# THE RELATIONSHIP BETWEEN DOE CONDITION AND FETAL GROWTH IN MULE DEER

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Abstract. The relationship between maternal physical condition and fetal growth in California mule deer (*Odocoileus hemionus californicus*) was examined in 1974 and 1975. All does were collected during the last 4 months of pregnancy. Nineteen does and 30 fetuses were collected in 1974, and 27 does and 48 fetuses were collected in 1975. In 1974 there was a significant change ($P<.05$) in the depot fat indices of the does following the spring migration. This change indicated that the does were in poor physical condition. In 1975 the does maintained their depot fat indices through the course of pregnancy. The drop in maternal condition had no apparent effect on fetal growth as growth rates were not significantly different ($P>.05$) between years and fawn mortality was 22 percent higher in 1975. Weight relationships between twin fetuses suggested there was a differential growth rate during the last trimester of gestation.

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## INTRODUCTION

The California mule deer (*Odocoileus hemionus californicus*) is a migratory deer inhabiting the west slope of the Sierra Nevada. A decrease in fawn survival for the past 20 years has resulted in a significant population decline in many herds of this valuable game species. The North Kings deer herd, considered representative of many of these herds has declined approximately 70 percent since 1953. In response to the attitudes of local sportsmen, and because of its geographical location and size, the North Kings deer herd was chosen for a 10-year pilot study, the North Kings Deer Herd Project. This project was initiated to determine the factors responsible for the decrease in fawn survival and the effects of various management techniques on a migratory deer herd.

Previous work by Salwasser (1974) had shown that the reproductive potential of the North Kings deer herd averaged 135 fawns per 100 does at parturition;

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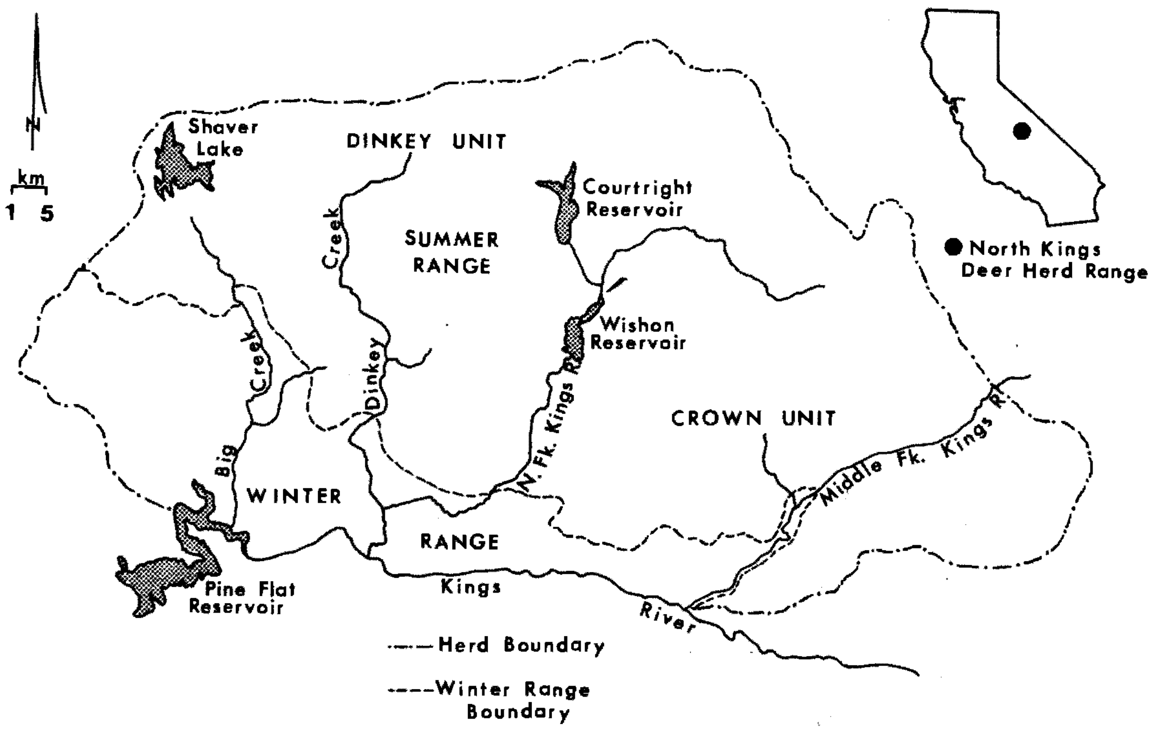


Fig. 1. Range of the North Kings deer herd, Fresno County, California.

however, there was a 50 percent neonatal loss. The neonatal loss had been hypothesized to be largely due to an acute nutritional stress placed on the does during the spring migration, resulting in the retardation of fetal growth rates during the last trimester of pregnancy. Many of the fawns were then born weak or small, and incapable of surviving the first few days of life. The objective of the present study was to re-examine the hypothesis and determine if a relationship could be shown between the physical condition of a doe, fetal growth, and fawn mortality.

Financial support for this study was provided in part by the California Department of Fish and Game (P-R Proj. W-51-R). I would like to offer special thanks to Gordon Ashcraft, of CDFG, who directed various aspects of the study and provided me with the opportunity to work on the North Kings Deer Herd Project. Thanks are also extended to R. Bertram, W. Stewart, and R. Remple of Region IV, CDFG, for the collection of deer and herd composition counts. I would also like to offer special thanks to David Chesemore, my major professor at California State University, Fresno, who offered valuable advice throughout the study.

## The Study Area

The North Kings deer herd lies entirely within Fresno County, California, northeast of the city of Fresno. It encompasses approximately 300 $km^2$ of the Kings River Watershed. Approximately 90 percent of the range is administered by the U.S. National Park Service and the U.S. Forest Service. The herd is divided into two management subunits, the Dinkey and Crown subunits, with the two separated by the North Fork of the Kings River (Fig. 1).

The herd is present on the winter range from about mid-November to late April. Elevations on the winter range vary from approximately 340 m to 1,370 m. The topography is characterized by steep, heavily wooded slopes, interrupted by occasional open benches of annual grasses and forbs. The vegetation is characteristic of the Foothill Woodland and Chaparral communities as described by Munz (1959). The upper reaches of the winter range may extend into the lower limits of the Yellow Pine community.

Elevations on the summer range vary from approximately 1,370 m to 3,040 m. The deer are normally present from late May to early November. The topography is generally moderate; however, rugged peaks approaching 4,000 m are present. The vegetation is characteristic of the Yellow Pine community at the lower elevations and extends up through the Red Fir, Lodgepole Pine, and Subalpine communities. Numerous meadow complexes are present within all plant communities on the summer range.

## METHODS

Four collections of does were conducted annually in 1974 and 1975 at 3 to 4 week intervals beginning in late March and terminating in mid-June. Two collections were made on the winter range and two on the summer range. The exact timing of each collection was determined by weekly monitoring of the movements of radio-collared does. On the winter range, deer were collected from all elevations, while on the summer range the does were generally collected from between 1,825 m and 2,290 m. Does were normally collected with a rifle; however, when possible, does that died in traps were necropsied.

Following the collection, all animals were transported to a field camp where the necropsy was performed. The animals were weighed to the nearest kg, on a spring scale, and standard museum measurements, including the chest girth, were taken to the nearest cm with a steel tape. All adult animals were aged according to tooth replacement and molariform wear, comparing them to known-aged jaws previously collected from the North Kings deer herd by CDFG.

Depot fat deposits were used as indicators of physical condition. The kidney fat index (KFI), as developed by Riney (1955), was calculated as 100 times the weight of the fat surrounding both kidneys, divided by the fat-free weight of the kidneys. Additionally, the body fat index (BFI), developed by Bischoff (1954) was also used. For this index, the amounts of fat on the ribs, brisket, rump, kidneys, mesentery, and heart were subjectively given a rating of none, light, moderate, or heavy, assigning 0, 1, 2, or 3 points, respectively. The BFI is then the sum of these 6 ratings. Therefore, as an index of physical condition, 18 would be considered excellent, 12 good, and below 6 poor.

The intact uterus was removed from each animal and weighed on a balance to the nearest g. The umbilical chord of each fetus was ligated and severed, and the fetus removed from the uterus and weighed to the nearest g. Measurements in mm of the right hindfoot length, body contour length, chest girth, ear and tail lengths were also recorded. The eye lenses were removed from each fetus, fixed in 10 percent formalin, and later dried at 90 C until there were no further changes in weight, and weighed to the nearest mg. All fetal ages were assigned in days, using the hindfoot length growth curve developed by Salwasser (1974). In the case of multiple fetuses, the average age of the fetuses was recorded. A 203 day gestation period was assumed for all litters (Robinette et al. 1973).

Previous work, relating the physical condition of a doe, fetal growth, and fawn survival has shown that fetal weight gains and subsequent fawn survival is dependent on the doe's nutritional plane during pregnancy. This work has also shown that birth weights of fawns from multiple litters often vary appreciably (Verme 1963). The criteria for fetal condition in the present study were based on the rates of fetal weight gain, a comprehensive measurement of growth, and the percentage difference between fetal weights of twins.

Fawn mortality on the summer range was estimated by herd composition counts conducted by CDFG personnel in October, prior to the fall migration.

Statistical analysis of the physical condition indices was performed using two-tailed Kruskal-Wallis and Mann-Whitney nonparametric tests (Sokal and Rohlf 1969). Regression and correlation analysis were used to determine the growth rates of the fetuses. The line of best fit was determined by least squares analysis.

Additional data obtained in this study have been published previously by Holl (1976).

## RESULTS

During the 2 year study, a total of 46 does was collected and 78 fetuses obtained from the North Kings deer herd. Nineteen does in 1974 and 19 in 1975 were collected from the Dinkey subunit, an additional 8 were collected from the Crown subunit in 1975. Thirty fetuses were obtained in 1974 and 48 in 1975.

In late March, 1974, the BFI and KFI indicated that the does were in good physical condition (Fig. 2). In late April the BFI and KFI increased to 15.7 ± 2.1 and 71.9 ± 18.6 percent respectively, when the does were at their optimum physical condition. The KFI, as represented, is too high for the month of April, due to the insufficient removal of perinephric fat prior to weighing. By late May, after the does arrival on the summer range, there had been a significant change ($P<.05$) in both the BFI (6.0 ± 2.6) and the KFI (14.5 ± 8.2). This change indicated that the does were in poor physical condition. By the middle of June, after being on the summer range approximately 3 to 4 weeks, there was a further drop in the physical condition indices.

The depot fat indices of the does collected from the Crown subunit in 1975 were not significantly different ($P > .1$) from those of the Dinkey subunit; therefore, the data were pooled.

In late March, 1975, the physical condition indices of the does indicated that they were in good physical condition. In late April, contrary to 1974, the physical condition of the does had decreased slightly (BFI, 10.1 ± 4.3; KFI, 29.8 ± 22.5). Immediately following the does arrival on the summer range the BFI (10.2 ± 4.6) and KFI (27.4 ± 22.3) had changed only slightly from the previous months levels. By mid-June, after being on the summer range for 2 to 3 weeks, the physical condition indices of the does had increased.

The hindfoot length measurement was used as the determinant of fetal age and the strongest correlations (>.900) with this were contour length (.985), eye-lens weight (.972), and body weight (.941).

The equations for these measurements, where X equals fetal age in days, are given in Table 1. There were no significant differences ($P > .05$) between years for these growth rates; therefore, the data were pooled for both years. Contour length and eye-lens weight followed linear patterns similar to that of the hindfoot length. Body weight followed a nonlinear curve, where the greatest rate of growth was during the last trimester of pregnancy (Fig. 3).

The growth rate for the linear measurements was constant, at least during the last two-thirds of gestation. The growth rate for body weight changed during the last 2 trimesters. The calculated growth rate was 12.4 g/day during the second trimester and 40.9 g/day during the final trimester of gestation. The estimated mean term weight (203 days) for all fetuses was 3.69 kg. The mean weight of 3 sets of twins, 1 to 3 days old, captured in 1975, was 3.07 ± .17 kg. This was 6 percent of the estimated body weight of an adult nonpregnant doe from this herd.

Table 2 presents the mean and standard deviation for the percentage difference in weight for twin fetuses for each collection period. This calculation allows for an estimate, on a percentage basis, of how much larger one fetus was than its litter mate at each collection period, regardless of age.

The data for both years followed similar patterns. Prior to the spring migration there was a slight difference between the weights of litter mates. In 1974, following the spring migration, the size differential more than doubled. In 1975 it increased more than 50 percent. In mid-June the size differential decreased to almost the identical level in both years. The mean percentage weight difference for 3 sets of twins, 1 to 3 days old, captured in 1975 was 7.7 ± 5.5 percent.

In 1974, estimates of fawn mortality, based on herd composition counts in the Dinkey subunit prior to the fall migration was 39 percent. In 1975, fawn mortality on the summer range was estimated to be 55 percent.

## DISCUSSION

In March and April of 1974 and 1975, the does were in better physical condition than that reported by Salwasser (1974), for a comparable period. I believe the improvements in physical condition were the result of an increased annual rainfall, over previous years, increasing the quantity and/or quality of the forage available on the winter range.

In 1974, following the spring migration, the physical condition indices were similar to those reported by Salwasser (1974). In 1975, the lack of a significant change in the physical condition indices may have been associated with the shorter amount of time that the deer spent on the migration corridors. Deer normally spend 4 to 7 weeks migrating from the winter to the

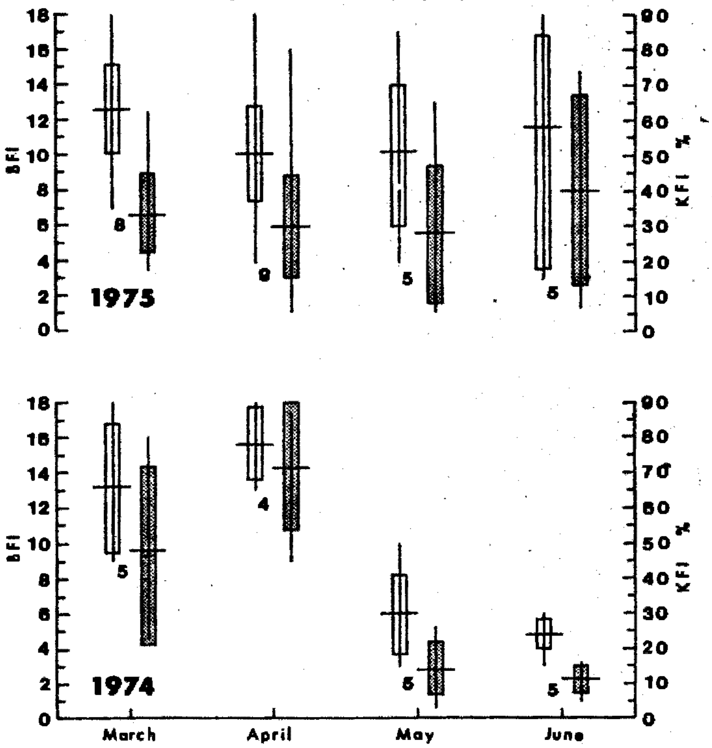


Fig. 2. Mean, range, and 95 percent confidence limits for the body fat indices (open) and kidney fat indices (stipled) of does collected from the North Kings deer herd, 1974 and 1975. Sample size indicated below the body fat index.

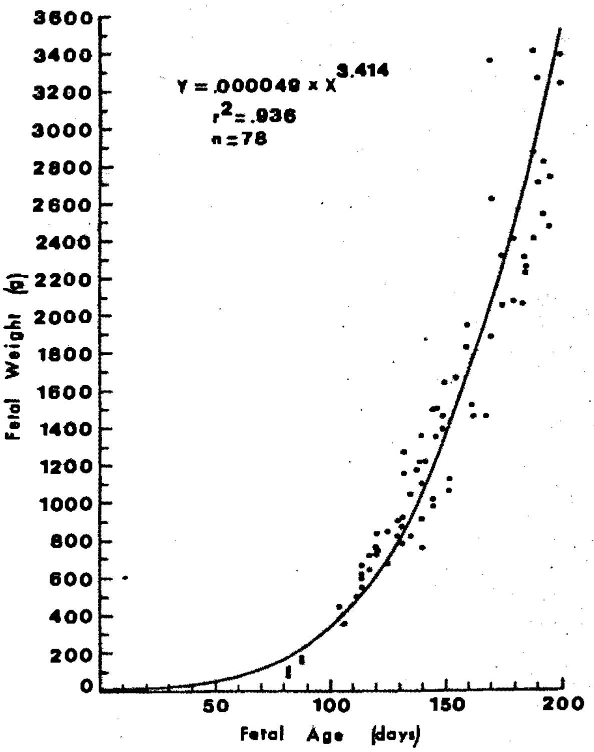


Fig. 3. Fetal growth curve for mule deer fawns obtained from the North Kings deer herd, 1974 and 1975.

summer range (R. Bertram, personal communication). In 1975 the spring migration lasted 2 to 3 weeks for most of the deer. Therefore, the change in physical condition which has been hypothesized to be related to migration was minimized in 1975 when the stressful period was decreased by approximately one-half.

The physical condition of a deer, as determined by the use of body fat and kidney fat indices, indicates short-term changes in food supply and hormonal balance (Caughley 1972). There may be additional effects on an animal's physical condition, related to the increased energy demands of pregnancy, lactation, and migration. However, since the collections were made during similar chronological periods, the associated physiological changes may be considered constant.

In the present study, the does were in their poorest physical condition 2 to 4 weeks prior to parturition. Recent works, dealing with depot fat indices and weight relationships in wild and pen-raised large ungulates (Wood et al. 1962, McEwan 1968, Bandy et al. 1970, Caughley 1970, 1972, Anderson et al. 1972, 1974, Dauphine 1976) have shown that these measurements follow a predictable annual cycle. In each of these studies, the does examined have been at their maximum weight and optimal physical condition just prior to the rut, and in their poorest physical condition just prior to parturition. The apparent proximate control of these annual changes has been hypothesized to be physiological rather than environmental. Therefore, although the magnitude of the change in physical condition associated with migration may be influenced by food availability and the amount of time spent in migration, the cause of the change in physical condition should not be attributed entirely to a nutritional stress.

Murphy and Coates (1966) showed that neonatal mortality in white-tailed deer (Odocoileus virginianus) is increased when the nutritional plane of the doe is reduced during pregnancy. Verme (1963) has shown that near the beginning of the last trimester of gestation, inadequate nutrition begins to retard fetal growth, thus increasing neonatal mortality. Results of the present study showed that although the pattern for the physical condition indices of does during the later stages of pregnancy differed between years, there were no significant differences in fetal growth rates, and estimates of fawn mortality were 22 percent higher in 1975 when the does had maintained their physical condition.

While the fitted growth curve for fetal mass removed 93 to 94 percent of the variability, the estimated term weight for all fetuses was approximately 18 percent heavier than that of the observed weights. However, equations of this type often tend to over-estimate the term weight because of an apparent slowing of the total growth rate prior to parturition (Rattray et al. 1974, (Robbins and Moen 1975).

Cowan and Wood (1955) noted that fawn birth weights averaged 5 percent of the body weight of pen-raised, nonpregnant does. Live weights of fawns, 1 to 3 days old, in this study were 6 percent of the estimated weight of an adult nonpregnant doe. Mankins (1956) reported that the mean weight of fawns, 1 to 3 days old, from the Barton's Flat deer herd, south of the North Kings was 3.3 kg (n = 11). This was slightly heavier than that recorded for 3 sets of twins captured in 1975 from the North Kings deer herd.

Although the change in physical condition seen in the does differed between years, the percentage difference in weight between twin fetuses followed similar patterns each year. For each year, whether or not there was a significant drop in the does physical condition following the spring migration, the difference between twin fetal weights increased. After the does had been on the summer range for a few weeks, the differential in fetal weight decreased to almost the same level each year, even though the responses of the does physical condition differed. Therefore, the patterns of differences between twin fetal weights appeared to remain constant, regardless of the does physical condition. Although the mechanism of this is unknown, it suggests a differential growth rate of twin fetuses during the last trimester of pregnancy.

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TABLE 1. Growth equations for selected measurements from fetuses obtained from the North Kings deer herd, 1974 and 1975. X equals age in days, N equals 78.

| Measurement | Equation | Correlation Coefficient |
|---|---|---|
| Contour length (mm) | $Y = -32.69 + 3.32X$ | .97 |
| Eye lens weight (mg) | $Y = -50.51 + .915X$ | .97 |
| Body weight (g) | $Y = .000049 \times X^{3.414}$ | .96 |

TABLE 2. Mean ± S.D. for the percent difference between twin fetal weights for each collection period for fetuses obtained from the North Kings deer herd, 1974 and 1975 (N in parenthesis).

| | Late April | Late May Early June | Mid-June |
|---|---|---|---|
| 1974 | 6.6 ± 2.7 (2) | 15.4 ± 9.7 (4) | 8.6 ± 2.8 (4) |
| 1975 | 10.0 ± 4.2 (6) | 17.7 ± 10.5 (3) | 8.4 ± 7.1 (4) |