EVALUATION OF A RACCOON TRANSLOCATION ATTEMPT IN EAST TENNESSEE

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Abstract: A total of 286 western Tennessee raccoons (*Procyon lotor*) were ear-tagged and released in portions of Blount and Loudon Counties, eastern Tennessee, over a 3-year period. Twenty-nine (10.1%) were recovered. Illegal kills comprised 41.4% of all tag recoveries. Seven of 11 recovered females had produced off spring. Weight gains averaged 1.14 kg over 432 days. Average linear dispersal was 4.9 km. Dispersal distances for males and females were not significantly different and dispersal directions were randomly distributed. Home ranges of 14 radio-monitored raccoons were not significantly different than those of resident raccoons in the same area. The translocation of raccoons may be a valid management technique provided that suitable habitat exists, resident raccoon populations are low, animals are transferred from similar habitat types, and illegal or dog training mortality can be controlled.

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Historically the translocation of game species for population restoration has been a successful wildlife management technique; numerous attempts have been made over the past 50 years to restore or establish viable raccoon populations throughout the United States and other countries (Johnson 1970). However, translocation efforts have exhibited varying results, with most investigators reporting substantial dispersal and poor survival of stocked animals (Giles 1943, Butterfield 1944, Ellis 1964, Johnson 1970, and Wright 1977).

Raccoon hunters and hunter clubs in Tennessee and other southeastern states have imported thousands of raccoons from Georgia, Florida, and Texas for stocking purposes without evaluation of results (Whitehead 1975). The fate of these animals is largely unknown. However, if the wide dispersal and poor survival patterns found by Wright (1977) in Kentucky occur elsewhere, stocking does not improve local raccoon populations or hunter harvest. Importation of animals from coastal areas may also introduce new parasites and diseases, further depressing resident populations (Johnson 1970, Nettles and Martin 1978, and Schaffer et al. 1978).

Realizing the potential for disease transmission through stocked raccoons, the Tennessee Wildlife Resources Agency (TWRA) prohibited the importation of raccoons from Georgia and Florida. The agency also initiated a statewide research program to develop management practices for increasing and maintaining adequate populations without the importation of coastal animals. Under this statewide program, an intensive, 3-phase project was established in eastern Tennessee. The objectives of this project were: (1) to delineate the habitat characteristics of a large area typical of raccoon habitat in eastern Tennessee and determine the population density of raccoons in the area (Warr 1978), (2) to determine the movement ecology of resident raccoons in the area before, during, and after the introduction of other raccoons (Hardy 1979), and (3) to determine the movement ecology of western Tennessee raccoons translocated to the area (Taylor 1979). This latter investigation was initiated to evaluate restocking efforts in terms of survival, dispersal, and reproduction.

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STUDY AREA

The study area is located in the Little Tennessee and Tennessee River valleys and includes 27,740 ha of Blount and Loudon Counties, TN. The area is characterized by low, roughly parallel ridges separated by gently rolling valleys and is considered typical of raccoon habitat found in much of eastern Tennessee.

Approximately 9500 ha (40%) of the study area are forested, with mixed forest land (oak-hickory-pine) comprising 76% of the forest cover (Warr 1978). Forest stands range from farm woodlots of sawtimber-size trees to continuous forest stands of pole to small sawtimber trees along dry ridge tops (TVA 1971, 1973). Prior to this investigation, much of the forest cover along the Little Tennessee River and adjacent streams was eliminated by the Tennessee Valley authority (TVA) in preparation for the completion of the Tellico Lake Project.

Approximately 60% of the study area is characterized by small farms, with pasture lands comprising the largest proportion of the available agricultural lands. Farms lands located in the fertile river bottoms and level valleys are intensively cultivated, primarily for corn and soybean production.

Hunting, dog training, and trapping seasons were closed to hunters of raccoons and opossum (*Didelphis virginiana*) in the study area. However, the year-round dog training season in the Loudon County portion of the area remained open through county legislation which supersedes TWRA proclamations. This legislation was initiated by raccoon hunting clubs in Loudon County; clubs held field trials and competitive hunts in the study area and annually released raccoons from Georgia and Florida in the study area prior to this project. However, Warr (1978) stated that raccoon numbers were so low in this area, that a reliable estimate of the population could not be calculated.

MATERIALS AND METHODS

All raccoons released in the study area were translocated from bottomland hardwood sites along the Mississippi River at the Meeman-Shelby State Park and Forest, Shelby County, Tennessee, and the Hatchie National Wildlife Refuge, Haywood County, Tennessee. Habitat types on these areas are described by Taylor (1979).

Raccoons were tagged with 1 numbered, plastic Standard Rototag (No. C1635N, NASCO), and 1 numbered, metal Monel Tag (No. 4, National Band Co.). The metal ear tag was also marked "Notify TWRA".

Raccoons selected for telemetry purposes were immobilized with Sernylan (Phencyclidine hydrochloride) (Keeler 1978, Montgomery 1964, and Seal and Erickson 1969) administered intramuscularly with a disposable, plastic, 1 cc tuberculin syringe at a dosage of 0.66 mg kg (Warr 1978). Estimated weights were used to calculate dosages for each raccoon. Standard mammal measurements, weight, and a subjective consideration of physical condition based on apparent fat reserves and pelage appearance were also recorded. Age was determined by a combination of methods based on dental characteristics (Montgomery 1964, and Grau et al. 1970). Reproductive status of females was determined according to the methods described by Stuewer (1943a). Reproductive status of males was determined by body weight (Johnson 1970) and by descent of the testes (Keeler 1978).

Raccoons were fitted with radio transmitters operating in the 150.850 to 151.450 mHz range (Wildlife Materials, Inc., Carbondale, Il.). Also attached to the radio-collar was a return address tag.

After release, attempts were made to locate the translocated raccoons at least once every 24 hours. Diel movement patterns were recorded in addition to night locations to increase the accuracy of home range information. Aerial searches using the TWRA's single engine airplane were conducted when ground surveys failed to locate an animal. A minimum of 3 azimuths were used to determine the location of radio-collared raccoons. Azimuths were triangulated in the field to exclude inaccurate locations. Raccoons often were tracked to den sites and daytime resting locations to verify triangulation accuracy.

Release sites for the translocated raccoons consisted of areas with at least 150 ha or more of contiguous hardwood-mixed forest and a minimum of 1 permanent water source. Sites were selected from topographic maps and aerial observations and then examined on the ground. Raccoons were released in groups of 15 or less, depending upon the size and quality of the habitat immediately surrounding the release site.

Home range sizes of translocated raccoons were determined by: (1) the maximum, or convex polygon, (2) the minimal polygon, and (3) a bivariate home range model (Koeppel et al. 1975 and Sokal and Rohlf 1969). Differences and advantages of the 3 techniques of home range estimation are given in Taylor (1979).

To obtain dispersal and survival information on raccoons released without radio-collars, a controlled hunt was held on 3-4 and 10-11 November 1978. The number of hunters allowed to participate was limited to a random drawing of 50 parties of 2 hunters each, with 25 parties per hunt. Hunting was limited from sunset to 0300 hours and hunters were required to report to check stations prior to and after hunting. Harvest was limited to 1 raccoon per party per hunt.

RESULTS AND DISCUSSION

From July 1975 to May 1978, 286 raccoons (131 males, 155 females) were ear-tagged and released in the study area; 139 were released in 1975 and 147 were released between March 1977 and May 1978. Of these 286, 10% (13 males and 16 females) were recovered by November 1978; they consisted of 12 illegal kills, 7 live-trap recaptures, 6 legal kills during the 4-night hunt, and 6 apparent natural deaths.

In recent years, data from tag returns have been used primarily to measure the success or failure of raccoon translocation efforts. In these investigations, tagged raccoons were released in areas with unrestricted hunting during open seasons. Recoveries of tagged animals were largely dependent upon voluntary tag returns by hunters; this probably does not yield a sufficiently large sample size to evaluate a stocking program quantatively (Stuewer 1943a). Cooperation from county raccoon clubs and hunters in eastern Kentucky varied from excellent (2 counties) to poor (Wright 1977). Approximately 86% of all tag returns reported by Wright were made by cooperators in 2 counties; only 0.5% of 1,368 raccoons released in other areas were reported killed by hunters. Since our intent was to restore a raccoon population and not promote "put-and-take" raccoon management, tag returns in the present study were considered indicators of survival rather than a measure of the effectiveness of stocking for increasing hunter kill. Recovery of 10.1% of the tags in this study is still higher than reported for most investigations undertaken with no restrictions on raccoon hunting during open seasons (Giles 1943, Stuewer 1943a, Kellner 1953, Nelson 1955, Johnson 1970, Clements 1972, Frampton 1974, Wright 1977).

Survival

Raccoons (29) recovered in the field survived an average of 344 days (1-1,207). Raccoons recovered from releases in 1975 (11) survived an average of 610 days before recovery; this indicates that some animals released in 1975 survived through at least 1 breeding season and had the opportunity to contribute to the total population increment.

Raccoons found dead in the study area (2 road kills and 3 apparent natural deaths) survived an average of 83 days (Table 1). Mean survival time for raccoons illegally killed was 342 days; recaptured raccoons survived an average of 352 days in the field; and quota hunt recoveries survived a mean of 597 days (337-1,207 days). Tag returns from illegally killed raccoons were significantly higher ($P<.001$) during summer and winter than at any other time. Summer mortality likely reflects increased vulnerability of juvenile raccoons during dog-training seasons.

TABLE 1. Recovery methods for translocated raccoons in East Tennessee.

Recovery method	Number male	female	Mean days to recovery	Median days to recovery	Range
Found dead	1	4	83	80	18 - 187
Recaptured	3	4	352	339	72 - 727
Illegal kills	7	5	342	179	1 - 1091
Controlled hunt	1	4	597	477	337 - 1207
Total	12	17	344	269	1 - 1207

Reproduction

Of 16 females recovered from release efforts, 11 survived through at least 1 breeding season. Examination of the teats of these 11 animals (Stuewer 1943b) indicated that parturition occurred in 7 of them. If 56.2% of all females released survived through at least 1 breeding season with 63.3% successfully reproducing and a mean litter size of 2.8 (Woods 1978), then the potential addition to the study area population was approximately 138 animals. However, our mortality data suggest that 41.4% of these raccoons would be illegally killed before they reached sexual maturity.

Physical Change

Changes in the physical condition of raccoons between release and recovery periods has been used in previous translocation efforts as an indicator of the animal's success in adapting to unfamiliar environments. Increases in weight were recorded for 8 of 9 recaptures (2 males, 7 females) in this study (Table 2). Weight increases ranged from -0.40 to 2.95 kg with a mean of 1.14 kg (+29%) and were recorded over an average period of 432 days (2.6 g/day). Adult females (5) gained 16% in weight over 484 days (1.2 g/day). Adult male weights increased 38% (1.99 kg or 4.8 g/day) during 423 days. These weight gains suggest that western Tennessee raccoons had adapted to eastern Tennessee habitat types. If the translocation process was detrimental to the health of these animals, it seems likely that a larger percentage of the raccoons would be in a more debilitated condition. Frampton (1974) in South Carolina, reported an overall weight gain of 28.3% over an average period of 148 days for Coastal Plain raccoons released in the Piedmont region.

Poor condition of raccoons released by hunter clubs is a possible factor contributing to the low survival rates reported from other translocation studies. Nettles and Martin (1978) stated that raccoons live-trapped by game agencies and released in unfamiliar habitats were in significantly better condition than animals purchased by hunter clubs

TABLE 2. Weight changes of 9 translocated West Tennessee raccoons between release and recovery dates.

Sex	Release age	Release weight (kg)	Recovery weight (kg)	Weight change (kg) (%)	Days to recovery
F	Juvenile	1.82	2.85	+ 1.03 (36.1)	147
F	Juvenile	1.36	3.63	+ 2.27 (63.0)	447
F	Adult	3.18	3.21	+ 0.03 (1.1)	1207
F	Adult	3.18	3.55	+ 0.37 (10.0)	339
F	Adult	3.85	4.31	+ 0.46 (11.0)	337
F	Adult	2.27	4.80	+ 2.53 (53.0)	458
F	Adult	2.70	2.30	-0.40 (17.0)	80
M	Adult	3.18	4.20	+ 1.02 (24.0)	365
M	Adult	3.18	6.12	+ 2.95 (48.0)	505
	$\overline{X}$	2.75	3.89	+ 1.14 (29.0)	431.7

and were better suited to adjust to new areas. The weight increases exhibited by the western Tennessee raccoons may have resulted from their good physical condition at the time of release.

Dispersal

Average dispersal (straight line distance between release point and recovery site or home range boundary) for 29 tag returns was 4.9 km (median = 2.1 km) over an average of 344 days. The greatest linear distance traveled was by a male released 7 July 1977 and illegally killed 37.1 km away on 2 November 1977. Of the 29 raccoons, 21 moved less than the average distance of 4.9 km from the release site. Dispersal distance and the number of days to recovery were not significantly related ($P<.10$). Mean dispersal distance for males (6.8 km) was not statistically different from females (3.4 km). Dispersal direction was random - 31% north, 27.6% south, 17.2% east, and 24.1% west.

Dispersal also has been used to measure the effectiveness of raccoon restoration programs and, as with recovery rates, reported dispersal distances vary among investigators (Giles 1943, Stuewer 1943a, McLaughlin 1953, Kellner 1953, Nelson 1955, Johnson 1970, Clements 1972, Frampton 1974, Wright 1977). In comparison with reported dispersal distances, the minimal dispersal of raccoons from release sites in this investigation was indicative of successful re-establishment of raccoons in the study area. Movements of translocated raccoons from release sites were negligible and movement out of the immediate area was nonexistent. Most translocated raccoons remained relatively close to the release sites and for periods long enough for them to be considered resident animals; it is felt that this contributed to the overall density and distribution of raccoons in the study area.

Radiotelemetry

From March 1977 to May 1978, 6 males and 11 females were equipped with radio transmitters and released in the study area; 3 racoons were killed before home range information was obtained. The remaining 5 males and 9 females were monitored for 1,963 days (X = 140 days) during which time, 1,464 radio locations ($\overline{X}$ = 104 locations per

raccoon) were recorded. Radiotracking efforts were distributed over a 21-month period, with 13 raccoons monitored during spring, 10 in summer, 7 in fall, and 7 during winter.

The average home range size for telemetered raccoons during all seasons was 106.4 ha (minimal polygon), 226.1 ha (maximum polygon), and 383.3 ha (95% confidence ellipse). There was no significant relationship ($P<.05$) between the number of days monitored or the number of locations recorded and home range size as estimated by any of the 3 methods. Nine of the 14 raccoons established home ranges that encompassed the release site and 3 ear-tagged raccoons were recovered a maximum of 2.16 km from their release site after a period of over 3 years in the field.

Although several investigators have radio-monitored translocated raccoons, this study is the first to report home range size and unfortunately comparisons cannot be made. However, home ranges of the translocated raccoons were not significantly different than home ranges reported for native raccoons in the study area (Hardy 1979).

Quota Hunt

The 4-night hunt held in the study area was a final measure of the effectiveness of the raccoon translocation process. A total of 46 hunting parties participated in the controlled hunt and 19 parties harvested 1 raccoon per party. Group hunting hours totalled 115.5 or an average of 2.5 hours hunted per party, with a mean kill of 0.17 raccoons per party per hour. Successful hunting parties averaged 2.49 hours per night and harvested 0.40 raccoons per party per hour.

Of the 19 raccoons killed, 6 were ear-tagged raccoons that were released in the study area. Seven of the 13 non-tagged raccoons were less than 1 year old, and could have been the progeny of translocated animals.

Hunter success and kill per hour equalled those reported for statewide raccoon hunters in 1969. On Chuck Swan Wildlife Management area, approximately 100 km north of the study area, Woods (1978) reported a hunter success of 21.3% over 9 nights of hunting. Only Stuewer (1943a) reported a higher tag return (42.8%) of stocked raccoons. However, he released pen-reared raccoons and utilized an entire fall hunting season to recover tags in the same year of release.

CONCLUSIONS

Movement, survival, and reproductive characteristics of raccoons released in Blount and Loudon Counties indicated that this translocation attempt was successful in establishing western Tennessee raccoons in eastern Tennessee habitats. Dispersal distances were minimal, and survival rates high enough to allow some of the animals to establish home ranges and provide input into the total raccoon population. The fact that home range characteristics of translocated raccoons were equivalent to those of the resident animals further indicates the adaptability of the raccoon and the success of translocation efforts. Information collected during the controlled hunt demonstrated that, even after 3 years, released raccoons had remained near release sites and were available to hunters, an important aspect to consider where management commitments are concerned. However, no raccoon population, resident or translocated, could be expected to increase or remain stable under the amount of illegal mortality suggested by our data.

In reviewing past raccoon restoration efforts, it appears that 3 factors were primarily responsible for the success of the present attempt (1) raccoons slated for translocation were live-trapped from areas which contained a food base similar to the release area, (2) the resident raccoon population was low, and (3) raccoons were released under closed hunting (taking) season conditions.

Many investigators have stated that one of the principal factors contributing to the failure of raccoon restoration programs was the significant difference in habitat types

between capture sites and release sites (Johnson 1970, Clements 1972, Frampton 1974, and Wright 1977). It has also been suggested that raccoons stocked in areas containing moderate resident raccoon populations are immediately disadvantaged as the desirable habitats would already be occupied by other individuals (Frampton 1974). By closing the hunting season prior to, during, and after releases were made, the potential survival of transplanted raccoons was increased, since the primary mortality in raccoon populations can be attributed to hunting (Stuewer 1943a, Atkeson and Hulse 1953, Johnson 1970, and Woods 1978).

The restocking of raccoons, or any game species, as a management practice, is justified only to establish a minimum number of breeding animals in areas where the resident population has been extirpated or depressed by factors not related to existing habitat characteristics. This practice cannot be expected to increase the huntable population of raccoons immediately nor should it be used as an annual population maintenance program to provide hunters with a harvestable surplus.

In areas where resident raccoon populations are low, but suitable habitat exists, management programs should first entail protection of the animals during breeding and young-rearing periods, manipulation of the environment to provide more optimum habitat, and regulating the hunting seasons to insure a harvest of only the surplus animals. Raccoon translocation becomes a viable management alternative only if the resident population has been depressed to such a low level that these other techniques cannot provide the desired results in a reasonable length of time.

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