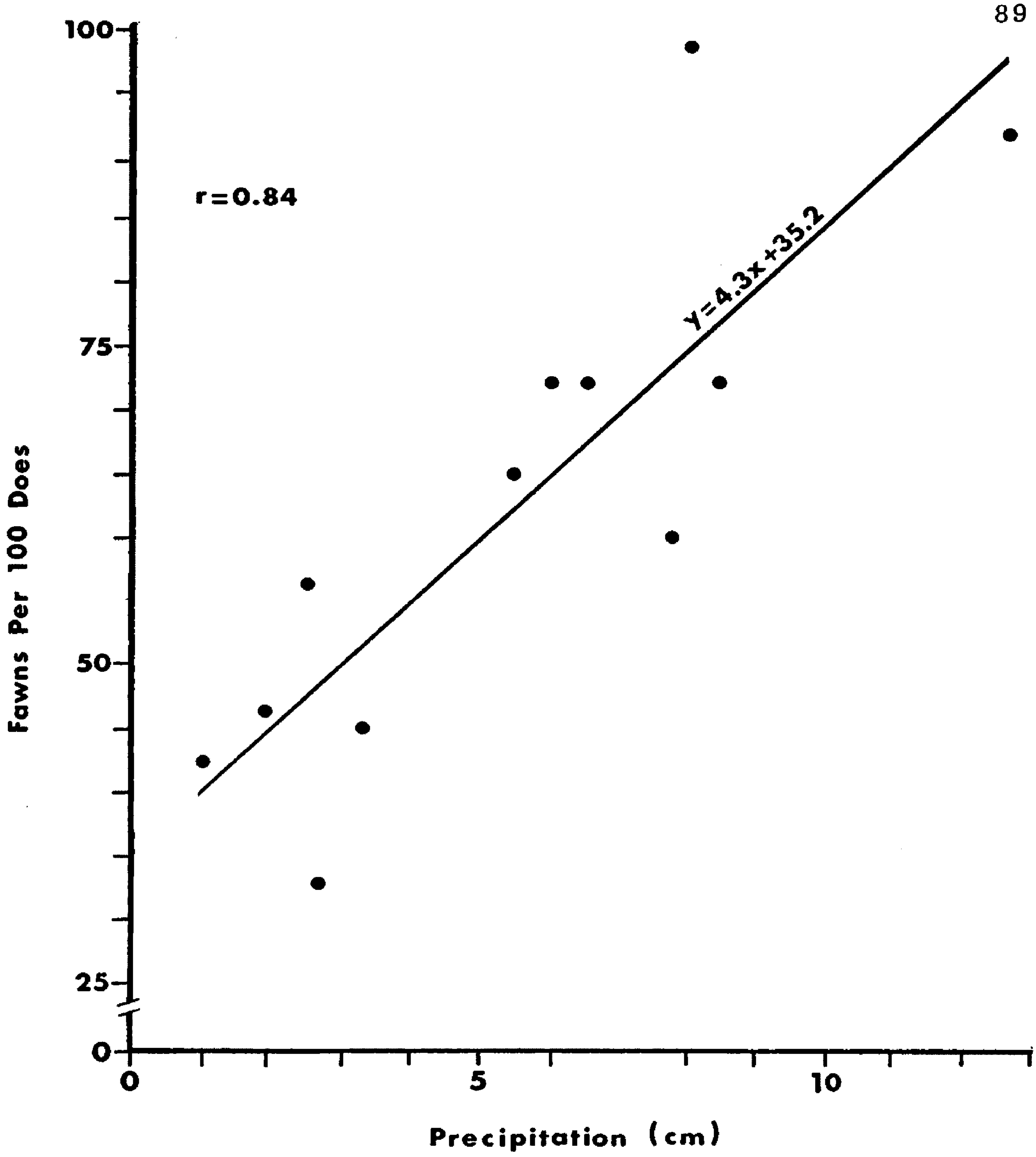


Fig. 11. Fawns per 100 does in July related to July through October precipitation the previous year, 1955 through 1966.

Hunting Season

Fichter and Autenreith (1978) considered the possible genetic effects of trophy hunting on pronghorn populations. They felt that because of the species' social organization, trophy hunters could select bucks that were high in the dominance hierarchy, and, therefore, most likely to breed. No conclusion was reached as to the impact trophy hunting might have, but selection for breeding by less vigorous bucks was one likely consequence.

The timing of the Sheldon hunt could affect breeding success. Territorial bucks defend well-defined areas and will return to those areas if disturbed. That habit makes territorial bucks more vulnerable to hunters because it provides the hunter with the opportunity to "stake-out" a territorial buck. Territoriality results in the establishment of doe movement patterns that minimize harassment by bachelor bucks and insure optimum forage availability (Kitchen 1974). If territorial bucks are removed just prior to the rut, the social structure that insures successful breeding by the most vigorous bucks could be weakened. If the removal of territorial bucks is localized, as it could be in easily accessible areas, the territorial system could collapse and breeding success suffer.

Postponing the hunting season on the Sheldon until after the rut would minimize the possible deleterious effects on breeding success. In addition, cooler temperatures would reduce the chance of meat spoilage, a potential problem associated with the late August-early September hunts.

Population Trends

During the years of predator control (1955 through 1966), pronghorn numbers on the Sheldon showed a significant, yet small, upward trend (Cox-Stewart test of trend, $p = 0.0312$); and the mean fawn:doe ratio was significantly greater than during the more recent period of no control (1968 through 1979) ($p < 0.001$). However, the upward trend was marked by fluctuations and the 1966 count was actually less than the 1955 count, and the average fawn:doe ratio of 61:100 during the years of predator control was still less than long-term fawn:doe ratios of approximately 100:100 reported in portions of Montana, North Dakota, South Dakota, and Wyoming (Vriend and Barrett 1978).

Since 1968, when predator control ceased, no significant trend in pronghorn numbers has been noted although the aerial count in 1979 was the highest recorded since 1955. No overall trend was apparent between 1955 and 1979 ($p = 0.145$, Fig. 12).

Despite greater fawn recruitment, no dramatic increase in pronghorn numbers was evident after 12 years of intensive predator control. However, the effects of immigration and emigration on the Sheldon population are not known. Aerial censuses have recorded as

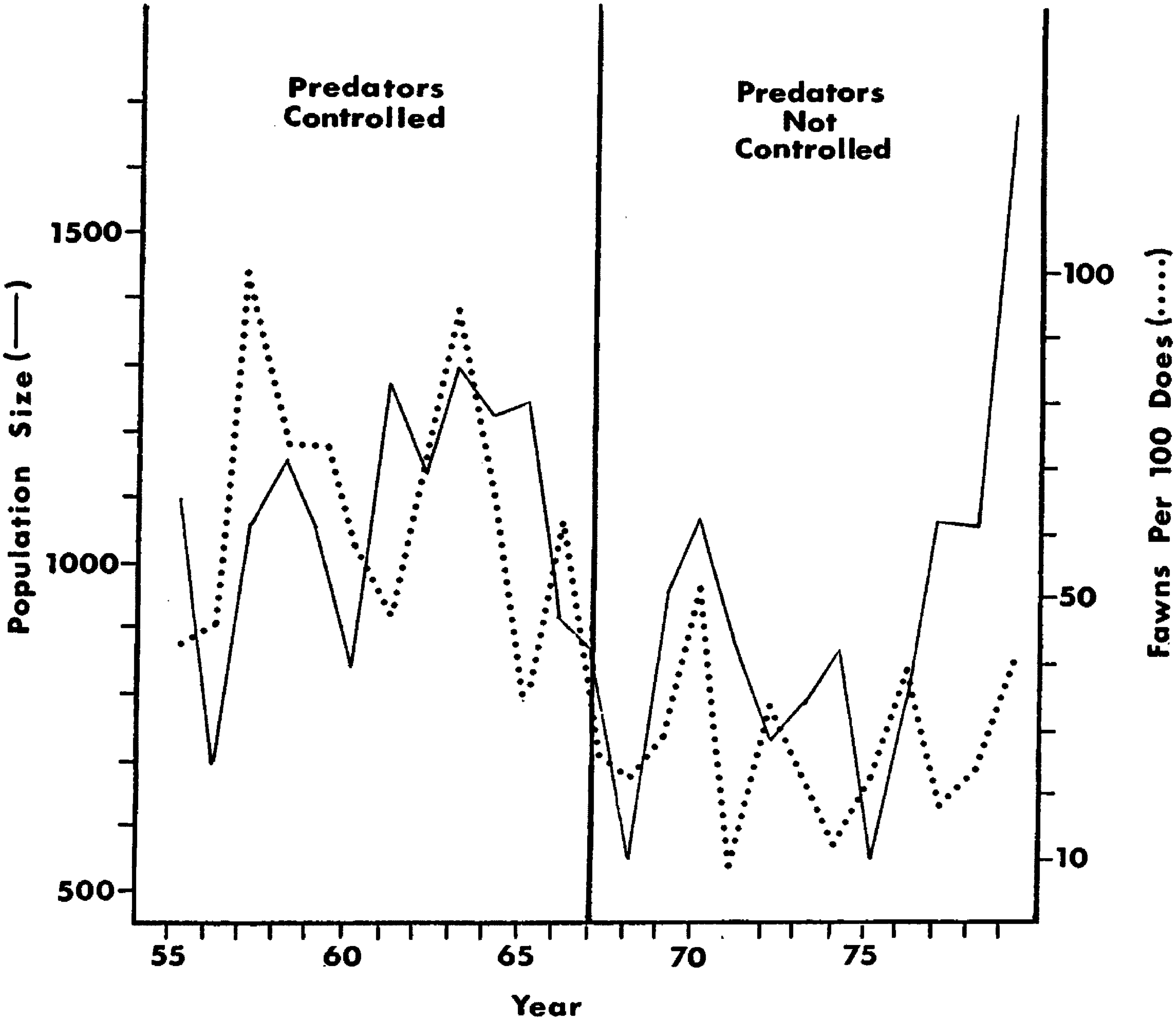


Fig. 12. Total population and fawn recruitment trends, 1955 through 1979. (Data from July aerial counts, Sheldon National Wildlife Refuge files, Lakeview, OR.)

many as 2000 pronghorns on winter ranges along the northern boundary of the Refuge, but the highest summer survey was approximately 1600 animals (Anonymous 1978). Therefore, the Sheldon subpopulation is not closed, but is a large continuous population extending northward into Oregon. Possibly, the fluctuations in population numbers are related to the fidelity of the Sheldon pronghorns. During some years a greater or lesser proportion of the wintering animals may move to other summer ranges, outside the Sheldon, where habitat resources may periodically be more appealing. A pronghorn movement study currently underway may provide answers to the immigration-emigration question.

The age structure of the population is also important in assessing the health of the herd. Unfortunately, the age structure of the Sheldon herd is unknown. On the National Bison Range, the pronghorn population exhibited sporadic growth for 7 years despite annual fawn mortality rates of up to 93% (Corneli 1980). However, the age structure of that population became increasingly unstable as old animals began to make up an unusually high proportion of the total population. As a result, a major population decline was predicted, and during the winter of 1978-1979, approximately 1/3 of the adult pronghorns died.

The fawn recruitment and population trends shown in Fig. 12 suggest that:

1) other factors, at least periodically, are more important than predation in limiting fawn recruitment, and
2) habitat resources may be insufficient to allow a substantial increase in the Sheldon population.

Most likely, the impact of each limiting factor varies from 1 year to the next, and in any given year the various limiting factors collectively act to limit population growth. Therefore, the total effect is variable from year to year and during those years when the intensities of most individual limiting factors are high, population growth is precluded. It follows that management actions taken to remove any 1 of the restraints on population growth will not result in a population increase proportional to the success experienced in removing that limiting factor.

Cattle-Pronghorn Interactions

Spatial Interactions

Avoidance. The reactions of pronghorn bucks, yearling females, and adult females to cattle were different. Avoidance behavior was observed in both pre- and postparturient does, but bucks and yearling females were often seen grazing near cattle. However, pronghorns were never observed at water holes when cattle were present, although both species often used the same water source.

Prenzlow et al. (1968) documented the excitability of pre- and postparturient does. They noted a change in behavior in pregnant does around mid-May. "[Does] became more nervous, watching their surroundings closely. If disturbed they readily took flight, even from other pronghorns." Postparturient does exhibited similar behavior. Bromley (1977) noted even minor disturbances elicited an avoidance response in preparturient does. He observed a doe in the early stages of labor jump from her bed and run out of sight when a sharp-tailed grouse walked past.

Reference to general avoidance of cattle by pronghorns was made by Pyrah (1971). He studied pronghorns in several pastures occupied by cattle in Montana and concluded that pronghorns tend to avoid cattle throughout the summer. In Alberta, concentrations of livestock on fawning areas were a direct mortality factor. Two fawns were trampled by livestock, and aggressive behavior toward fawns by livestock was observed on 4 occasions during that study (Barrett 1978). However, Buechner (1950) did not observe any avoidance of cattle by pronghorns in Texas and believed that the 2 species were compatible.

Shift in fawning areas. The intolerance of preparturient does to disturbance may have been responsible for the use of different fawning areas during 1978 and 1979 in the Mule Mountain area. Although the concept of traditional fawning areas has been questioned, the west slope and adjacent low sage flats of Mule Mountain have, in the past, been consistently used by pronghorns as a fawning ground (Worden, USFWS biologist, pers. comm.). In 1978, cattle were not present near Mule Mountain during the fawning period and a large proportion of the fawn activity locations (birth sites, capture sites, and bedsites) were recorded in that area. In 1979, 150 cattle were trailed into this "traditional" fawning ground on 1 May. The proportion of fawn activity locations in the "traditional" area was significantly lower in 1979 than in 1978.

As noted, the traditional fawning ground concept advanced by early workers (Einarsen 1948) may be erroneous. Fichter (1974) and Autenreith (1976) felt that ground condition, vegetative type, brush height, and canopy coverage influenced the birth site selection process. Therefore, with changes in those conditions, fawning areas may change. Bromley (1977) gave supporting evidence to the hypothesis that for birth sites "(1) does avoid areas offering great visual coverage of the habitat, (2) avoid areas where predators have been encountered before, and (3) avoid any area where a direct disturbance occurs." Evaluating those criteria in reference to the location of Sheldon fawning activities in 1978 and 1979, avoidance of cattle evidently was a factor in the observed shift in fawning activities.

The majority of fawn activity locations in 1979 were north and east of Mule Mountain on low sage flats bordering Catnip Canyon. The surrounding area was easily seen from most points on those flats. West of Mule Mountain, the sage flats were less extensive, and drainage patterns created a more broken, rolling landscape. If does select for reduced visual coverage of surrounding areas, the "traditional" fawning ground used in 1978 appeared to be more appropriate than the sage flats used in 1979.

Coyotes were often seen in both areas during both years. Heavy predator pressure on the 1978 fawning grounds could have discouraged does from using that area in 1979, but the home range of a coyote is sufficiently large (Berg and Chesness 1978, Neff and Woolsey 1979) to easily encompass both fawning areas simultaneously.

Bromley's third criterion, avoidance of disturbance, was most consistent with the observed shift in fawn activities. The majority of fawn activity locations in 1979 were in areas that were inaccessible to cattle because of fences. However, I did not quantify or test the visual coverage and predator encounter criteria on the Sheldon. Although cattle grazing appeared to be a factor leading to the change of fawning areas, other, unknown factors may have been more important in causing the observed shift.

Dietary Overlap

The composition of pronghorn diets is seasonally variable, but grasses and forbs are often listed as major components of their spring diet. Sandberg bluegrass was the most common grass in the spring diets of pronghorns on sagebrush-grasslands of southern Oregon and made up 36% of the March-through-May diet (Sneva and Vavra 1978). However, it was most common in March and April diets and was only 10-15% of the diet by early May. Similar results have been reported in Wyoming and Utah (Severson and May 1967, Beale and Smith 1970).

The utilization of forbs by pronghorns is related to precipitation which affects forb availability. In Utah, 90% or more of the March-through-June diet consisted of forbs during wet years while less than 20% of the diet was forbs during dry years (Beale and Smith 1970). Forbs were the major component (57%) of pronghorn spring diets in Alberta (Mitchell and Smoliak 1971), and May diets of Oregon pronghorns contained as much as 75% forbs (Sneva and Vavra 1978).

The use of grasses by pronghorns during the spring creates a potential for competition between cattle and pronghorns on spring ranges. On Wyoming's Red Desert, Taylor (1975) found a 14.7% diet overlap between cattle and pronghorns, all of which was due to Sandberg bluegrass. Grasses made up 32.5% of pronghorn spring diets on a Colorado grassland and cattle-pronghorn diet overlaps were as high as 85% in March but declined to approximately 60% in May (Schwartz and Nagy 1976). However, the results from the analysis of mid-May through late June fecal samples collected on the Sheldon showed little diet overlap between cattle and pronghorns. The greatest overlap occurred in late June when both species were grazing the Bald Mountain Lake playa. In mid-May and early June, cattle diets were 40% bluegrass, but only 0.4% of the pronghorn diet consisted of bluegrass. This was surprising because other studies in similar habitats have indicated a declining but substantial use of bluegrass by pronghorns through May. Availability was not a factor. Range transects run concurrently with the fecal sampling indicated native bluegrass to be the most common species on the range, with a mid-May frequency of 99% and an early June frequency of 95%.

Forbs comprised 36% of the pronghorn diet on shrub-grasslands in mid-May and early June and 35% of the diet when pronghorns grazed the Bald Mountain Lake playa in late June. However, 83% of the forb use on the shrub-grasslands was confined to tansymustard (Descurainia spp.). A more diverse forb diet was evident from the playa samples but Descurainia still comprised 23% of the total diet and 66% of the total forb intake. Again, these results are somewhat surprising. Mason (1952) analyzed rumen contents of pronghorns from Hart Mountain, Oregon, 65 km north of the Sheldon. Various composites, clover (Trifolium spp.), and desert parsley (Lomatium spp.) made up 22.3% of the May diet and composites made up 75% of the June diet in that study. Those preferences were not reflected in the Sheldon samples, although those species were common in the range transects. Lomatium had a mid-May frequency of 52%, Trifolium an early June frequency of 69%, and those composites listed by Mason as being suitable pronghorn forage had frequencies of up to 90% in this study. Yet, Lomatium and Trifolium were not found in the fecal samples and composites comprised less than 2% of the pronghorn diet on shrub-grasslands and 9% of the pronghorn diet on the playa. Also, primrose (Oenothera caespitosa), listed by Beale and Smith as a preferred forb by pronghorns in Utah, was not found in any of the Sheldon fecal samples, yet it was common on the playa with a frequency of 60%.

A number of factors may be responsible for the relatively poor showing of grasses and various forbs in the diets of Sheldon pronghorns in 1979. In Utah shrub-grassland communities, Beale and Smith (1970) found browse replaced forbs in the spring diets of pronghorns during dry years, and, in 1979, May and June were dry months on the Sheldon. Probably, on some sage-grassland ranges, browse species normally make up the major part of the pronghorns' spring diet. Bodie (1979) reported that 70% of the May-June diet of pronghorns in the Pahsimeroi Valley of Idaho was browse, but grasses in that study still contributed 10% of the total diet. In addition, the accuracy and reliability of fecal analysis in determining diet composition has been questioned. Anthony and Smith (1974) compared rumen and fecal analysis in determining Arizona deer diets. Shrubs tended to be over-represented in the fecal samples as did grasses, while forbs were under-represented. Similar results were obtained for forb and grass percentages in a comparison of steer fecal and esophageal samples (Vavra et al. 1978).

The differential digestibility of shrubs, grasses, and forbs may result in a misrepresentation of actual diet composition. Because diet compositions are given in percentages, an artificially high percentage in any diet component results in an artificially low percentage of at least some of the other components.

CHAPTER VI

MANAGEMENT RECOMMENDATIONS

1. Recommendation: Defer cattle grazing on major pronghorn fawning areas until 15 June.

Rationale: The presence of cattle on preferred fawning areas may cause does to select less favorable sites. Cattle can also be a direct mortality factor. They have been known to act aggressively toward and trample bedded fawns (Barrett 1978). In addition, cattle may inadvertently flush young fawns from their beds, making the fawn more visible to predators. This recommendation is in agreement with previously established guidelines for the management of pronghorns on cattle ranges (Autenreith 1978).

2. Recommendation: Refrain from constructing fences near or across the major fawning areas, and remove or alter fences that do not conform with all BLM recommendations for fence construction on pronghorn ranges.

Rationale: Fences create barriers to young fawns following does and may cause temporary separation of the doe and fawn (Buechner 1950, Corneli 1980). A doe's ability to defend a fawn from predator attack is reduced if the predator can use a fenceline to gain an advantage, as observed in this study. Guidelines established for the management of pronghorns suggest that livestock should be herded or driven in lieu of extensive range fencing (Autenreith 1978).

3. Recommendation: Conduct pronghorn hunting seasons in early to mid-October.

Rationale: The timing of the hunting seasons on the Sheldon in the past may have interfered with the rut, weakening the territorial breeding system and possibly affecting breeding success. Territorial bucks are more vulnerable to hunters before or during the rut than after the breeding season when their movements become less predictable. Also, killing territorial bucks just before the rut negates the advantages of the territorial system to the species.

4. Recommendation: Allow limited either-sex hunting of pronghorns and de-emphasize trophy hunting.

Rationale: Either-sex hunting would allow collection of reproductive and age structure information from the female segment of the population. This information is necessary for the effective management of the Sheldon herd. Removing the emphasis on trophy hunting should result in a more biologically sound harvest by curtailing the possibility of adverse genetic effects created by removal of the most vigorous, trophy bucks (Fichter and Autenreith 1978).

5. <u>Recommendation</u>: Do not resume extensive predator control efforts on the Sheldon.

<u>Rationale</u>: Without the use of toxicants, predator control would be costly and ineffective on the Sheldon. Often, control stimulates production in the predator species (Connolly and Longhurst 1975). Past predator control efforts on the Refuge increased fawn recruitment, but increases in total population numbers were small and irregular over a 12-year period. Data gathered during this study indicated that combinations of other factors are also important in limiting fawn recruitment on the Sheldon. However, the age structure of the Sheldon population is unknown. If future studies reveal an old age structure and a declining population, any increase in fawn recruitment would be beneficial, and intensive predator control shortly before and after the fawning period could be justified.

CHAPTER VII

SUMMARY

During 1978 and 1979, the causes of low pronghorn fawn recruitment were investigated on the Sheldon National Wildlife Refuge in northwestern Nevada. Thirty-four fawns were monitored with the aid of radiotelemetry equipment.

During 1978, only 3 sets of twins were observed and 8 of 13 fawns were singles when captured. During 1979, only 5 of 21 fawns were singles when captured. The estimated fawning period, 12-24 May, was earlier than those reported by other workers in similar areas. Cold, wet weather during the 1978 fawning period may have contributed to the unexplained, but apparently high, mortality of neonates. Fawns captured in 1978 were smaller and lighter than those captured in 1979, possibly reflecting the relative condition of does during the 2 fawning periods. The rate of predation was higher on healthy fawns than on sick or weakened ones, indicating that, in areas of heavy predator pressure, selection may favor inactive fawns.

Coyote predation was the major proximate cause of natural mortality, claiming 41% of the marked fawns. In addition, 3 unmarked fawns were killed by coyotes while under observation by capture crews.

One eagle kill was the only other documented source of predator-induced mortality. Three fawns probably died as an indirect result of handling. Accidental deaths and death from undetermined causes accounted for the remainder of the mortality. Total mortality, excluding deaths related to handling, was 63%, and 90% of it occurred during the first 3 weeks after birth.

July through October precipitation and fawn recruitment data were analyzed for 1955 through 1966. A significant positive correlation existed between fawn survival and late summer precipitation during the previous year. That correlation was possibly related to late summer forage condition and, in turn, to the condition of does going into the winter.

Blood samples were collected from 17 fawns during 1979. A comparison between blood parameters from Sheldon fawns and those collected by Barrett (1978) in Alberta revealed a number of significant differences. Lower energy intake in the Nevada fawns was indicated by the significantly lower red blood cell and calcium values and the higher mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration values. Blood urea nitrogen and total protein values were similar in both populations, indicating that protein intake was similar.

Two potentially pathogenic bacteria, Pseudomonas spp. and Streptococcus spp., were collected from throat and rectal swabs taken from captured fawns in 1979. None of the mortality was attributed to disease, but respiratory problems in newborn fawns was common and probably related to infection by those pathogens.

Compared to control sites, bedsites were characterized by significantly lower vegetative cover and volume on the Bed Plot and significantly higher cover and volume within 0.3 m of the Bed Plot. Compared with bedsite measurements from other areas, the Sheldon sites had lower cover and volume values, suggesting bed cover is suboptimal on the Sheldon. Past abuse by livestock was responsible for deterioration of the range, and future management should be aimed at increasing the overall plant height, density, and diversity on fawning areas.

Mean home range sizes of Sheldon fawns were significantly greater than those reported in a Texas study. That difference may have indicated a lower density of preferred forage on the Sheldon than on the Texas study area. In addition, long distance movements would increase the visibility of young fawns and make them more susceptible to predation.

Pre- and postparturient pronghorn does avoided cattle and horses, and major fawning areas were located peripheral to cattle or horse concentrations. The shift in fawning areas between 1978 and 1979 on the Mule Mountain area was probably in part due to the presence of cattle on the "traditional" fawning ground during 1979.

Spring diets of cattle and pronghorns were determined from fecal analyses in 1979. Diet overlaps on shrub-grassland ranges were less than 3%. Diet overlap on the Bald Mountain Lake playa was 7.3%. Range transects, run concurrently with fecal sampling, indicated that pronghorn food items documented in other studies were available and abundant, but their abundance was not reflected in the fecal analyses. A potential competition problem existed on the dry lake beds in late summer when succulent forage became available, attracting both cattle and pronghorns.

Population trends since 1955 were evaluated. Although no overall trend existed, a small but significant upward trend was found for the 12-year period (1955-1966) when intensive predator control was practiced. Significantly higher fawn recruitment existed during years of predator control, but average fawn recruitment was still low relative to some other pronghorn populations. The past response of the pronghorn population to predator control combined with the current ban on predicides, suggested that future predator control efforts would be expensive and probably would not result in a significant increase in total population numbers.

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APPENDIX A

PHYSICAL CHARACTERISTICS OF CAPTURED FAWNS

Table 1. Physical characteristics of fawns captured on the Sheldon National Wildlife Refuge during 1978 and 1979.

Fawn no.	Sex	Estimated age	Weight (kg)	Length-girth-neck (cm)	Rectal temp. (°C)
1978					
1	♀	6 hours	3.7	60-41-17	38.5
2	♀	4 hours	3.3	59-35-15	37.3
3	♂	4 hours	3.5	61-35-17	37.4
4	♀	1 day	4.0	65-39-19	40.5
5	♂	2 days	4.4	62-38-18	39.4
6	♂	1 day	3.9	63-37-17	38.0
7	♂	2 days	4.9	65-40-17	39.0
8	♀	1 day	4.0	64-39-17	39.3
9	♂	2 days	4.1	64-37-17	38.8
10	♂	2 days	4.3	66-41-19	39.8
11	♀	4 days	5.0	61-41-21	39.2
12	♀	4 days	---	---	---
13	♂	7 hours	4.0	63-39-16	39.1
1979					
14	♂	1 day	4.0	66-41-17	39.2
15	♂	1 day	4.4	68-39-20	39.4
16	♂	2 days	4.4	71-39-18	41.3
17	♀	1 day	3.5	60-35-16	39.4
18	♀	1 day	4.2	67-37-17	39.8
19	♂	1 day	4.3	63-39-18	40.0
20	♂	2 days	4.2	69-39-19	38.7
21	♀	2 days	4.9	70-39-19	40.5
22	♀	5 days	6.0	76-43-19	40.7
23	♂	2 days	4.1	68-39-17	39.8
24	♂	4 hours	3.1	59-34-15	37.9
25	♂	4 hours	4.3	68-39-17	37.9
26	♀	3 days	5.0	67-43-17	40.1
27	♀	4 days	4.8	60-43-19	38.5
28	♂	2 days	4.5	75-40-17	40.1
29	♀	2 days	4.6	72-39-15	39.8
30	♂	4 hours	4.4	67-37-17	39.9
31	♀	4 hours	4.0	72-39-17	39.9
32	♂	2 days	4.8	69-40-17	40.4
33	♂	4 hours	3.6	68-41-18	39.5
34	♂	4 hours	3.6	61-39-19	40.1

APPENDIX B

WHOLE BLOOD AND SERUM PARAMETERS

Table 1. Whole blood parameters from 17 pronghorn fawns captured during 1979.

Fawn no.	RBC ($10^6/mm^3$)	WBC ($10^3/mm^3$)	MCV (u^3)	Hb (g/100 ml)	Hct (%)	Differentials (%)				
						Segs	Bands	Lymphs	Monos	Basos
14	5.86	3505	57	15.0	32.0	---	---	---	---	---
15	6.35	1300	59	13.6	36.1	60	0	36	4	0
16	5.72	2030	57	14.2	31.2	71	0	25	4	0
17	4.97	3625	55	13.7	26.3	80	0	16	4	0
18	4.94	4540	55	11.7	26.1	74	0	12	4	0
19	5.59	2640	56	---	30.2	60	0	36	4	0
20	5.64	2070	56	14.7	30.6	62	0	36	2	0
21	4.65	2105	55	13.0	24.7	72	0	24	4	0
22	5.45	3104	57	14.1	30.1	76	0	24	0	0
23	4.88	2870	56	12.2	26.4	68	0	28	4	0
26	5.48	903	57	13.1	30.3	63	0	28	9	0
27	6.52	1600	60	16.6	37.7	74	0	18	8	0
28	4.79	2270	55	11.7	25.5	45	0	49	6	0
29	6.46	1795	57	13.6	35.6	78	0	20	12	0
30	6.46	2676	64	15.7	40.0	92	2	5	0	1
32	6.32	1505	59	13.7	36.1	42	0	58	0	0
33	6.54	1290	57	15.1	35.7	---	---	---	---	---

Table 2. Serum parameters from 15 fawns captured during 1979.

Fawn no.	Gluc. (mg/dl)	B.U.N. (mg/dl)	Creat. (mg/dl)	Uric acid (mg/dl)	Na (meq/L)	K (meq/L)	Cl (meq/L)	Ca (mg/dl)	P (mg/dl)	Fe (meq/dl)	Total protein (gm/dl)	Alb. (gm/dl)	Glob. (gm/dl)	Alk. phos. (U/L)	SGOT (U/L)	LDH (U/L)	G-GTP (U/L)	Total bil. (mg/dl)	Dir. bil. (mg/dl)	Ind. bil. (mg/dl)	Chol. (mg/dl)	Trig. (mg/dl)
14	120	14	0.5	1.5	150	6.0	100	10.6	9.7	153	4.7	1.6	3.1	986	181	867	1258	4.3	0.9	3.4	33	20
15	176	13	0.9	[illegible]	148	6.2	101	9.9	9.4	190	4.1	1.8	2.3	799	152	1072	720	3.9	0.9	3.0	38	23
17	145	16	[illegible]	1.1	151	5.9	99	10.4	10.1	335	4.1	1.8	2.3	1103	152	997	105	3.7	0.9	2.8	40	31
18	110	31	0.5	1.5	148	4.8	103	10.4	10.5	290	4.7	1.7	3.0	939	223	1321	138	4.3	0.9	3.4	55	48
19	234	20	0.9	1.2	148	4.4	104	10.4	9.0	280	5.3	1.8	3.5	888	172	978	872	3.6	0.9	2.7	46	23
20	187	13	1.2	1.2	155	4.7	107	11.7	9.1	371	5.3	2.2	3.1	565	122	773	207	3.3	0.9	2.4	74	[illegible]
21	72	21	1.1	1.1	157	5.3	110	9.8	8.3	202	5.4	1.8	3.6	1039	238	1280	448	1.3	0.5	0.8	37	27
22	150	13	0.7	1.2	[illegible]	5.3	102	10.6	10.1	472	4.1	2.4	1.7	661	133	1396	118	3.3	1.0	2.2	120	20
23	245	6	0.7	[illegible]	145	5.5	104	10.5	11.3	340	4.2	1.8	2.4	533	93	588	74	3.6	1.0	2.6	66	46
24	231	20	[illegible]	1.5	146	4.6	104	10.3	8.3	282	5.3	1.8	3.5	389	169	934	877	3.5	0.9	2.6	47	26
27	161	10	0.5	1.2	155	4.9	112	11.4	10.7	309	4.7	2.3	2.4	634	111	536	39	1.4	0.6	0.8	100	32
28	121	9	0.8	0.9	154	5.4	104	10.9	10.1	331	4.3	2.2	2.5	772	118	953	49	4.0	1.0	3.0	62	46
29	---	8	1.6	0.2	[illegible]	7.5	10[illegible]	11.7	10.0	441	4.6	2.0	2.6	688	111	1012	75	---	---	---	51	29
30	249	23	1.9	1.5	157	4.6	105	10.1	9.7	162	3.9	2.0	1.9	1135	130	813	587	2.7	0.7	2.0	28	27
32	170	7	0.9	[illegible]	155	4.2	104	10.7	10.6	232	4.5	1.9	2.6	461	107	699	269	3.8	1.0	2.8	55	44

APPENDIX C

RESULTS OF VEGETATION TRANSECTS AND FECAL ANALYSIS

Table 1. Results of vegetation transects and analysis of fecal samples from the mid-May sampling period (shrub-grassland).

Species	Percentages found in vegetation transects		Percent relative density in fecal samples	
	Cover	Frequency	Pronghorn	Cattle
Artemisia spp.	5	24	65	1
Cercocarpus ledifolius	0	0	T	0
Juniperus occidentalis	0	0	1	0
Rosa woodsii	0	0	0	T
Agropyron spp.	0	0	T	5
Bromus tectorum	0	0	T	1
Carex spp.	0	0	0	10
Eleocharis spp.	0	0	0	2
Elymus spp.	0	0	0	1
Juncus spp.	0	0	0	3
Koleria cristata	0	0	T	1
Oryzopsis hymenoides	0	0	0	1
Poa spp.	12	99	T	40
Sitanion hystrix	6	71	0	T
Stipa spp.	T	5	0	1
Antennaria dimorpha	T	4	a	a
Agoseris glauca	T	T	a	a
Allium sp.	T	2	0	0
Arenaris congesta	1	14	0	0
Aster scopulorum	T	1	a	a
Astragalus spp.	T	1	2	0
Balsamorhiza hookeri	T	3	0	0
Balsamorhiza serrata	T	8	0	0
Colinsia parviflora	2	90	0	0
Crepis spp.	2	45	a	a
Descurainia spp.	0	0	28	0
Draba douglasii	T	T	0	T
Erigeron linearis	T	1	a	a
Erigeron spp.	1	6	a	a

Table 1. (continued)

Species	Percentages found in vegetation transects		Percent relative density in fecal samples	
	Cover	Frequency	Pronghorn	Cattle
Eriogonum spp.	T	T	0	0
Haplopappus acaulis	T	1	a	a
Haplopappus stenophyllus	1	15	a	a
Lithophragma sp.	T	4	0	0
Lomatium sp.	2	52	0	0
Mertensia oblongifolia	T	2	0	0
Phlox hoodii	T	T	0	0
Phlox longifolia	2	49	0	0
Ranunculus glaberrimus	T	8	0	0
Trifolium macrocephalum	4	49	0	0
Misc. Composites	---	---	2	0
Unknown Forbs	T	5	T	0

[T] Less than 0.5%.

[a] Percent relative densities summed and listed as Misc. Composites.

Table 2. Results of vegetation transects and analysis of fecal samples from the early June sampling period (shrub-grassland).

Species	Percentages found in vegetation transects		Percent relative density in fecal samples	
	Cover	Frequency	Pronghorn	Cattle
Artemisia spp.	4	21	56	T
Cercocarpus ledifolius	0	0	2	0
Chrysothamnus nauseosus	0	0	T	0
Leptodactylon pungens	0	0	1	0
Rosa woodsii	0	0	0	T
Agropyron spp.	0	0	0	2
Bromus tectorum	T	2	T	4
Carex spp.	0	0	0	23
Distichlis spicata	0	0	0	6
Eleocharis spp.	0	0	0	5
Elymus spp.	0	0	0	1
Festuca idahoensis	0	0	0	9
Juncus spp.	0	0	0	5
Oryzopsis hymenoides	0	0	0	4
Poa spp.	10	95	T	40
Sitanion hystrix	9	79	T	0
Stipa spp.	1	14	0	1
Antennaria dimorpha	1	7	a	a
Agoseris glauca	T	2	a	a
Arabis puberula	T	1	0	0
Arenaria congesta	5	33	0	0
Aster scopulorum	T	1	a	a
Astragalus spp.	T	T	1	0
Balsamorhiza spp.	T	5	1	0
Colinsia parviflora	2	70	0	0
Crepis spp.	2	38	a	a
Descurainia spp.	0	0	31	0
Draba douglasii	T	T	T	T
Epilobium paniculatum	T	20	0	0

Table 2. (continued)

Species	Percentages found in vegetation transects		Percent relative density in fecal samples	
	Cover	Frequency	Pronghorn	Cattle
Erigeron chrysopsides	T	T	a	a
Erigeron linearis	T	1	a	a
Eriogonum spp.	T	T	T	0
Haplopappus stenophyllus	3	29	a	a
Linantus harkensii	T	2	0	0
Lomatium sp.	T	21	0	0
Mertensia oblongifolia	T	3	T	0
Navarretia braweri	T	1	0	0
Penstemon humilis	T	T	0	0
Phlox hoodii	T	11	0	T
Phlox longifolia	T	36	0	T
Senecio sp.	T	1	a	a
Sphaeralcea spp.	0	0	1	0
Trifolium macrocephalum	5	69	0	0
Zigadenus sp.	T	T	0	0
Misc. Composites	---	---	T	0
Unknown Forbs	T	T	1	0

[T] Less than 0.5%.

[a] Percent relative densities summed and listed as Misc. Composites.

Table 3. Results of vegetation transects and analysis of fecal samples from the late June sampling period (playa).

Species	Percentages found in vegetation transects		Percent relative density in fecal samples	
	Cover	Frequency	Pronghorn	Cattle
Artemisia spp.	0	0	54	0
Cercocarpus ledifolius	0	0	1	0
Chrysothamnus nauseosus	0	0	1	0
Juniperus occidentalis	0	0	1	0
Leptodactylon pungens	0	0	T	0
Purshia tridentata	0	0	6	0
Agropyron spp.	0	0	T	2
Bromus tectorum	0	0	1	1
Carex spp.	0	0	0	8
Distichlis spicata	0	0	0	1
Eleocharis spp.	3	29	0	54
Juncus spp.	0	0	T	12
Koleria cristata	0	0	0	T
Muhlenbernia spp.	3	35	0	0
Oryzopsis hymenoides	0	0	0	T
Poa spp.	0	0	0	17
Sitanion hystrix	0	0	0	T
Stira spp.	0	0	0	2
Achillea lanulosa	0	0	0	T
Astragalus spp.	0	0	0	T
Balsamorhiza spp.	0	0	9	0
Descurainia spp.	0	0	23	T
Eriogonum spp.	0	0	T	0
Haplopappus lanceolatus	3	52	a	a
Iva axillaris	2	54	0	0
Oenothera caespitosa	3	60	0	0
Pediocactus simponsii	0	0	T	0
Sphaeralcea spp.	0	0	0	T
Misc. Composites	0	0	T	0
Unknown Forbs	0	0	T	0

[T] Less than 0.5%.

[a] Percent relative densities summed and listed as Misc. Composites.