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Raccoon (*Procyon lotor*) Survival in West-Central Illinois

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ABSTRACT

Raccoons (*Procyon lotor*) were livecaptured (n = 347) during 1989-93 on an area open to hunting and trapping in west-central Illinois to determine the effects of harvest, body condition, breeding condition and exposure to disease on survival. Survival was determined from radiotelemetry (n = 45) and analyzed using Kaplan-Meier survival estimates (S = 0.74). Human-related activities accounted for 81% of mortality (68% from harvest and 13% from vehicles) on the study area. Age groups were similar in susceptibility to harvest. Survival curves were not different between male and female raccoons. Adult female raccoons had a higher condition index than female juveniles or yearlings ($P < 0.001$). Body condition index was not related to survival or a cause of death in either males or females. Eighty-five percent of adult and 50% of yearling female raccoons bred during the year they were captured. Of 229 raccoons tested for exposure to diseases, 73% tested seropositive for at least one of the following: distemper (28%), leptospira (50%), toxoplasma (57%) and pseudorabies virus (22%). We found no difference in survival between raccoons testing positive and those testing negative for at least one disease. Mortality on the study area was primarily related to human, not physiological factors, such as body condition, disease, or breeding condition.

INTRODUCTION

Raccoons are abundant in Illinois, in part, because of omnivorous food habits, willingness to make a den in almost any natural or artificial cavity and an adaptability to urban conditions (Hoffmeister 1989). Because of the prevalence of legal harvesting of raccoons, many studies of mortality concentrated on harvested populations (Glueck et al. 1988, Clark et al. 1989, Brown et al. 1990, Hasbrouck et al. 1992, Rolley and Lehman 1992).

Several factors have been related to mortality in raccoons, including hunting, trapping, vehicle collisions and disease (Glueck et al. 1988, Clark et al. 1989, Brown et al. 1990, Hasbrouck et al. 1992, Rolley and Lehman 1992). In addition to population management issues, concern over the raccoon as a vector for disease transmission has increased as more humans, pets and livestock come into contact with abundant raccoon populations (Brown et al. 1990, Fischman et al. 1992, Torrence et al. 1992, Hill et al. 1993, Roscoe 1993).

Hasbrouck et al. (1992) reported differential mortality between sexes of adult raccoons and among age groups. Juvenile survival is important in the demography of raccoon populations (Sanderson and Hubert 1981, Hasbrouck et al. 1992, Judson et al. 1994). Juvenile raccoons could suffer higher mortality due to increased movements during that period of life (Hasbrouck et al. 1992). Johnson (1970) noted that the highest mortality in Alabama raccoons was during the first 2 years of life.

Factors which reduce longevity will, in turn, affect the reproductive capacity and, therefore, population density. In addition to reproductive costs in relation to pregnancy and lactation (Millar 1975, Millar 1977, Gittleman and Thompson 1988, Oftedal and Gittleman 1989), breeding condition and corresponding behavior of female raccoons could increase their vulnerability to various causes of mortality.

We studied raccoon survival in a population open to hunting and trapping. The objectives of the study were to determine the survival rates (based on radiotelemetry) of raccoons and identify sources of mortality for harvested populations. We also analyzed raccoon survival as influenced by disease, body condition and female breeding status.

METHODS

Raccoons were live-captured between fall 1989 and fall 1993 on a 2,310 ha area in Brown County, west-central Illinois. The study area consisted of row crops (mainly corn and soybeans) (59%), pasture (15%), shrub and cut-over forest (25%) and a few small ponds (<1%). The study area was open to hunting and trapping each fall. Minimum raccoon density on the area was estimated at 4.5 raccoons/km^2 (Nixon et al. 1995).

A total of 347 raccoons were live-trapped during April-June and August-November each year. Live-traps were baited with an egg and sardines and opened for 10 to 30 days on each site per season. Raccoons were sedated using Ketaset or Telozol, sexed, weighed and field aged, examined for external parasites, bled using heart puncture (5-10 ml) and measured for length. A fecal sample was taken and a premolar extracted for aging using tooth cementum annuli (Grau et al. 1970). Raccoons were eartagged and released at the trap site. Raccoons < 12 months of age were considered juveniles, those 12 to 23 months old were classified as yearlings, and raccoons ≥ 2 years of age were considered adults. Breeding status of females was classified as breeding (nursing or pregnant) or not breeding.

Radio transmitters equipped with a mortality-sensitive switch were placed on 21 male and 24 female raccoons, including 17 adults, 13 yearlings, and 15 juveniles. Radiocollared raccoons were located at least once a week throughout the study using two truck-mounted 8-element yagi antennas aligned in a null configuration.

Blood samples were taken from all raccoons examined (n = 347) to detect the exposure of the animals to specific diseases, including canine distemper virus, leptospira *(Leptospira* sp.), toxoplasma (*Toxoplasma gondii*) and pseudorabies virus (suid herpes virus 1). Sera were separated and immediately frozen. Tests for leptospira antibodies and pseudorabies virus was performed at the University of Illinois College of Veterinary Medicine, Urbana, Illinois. Canine distemper testing was conducted at the New York State Animal Diagnostic Laboratory, Ithica, New York, and toxoplasma testing was performed at the USDA laboratory in Bethesda, Maryland (Nixon et al. 1995).

We calculated a condition index for each raccoon during each trapping period using the formula body mass/(body length)^3 x 100,000 after Hasbrouck et al. (1992). For survival analyses, physical condition was classified as either above or below the median of the condition index for each age group of radio-collared raccoons. All other associations with body condition (sex, female breeding status) used all live-trapped animals for which body length and weight also were available. Dead raccoons were necropsied on site or at the University of Illinois School of Veterinary Medicine to determine cause of death.

The survival analysis, using only radio-collared raccoons, was calculated using the staggered-entry design of the Kaplan-Meier product limit estimator (Kaplan and Meier 1958, Pollock et al. 1989) and the log-rank test for homogeneity between groups. To calculate age specific mortality and the average expected years of life upon reaching a given age, we constructed a life table using the cohort born in 1990 for which we had the most data (Begon and Mortimer 1986, Downing 1980). Only those raccoons captured or known to be alive at the beginning of each year were used in the life table analysis.

Analysis of variance was used to compare condition indices between sexes, age groups, and years for all live-trapped raccoons. Chi-square tests were used to separately analyze each variable (disease, cause of death and breeding status).

RESULTS

Of 347 raccoons (138 females and 209 males) captured during this study, 117 were juveniles, 115 were yearlings, and 115 were adults when first captured. The ultimate fate was known for 80% of radio-collared raccoons (20% had a lost signal, battery died, etc.) and 31% of non-radioed raccoons (69% were never captured or reported again).

Survival

There was no difference in Kaplan-Meier survival distributions between yearling and adult radio-collared raccoons ($X^2 = 0.04$, df = 1, P = 0.86). Mean annual survival (SE) for the combined yearling and adult radio-collared raccoons was 0.74 ± 0.07 SE. There was no significant difference in survival between males and females ($X^2 = 0.22$, df = 1, P = 0.67) (Fig.1). Survival estimates were not calculated for juvenile raccoons since the spring trapping session did not sample the very young, and those not surviving to the fall trapping session were unavailable for capture.

Fourteen (31%) of radio-collared raccoons and 70 (23%) of non-radioed raccoons were taken by hunters or trappers. The 14 radio-collared raccoons which were harvested (hunted or trapped) during the study consisted of 6 females and 8 males, of which 2 were shot out of season. For radio-collared and non-radioed raccoons combined, harvest mortality accounted for 74% of all known deaths of non-radioed raccoons and 48% of radio-collared (Table 1). Susceptibility to harvest was similar ($X^2 = 0.51$, df = 2, $P = 0.78$) between age groups for radioed and non-radioed raccoons.

Based on tooth age, the maximum age for females was 9 years old ($\bar{x} = 4.0$ years ± 1.6 SD, n = 50) and 7 years old for males ($\bar{x} = 3.3$ years ± 1.4 SD, n = 65). At the time of capture, only 5% of all raccoons were ≥ 4 years of age. Of the 6 causes of death recorded on the study area (Table 1), hunted raccoons had the lowest average age (2.0 years ± 1.41 SD). The mean age for all raccoons (n = 124) which were known to have died during the study period (Table 1) was 2.4 years ± 1.66 SD.

<u>Disease</u>

Of 229 raccoons tested for exposure to one or more of 4 diseases, 168 (73%) tested positive for at least one disease. Twenty-eight percent of those tested for distemper were seropositive, 50% for leptospira, 57% for toxoplasma and 22% for pseudorabies virus. Forty-one percent (n = 93) of tested raccoons showed exposure to 2 or more diseases. The mean age of raccoons (both sexes) killed by disease (Table 1) was 3.0 years (n = 15). For radio-collared raccoons, we found no difference in survival distributions between raccoons testing positive and those testing negative for at least one disease ($X^2 = 0.90$, df = 1, $P = 0.37$).

Of the 168 raccoons tested positive for at least one disease at the time of capture, 51 died from various causes, including disease, and were later recovered. Thirty-four of the 51 were killed by hunters or trappers, 8 were killed by vehicles, 6 died from disease, 2 were killed by dogs and one died from an unknown cause. An additional 9 raccoons died from disease, of which 4 tested negative at the time of capture and 5 were not tested for disease exposure (Table 1).

<u>Body condition</u>

Survival of radio-collared raccoons was not related to body condition index ($X^2 = 0.57$, df = 1, $P = 0.47$). For radioed and non-radioed raccoons combined, body condition did not differ among years within any age group ($F = 0.92$; df = 7, 240; $P = 0.49$). There were no significant differences in condition indices between male and female raccoons within any age group ($F = 1.61$; df = 4, 243; $P = 0.17$). Monthly condition indices of females were similar ($F = 0.97$; df = 6, 62; $P = 0.45$), while condition indices of males increased from April through November ($F = 4.84$; df = 6, 88; $P < 0.001$) (Fig. 2). Adult female raccoons had a higher mean condition index than female yearlings or juveniles ($F = 4.81$; df = 2, 102; $P = 0.01$). Regardless of age or sex, body condition was not different among causes of death in raccoons ($F = 0.19$; df = 5, 79; $P = 0.97$). Condition indices were similar between animals which tested positive or negative for exposure to disease ($t = -0.18$, df = 224, $P = 0.86$).

Female breeding

Yearling female breeding averaged 46% for 1990-1993 and adults averaged 87% breeding. Sample sizes were too small to detect a difference in survival based on breeding status. Female breeding status was not related to body condition (t = 0.49, df = 73, P = 0.62).

DISCUSSION

As in other studies (Johnson 1970, Kaufmann 1982, Hasbrouck et al. 1992), human activities were the primary cause of mortality in raccoons in the west-central Illinois study area. Human-related mortality (harvest and roadkills) accounted for 81% of deaths, similar to the 88% of all deaths reported for Iowa raccoons (Clark et al. 1989). The annual survival rate for raccoons at least one year old (0.74) was higher compared to yearling (0.51) and adult (0.53) raccoons in Iowa (Hasbrouck et al. 1992). The lower survival in Iowa might be accounted for by the increased harvest rate imposed as part of their study.

Juvenile vulnerability to harvest has been noted for various furbearers (Pils et al. 1981, Payne 1984, Clark et al. 1989). Sanderson and Hubert (1981) reported that juveniles made up 68% of harvested raccoons in Illinois, but in our study, juveniles accounted for only 30% of those harvested.

Female raccoons have been shown to have smaller home ranges than males (Fritzell 1978). Nixon et al. (1995) reported that breeding females reduced the range of their daily movements, remaining closer to the natal den in spring and summer. Restricting their movements could reduce the female's chance of being killed by a vehicle, or encountering a predator, hunter or trap (Kaufmann 1982, Hasbrouck et al. 1992). We did not find a difference in survival between sexes, possibly due to small sample sizes.

Although adult female raccoons had a higher condition index than younger females, it did not appear to be related to breeding success. Female breeding rates, based on breeding status at the time of capture, were similar to those reported by Fritzell et al. (1985) for Illinois and Missouri and by Clark et al. (1989) in Iowa.

Certain diseases are more likely to affect survival than others, but our analysis was unable to partition the cumulative effect of chronic disease exposure on the survival risk of individual raccoons. Leptospira do not usually kill their host outright, but may result in a chronic long-term health risk (Shotts 1981). The data suggest that disease did not influence survival given that only 4% of those testing positive to chronic disease exposure had later died from disease. Even if we assume that the seropositive animals would eventually die from disease, most individuals lived long enough to produce offspring for several years, as indicated by the breeding rate and high average age of females. In addition, we found no significant relationship between a condition index and subsequent survival of raccoons. Hasbrouck (et al. 1992) also found no relationship between survival and condition in Iowa raccoons.

Our study, and others, show that raccoons are vulnerable to a wide array of hazards of which have variable impact on survival. Hunting and trapping were the major causes of mortality in this study. The annual survival of raccoons will not likely be the result of one factor alone, but rather a combination of different environmental conditions and behavioral components (Kaufmann 1982, Sanderson 1987).

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Table 1. Mean age at time of death by cause of death for raccoons in west-central Illinois 1989-93.

Cause	Mean	SD	N
Dog	4.2[a]	1.93	5
Disease	3.0	1.27	15
Road	2.7	2.20	17
Trapping	2.7	1.80	24
Misc[b]	2.6	0.54	3
Hunting	2.0	1.41	60
Total	2.4	1.66	124

[a] Significantly different from other causes ($P < 0.05$)
[b] 1 poisoned, 1 electrocuted and 1 unknown cause

Figure 1. Kaplan-Meier survival curves of radio-collared male (N = 21) and female (N = 24) raccoons in west-central Illinois 1989-93.

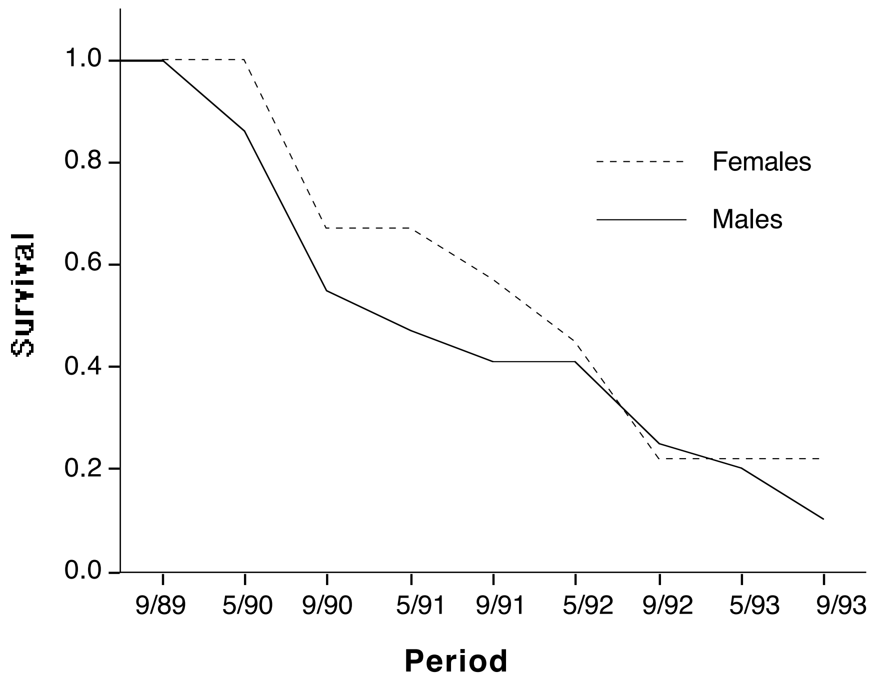

Figure 2. Mean monthly condition indices ((body mass/body length^3) x 100,000) for after-birth-year male (N = 95) and female (N = 69) raccoons in west-central Illinois 1989-93.