MORTALITY AND MOVEMENTS OF MULE DEER FAWNS IN WASHINGTON[1]

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Abstract: Thirty-nine mule deer fawns (*Odocoileus hemionus hemionus*) were captured in south-central Washington in 1977. The fawns were 1–24 days old and weighed 2.9–9.7 kg. The average age at capture was 6.9 ± 5.2 days. Fawns were located daily May through August, and monthly through December. Average distance traveled by fawns from the previous day's location during an approximate 24-hour period for the 1st 3 months of life was highly variable and averaged 438 m. The mean home range was 257 ha for fawns approximately 60 days old or older. Total mortality was 14 out of 26 radio-instrumented fawns. Predation by coyotes (*Canis latrans*) accounted for 10 of the losses. Drowning caused 3 deaths, and circulatory collapse accounted for 1 death. Combined fawn mortality was 54%. High variability in average daily distance traveled by individual fawns indicates that age is not reliable as the sole factor for predicting fawn movements. Intensive coyote removal on the study area probably would not substantially reduce total mortality in the fawn population.

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This study addressed factors responsible for neonatal mortality of radio-instrumented mule deer in south-central Washington. The research was conducted on the United States Department of Energy Hanford Reservation. To the north and east, the reservation is bounded by the Columbia River. Hunting has not been permitted on the Benton County portion of the Hanford Reservation since the federal government took control of the land in 1943. However, coyote control programs continued through 1970. The Hanford Reservation has not been used for agriculture or ranching during the past 30 years, and unauthorized personnel are not permitted on the area.

All known past and current studies of natural mortality of mule deer fawns have been or are being conducted in areas open to seasonal hunting of mule deer and unregulated predator control programs. An ideal area for studies of natural mortality should feature special characteristics such as a nonmigratory herd of mule deer; minimal disturbance or harassment by man; absence of hunting of deer and coyote; absence of coyote control programs; lack of competition for forage between deer and livestock; and no alternate large prey species, such as sheep, for coyote populations. The Hanford Reservation closely approximates these special characteristics.

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STUDY AREA

This study was conducted on the islands, river shoreline, and old townsites associated with the 77-km section of the free-flowing Columbia River traversing the Hanford Reservation. The climate is xeric, with an average of 16.5 cm of precipitation per year, about 60% falling between October and February as snow. The Hanford region has hot, dry summers and moderately cold winters. July is the hottest and driest month and January is the coldest and wettest (Hinds and Thorp 1969). Little surface water is found in the surrounding area, and the nonmigrating mule deer population tends to remain near the river during most of the year. The river flowing through the reservation was closed to public use from 1943 to 1971. Public access and hunting have been allowed since 1971 on the lower 37-km section of the river and islands on the study area. A total aerial census of the river islands and southern shoreline out to 0.8 km indicated about 1 deer per 58 ha and approximately 1 coyote per 388 ha during August 1977. The population of black-tailed jack rabbits (*Lepus californicus*) was estimated from May through September 1976 at approximately 1/28 ha for the entire Hanford Reservation (Vaughan and staff 1977). Coyotes are the only large predator on the study area.

Hedlund (1975) described the vegetation of the islands and riparian strip as scattered stands of lupine (*Lupinus* sp.), buckwheat (*Eriogonum compositum*), absinthe (*Artemisia absinthium*), and ryegrass (*Elymus cinereus*). Shrub cover is sparse but does include occasional thickets of willow (*Salix* sp.), mulberry (*Morus rubra*), and currant (*Ribes cereum*) (Hanson and Eberhardt 1971). Dominant vegetation bordering the river includes bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), Russian thistle (*Salsola kali*), cheatgrass (*Bromus tectorum*), and rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*). Approximately 51 km² of pre-1943 farmland on the reservation has grown over with nearly pure stands of cheatgrass. Small groves of assorted ornamental and fruit trees persist at former townsites and homesteads.

METHODS

Thirty-nine newborn mule deer fawns were captured between 25 May and 15 June 1977. Seventeen fawns were located and hand-captured by walking a grid pattern in areas where does were believed to have fawns. A helicopter and boat were used to locate and capture 22 fawns on the islands and shoreline along the river during 26–27 May and 14–15 June. Captures were made with a long-handled hoop net or by hand. Older, active fawns were driven into the river by helicopter and picked up offshore from a boat. This technique minimized stress on older fawns that otherwise would have escaped or would have been subjected to an extended chase.

All fawns less than 1 week of age were handled with disposable rubber gloves. Fawns were aged, sexed, and weighed at capture. Age was determined by front-hoof growth and body weight (Robinette et al. 1973). The capture location of each fawn was plotted on a contour map. Other data recorded included minimum and maximum circumference of neck, ear length, condition of the navel (Haugen and Speake 1958), rectal temperature, and the physical appearance of the fawns. Sterile rectal and nasal swabs were taken to determine the presence of pathogens. Photographs provided a permanent record of each fawn. Fawns were marked with 2 ear tags—a small metal tag in the right ear and a larger, numbered yellow tag in the left ear.

Thirty-five fawns were equipped with radio transmitters mounted on a brown, nylon, fully expandable collar developed for this study. Prior to use, radio transmitters were painted a brown, camouflaging color and then placed in plastic bags containing sagebrush leaves to mask foreign odors. A mortality sensor in the transmitter circuitry doubled the pulse rate following approximately 5 hours of cessation of movement of the transmitter. Fawns were observed frequently during the daily telemetric location by triangulation but the mortality sensor in the transmitter precluded the need to harass each fawn to determine condition. Mean weight of the transmitter-collar unit was 245 g, and averaged 5% of the mean capture weight of the fawns. Frequent visual contact with radio-collared fawns revealed that the neck-mounted transmitter did not appear to hinder movement, even while swimming.

Each fawn was radio-located daily or twice daily through 30 August, and monthly through 15 December. Daily field notes for each fawn included time of day, location, ambient temperature, wind speed and direction, presence of other deer, and activity and physical condition of the fawn when visually sighted. Each fawn was located at approximately the same time every day. A truck-mounted 8-element Yagi antenna was used for triangulating and establishing locations. Visual sightings of fawns were made at weekly intervals. If a visual observation was required, an attempt was made to minimize the disturbance to the fawn, doe, and other nearby deer. Radio-locations and visual sightings were plotted on contour maps and were used to determine the mean daily distance traveled. Home ranges were determined by connecting outside points plotted on the daily logs (Carroll and Brown 1977).

Kills by predators were determined by canine marks on the head, neck, and shoulders when carcass remains were found. When only the collar was found, it was inspected for tooth marks on the transmitter casing, collar retractor, and in the nylon collar. The presence of blood soaked into the collar was evidence that the carcass was not scavenged. The site was checked for dried blood, tracks, and evidence of struggle.

RESULTS

Mortality

The peak of fawning occurred on 29 May ± 6.9 days. This date corresponds closely with the fawning peak of 30 May ± 9.1 days estimated from 45 fawns captured by Battelle Pacific Northwest Laboratories, Richland, Washington, on the same study area during a 3-day capture period in the month of June, 1975 and 1976. The average age at capture was 6.9 ± 5.2 days (range 1–24 days). Eighteen (46%) of the fawns were born on islands in the Columbia River.

Of the 35 fawns equipped with radio-collars, 6 lost their collars during the study. Three deaths were attributed to losses precipitated by capture: 1 by drowning and 2 by starvation. These were not considered natural mortality and thus were not included in the mortality statistics. Twenty-six fawns were included in statistical calculations.

During the 7-month study period, 14 fawns (54%) died of natural causes. Among these losses, 10 were attributed to coyotes, 3 to drowning, and 1 to circulatory collapse.

Two of 3 fawns that drowned were born on islands. Attempting to negotiate the river at an age premature to sufficient swimming ability, swimming during a high stage of river flow, or swimming while not in the company of the doe were reasons implicated in the 3 drownings. Laboratory necropsy of recovered fawn carcasses did not implicate viral infections as contributors of death. The average age at death was 45.5 ± 43.8 days (range 12–139 days). Seven fawns perished during the 1st month of life, 5 died during the 2nd month, and 2 succumbed during the 5th month. Twelve radio-collared fawns survived the study period.

Two nonsibling fawns, captured on different islands, showed anatomical deformities. One, captured at 3 days of age, was born with fused hooves and the lower jaw approximately 2.9 cm shorter than the upper jaw. Although the capture weight was 38% less than that of its twin and it appeared weak and gaunt at capture, it swam from the island to the mainland 3 times before taking up residence on the mainland. The fawn was killed at age 46 days by coyotes. The 2nd fawn, captured at 24 days of age, had enlarged rear fetlock joints, causing the hoof tips to be pointed downward, and the lower jaw was approximately 2 cm shorter than the upper jaw. This fawn survived the study period.

Twenty-six (56%) of the 39 captured fawns were known to be twins. Of the 26 fawns whose fate was known throughout the course of the study, 17 were known twins. Ten of the 14 that died were twins. In 1 case, both members of a set were killed during a coyote attack.

The sex ratio at capture was 160 males to 100 females. Only 3 of 14 fawns that died were females; 2 succumbed to drowning and 1 to coyote predation. Nine of 10 fawns killed by coyotes were males. The higher proportion of male fawns accounts for, in part, the greater mortality of males (79%). Necropsy in the laboratory indicated circulatory collapse as the cause of death for 1 male.

Seven of the Hanford fawns, all at least 40 days old, died after 1 July as a result of coyote predation. The final 8 consecutive deaths were attributed to coyotes. We believe these deaths closely correspond to the maturation of coyote young and the formation of familial hunting packs. In 5 of the final 8 deaths, packs of 3 or more coyotes were suspected to be involved. In all cases of coyote predation, fawns were known to be traveling with the doe prior to their deaths. This might facilitate coyotes in finding fawns. In 5 cases of predation, fawns were killed on open, sandy or rocky beaches along the river. In 4 of these kills, the river was bordered by a steep sand embankment that could hinder escape. This may suggest a hunting strategy by the coyotes. In 2 cases, coyote and deer tracks in the wet sand on the beach left an obvious story of the attacks. Fawn #3BH1 and several does were attacked by 2 or more coyotes on a beach bordered by a 10-m sand bluff. The coyotes attacked just 30 m from the end of the 200-m beach from which the does and single fawn entered. Tight circles of tracks were made by the does in the sand; does probably circle to protect their flanks from attack or to protect the fawn. The fawn was killed within 30 m of the initial point of attack. Hair from the does and tight circles of tracks continuing at intervals down the beach were evidence that several of the coyotes continued to chase the does after the fawn was subdued. Fawn #8BH1 was killed in much the same manner; coyotes again chased the doe down the beach. This fawn was killed within 20 m of the initial point of attack. Two or more coyotes appeared to be involved. In most cases, the carcass was carried and dragged a considerable distance, averaging 2,898 ± 769 m (range 2,189–3,716 m, N = 3), before the transmitter-collar was torn from the body. Often only a bloody, chewed transmitter and collar, and a few scattered pieces of bone and hide, were found as evidence of coyote kills. In 2 cases, a large portion of the nylon collar was apparently eaten by coyotes.

Fawn Measurements

Average weight of all captured fawns was 5.2 ± 1.6 kg (range 2.9–9.7 kg). Mean weight at capture of fawns 4 days old or less was 3.8 ± 0.5 kg (N = 19), singles weighing 4.0 ± 0.4 kg (N = 7) and twins 3.8 ± 0.5 kg (N = 12). Mean rectal temperature was 38.9 ± 1.3 C (range 33.9–41.7 C). Average ear length (skull to tip) was 12.0 ± 1.4 cm, and mean neck circumferences for minimum and maximum measurements were 18.5 ± 2.2 cm and 20.2 ± 2.1 cm, respectively.

Movements and Activity

Mean distance traveled from the previous day's location for an approximate 24-hour period was recorded for each fawn (Table 1). Mean daily distance traveled increased with increasing age; however, a significant linear correlation between age and distance was not found. This was due to the high variation in movement shown by individual fawns. Analysis by multiple regression for average daily movement in relation to fawn age, maximum ambient temperature for the previous day, the temperature differential between transmitter temperature (fawn microclimate temperature), and ambient temperature yielded a positive linear relationship ($r = 0.29$, $P < 0.01$). This indicates that age is not reliable as the sole factor for predicting fawn movements. Fawns moving after daily observations and returning to the same site prior to the next daily observation would not be recorded as having moved.

Table 1. Distance traveled by mule deer fawns since the preceding day's location of each one, in south-central Washington.

Age category (days)	Locations (N)	Mean (m)	Standard deviation (m)	Range (m)	Coefficient of variation
1–30	534	319	399	10–3,160	124.8
31–60	455	480	530	10–5,805	110.2
61–90	176	641	624	15–2,440	97.4
Total	1,165	438	508	10–5,805	116.0

Home ranges were large and highly variable. Home ranges of fawns were believed to reflect home ranges of dams when fawns were 60 days old. The mean home range from birth through August for fawns 60 days and older was 256.9 ± 192.7 ha (range 31.7–689.1 ha, CV = 71.8%). Maximum movement from the capture site, averaged for the surviving fawns, was 2,555 ± 950 m (range 990–4,035 m, CV = 37.2%). Average distance from capture site to the location of the collar of a dead fawn, including the distances that coyotes were known to carry the carcass before tearing off the collar, was 2,284 ± 1,672 m (range 265–5,840 m, CV = 73.2%).

DISCUSSION

Research on the Welder Wildlife Foundation, Sinton, Texas, showed high neonatal fawn mortality to be the dominant factor stabilizing the white-tailed deer (*O. virginianus*) herd (Cook et al. 1971). That study listed principal causes of mortality in young fawns as nutritional failure, disease, accidents, and predation, and reported up to 73% of radio-instrumented fawns succumbed to these factors. Absence of mortality among radio-equipped fawns from mid-July to late September in Oregon suggested that major losses of young fawns were confined to about 45 days postpartum (Trainer 1975). Knowlton (1968) concluded that over 90% of the mortality in white-tailed fawns he studied occurred during the 1st 3 weeks of life. Of the fawn loss reported by Cook et al. (1971), 93% occurred in the 1st month of life, and 7% in the next 30 days.

Cook (1966) found that 31 of 34 radio-collared white-tailed fawns died, and predators were considered responsible for 68% of the total mortality. Cook et al. (1967) concluded that 13 of 24 deaths of radio-collared white-tailed fawns were mortalities in which predators were considered to be involved. Another study on neonatal survival of white-tailed fawns in Texas showed a combined fawn loss of 47% over a 3-year period (Carroll and Brown 1977). In that study, predation accounted for 50%, and disease and starvation for 34%, of the overall mortality. Of 24 mule deer fawns radio-collared in Colorado, 50% were thought to have died from predation (Anderson 1976). A 7.6% loss of captive mule deer fawns to stillbirths, deformities, and abandonment was noted by Robinette et al. (1973). Trainer (1975) noted that predation, mostly by coyotes, was the direct cause of mortality in 55% of 29 deaths among 102 mule deer fawns radio-monitored during their 1st 45 days of life during 1971–74. Michael (1967) concluded that coyotes killed and ate many fawns that were less than 4 weeks old, but few that were older.

Habitat conditions were considered to be minimal for additional growth of the mule deer herd on the study area. The orchards and understory shrubs planted by the early inhabitants of the area were decadent or dead. Much of the study area was abandoned agricultural lands dominated by cheatgrass. The large home ranges of the deer indicate that long distances often were traveled between the foraging areas, orchard cover, and the river.

Research conducted by Battelle Pacific Northwest Laboratories, which used a helicopter to facilitate tagging of fawns on the study area, provided information on trends in the population. During 8 consecutive years of tagging (1969–76), a marked decline occurred in the observable fawn population. Numbers of fawns hand-captured and tagged were 24, 51, 52, 53, 48, and 34 in 1969–74, respectively (Hedlund 1975); 19 in 1975 (Hedlund et al. 1976); and 26 in 1976 (Battelle Pacific Northwest Laboratories, Richland, Washington, unpubl. data). The same study area and a 3-day period of capture were used during all 8 years. The decline in number of fawns closely corresponds to the cessation, in 1970, of government programs of coyote control and the lifting of restrictions on public access to the lower 37-km section of the river in 1971. The significant rise in captured fawns to 39 in 1977 was attributed to a greater intensity of effort and expenditure of time by researchers.

Many does seemed to swim purposefully to the islands to fawn. Some islands were free of resident coyotes, but devoid of vegetation sufficient to support the lactating doe. Does often were seen to swim to adjoining islands or to the mainland. Younger fawns waited on the islands for the return of the doe while older fawns accompanied the females. On 1 island (7.2 ha) that was nearly devoid of vegetation, 4 does and 8 fawns were observed. The island immediately downstream bore vegetation, and housed 2 resident coyotes but no deer with newborn fawns. Coyotes occasionally were observed to swim to islands. Upstream dams releasing water during peak demands of electricity caused the river to fluctuate as much as 3 m daily. High levels of the river presented additional hazards to swimming fawns, forcing them to exert more energy to keep pace with the doe.

Verme (1969) suggested that nutritional levels of does at or just before breeding may be an important determinant in the sex ratio of fawns. He reported a higher proportion of male fawns from white-tailed deer does on a low nutritional plane than on a high one. Robinette et al. (1977) reported a preponderance of male mule deer fawns in Utah where the summer range had been depleted so badly that condition of the does at the start of breeding was below an optimum level. If this relationship is valid, the depleted habitat on the study area possibly would explain the sex ratio at capture of 62% males to 38% females. Robinette et al. (1977) observed that several times when male and female mule deer twins were captured, the male appeared more tractable. Further, he observed that the male twin was captured more often than the female when 1 of the pair was known to escape.

Although habitat was in marginal condition over a large portion of the study area, the Hanford deer herd evidently was experiencing little disease or direct starvation. Much of the study area was composed of early-growing, annual grasses and riparian vegetation. Thus, the habitat is relatively stable even during drought years. The habitat, as currently managed, could support few additional deer. Considering that (1) 71% of the total mortality was due to coyote predation, (2) habitat quality was relatively stable at a low level, and (3) the fawn population had declined due in part to the loss of the lower half of the river habitat, intensive removal of coyotes on the study area probably would not substantially reduce total mortality in the fawn population. Rather, it probably would cause a shift in mortality to factors other than coyote predation.

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