Transactions of the Illinois State Academy of Science
(1995), Volume 88, 1 and 2, pp. 49-59

Some Aspects of Raccoon Life History in Lee County, Illinois

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ABSTRACT

Raccoons (*Procyon lotor*) were livetrapped and marked during summers 1990-1993, in mixed wetland, forest, and agricultural habitats on 2 sites, the 656-ha Richardson Wildlife Foundation (RWF) and the 297-ha Amboy area (AA) in Lee County, northcentral Illinois. Males predominated in captures of juveniles through 2 years of age, but females dominated older age classes. Estimated fall densities ranged from 7.5 to 18 raccoons per 100 ha. Yearling female breeding rates averaged 40% (range 25-50%); older females averaged 83% (range 50-100%). The age structure of females indicated that yearling breeding contributed only about 20% of the production of young on both study areas. Annual recovery rates (sum of death and dispersal) for sexes combined were 0.57 and 0.18 for juveniles and 0.61 and 0.66 for adults on the RWF during 1990-1991 and 1991-1992, respectively. For AA raccoons, adult recovery rates were 0.64 for 1990-1991; for juveniles, they were 0.53 and 0.42 for 1990-1991 and 1991-1992, respectively. During the growing season, raccoons were most abundant in water associated habitats. They avoided grasslands, restored and native prairies as well as corn and soybean fields. Current exploitation levels on both study areas were below the threshold of sustainability postulated for raccoons in the Midwest and raccoon numbers increased during our study. Low pelt prices have reduced human exploitation, and annual postweaning survival exceeded 60% during our study.

INTRODUCTION

There have been few studies of raccoon populations in Illinois. Sanderson and Hubert (1981) reported on the demographic characteristics of raccoons harvested by hunters and trappers in Illinois. They found that sex ratios of harvested raccoons favored males, that juveniles made up about two-thirds of the harvest, and that parous females averaged about 3.5 young per litter. Based on these data collected over 25 years (1955-1980), they concluded there had been little demographic change in the raccoon population in Illinois during that interval. Ellis (1964) used radio tracking to investigate home range and movements of 7 raccoons in east-central Illinois woodlots. Home ranges averaged 55 ha in a 600 ha woodlot and 68 ha in a 24 ha woodlot.

We studied raccoon population dynamics and summer habitat selection of raccoons from the fall of 1990 until the early fall of 1993 using livetrapping on 2 sites in Lee County, Illinois. Our objectives were to (1) investigate current raccoon exploitation rates in northern Illinois and; (2) contribute to life history data base of raccoons in Illinois.

METHODS

Both study areas were privately owned. The 656-ha Richardson Wildlife Foundation (RWF) was a refuge from hunting, but 1 person trapped in 1992 and 1993. Habitat composition on the RWF was 60% cropland (corn, soybeans, sunflowers, forage crops), 16% restored prairie, 13% early successional woodland, 10% wetland, and 2% miscellaneous cover (buildings, roads, etc.). The 297-ha Amboy Area (AA), open each year to both hunting and trapping, was comprised of 51% woodland, 24% pasture, 12% cropland, 6% wetland, 5% miscellaneous cover, and 2% restored prairie.

Raccoons were livetrapped during 2- to 3-week periods on each study area during August-October 1990 and June-September 1991-1993. We also livetrapped for 8-day periods in March 1992 and 1993 on the RWF. Traps were set throughout each site in habitats likely to harbor raccoons during 1990 and 1991 at densities of 1 trap per 25 ha (RWF) and 1 trap per 10 ha (AA). In 1992 and 1993 traps were set in proportion to the available habitat at densities of 1 trap per 14 ha (RWF) and 1 per 10 ha (AA). Captured raccoons were weighed to the nearest 0.1 kg and immobilized using ketamine hydochloride (100 mg/ml, 0.1 cc per 0.45 kg of body weight). Raccoons were then sexed, examined for external parasites and injuries, examined for breeding activity (females pregnant or lactating, males if penis extrusible [Sanderson 1961]), ear tagged with serial-numbered plastic tags, and released after recovery at the trap site. A lower first premolar was extracted from all raccoons ≥1 year for aging using tooth cementum (Grau et al. 1970).

We estimated raccoon numbers each year using the software package CAPTURE (Rexstad and Burnham 1991). Because we made only a few recaptures each trapping period, we used estimators that assume capture probabilities vary by behavioral response to capture (Mb) and by individual animal as well as behavioral response to capture (Mbh). These estimators use the number of unmarked animals captured and do not require large numbers of recaptures to compute a population estimate (Rexstad and Burnham 1991).

We attempted to simulate the effect of fall harvests of males on the subsequent population dynamics of raccoons by removing captured yearling and adult males from the RWF in fall 1990 (N = 7), 1991 (N = 3), and 1992 (N = 14). These males were transported 33 km away to the Green River Conservation area and immediately released.

Raccoon captures were compared among sexes, ages, areas, and years using a contingency table analysis and likelihood ratio chi-square tests assuming that the response rates are the same in each sample (SAS Institute 1994). Seasonal changes in weight were compared for males only (female weights affected by pregnancy and the metabolic demands of nursing young) among areas, ages (yearling vs. adult), and years using analysis of variance (ANOVA). Monthly comparisons of changes in mean weight were made using Tukey-Kramer HSD tests (SAS Institute 1994).

Adult female breeding rates were estimated each year based on whether females were pregnant (palpated fetuses), nursing, or anestrous. Chi-square tests with one degree of freedom were used to compare breeding rates of adults and yearlings, and capture sites.

Grids in both areas were arranged as 1-ha blocks, and each block was assigned a habitat type based on the dominant (≥50%) vegetation present. In both 1992 and 1993, traps were apportioned over each study area using random grid numbers to place traps (maximum number of traps used = 48 on RWF and 28 on AA) according to habitat availability. Chi-square analysis with one degree of freedom was used to compare expected captures based on habitat availability with actual captures in each habitat type.

Annual recovery rates on each study area (combined death and dispersal, September-September) were calculated for juveniles and raccoons ≥1 year, sexes combined, for 1990 and 1991 using the program JOLLY.AGE (Pollock et al. 1990). Sample sizes were too small to separate the sexes on each area. Male raccoons removed from the RWF were not used in the calculation of adult recovery on the RWF. Two X two chi-square tests of independence was used to compare recovery rates among years and age classes.

RESULTS AND DISCUSSION

Population Characteristics

There were 176 and 111 raccoons captured and released on the RWF and AA, respectively. Males predominated in captures on the AA but not on RWF (likelihood ratio chi-square = 12.9, df = 1, P = 0.0003) (Fig. 1). Combining areas, males predominated among juveniles and yearlings and females among adults (likelihood ratio chi-square = 4.6, df = 2, P = 0.09). Sex ratios did not differ among years on either area but we captured proportionally more adults on the AA (likelihood ratio chi-square = 8.1, df = 2, P = 0.02). Combining areas, adults were more common in our captures in 1992 and 1993 compared with 1990 and 1991 (likelihood ratio chi-square = 20.6, df = 6, P = 0.002). More juvenile males were captured on the RWF than on the AA after we removed older males from the RWF, but yearling males were proportionally more abundant on the AA (Fig. 1). The oldest females captured were 10 and 7 years old and the oldest males captured were 5 and 4 years old on the RWF and AA, respectively.

The mean number of raccoons captured/traps set each summer was also used as an index to raccoon abundance on each area. Mean captures per trap set were nearly identical on both areas, averaging 0.041 on the AA and 0.0405 on the RWF (one way ANOVA = 0.0018, df = 1, P = 0.96). However, calculated estimates of raccoon numbers using software program CAPTURE indicated that raccoons were more abundant on the AA, even though raccoons were hunted and trapped on the area (Table 1).

<u>Breeding</u>

Breeding rates for yearling females for both areas combined averaged 40% (N = 20), ranging from 25% (1990, N = 4) to 50% (1992, N = 6). Adult female breeding rates averaged 83% (N = 36), with a range of 50% (1992, N = 2) to 100% (1990, N = 9), and did not differ significantly (P>0.05) among years. Yearlings accounted for about 37% of the females ≥1 year old captured on both study areas. With a lower breeding rate compared with adults, yearlings contributed less to the total breeding effort in Lee County than in areas where yearlings constitute a higher proportion of the female population (Fiero and Verts 1986). Using the age structure of captured females to estimate potential production of young indicates that yearlings in an average year would contribute only about 20% of the young produced on the study areas during our study.

Stuewer (1943) reported that 53% of yearling females bred in 1 year in Michigan. Fritzell et al. (1985) reported yearling breeding rates between 38% to 77% for raccoons in Missouri and Illinois over a 3-year period, with pregnancy rates greater in Illinois. Adult females averaged a 95% breeding rate in Illinois and 81% in Missouri (range 68-96%) (Fritzell et al. 1985). Yearlings averaged a 62% breeding rate and adults 91% for a 3-year period in Iowa (Glueck 1985). Payne and Root (1986) found that 32% of the yearling females and 91% of the adults bred in southwestern Wisconsin over a 2-year period.

Movements

Movements between trapping periods were noted for 9 raccoons, 8 juveniles and 1 adult. Three juveniles and an adult moved <900 m between the capture site and site of recovery, and a juvenile male moved 5 km NE of the RWF, all within 1 year of capture. A juvenile male dispersed 26 km north of the RWF and was killed on the highway 2 years after capture. Another juvenile male dispersed 41 km SW of the RWF and was killed on the highway 16 months after capture. Two juveniles, a male and female, dispersed 2.5 km from the AA and RWF, respectively, both within 2 months of capture.

Body Weights

Raccoons were weighed at first capture during March (RWF only) and May through September (both areas). Combining data from both study areas, adult male body weights were similar among years ($F = 1.6$, df = 3, $P = 0.16$) and areas ($F = 0.004$, df = 1, $P = 0.99$). Body weights (mean ± S.E.) of adult males, areas and years combined, were significantly heavier ($F = 3.8$, df = 6, $P = 0.004$) in September (7.2 ± 0.31 kg, N = 9) compared with March (5.7 ± 0.35 kg, N = 7, RWF only), June (6.4 ± 0.29 kg, N = 11), and July (6.2 ± 0.42 kg, N = 5). Adult male weights did not differ among June , July, and August (6.9 ± 0.26 kg, N = 13) captures. Yearling males gained weight ($F = 4.9$, df = 6, $P = 0.008$) between March (4.7 ± 0.27 kg, N = 8) and June (5.5 ± 0.18 kg, N = 18) and July (5.4 ± 0.27 kg, N = 8).

Lipid deposition and weight gain occurs in temperate raccoons from mid-July until December (Lotze and Anderson 1979, Hanni and Millar 1993, Mech et al. 1968, Zeveloff and Doerr 1985). Sanderson and Hubert (1981) found November-December males from north-central Illinois to average 8.8 kg for adults and 5.4 kg for juveniles, while adult females averaged 7.6 kg for parous females and 7.5 kg for nulliparous females, significantly lighter than males in late fall (Sanderson and Hubert 1981).

Recovery Rates

Recovery rates were the product of deaths and dispersals on each area. The annual juvenile recovery rate (proportion recovered on the study area = 0.57) of RWF raccoons was comparable to the adult recovery rate (0.61) for 1990-1991, but the juvenile recovery rate was lower than the adult tag recovery in 1991-1992 (juvenile = 0.18, adult = 0.66, (2X2 chi-square test, $X^2 = 3.67$, $P<0.05$). The juvenile recovery rate of AA raccoons was 0.53

for 1990-1991 and 0.42 for 1991-1992. The tag recovery of 0.64 for adults on the AA for 1990-1991 did not differ from the juvenile tag recovery, but recaptures were too few to calculate an adult recovery rate for 1991-1992.

Juvenile tag recovery did not differ between areas for 1990-1991 or 1991-1992, even though the juvenile recovery rate was considerably higher on the AA than on the RWF for 1991-92, 0.42 vs. 0.18 ($X^2 = 1.2$, df = 1, $P = 0.30$). There was no indication that removal of older males significantly improved recruitment of juvenile and yearling raccoons into the RWF population. Sanderson (1987), using productivity and sex-age data collected from Illinois hunters and trappers for 1981-1984, estimated juvenile male annual survival at 0.28. Annual survival of after-birth-year males (0.58) exceeded that of after-birth-year females (0.42) (Sanderson 1987). Annual survival of adult raccoons averaged 0.68 for 2 areas in an epizootic rabies area in Pennsylvania (Brown et al. 1990).

All but 7 of 24 known deaths of raccoons marked on the RWF were human induced; 11 raccoons were trapped, 5 were killed by vehicles, 7 died of disease, and 1 was killed by a farm dog. There were 17 known deaths reported for raccoons marked on the AA; and only 2 of these were natural deaths. Twelve were shot by hunters, 2 died of disease, and 1 each died because of trapping, a highway accident, and a farm dog. Trapping accounted for 45% of the deaths among RWF raccoons, and hunting and trapping combined accounted for 76% of the deaths among AA raccoons. Hasbrouck et al. (1992) reported hunting and trapping accounted for 71% of the deaths of raccoons in Iowa.

Habitat Selection

During the growing seasons of 1992 and 1993, water-associated habitats, particularly emergent wetlands, attracted raccoons on both study areas. On the RWF in summer raccoons were captured more often in upland forest and around ponds and wetlands and less often in sunflower fields, soybeans, hayfields, and prairies (Table 2). On the AA, raccoons avoided pastures and corn fields and were captured more often in wet forest, and around ponds, wetlands, and marshes (Table 2).

CONCLUSIONS

Our estimates of 7-18 raccoons per 100 ha on each area fall within reported densities in North America. Raccoons averaged 10 per 100 ha in upland hardwoods in Virginia (Hallett et al. 1991) whereas Kennedy et al. (1991) estimated 13 raccoons per 100 ha of lowland forest in Tennessee. Conner and Labisky (1985) estimated 12 raccoons per 100 ha for a site in northern Florida. The highest published densities of raccoons were 167 raccoons removed from 41 ha on a lowland site in Missouri (Twitchell and Dill 1949) and 1 raccoon per 0.3 ha in an area of mixed agriculture and forest in Quebec (Riverst and Bergeron 1981).

Based upon age-specific life expectancy estimates and population age structure, longevity of raccoons in Lee County, Illinois, was <3 years. Females currently outlive males on our study areas. Although not presented here because of low sample size, male recovery rates were lower than females on both study areas, a reflection of higher dispersal rates for males (Nixon et al. 1993) as well as a higher probability of capture by hunters and trappers (Sanderson and Hubert 1981). Polygonous mating also often results in a higher mortality of males as a result of longer and more frequent seasonal movements in inclement winter weather and conflicts with other males. Sexual dimorphism in size favoring males (Sanderson 1987) and female-biased sex ratios in adult age classes are often characteristic of a polygnous mating system (Ritke and Kennedy 1993).

Raccoons were more abundant in summer on the AA area apparently in response to the greater amount of wetland associated habitats present on the area. Wetand habitat covered nearly 20% of the AA compared to only 9% of the RWF (Table 2) and these additional areas attracted more raccoons. Leberg and Kennedy (1988) found that raccoon densities were highest in bottomland deciduous forests in west Tennessee and that wetland habitats supported more females and young than upland habitats. Fritzell (1978a) observed that raccoons favored wetland-associated habitats in spring and summer in North Dakota. Glueck (1985) found lowland forest to be the favored habitat for raccoons in Iowa, with the use of upland forest being important only in the fall. Leberg and Kennedy (1988) found juveniles more abundant in bottomland habitat and attributed this difference to habitat -specific reproduction, with more young produced in wetlands. We found juveniles more abundant on the RWF, although wetland associated habitats were more abundant on the AA (Table 2).

There is conflicting evidence for territorial behavior among male raccoons. Fritzell (1978b) reported territorial behavior among males in North Dakota, but Johnson (1970) in Alabama and Allsbrooks and Kennedy (1987) in Tennessee reported overlapping ranges. We found that both sexes had some sharing of ranges during the summer months. Fifty-four of 98 males (55%) were captured in the same trap or within the same hectare as another male during the same summer. Of these captures, 6 were of 2 yearlings, 12 were of an adult and a yearling, and 12 were of 2 adults. For 69 females, only 20 (29%) were captured in the same trap or hectare as another female during the same summer of trapping. Of these captures, 3 were of 2 yearlings, 5 were of an adult and a yearling, and only 2 were of 2 adults. These capture rates were different (Fisher's exact test $P = 0.0009$) between the sexes and suggest that females may be less tolerant of same sex conspecifics than males, at least during the litter-rearing period in summer. Females may also be more tolerant of yearling females than of older females within their postpartum ranges. These yearlings may also have been related to the adult female and shared portions of her range, although philopatry has not been specifically reported for the raccoon. Indeed, both sexes may mutually avoid one other during the summer (Mech et al. 1966, Johnson 1970). Fritzell (1978b) found extensive summer range overlap among parous females in North Dakota, but these females avoided contact with other raccoons except for their young. Twitchell and Dill (1949) removed more than 100 raccoons from dens in Missouri and found males more likely to den with others (32/40, 80%) than were females (28/60, 47%).

Apparently our male removals from RWF were too small (average = 8 per year) to affect male recruitment from resident young or immigrants, based on a between-area comparison of recovery rates of males marked as juveniles and the recruitment rates of yearlings after male removals (total captures of yearlings). The proportion of males captured each year did not differ between areas either before or after male removal from RWF, ranging between 40% (RWF 1990) and 74% (AA 1991).

Total known losses of captured males from the RWF (assuming the males removed each year were tagged and in the population each fall) totaled 43% (7/16), 17% (4/23), and 49% (18/37) for 1990, 1991, and 1992, respectively. Numbers of trap-susceptible males were not affected by these losses, and annual recovery rates of adults averaged about 60% on both areas during 1990-1991. Clark et al. (1989) estimated a maximum sustainable potential harvest of 41% of preharvest numbers for raccoons in Iowa. Sanderson (1987) estimated sustainable harvest levels ranging from 49% to 59% of the total population for 3 levels of fecundity for raccoons in west-central Illinois. However, harvests of juveniles could be considerably higher than these levels, up to 76% for males and up to 60% for females in high-fecundity populations. Sustainable harvest levels for adults were considerably lower, between 29% and 33% for males and 46% and 54% for females (Sanderson 1987). Known losses of males exceeded these levels for 1990 and 1992, but recruitment of males was sufficient to sustain the male population.

These data were collected at a time of low pelt prices and reduced harvests compared to the long-term mean for raccoon harvests in Illinois (Bluett and Hubert 1992). The low harvests and generally mild winters allowed raccoon numbers to increase during the study on both study areas. Postweaning annual mortality levels appear to be <40% from all causes, based on recoveries of marked raccoons in northern (this study) and west-central Illinois (Nixon et al. 1993).

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of G.F. Hubert, Jr, Illinois Dept. Conservation, for assistance in all phases of the study. Mr. E. Richardson and T. Moyer, provided access to the Richardson Wildlife Foundation, provided lodging during livetrapping operations, and assisted in our investigations in many ways. We also thank Mr. M. Spears, Mr. W. Fedenhagen, and Mr. C. Erbes who allowed us to livetrap raccoons on their properties. Dr. P.C. Mankin, U. of Illinois, provided statistical assistance. Drs. G.C. Sanderson and S.K. Robinson, and the editorial office, Illinois Natural History Survey, and G.F. Hubert, Jr., Illinois Dept. Conservation reviewed the manuscript. This report is a contribution (in part) of Federal Aid in Wildlife Restoration Project W-104-R, the Illinois Dept. of Conservation, the U.S. Fish and Wildlife Service, and the Illinois Natural History Survey, Cooperating.

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Figure 1. Sex and age of raccoons captured on the Richardson Wildlife Foundation (RWF) and the Amboy Area (AA), Lee County, Illinois, 1990-1993.

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Table 1. Estimated number of raccoons present in late summer on the Richardson Wildlife Foundation (RWF) and Amboy Area (AA), Lee County, Illinois, 1990-1992.

		Capture Estimates				
Year	Area	Mb[a]	95% Conf. Interval	Mbh[b]	95% Conf. Interval	Aver. No. Per 100 Ha
1990	RWF	49	39-93	40	37-67	7
	AA	28	19-93	18	–	8
1991	RWF	28	26-42	28	26-42	4
	AA	38	30-77	36	28-67	12
1992	RWF	42	36-68	42	36-68	6
	AA	51	41-70	55	44-81	18

[a] Mb = Model where capture probabilities change due to behavioral response from first capture (Pollock et al. 1990).
[b] Mbh = Model where heterogeneity of capture probabilities are found and capture probabilities change with capture history.

Table 2. Observed and expected raccoon captures on the Richardson Wildlife Foundation and Amboy Area with traps set in proportion to habitat availability during summer-early fall 1992 and 1993. P-Values are for one degree of freedom.

Habitat type	Proportion available	Observed captures	Expected captures	Chi-square values	P value
		RICHARDSON WILDLIFE FOUNDATION			
Corn	0.28	29	31.8	1.2	0.30
Grasses	0.14	2	16.0	16.6	0.0005
Prairie	0.14	6	15.3	8.1	0.005
Soybeans	0.09	1	9.6	9.7	0.005
Forest	0.06	21	7.0	28.6	0.0005
Pines	0.06	9	7.0	0.7	0.40
Ponds	0.04	15	4.9	18.9	0.0005
Oats	0.04	0	4.6	5.1	0.025
Wetlands	0.04	28	4.5	125.6	0.0005
Sunflowers	0.03	0	3.2	3.9	0.05
Buildings	0.01	0	1.2	1.6	0.30
Wet forest	0.01	1	1.1	1.4	0.30
		AMBOY AREA			
Pasture	0.24	5	11.1	5.1	0.05
Pines	0.18	5	8.5	2.1	0.20
Wet forest	0.14	17	6.7	17.5	0.0005
Bur Oak	0.13	5	6.2	0.4	0.60
Corn	0.07	0	3.4	3.9	0.05
Soybeans	0.04	0	2.0	2.3	0.20
Succ. forest	0.04	1	1.8	0.5	0.50
Ponds	0.04	5	1.7	6.4	0.025
Prairie	0.02	0	0.9	1.0	0.40
Oats	0.02	0	0.7	0.8	0.40
Wetlands	0.01	5	0.6	25.4	0.0005
Marsh	0.01	3	0.5	12.5	0.0005