HISTORIC SURVIVAL RATES AND CAUSE-SPECIFIC MORTALITY FOR COLUMBIAN BLACK-TAILED DEER IN SOUTHWEST OREGON

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In contrast with other *Odocoileus* species, Columbian black-tailed deer (*Odocoileus hemionus columbianus*) population dynamics are not well understood throughout the species' range. Concerns over apparent long-term population declines have prompted efforts to fill basic knowledge gaps including estimates of vital rates (fecundity, recruitment and survival) and cause-specific mortality. The Oregon Department of Fish and Wildlife completed an extensive Columbian black-tailed (black-tailed) deer radio-collaring study in Oregon's south Cascade range from 1994 – 2000, with the goal of better understanding and anticipating the effects of different harvest management strategies on deer herds in the region. I utilized this historical data to conduct an in-depth investigation of seasonal sex- and age-specific survival rates and cause-specific mortality rates for marked black-tailed deer, using modern analytical techniques.

I used known-fate data for 293 male and female radio-collared black-tailed of 3 age classes (yearling, 2-year old, adult) to estimate seasonal survival and investigate a variety of factors including sex, age class, temporal effects (seasonal, annual and trends across season and year), and time-dependent large-scale regional climate covariates. Variation in survival rates for this population was best explained by an interaction between sex and age class, with decreased probability of survival with increasing age class. This effect was most pronounced in males, and while yearling males had higher survival rates than yearling females, female survival in the older age classes was higher than male survival as predicted. There was strong support for temporal variation in survival between summer and winter seasons, with winter survival best modeled as constant across years and summer survival variable across years. Winter survival was generally higher than summer except in 1997 when winter and summer rates were similar. Despite annual variation in summer survival rates, large-scale climate indices (SOI, PDO, and PDSI) did not explain any temporal variation in survival rates within seasons. Low survival rates during the summer season, particularly for older males, resulted in low estimates of annual survival in some years. Estimates for males ranged from 0.47 – 0.76 for yearlings, 0.29 – 0.60 for 2-year olds and 0.14 – 0.40 for adults across the 6 years of this study. Annual estimates for females were generally higher than for males but were some of the lowest documented for the species, ranging from 0.47 – 0.76 for yearlings, 0.46 – 0.75 for 2-year olds and 0.44 – 0.74 for adults.

I used the Nonparametric Cumulative Incidence Function Estimator (NPCIFE) to generate annual and seasonal cumulative incidence functions for four competing risks: harvest, predation, other low-incidence sources of anthropogenic or natural mortality, and unknown source. Annual and seasonal risk functions were pooled across all years of the study to maximize sample size. As predicted in this system with little antlerless harvest, cumulative risk of harvest across the entire annual cycle (365 days) was significantly higher for males (0.16, 95% CI = 0.11 – 0.21); a 16% annual cumulative risk compared to just 3% for females (0.03, 95% CI = 0.01 – 0.05). In addition, cause-specific mortality by male age class during the period of highest hunting pressure (general Cascade rifle season) suggested that 2-year-old

males had over twice the cumulative risk of legal harvest with 22% of this age class killed by hunters during the general rifle season (0.22, 95% CI = 0.12 – 0.33) compared to 10% of adults (0.10, 95% CI = 0.04 – 0.15). Most yearling males survived the harvest season as cumulative legal harvest risk for yearling males was low (0.02, 95% CI = -0.01 – 0.06) relative to 2-year-olds and adults. Cougars were the primary predator of marked black-tailed deer and there was no significant difference in annual cumulative predation risk between the sexes (males: 0.05, 95% CI = 0.02 – 0.08; females: 0.05, 95% CI = 0.03 – 0.08), with only 5% risk of predation each year for both males and females. There was strong evidence that cumulative predation risk for females was higher in winter (0.04, 95% CI = 0.02 – 0.06) compared to summer (0.01, 95% CI = -0.002 – 0.02), and an increase in cumulative risk from February to May provides supportive evidence that females are more susceptible to predation during these months.

High survival rates of yearling males with dramatic declines in survival once many of these deer became 2-year olds or older suggest that hunting pressure may have had an additive effect and been the primary cause of low survival rates observed for males. Observed variability in summer survival resulted in variable, and in some years very low, annual survival rates for adult females; a strong contrast to the generally stable annual survival rates reported for other populations of mule deer. The highest estimates of annual survival for yearling males and for females of all age classes (0.74) in 1997 are comparable to the low range of estimates observed in other populations, but in other years estimates are much lower than what has been previously reported for black-tailed deer. These low survival rates might suggest a mechanism resulting in population decline over time, but more information on other vital rates (fecundity, fawn survival, and recruitment), carrying capacity of the system and population size is necessary to understand the population dynamics of black-tailed deer in this region during the 1990's.

Properties of the data relative to male age classes in particular (low sample sizes, high censoring rates) decreased precision of these estimates and might have resulted in biased estimates. Adult females had consistently sufficient sample sizes over the course of the study to generate more precise, reliable estimates of survival, particularly in the latter 3 years of the study; these estimates should therefore be viewed with more confidence. Cause-specific mortality rates should be viewed as minimums due to the high number of unknown mortalities (40% of total) in the study population, but they suggest that hunting is the primary source of mortality for adult males and predation has the highest impact on seasonal female mortality rates as predicted. Given the historical nature of these results, my estimates should be used as a baseline and foundation for comparison with results from current black-tailed deer research in Oregon. These results have raised potential questions regarding harvest levels on male black-tailed deer in addition to possible resource constraints affecting both sexes on seasonal ranges, and can therefore focus new research to address these concerns.