# Coyote Condition and Reproduction in Response to a Reduction in Population Density

**Scott E. Henke**[*]

*Department of Animal and Wildlife Sciences, Campus Box 156, Texas A&M University-Kingsville, Kingsville, Texas 78363*

**Fred C. Bryant**

*Department of Range and Wildlife Management, Texas Tech University, Lubbock, TX 79409*

## ABSTRACT

**Four 5000-ha sites located in Andrews County, Texas, were studied during 1990 - 1992 to determine the effect of coyote (*Canis latrans*) population reduction on coyote physical characteristics, body condition, and reproduction. Seasonal coyote removal on two sites reduced coyote density from an estimated 0.12 to 0.06 coyotes km$^{-2}$. Coyote density remained stable on the other two sites throughout the study. Coyote removal did not create a change in coyote physical characteristics or body condition. Fetal sex ratios appeared to favor males at higher population densities. After about 9 months of coyote removal, a greater percentage of juvenile females from the experimental areas exhibited higher counts of corpora lutea and resorption placental scars. However, due to the higher resorption rate, juvenile females from the experimental areas minimally contributed to coyote population density. Adult female reproduction appeared unaffected by coyote removal.**

KEYWORDS: *Canis latrans*, corpora lutea, fat, growth, removal

Coyote (*Canis latrans*) management programs typically involve some level of coyote population control (Balser, 1964; Beasom, 1974; Connolly, 1982). However, an understanding of coyote reproduction and fitness is necessary to formulate effective and ecologically sound management practices. Connolly and Longhurst (1975) examined the effect of control on coyote populations using a simulation model, and determined that a minimum annual removal of 75% was needed to consistently lower coyote density. A stimulated reproductive rate was one factor that created the need for such a high annual removal. This simulation model was based on work by Knowlton (1972) who found that the number of uterine swellings per female and litter size varied inversely with density in Texas coyotes. Also, the density of the coyote's principle prey species may be a partial determinant in coyote density and, therefore, be a casual mechanism on the coyote reproductive rate, both in terms of litter size and percentage of females breeding (Clark, 1972).

Mammalian body condition is commonly related to species fitness (Clutton-Brock et al., 1982). Coyote body condition has been observed to decline over winter

---

Research was supported by the National Rifle Association, University of Texas Lands, and the Houston Livestock Show and Rodeo. [*]Corresponding author.

(Todd and Keith, 1983). Adult male coyotes are known to be heavier and taller than females (Bekoff, 1977; Daniel, 1973). However, information is lacking concerning the relationship between body condition and population density. Therefore, our objectives were to assess changes in coyote physical characteristics, body condition, and reproduction on areas of stable and declining coyote population densities in western Texas. This investigation was conducted jointly with a study of the ecological impacts of coyote removal (Henke, 1992).

## MATERIALS AND METHODS

The study was conducted between April 1990 and January 1992 in Andrews County, Texas. An expanded account of the study area and coyote densities is in Henke (1992). Four areas, approximately 5000 ha each, were chosen for study. Two areas in northeastern Andrews County served as the experimental areas where coyotes were removed seasonally, and the other two areas, in southern and western Andrews County, respectively, served as the comparison areas where only a limited number of coyotes were removed. To avoid ambiguity, the areas on which coyotes were controlled were referred to as experimental areas because coyote "control" was the treatment, whereas the areas that received no treatment were referred to as comparison areas. Coyotes were seasonally collected (April, July, October, and January) by aerial shooting. Complete coyote removal was attempted on the experimental areas, whereas five coyotes were collected from each comparison area each season. All coyotes were immediately retrieved and processed in the field.

Coyote relative abundance for each area was estimated by scent station lines as outlined by Roughton and Sweeney (1982). Scent station lines were conducted twice seasonally on the experimental areas, one week immediately before and one week immediately after aerial shooting. A synthetic W-U lure attractant gel (Fagre et al., 1983) was used as the scent throughout the study. Coyote populations on experimental areas were estimated by the removal method (Zippin, 1958). Density was estimated by dividing the population estimate by the search area. Equations predicting coyote density from scent station relative abundance indices were developed using least-squares linear regression.

Upon collection each coyote was sexed and then weighed to the nearest 0.2 kg. Body length was measured along the dorsal surface from the nose to the base of the tail. Shoulder height was measured from the base of the communal pads to the dorsal border of the scapula. Ratio of palatal width to length of the upper molar tooth row was calculated according to Howard (1949) to verify each specimen as *Canis latrans*. As an appropriate index of fat deposits, the relative amount of mesentery fat and subcutaneous fat thickness measured at the hip, back, and ribs were visually rated using a subjective scale of 0 (none) to 3 (abundant).

A lower canine tooth was extracted from each coyote. Age was estimated by enumeration of cementum layers in microscopic sections of canine teeth (Linhart and Knowlton, 1967) by Matson's Laboratory (Missoula, MT). For statistical analyses of condition and reproductive parameters, coyotes were classified as juveniles ($<$ 1 yr) and adults ($\geq$ 1 yr).

Female reproductive tracts were excised and kept on wet ice until examined in the laboratory. Ovaries were placed in 10% formalin for 48 hours, washed in tap water, sliced into 1 mm sections, and the number of corpora lutea recorded. Uterine horns were cut longitudinally and the number of primary and resorption scars were recorded (Gier, 1968). If pregnant, the number of fetuses were recorded, the sex was determined for each fetus, and the crown-rump length was obtained as outlined by Kennelly et al. (1977). Reproductive parameters of females were separated by age class. Corpora lutea counts were averaged from females collected in April, July, and October.

The experiment was a completely randomized design with repeated measures. Differing coyote densities caused by coyote removal was the major treatment source of variation through time. A general linear model's analyses of variance was used to test the effects of treatment, season, and year on scent station relative abundances. A general linear model's analyses of variance was used to test the effect of treatment and year on coyote weight, length, shoulder height, age, relative fat indices, percent females breeding, number of primary and resorption placental scars, and number of corpora lutea. Multiple comparisons were made using mean separation when a significant ($P < 0.05$) interaction between treatment and year was noted (Cochran and Cox, 1957). Homogeneity of variances among treatments was tested by using Bartlett's test at $P < 0.05$ (Steel and Torrie, 1980). Distributions of appropriate residuals were tested using Shapiro-Wilk tests at $P < 0.05$. Log transformation ($\log_{10}$) of the data was performed when non-normal distributions of residuals occurred. Transformed data was retested to assure that the assumption of normality was met. Homogeneity of the differences of variances between effects was tested using sphericity tests (Geisser and Greenhouse, 1958). The Greenhouse-Geisser epsilon coefficient was multiplied by both effect and error degrees of freedom to yield the corrected F-value when sphericity was violated (BMDP, 1990). Sex ratios and adult:juvenile ratios were analyzed by the chi-square test.

## RESULTS

Totals of 354 and 81 coyotes were removed from the experimental and comparison areas, respectively, from April 1990 to January 1992. Scent station indices were greater ($P = 0.024$) on comparison than experimental areas (Table 1). There were no season, season-treatment, year, and year-treatment effects ($P = 0.114$); however, a 3-way interaction occurred ($P = 0.029$). No difference ($P > 0.05$) was detected between comparison and experimental areas during spring 1990; however, scent station indices markedly decreased ($P < 0.05$) and remained lower on experimental areas after that time. Scent station indices immediately before aerial shooting of coyotes on experimental areas were greater ($P = 0.018$) than coyote responses to scent stations immediately after aerial shooting (Table 1). Coyote responses to scent stations declined 81.8% immediately following aerial shooting of coyotes on experimental areas (Table 1). From linear regression, coyote density on the experimental and comparison areas prior to removal efforts was estimated to be $0.12 \pm 0.01$ coyotes $\text{km}^{-2}$. Coyote density remained stable on the comparison areas throughout this study, whereas coyote density decreased to and remained at $0.06 \pm 0.01$ coyotes $\text{km}^{-2}$ on the experimental areas after 9 months of seasonal coyote removal. Eighty one and 178 coyotes were collected for necropsy from the comparison and experimental areas, respectively.

Table 1. Coyote scent station relative abundance between the comparison and experimental areas and the percent reduction in coyote scent station activity (Percent of operable scent stations visited x 1000) before and after aerial shooting of coyotes on the experimental areas.

| | Comparison Areas | Experimental Areas | | |
|---|---|---|---|---|
| Season | Index | Pre-shooting Index | Post-shooting Index | Reduction (%) |
| Spring 90 | 180 | 158 | 7 | 95.6 |
| Summer 90 | 205 | 34 | 14 | 58.8 |
| Fall 90 | 170 | 92 | 8 | 91.3 |
| Winter 90 | 200 | 124 | 36 | 71.0 |
| Spring 91 | 200 | 116 | 10 | 91.4 |
| Summer 91 | 178 | 100 | 10 | 90.0 |
| Fall 91 | 188 | 77 | 15 | 80.5 |
| Winter 91 | 188 | 92 | 22 | 76.1 |
| Mean | 189 | 99 | 15 | 81.8 |

Mean palatal ratio of juvenile and adult coyotes was 2.9 and 3.1, respectively. The number of adults on experimental areas in 1990 exceeded the number of juveniles ($X^2 = 11.01$, degrees of freedom = 1, $P < 0.05$). The juvenile:adult ratio on comparison areas was even in 1990 ($X^2 = 0.025$, degrees of freedom = 1, $P > 0.05$). During 1991, the juvenile:adult ratio did not deviate from a 1:1 relationship on either comparison or experimental areas ($X^2 < 3.51$, degrees of freedom = 1, $P > 0.05$). The number of males and females on comparison and experimental areas did not deviate from a 1:1 sex ratio ($X^2 < 2.02$, degrees of freedom = 1, $P > 0.05$) during 1990 and 1991 (Figure 1).

Juvenile coyote shoulder height increased ($P < 0.016$) while relative amount of back fat decreased ($P = 0.047$) during 1991 over 1990 estimates (Table 2). There were no differences ($P = 0.194$) in juvenile coyote mean body weight, length, shoulder height, age, and all relative fat indices between comparison and experimental areas (Table 2). Year-treatment interactions within the measured parameters were not detected ($P = 0.158$) for juvenile coyotes.

Adult coyote length and shoulder height increased ($P = 0.020$) during 1991 over 1990 estimates (Table 2). Relative amount of back, hip, and rib fat on comparison areas decreased ($P = 0.050$) during 1991 over 1990 estimates; however, relative amount of back, hip, and rib fat remained unchanged between the years on experimental areas (Table 2). There were no differences ($P = 0.085$) in adult coyote mean body weight, length, shoulder height, age, and relative amount of mesentery fat between comparison and experimental areas.

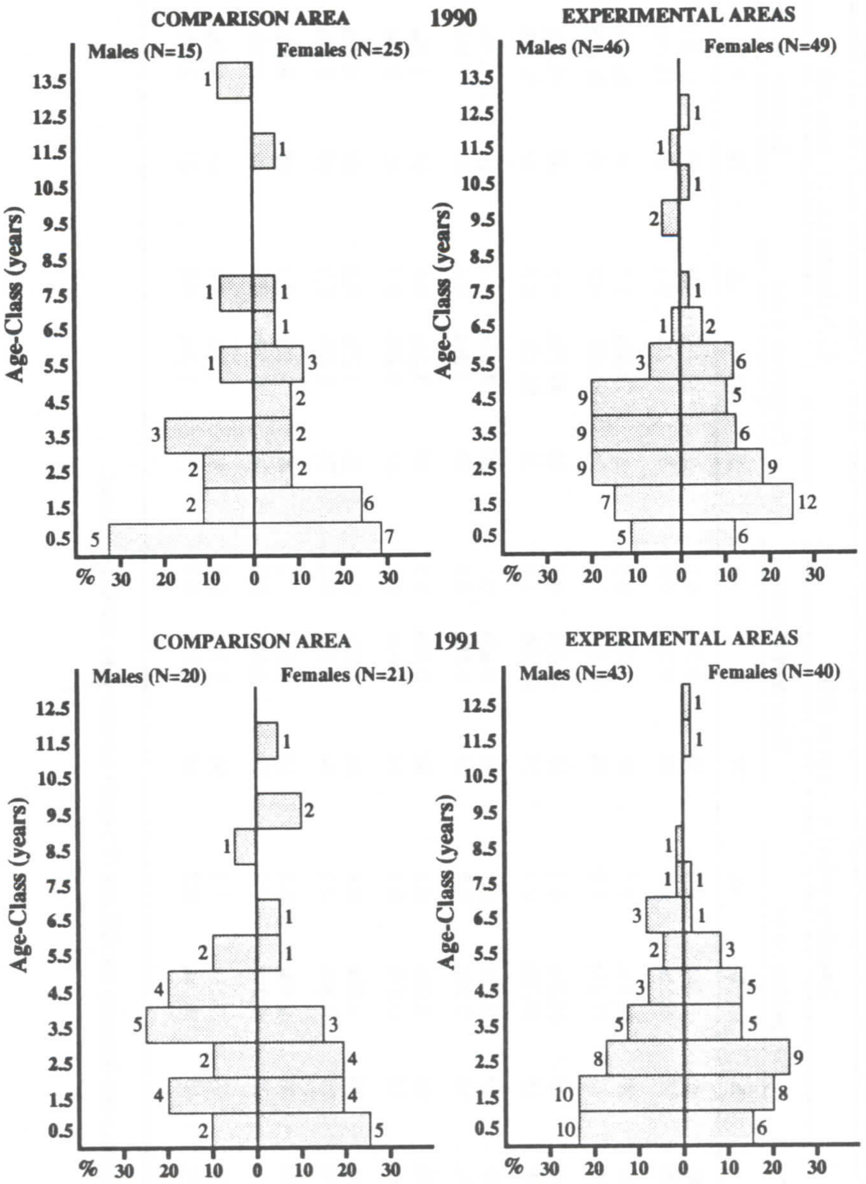

Figure 1. Population profile of coyotes on comparison and experimental areas during 1990 and 1991 in Andrews County, Texas.

Table 2. Age-specific mean body weight, length, height, age, and fat indices of coyotes from comparison and experimental areas, Andrews County, Texas.

| | | Juvenile Coyotes (< 1.0 years old) | | | | | | Adult Coyotes (≥ 1.0 years old) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Comparison Areas | | | Experimental Areas | | | Comparison Areas | | | Experimental Areas | | |
| Indices | | N | $\bar{x}$ | SE | N | $\bar{x}$ | SE | N | $\bar{x}$ | SE | N | $\bar{x}$ | SE |
| Weight (kg) | 1990: | 20 | 8.84a† | 0.2 | 30 | 8.58a | 0.9 | 20 | 10.79a | 0.6 | 65 | 11.18a | 0.2 |
| | 1991: | 15 | 9.51a | 0.3 | 34 | 9.64a | 0.4 | 26 | 11.21a | 0.1 | 49 | 11.48a | 0.2 |
| Length (cm) | 1990: | 20 | 75.51a | 1.5 | 30 | 77.90a | 0.5 | 20 | 78.94a | 0.2 | 65 | 80.98a | 0.2 |
| | 1991: | 15 | 77.37a | 1.3 | 34 | 76.81a | 1.5 | 26 | 82.42b | 0.5 | 49 | 81.84b | 0.5 |
| Height (cm) | 1990: | 20 | 44.86a | 0.2 | 30 | 45.57a | 0.5 | 20 | 47.29a | 0.5 | 65 | 48.97a | 0.5 |
| | 1991: | 15 | 49.22b | 0.5 | 34 | 48.00b | 1.5 | 26 | 51.13b | 0.5 | 49 | 50.67b | 0.2 |
| Age (years) | 1990: | 20 | 0.45a | 0.1 | 30 | 0.65a | 0.1 | 20 | 4.75a | 0.4 | 65 | 3.90a | 0.4 |
| | 1991: | 15 | 0.50a | 0.2 | 34 | 0.50a | 0.1 | 26 | 4.30a | 0.6 | 49 | 3.90a | 0.1 |
| Back fat | 1990: | 20 | 1.00a | 0.1 | 30 | 0.85a | 0.2 | 20 | 1.20a | 0.0 | 65 | 1.00a | 0.1 |
| | 1991: | 15 | 0.55b | 0.1 | 34 | 0.60b | 0.2 | 26 | 0.20b | 0.1 | 49 | 0.75a | 0.0 |
| Hip fat | 1990: | 20 | 0.90a | 0.0 | 30 | 0.80a | 0.1 | 20 | 1.20a | 0.0 | 65 | 0.85a | 0.0 |
| | 1991: | 15 | 0.30a | 0.2 | 34 | 0.55a | 0.2 | 26 | 0.20b | 0.1 | 49 | 0.55a | 0.0 |
| Rib fat | 1990: | 20 | 0.90a | 0.0 | 30 | 0.55a | 0.2 | 20 | 1.10a | 0.1 | 65 | 0.80a | 0.1 |
| | 1991: | 15 | 0.95a | 0.2 | 34 | 0.65a | 0.2 | 26 | 0.20b | 0.2 | 49 | 0.60a | 0.0 |
| Mesentery fat | 1990: | 20 | 1.30a | 0.1 | 30 | 1.30a | 0.1 | 20 | 1.70a | 0.0 | 65 | 1.45a | 0.2 |
| | 1991: | 15 | 1.15a | 0.2 | 34 | 1.15a | 0.1 | 26 | 1.20a | 0.1 | 49 | 1.40a | 0.2 |

†Means with the same lower case letter are not different ($P > 0.05$) between years within a treatment.

Table 3. Comparison of juvenile and adult female reproductive parameters from comparison and experimental areas in Andrews County, Texas, during 1990 and 1991.

| | Juvenile Coyotes (< 1.0 years old) | | | | | | Adult Coyotes (≥ 1.0 years old) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Comparison Areas | | | Experimental Areas | | | Comparison Areas | | | Experimental Areas | | |
| Indices | N | x̄ | SE | N | x̄ | SE | N | x̄ | SE | N | x̄ | SE |
| Primary scars | | | | | | | | | | | | |
| 1990: | 3 | 0.67Aa[†] | 0.7 | 2 | 0.00Aa | 0.0 | 20 | 1.10Aa | 0.2 | 43 | 1.70Aa | 0.8 |
| 1991: | 3 | 0.00Aa | 0.0 | 3 | 1.00Aa | 0.6 | 16 | 2.65Aa | 0.4 | 33 | 2.05Aa | 0.4 |
| Resorption scars | | | | | | | | | | | | |
| 1990: | 3 | 0.00Aa | 0.0 | 2 | 0.00Aa | 0.0 | 20 | 0.20Aa | 0.1 | 43 | 0.15Aa | 0.1 |
| 1991: | 3 | 0.00Aa | 0.0 | 3 | 5.67Bb | 0.7 | 16 | 0.45Aa | 0.2 | 33 | 0.45Aa | 0.2 |
| Corpora lutea | | | | | | | | | | | | |
| 1990: | 3 | 1.33Aa | 1.3 | 2 | 1.00Aa | 1.0 | 16 | 2.80Aa | 0.6 | 37 | 3.25Aa | 0.8 |
| 1991: | 3 | 0.67Aa | 0.7 | 3 | 7.33Bb | 0.9 | 12 | 3.95Aa | 0.6 | 24 | 4.15Aa | 0.1 |
| Females breeding (%) | | | | | | | | | | | | |
| 1990: | 3 | 0.33Aa | 0.3 | 2 | 0.00Aa | 0.0 | 20 | 0.70Aa | 0.0 | 43 | 0.76Aa | 0.2 |
| 1991: | 3 | 0.00Aa | 0.0 | 3 | 1.00Bb | 0.0 | 16 | 0.80Aa | 0.1 | 33 | 0.85Aa | 0.1 |
| Age (years) | | | | | | | | | | | | |
| 1990: | - | - | - | - | - | - | 20 | 3.25Aa | 0.4 | 43 | 3.15Aa | 0.8 |
| 1991: | - | - | - | - | - | - | 16 | 4.35Aa | 1.0 | 33 | 3.35Aa | 0.1 |

[†] Means with the same upper case letter are not different ($P > 0.05$) between treatments; means with the same lower case letter are not different ($P > 0.05$) between years within a treatment.

Adult female reproductive parameters were not different ($P = 0.546$) between comparison and experimental areas during 1990 and 1991 (Table 3). There were no year effects ($P = 0.066$) or year-treatment interactions ($P = 0.145$) detected in adult female reproductive parameters. The percent of females ovulating (ovaries containing follicles or corpora lutea) and the percent of females breeding (uterine horns containing implanted fetuses or placental scars) was the same ($P > 0.523$) between and within the treatment areas.

Juvenile female reproductive parameters were similar ($P = 0.495$) between comparison and experimental areas during 1990, and there was no difference ($P = 0.158$) in the number of primary placental scars between comparison and experimental areas during 1991 (Table 3). However, during 1991 the number of resorption placental scars and corpora lutea and the percentage of juvenile females breeding on the experimental areas was greater ($P = 0.004$) than on the comparison areas (Table 3). Also, the number of resorption scars and corpora lutea, and percentage of juvenile females breeding during 1991 increased ($P = 0.019$) on experimental areas from 1990. Juvenile female reproductive parameters did not vary ($P = 0.374$) among years on the comparison areas nor in the number of primary placental scars on the experimental areas. Six juvenile females were obtained during the January collections (approximately 9-month-old females). Juvenile females on the comparison areas (N = 2) did not appear sexually developed; however, all juvenile females on the experimental areas (N = 4) were pregnant and had an average of 6 ovulation sites and 6 implanted fetuses.

Totals of 18 and 26 fetuses were removed from female coyotes obtained during the January collection from the comparison and experimental areas, respectively. Of the sample obtained from the comparison areas, 14 fetuses were male and 4 were female, while fetuses obtained from the experimental areas contained 11 males and 15 females. Fetal sex ratios deviated from a 1:1 ratio ($X^2 = 4.5$, degrees of freedom = 1, $P < 0.05$) on the comparison areas but did not deviate from a 1:1 sex ratio ($X^2 = 0.35$, degrees of freedom = 1, $P > 0.05$) on the experimental areas.

## DISCUSSION

Aerial shooting from a helicopter appeared to produce an immediate 80% reduction in coyote population size on the experimental areas. However, due to possible immigration (Gier, 1968; Knowlton, 1972), long-term effects of population reduction of coyotes were less dramatic, producing only a 48% decline.

The calculated palatal ratios were at the lower limit suggested for coyotes (Howard 1949). If the ratio is greater than 3.1, the specimen is a coyote; if the ratio is less than 2.7, it is a dog (*Canis familiaris*). However, range of palatal ratios depend on subspecies (Bekoff 1977). Selected skulls from coyotes collected in Andrews County were of the subspecies *Canis latrans texensis* as determined by Choate et al. (1992). Therefore, hybridization between coyotes and feral dogs was not observed.

Adult coyote back, hip and rib fat indices were lower on comparison areas during 1991 than the 1990 estimates. This could be a result of a less abundant food supply. Henke (1992) observed lower densities of jackrabbits and rodents and a greater percent of empty coyote stomachs on comparison areas during this time period. Decreases of back, hip, and rib fat deposits without loss of body weight suggests that back, hip, and rib fat deposits are more sensitive indicators of body condition than body weight alone. Windberg et al. (1991) found a similar relationship in coyotes from South Texas. A progressive sequence of fat deposition has not been determined for carnivores; however, the sequence is assumed similar to ungulates (Riney, 1955). Based on data from this study, the progressive sequence of measured subcutaneous fat deposition in coyotes from western Texas appears to be (1) back, (2) hip, and (3) rib fat.

The percentage of adult female coyotes that breed varies from 33% to 90% (Gier, 1968; Knowlton, 1972). However, in years with adequate food supply, a greater percentage of females will breed (Gier, 1968). Because coyote density decreased on experimental areas, and subsequently rodent and jackrabbit densities increased (Henke, 1992), we predicted coyote litter size and percentage of females breeding would increase. However, this was observed only in juvenile females. Perhaps one year was not sufficient time for adult female reproduction to respond to environmental changes. All of the juvenile females on the experimental areas bred before their first year and they expressed a greater fecundity rate after approximately 9 months of coyote removal. However, because juvenile females on the experimental areas experienced a greater resorption rate, their potential live-birth litter size was small, and therefore, they did not significantly contribute to coyote density. This agrees with Knowlton (1972) who stated that yearling females minimally contribute to coyote populations. The high resorption rate of juvenile females could have been caused by inadequate nutrition, high parasite loads, insufficient hormonal levels, or a combination of these factors. Our data provides evidence that the nutritional plane of juvenile coyotes may have been deficient. Although not statistically significant, declining fat reserves during 1991 may have been biologically significant.

Connolly and Longhurst (1975) suggest an inverse relationship between coyote density and coyote reproduction; however, they did not include age-specific differences in coyote reproductive rates within their simulation model. This could mean that coyote control programs may not always result in increased live-birth rates. Therefore, a minimum annual removal of 75% may not be required to lower coyote density.

Conception dates, based on average fetal growth (Kennelly et al., 1977), occurred during mid-January for coyotes on the comparison and experimental areas during 1990 and 1991. Assuming an average gestation of 63 days (Kennelly et al., 1977), coyote pups for western Texas were born during mid-to-late March. This is slightly earlier than was previously reported for western coyotes (Gier, 1968; Kennelly, 1978).

Sex ratio at birth of females to males is considered to be 1:1 (Bekoff, 1977). However, our data suggests that higher coyote densities may favor a greater number of male births. To our knowledge, this phenomenon has only been documented in wild cervids (Verme, 1969).

Although the small sample size of the reproductive data prevents drawing many statistically valid conclusions, the data nonetheless stimulate new questions concerning coyote population ecology. Additional research is needed to validate these new findings. Successful attempts to model and understand coyote population dynamics will require much larger samples of adult and juvenile females, and must include data on coyote density, sex ratio, and age structure.

# REFERENCES

Balser, D.S. 1964. Management of predator populations with antifertility agents. J. Wildl. Manage. 28:352-358.

Beasom, S.L. 1974. Selectivity of predator control techniques in South Texas. J. Wildl. Manage. 38:837-844.

Bekoff, M. 1977. The coyote, *Canis latrans*. Mammal Species 79: 1-9.

BMDP. 1990. BMDP statistical software manual. Vol. 1, Univ. of Calif. Press, Berkeley, CA.

Choate, L.L., R.W. Manning, J.K. Jones, Jr., C. Jones, and S.E. Henke. 1992. Mammals from the southern border of the Kansan biotic province in western Texas. Occas. Papers, The Museum Texas Tech Univ. 152:1-34.

Clark, F.W. 1972. Influence of jackrabbit density on coyote population change. J.Wildl. Manage. 36:343-356.

Clutton-Brock, T.H., F.E. Guinness, and S.D. Albon. 1982. Red deer. Univ. Chicago Press, Chicago.

Cochran, W.G., and G.M. Cox. 1957. Experimental designs, 2nd ed., John Wiley & Sons, Inc. New York.

Connolly, G.E., and W.M. Longhurst. 1975. The effects of control on coyote populations: a simulation model. Univ. Calif. Div. Agric. Sci. Bull. 1872:1-37.

Connolly, G.E. 1982. U.S. Fish and Wildlife Service coyote control research. Proc. Great Plains Wildl. Damage Control Workshop 5:132-139.

Daniel, W.S. 1973. Investigations of factors contributing to sub-normal fawn production and herd growth patterns. Job Progress Rep. 10, Texas Parks and Wildl. Dept.

Fagre, D.B., W.E. Howard, D.A. Barnum, R. Teranishi, T.H. Schultz, and D.J. Stern. 1983. Criteria for the development of coyote lures. Verte. Pest Control and Manage. Mater. 4:265-277.

Geisser, S., and S.W. Greenhouse. 1958. An extension of Box's results on the use of the F-distribution in multivariate analysis. Annals Math. Stat. 29:885-891.

Gier, H.T. 1968. Coyotes in Kansas. Kansas Expt. Sta. Bull. 393:1-118.

Henke, S.E. 1992. Effect of coyote removal on the faunal community ecology on a short-grass prairie. Ph.D. dissertation. Texas Tech Univ., Lubbock.

Howard, W.E. 1949. A means to distinguish skulls of coyotes and domestic dogs. J. Mammal. 30:169-171.

Kennelly, J.J., B.E. Johns, C.P. Breidenstein, and J.D. Roberts. 1977. Predicting female coyote breeding dates from fetal measurements. J. Wildl. Manage. 41:746-750.

Kennelly, J.J. 1978. Coyote reproduction. p. 73-93. In M. Bekoff (ed.) Coyotes: biology, behavior and management. Academic Press, New York.

Knowlton, F.F. 1972. Preliminary interpretation of coyote population mechanics with some management implications. J. Wildl. Manage. 36:369-382.

Linhart, S.B., and F.F. Knowlton. 1967. Determining age of coyotes by tooth cementum layers. J. Wildl. Manage. 31:362-365.

Riney, T. 1955. Evaluating condition of free-ranging red deer, with special reference to New Zealand. New Zealand J. Sci. & Technol. 36:428-463.

Roughton, R.D., and M.W. Sweeney. 1982. Refinements in scent-station methodology for assessing trends in carnivore populations. J. Wildl. Manage. 46:217-229.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. 2nd ed. McGraw-Hill Book Co., New York.

Todd, A.W., and L.B. Keith. 1983. Coyote demography during a snowshoe hare decline in Alberta. J. Wildl. Manage. 47:394-404.

Verme, L.J. 1969. Reproductive patterns of white-tailed deer related to nutritional plane. J. Wildl. Manage. 33:881-887.

Windberg, L.A., R.M. Engeman, and J.F. Bromaghin. 1991. Body size and condition of coyotes in southern Texas. J.Wildl. Dis. 27:47-52.

Zippin, C. 1958. The removal method of population estimation. J. Wildl. Manage. 22:82-90.