Mobility and Behavior of Raccoons in Eastern South Dakota

George L. Geis

Follow this and additional works at: https://openprairie.sdstate.edu/etd

Part of the Natural Resources and Conservation Commons

Recommended Citation
https://openprairie.sdstate.edu/etd/247

This Thesis - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.
MOBILITY AND BEHAVIOR OF RACCOONS
IN EASTERN SOUTH DAKOTA

BY

GEORGE L. GEIS

A thesis submitted
in partial fulfillment of the requirement for
the degree Master of Science, Major in
Wildlife Management, South Dakota
State University

1966
MOBILITY AND BEHAVIOR OF RACCOONS
IN EASTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser 

Date

Chair 

Date

Wildlife Management Department
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>DESCRIPTION OF AREA</td>
<td>3</td>
</tr>
<tr>
<td>METHODS AND MATERIALS</td>
<td>8</td>
</tr>
<tr>
<td>Capture, Handling, and Marking</td>
<td>8</td>
</tr>
<tr>
<td>Development and Description of Radio-Tracking System</td>
<td>10</td>
</tr>
<tr>
<td>Transmitter</td>
<td>10</td>
</tr>
<tr>
<td>Receivers</td>
<td>13</td>
</tr>
<tr>
<td>Testing Equipment</td>
<td>14</td>
</tr>
<tr>
<td>Field Use of Radio-Tracking System</td>
<td>14</td>
</tr>
<tr>
<td>Food Habits Analysis</td>
<td>15</td>
</tr>
<tr>
<td>RESULTS AND DISCUSSION</td>
<td>16</td>
</tr>
<tr>
<td>Radio- and Ear-Tagging</td>
<td>16</td>
</tr>
<tr>
<td>Movement Activities as Determined by Radio-Tracking</td>
<td>17</td>
</tr>
<tr>
<td>Adult Raccoons</td>
<td>17</td>
</tr>
<tr>
<td>Juvenile Raccoons</td>
<td>22</td>
</tr>
<tr>
<td>Factors Influencing Movements</td>
<td>24</td>
</tr>
<tr>
<td>Food Habits and Feeding Activities</td>
<td>24</td>
</tr>
<tr>
<td>Weather Conditions</td>
<td>28</td>
</tr>
<tr>
<td>Denning Habits</td>
<td>29</td>
</tr>
<tr>
<td>Competition</td>
<td>33</td>
</tr>
<tr>
<td>Physical Barriers</td>
<td>33</td>
</tr>
<tr>
<td>Range and Dispersion</td>
<td>34</td>
</tr>
</tbody>
</table>
CONCLUSIONS.............. 38
LITERATURE CITED............ 39
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tracking periods of radio-tagged raccoons during 1965.</td>
</tr>
<tr>
<td>2</td>
<td>Average distance traveled the first four hours of nighttime movement during summer of 1965</td>
</tr>
<tr>
<td>3</td>
<td>Food habits of raccoons during 1964 and 1965 by percent frequency of occurrence in scats and digestive tracts</td>
</tr>
<tr>
<td>4</td>
<td>Distances traveled by recovered ear-tagged raccoons during 1964 and 1965</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Study area</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Cover types</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Handling and radio equipment</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Transmitter circuit diagram</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Radio fixes for adult male 63 from May 8, to June 17, 1965</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Radio fixes for adult female 65 from July 2, to September 4, 1965</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>Radio fixes for juvenile male 72 from July 29, to September 1, 1965</td>
<td>23</td>
</tr>
<tr>
<td>8</td>
<td>Radio fixes for juvenile male 74 from August 16, to October 14, 1965</td>
<td>23</td>
</tr>
<tr>
<td>9</td>
<td>Denning habitat</td>
<td>32</td>
</tr>
</tbody>
</table>
INTRODUCTION

Increasing populations of raccoons (*Procyon lotor*) and reports of depredation on upland game, poultry, and garden crops indicated a need for research concerning behavior, mobility, and range of raccoons. The raccoon has seemingly adapted to the dry environment of the northern agricultural plains. According to records, the original range apparently did not extend into South Dakota. Lewis and Clark did not report raccoons when they traveled along the Missouri River in 1804 and 1806 (Coues, 1893). Although Visher (1918) noted that raccoons were not rare in wooded areas along streams in western South Dakota, he made no mention of them along streams in the eastern half of the state. Sutton (1964) pointed out the extension of raccoon range into the Prairie Provinces of Canada well north of that previously recorded. Stoudt (1965) reported the raccoon as a serious predator on duck nests in the Aspen Parklands of Manitoba during 1961-65 where it was almost unknown during the previous 10 or 15 years. He noticed raccoons were somewhat limited to areas adjacent to main drainages in southern Manitoba, but were spreading rapidly to other areas.

This study was undertaken from March, 1964 to February, 1966 in east-central South Dakota in an effort to study the mobility and behavior of raccoons in an agricultural area. Data on denning and food preferences were obtained to reveal significant factors influencing behavior. A knowledge of these factors would help to explain
much of the daily and seasonal behavior and lead to suggestions for management.

In South Dakota raccoons have low fur value and are seldom hunted for sport. The meat is generally not an accepted article of food even though it is considered very palatable by people in other parts of the country. Management practices in the state consist only of control because raccoons are regarded as nuisance animals.

Several people have studied mobility and behavior of raccoons: Butterfield (1944) in Ohio; Cabalka, Costa, and Hendrickson (1953) in Iowa; Sharp and Sharp (1956) in Nebraska; Stains (1956) in Kansas; and Stuewe (1953) in Michigan. The technique of monitoring animal movements by radio telemetry has stimulated interest in behavior studies. Recent studies of this type include work on raccoons in Illinois by Cochran and Lord (1963) and Ellis (1964), and in Missouri by Slagel (1963).

The author wishes to acknowledge Dr. D. R. Progulske, the author's major advisor, for consultation on research and editorial assistance, Darwin Bayerkohler and the Department of Electrical Engineering for advice and assistance concerning construction of a radio telemetry system, Ken Knutson for cooperation concerning access to the study area, graduate students of the Departments of Wildlife Management and Entomology-Zoology for field assistance, and the South Dakota Cooperative Wildlife Research Unit for use of radio equipment.
DESCRIPTION OF AREA

The study was conducted on 2,760 acres of privately owned farm-
land in the flood plain of the Big Sioux River, 5 miles west of
Brookings, in east-central South Dakota (Fig. 1). The general area
lies in the south-central Prairie Coteau, a glaciated, undrained high-
land that dominates eastern South Dakota between the Minnesota and
James River Valleys.

The Big Sioux River, originating about 75 miles north of
Brookings in the Coteau, divides the study area in half. According to
Flint (1955), the river is believed to have formed when two large ice
blocks covered opposite sides of the Prairie Coteau and left a long,
narrow, glacier-free strip where melt water could escape. U. S. High-
way 14 divides the northern part of the study area.

Soils of the area are characteristic of the Big Sioux River
bottom lands where soils are intermittently to constantly wet. Soils
are somewhat poorly drained Chernozem-Humic Gley intergrade, develop
under tall grasses in 42 inches or more of medium-textured alluvium
(Westin et al., 1958).

Extreme temperatures are common, and seasonal and daily fluctu-
ations are sometimes great. Temperatures range between 107 F and
-41 F. Mean winter temperature is 13.1 F, and that of summer is 71.8 F
(U. S. Dept. of Agriculture, 1941). Spring is usually moist, cool, and
windy; summer is sunny and hot; autumn is dry, cool, and sunny; and
winter is cold and sometimes severe. Precipitation in spring, autumn,
Fig. 1. Study area.
and winter is generally frontal; and that of summer is mostly from thunderstorms. The mean annual precipitation is 20.36 inches (U.S. Dept. of Commerce, 1963).

Land of the study area was utilized during the study as follows: corn and soybeans (40 percent); pasture, hay, and forage crops (30 percent); timber and marsh (20 percent); and small grains (10 percent).

Each year from April to mid-May, spring runoff and heavy rain caused flooding that filled oxbows and marsh areas to early July. A sewage lagoon was located on the west part of the area, and a dugout and marsh bounded the north. The area became dry in late summer with only the river, sewage lagoon, and dugout containing water.

Heavy vegetative cover was predominantly in the river oxbows and marshes; however, two abandoned farmsteads situated about 1/4 mile from the river provided a variety of cover types (Fig. 2). River bulrush (Scirpus fluviatilis), smartweed (Polygonum sp.), prairie cord-grass (Spartina pectinata), and cattail (Typha latifolia) were the principal cover in oxbows and marsh areas, and farmsteads supported thick growths of giant ragweed (Ambrosia trifida), stinging nettle (Urtica sp.), and Canadian thistle (Cirsium arvense). Buck brush (Symphoricarpos occidentalis), Canadian thistle, milkweed (Asclepias syriaca), and vervain (Verbena sp.) were abundant in clumps on the pastures. Willow (Salix sp.), cottonwood (Populus deltoides), and boxelder (Acer negundo) were the principal trees along river banks. Along oxbows and some marsh areas, willow and cottonwood were
Fig. 2. Cover types. (A) Vegetation along river oxbow. (B) and (C) Cover types along river.
more common. Around farmsteads, cottonwood, boxelder, American elm
(Ulmus americana), and a few hackberry (Celtis occidentalis) were
found. Wild plum (Prunus sp.) grew at two locations near the river
and at one farmstead. Most of the wooded areas were subject to
grazing some time during the year.

Raccoons present on the study area in mid-summer were estimated
to number 15 to 20 per square mile. This estimate was calculated from
numbers of animals captured at permanent trap sites along water areas
during the summer. Striped skunks (Mephitis mephitis) and red foxes
(Vulpes fulva) ranged the entire area, while cottontail rabbits
(Sylvilagus floridanus) were common around buildings and wood lots.
Ratger (Majidea tarus) diggings were common in the pastures, hay-
fields, and fence rows. Beaver (Castor canadensis) and muskrats
(Ondatra zibethica) inhabited the river banks. Wood ducks (Aix
spons) were observed along the river, and a few ring-necked pheasants
(Phasianus colchicus) nested in the heavy cover around marsh areas and
in hayfields. Crayfish (Cambare sp.) and frogs (Rana sp.) were gen-
erally abundant along the banks from the end of April to October. The
river supported high populations of carp (Cyprinus carpio) and black
bullheads (Ictalurus melas).

Trapping rights were leased during the open seasons, but the
area was not extensively trapped. There was some aerial fox hunting
during December, January, and February. Two land owners kept hounds,
but hunted with them only three times in the period of study.
METHODS AND MATERIALS

Capture, Handling, and Marking

Steel traps (No. 1 1/2 long spring and No. 3 long spring) and live traps (No. 3A Havahart) were used for capture. Jaws of the steel traps were wrapped with cloth and electrical tape to minimize harm to the animals. Some of the live traps were set with only one end open so larger raccoons would have to completely enter the trap to reach the bait. Traps were set at permanent trap sites along the river at about 500-yard intervals, at small potholes, in travel lanes, near farm buildings, and near tree dens. They were checked daily in spring, summer, and autumn. Winter trapping was conducted near buildings and dens that were known to be occupied by raccoons. Sardines packed in soybean oil and a prepared fish scent were used for bait.

A numbered ear tag was placed on the back edge of each ear for later identification as described by Butterfield (1954). Colored streamers tied to ear tags were also attached to a few animals. Eight raccoons were equipped with radio transmitters to study movement activities.

Captured raccoons were transferred to a wooden box with a sliding door on one end (Fig. 3). Cotton soaked with ether was put into the box to anesthetize the animals for handling. While radio-tagging, the legs and mouth of the animal were secured with tape (Fig. 3). An assistant held the animal while the transmitter was fixed around the neck. To facilitate release, all tagging was done in the field. The operation took approximately 10 minutes.
Fig. 3. Handling and radio equipment. (A) Anesthetizing box. (B) Raccoon secured with plastic tape. (C) Transmitter (arrow shows placement of batteries). (D) Testing equipment.
Development and Description of Radio-Tracking System

Development of a radio-tracking system suitable for use on raccoons began in the spring of 1964. The project included three phases: developing a transmitter, devising a method of attachment, and choosing a suitable receiver.

The Transmitter

The first transmitter was designed after that of Cochrane and Lord (1963). An amplification stage was added to the basic design, but its power requirements demanded too large a battery. This model used a whip antenna which proved unsuitable for use on raccoons. The Slagel (1963) transmitter was reviewed, but was not acceptable because it also used a whip antenna and was attached to the animal by means of a harness. A transmitter developed by Holle and Robbins (1963) for use on wild turkey was also considered for raccoons. This model was believed to be too large and expensive for this project. Consequently, a model chosen for radio-tracking raccoons was similar to one Verte (1963) used on striped skunks. The transmitter, a modification of the Cochrane and Lord (1963) system, was a collar type that emitted a constant signal (Fig. 3). Three of the electronic components had fixed values: a capacitor, transistor, and a crystal. The two remaining components, a high value resistor and a mica-dipped capacitor, varied with the transmitter and had to be matched with the three fixed components (Fig. 4).
Fig. 4. Transmitter circuit diagram

B Mallory RM1R-T2 mercury cells (1.35 volts, 2 in series for 2.7 volts)
C1 220 microfarad mica-dipped capacitor
C2 0.01 microfarad disc ceramic capacitor
L 1/4-inch (outside diameter) aluminum tube
Q Philco or Sprague 2N1742 transistor
R 15 K ohm-180 K ohm carbon resistor
X Crystal (27mc)
Collar antennas were first constructed from 5/8-inch (width) copper strips formed into a loop. Later, aluminum strips replaced the copper, which in turn were replaced by aluminum tubes to lighten the unit. The aluminum tubes, 1/4-inch (outside diameter) and 1- to 1-1/2-inches long, were formed into a loop and the adjoining ends flared. Holes were drilled in the ends to insert copper rivets which fastened a webbed collar and provided a copper surface for soldering leads. A 1/2-inch space was left between the adjoining ends of the antenna for transmitter components.

Collars were made of 5/8-inch (width) webbing material inserted concentrically inside the aluminum loop and attached by the copper rivets in the manner described by verts (1963). The inside collar was tightened around the neck of the animal and held in place by two additional rivets. Adult and juvenile raccoon transmitters were the same size except for the size of the loop antenna.

After testing, the transmitter was embedded in 346 Copolymer Denture Material and Cold Cure Acrylic (Penta Hardener, Hygienic Dental Mfg. Co.). Two sets of paired mercury cells were soldered together as terminals, wired parallel, then attached and embedded below the transmitter. All leads except one were soldered and embedded. This resulted in only one connection to make when attaching the collar and transmitter to an animal. The transmitter, including the antenna, was coated with Silastic RTV 732 Adhesive Sealant (Dow Corning Corp.), and wrapped with plastic electrical tape. The entire package weighed 162 grams.
A multivibrator switching circuit, designed by Darwin Bayerishler, Department of Electrical Engineering, South Dakota State University, was added to the transmitter to increase range by using more current and emitting a pulsed signal. Resulting performance was no better than the original transmitter.

\*\*\*\*\*\*

**Receivers**

Special receiving equipment, designed for field use, consisted of a commercially manufactured walkie-talkie (EA-Lafayette Walkie-Talkie) modified with a directional receiving loop antenna, beat frequency oscillator, and a manual sensitivity control. It was developed by Frank Hoxie, Overton, Nebraska. A Cadre Model 51C-A (Cadre Industries Corp., Endicott, N. Y.) was modified with a beat frequency oscillator (BFO) necessary to produce an audible tone from the Cadre to indicate the presence of an unmodulated signal from any transmitter. Several BFO circuits were studied but none could be used without modifications. An original BFO was developed from a basic Hartley oscillator circuit and installed in a metal box attached to the rear of the Cadre transceiver chassis. It was turned on with the Cadre main on/off switch and tuned by adjustment of the "I.F. can" coil visible at the top of the BFO box. Performance was satisfactory.

The Cadre transceiver was used with a 5-element beam antenna (Knight Mfg.) mounted on a 30-foot mast. A preamplifier and loop antenna similar to the Hoxie modified walkie-talkie were also constructed for use on the Cadre. Although an audible signal was produced
with aid of the BFO, performance of the cadre receiving system did not equal that of the talkie-talkie unit. Unsatisfactory results could not be directly traced to the antenna system which left the performance of the transceiver in doubt.

Testing Equipment

Transmitting equipment consisted of a milli-meter, variable capacitor, and variable resistor (Fig. 3). Fixed value components were connected to the radio testing units and then tuned using a current ranging between 0. ma. and 1.3 ma. Current, variable components were attached in place of the terminals. All transmitters were field tested prior to embedment. If a signal was audible at 3/4 mile, the transmitters were considered satisfactory.

Field Use of Radio Tracking System

Radio-tracking was done by obtaining radio fixes similar to that described by Cochran and Lord (1963). One receiving unit was used to track the animals. Fixes were taken by triangulation within 1/4 mile of each radio-tagged raccoon. Position of an animal was located within an area of approximately 50 square yards and plotted on a map. Movements could easily be detected by a wavering signal from the transmitters. Cochran and Lord (1963) stated that the movements of an animal have a slight effect on the frequency and output of the transmitter that results in a wavering signal.

At least two full nights (sunset to sunrise) per week were spent tracking raccoons. The raccoon's position was determined at intervals
of 1/4 to 1 hour when tracked a full night. When the animals were not tracked continuously, they were followed as they left day retreats and once about 4 hours after they began their movement. It was believed the 4-hour interval gave the raccoons time to travel the maximum distance from their day retreats before returning. Sharp and Sharp (1956) found that most raccoons left a winter feeding station by 12:00 PM, most feeding 3 to 4 hours after sunset.

Food Habits Analysis

Food habits were studied by collecting scats from various scat stations throughout the study area. Digestive tracts were collected only from highway- and hunter-killed raccoons. Food items in scats were analyzed in the field and tallied by percent frequency of each item, and digestive tracts were analyzed in the lab and food items tallied by percent volume and frequency. Data were collected during all seasons of 1964 and 1965.
RESULTS AND DISCUSSION

Radio- and Ear-Tagging

The modified Verto (1963) transmitters were used for radio-tracking raccoons because they gave adequate reception and were inexpensive (less than $10.00) and easy to assemble with a minimum of testing equipment. Reception ranged between 1/4 to 1 mile depending upon position of the animal relative to fencelines and terrain. If a radio-equipped raccoon was close to a fence, the radio would transmit a stronger signal which increased the range as the wire in the fence served as an additional antenna. Range was reduced to less than 1/4 mile when a radio-equipped animal was below the river bank and the receiver bearing was perpendicular to the bank. Water affected a transmitter worn by one raccoon. The signal from this transmitter cut out when it was periodically submerged as the animal foraged the shore of an open marsh.

The Hoxie walkie-talkie receiver was light and mobile, crystal change required little effort, and battery life was nearly 2 months. On certain days static and interference reduced audibility of the constant signal emitted from the transmitter. Summer weekends were particularly poor in this respect, probably because of increased operation of amateur radios.

Neck abrasions or chafing was not observed on three raccoons equipped with transmitters for periods of 7 days, 18 days, and 6 months. One juvenile male was observed 3 months after radio-tagging
with three other raccoons along a marsh. His activities did not differ noticeably from others of the group.

Sixty-five raccoons were marked with ear tags and released at capture sites. Of the 65 tagged, 23 were recaptured for identification. Of the recaptures, 3 carried tags intact for 1 year and 15 for an average of slightly over 2 months. Four of the remaining recaptures had only one tag and another was missing both tags. Two other raccoons with both tags missing were reported about 1 year following initial tagging. The four with one tag missing had been marked with streamers. The streamer-type tags were easily pulled loose; therefore, this method was abandoned.

Ear tags when properly attached are a good means for identification of raccoons. In this study there was no known loss of an ear tag without a streamer; however, close observation was sometimes necessary because the tags became encrusted with mud. Butterfield (1954) recorded an 8.5 percent loss of tags from 123 raccoons carrying numbered ear tags over periods ranging up to 2 years.

Movement Activities as Determined by Radio-Tracking

**Adult Raccoons**

Two males and one female were radio-tracked for a total of 117 days (Table 1 and 2). Radio contact was lost with two additional females the day of release.

Adult male 63 was radio-tagged and released at capture site 2:00 PM, May 8, 1965. After release he ran 200 yards to a muskrat den in
Table 1. Tracking periods of radio-tagged raccoons during 1965.

<table>
<thead>
<tr>
<th>Number</th>
<th>Age</th>
<th>Sex</th>
<th>Tracking Period</th>
<th>Number of Fixes</th>
<th>Day</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>41*</td>
<td>Adult</td>
<td>F</td>
<td>July 2-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50*</td>
<td>Adult</td>
<td>F</td>
<td>August 7-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60**</td>
<td>Juvenile</td>
<td>F</td>
<td>October 18-October 20</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Adult</td>
<td>M</td>
<td>May 8-June 17</td>
<td>30</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Adult</td>
<td>F</td>
<td>July 2-September 4</td>
<td>54</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Juvenile</td>
<td>M</td>
<td>July 29-September 1</td>
<td>31</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Juvenile</td>
<td>M</td>
<td>August 16-October 14</td>
<td>42</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>75*</td>
<td>Juvenile</td>
<td>M</td>
<td>September 17-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>Adult</td>
<td>M</td>
<td>September 22-October 2</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

* Signal lost day of release.
** Radio-tagged 1964 (signal lost after 3 days).

Table 2. Average distance traveled the first four hours of nighttime movement during summer of 1965.

<table>
<thead>
<tr>
<th>Tracking Period</th>
<th>Average Distance (Yards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Male (63)</td>
<td>May 8-May 30</td>
</tr>
<tr>
<td></td>
<td>June 1-June 17</td>
</tr>
<tr>
<td>Adult Female (65)</td>
<td>July 2-July 6</td>
</tr>
<tr>
<td></td>
<td>July 7-August 1</td>
</tr>
<tr>
<td></td>
<td>August 2-September 4</td>
</tr>
<tr>
<td>Juvenile Male (72)</td>
<td>July 29-August 10</td>
</tr>
<tr>
<td></td>
<td>August 11-September 1</td>
</tr>
<tr>
<td>Juvenile Male (74)</td>
<td>August 16-September 16</td>
</tr>
<tr>
<td></td>
<td>September 17-October 14</td>
</tr>
</tbody>
</table>
a nearby marsh. That night he moved 1/2 mile to an abandoned farmstead where he stayed under the house for 63 hours, probably because of an injury from the steel trap used for capture. The next 4 nights he was found foraging along roadsides, wet areas, and the river. During the day he occupied tree dens: one about a mile south of the house in a grove and two near the river about a mile east of the house. He returned to the house during the fourth night. The air-line distance between fixes of the 4 nights was 3 1/2 miles, an average of 1400 yards per night (Fig. 5).

Until May 30, the animal left the house regularly at sunset, traveled through a wood lot, moved on to fields adjacent to the farmstead and river, and returned to the house before sunrise. He spent much of the time in picked cornfields between the farmstead and the river. Investigation of these areas indicated that corn had been eaten by raccoons.

From May 30 to June 17, he never returned to the area of the farmstead, but shifted his activity to the river and a small tributary. As before, activity began at sunset, but continued until 1 to 3 hours after sunrise. Activity consisted of roaming along the river and creek where many tracks and diggings indicated that raccoons had foraged for crayfish. Day retreats during this period were in four trees on the river bank and one ground den near the tributary. The signal was lost at the ground den June 17. It was also lost 7 of 41 days during the tracking period.
Fig. 5. Radio fixes for adult male 63 from May 9, to June 17, 1965.

Fig. 6. Radio fixes for adult female 65 from July 2, to September 4th, 1965
The other adult male (85) was radio-tagged September 22, 1965 and tracked 11 days before he died from a possible trap injury. After release, he traveled one mile east to a marsh. During the tracking period, he made daily retreats in the marsh and nightly trips along a small creek that flowed through the marsh.

The adult female (65) accompanied by a month-old juvenile male (presumed to be her kit) was tracked from July 2 to September 4, 1965. She spent the first 6 days in a wood lot near a farmstead about 1,000 yards from the release site and denned in a depression in a fallen tree limb. She then concentrated her activities in an oxbow 1/4 mile west of the wood lot where she foraged in the marsh vegetation and along a road ditch at night. This oxbow contained about 1 1/2 feet of water and an abundance of crayfish. She also made a few trips to hog feeders about 1/4 mile away. During the day she rested in the marsh vegetation of the oxbow.

This raccoon usually did not move very far from the day retreat during July although movement in the vicinity of the retreat was detected 1 to 2 hours after sunset by the wavering signal of the transmitter. A change of position was not evident on some nights until after midnight when she moved a distance of approximately 300 yards. Later in the season (August 2 to September 4) the animal moved farther from the day retreat on foraging trips. She had no set pattern of return to day retreats. When she traveled, it was common for her to depart and return several times nightly. The longest recorded
distance traveled was on August 29, when she went 1/2 mile to a stand of wild plums near the site of capture.

On September 4, 1965, radio contact was lost at the lower part of the oxbow near the river. On February 3, 1966, 65 was killed by hunters near the river 1/4 mile from the summer denning area. She was taken with two other raccoons from a squirrel nest.

Juvenile Raccoons

Four juveniles were radio-tagged, but two of them were tracked for only 3 days because of transmitter malfunctions. Data were collected on juvenile male 72, tagged July 29, 1965 and juvenile male 74, tagged August 16, 1965 (Table 1).

The latter two (72 and 74) were about a month old and possibly from the same litter. Their movements were similar when they were tracked during the same period (Fig. 7 and 8). They traveled only at night except when disturbed at their day retreats. Throughout July and August they foraged along the river and wet marsh areas, and rested in the dry parts of the marsh during the day. They used 5 and 11 day retreats, respectively, all of which were in heavy ground vegetation. They were together in one retreat for four consecutive days in August but were together only one night of this period. Radio contact with 72 was lost September 1, but was maintained with the other until October 14.
Fig. 7. Radio fixes for juvenile male 72 from July 29 to September 1, 1965.

Fig. 8. Radio fixes for juvenile male 74 from August 15 to October 14, 1965.
Raccoon 74 continued the same pattern of movement until late August when he was found in a sweet corn patch two consecutive nights in the north part of the study area. He rested in a marsh adjacent to the cornfield during the 2 days he spent in this area. Throughout most of September he was tracked to cornfields and to wild plums growing near an abandoned farmstead at the east end of the study area and near the river at the western boundary. He was found feeding on plums at the farmstead with other raccoons September 12, 16, and 20. These feeding sites were about 1/4 mile from where the raccoon spent the day.

His nightly foraging activities in the remaining tracking period were along the river bank and in picked cornfields adjacent to the river. Radio contact was lost at one of the usual day retreats.

Factors Influencing Movements

Food Habits and Feeding Activities

During 1964 and 1965, 367 raccoon scats (fecal droppings) and nine digestive tracts were analyzed for their food content (Table 3). Results of the 2 years were similar. Corn (Zea mays) was utilized heavily by raccoons in autumn and early winter and to a lesser degree in spring. Crayfish were the summer staple food from May through August. Insects were taken in abundance in autumn and plums were an
Table 3. Food habits of raccoons during 1964 and 1965 by percent frequency of occurrence in scats and digestive tracts.

<table>
<thead>
<tr>
<th></th>
<th>Spring (Mar.-Apr.-May)</th>
<th>Summer (June-July-Aug.)</th>
<th>Autumn (Sept.-Oct.-Nov.)</th>
<th>Winter (Dec.-Jan.-Feb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Scats</td>
<td>37</td>
<td>116</td>
<td>188</td>
<td>35</td>
</tr>
<tr>
<td>Number Tracts</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td><strong>Vegetable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>53</td>
<td>14</td>
<td>72</td>
<td>64</td>
</tr>
<tr>
<td>Plum</td>
<td>--</td>
<td>--</td>
<td>17</td>
<td>--</td>
</tr>
<tr>
<td><strong>Vertebrate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammal</td>
<td>5</td>
<td>4</td>
<td>tr*</td>
<td>20</td>
</tr>
<tr>
<td>Bird</td>
<td>8</td>
<td>3</td>
<td>tr*</td>
<td>2</td>
</tr>
<tr>
<td>Fish</td>
<td>20</td>
<td>2</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td><strong>Invertebrate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crayfish</td>
<td>5</td>
<td>73</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Insects</td>
<td>14</td>
<td>9</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>Earthworm</td>
<td>--</td>
<td>tr*</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

* 1 percent and less.
important food in mid-September. Only a few small mammals were con-
sumed during autumn and winter, while fish were taken from pools after
spring flooding.

Sweet corn in a local patch was eaten in August of two consec-
tutive years. The animals would pull down a stalk, take a few bites
from the ears, and move to another stalk. In August, 1964, the
raccoons destroyed the 1/4-acre patch in two consecutive nights by
this method. Although the sweet corn was planted beside a field-corn
plot, the latter was not damaged, showing that raccoons are often
highly selective of certain foods. Wood (1954) also points out that
selectivity is characteristic of raccoons. They sometimes will travel
to unfamiliar areas for a more palatable food. This was indicated by
observations on a radio-equipped raccoon which traveled 1/4 mile from
its usual area of activity to the sweet-corn patch in August, 1965.
It rested during the day in a marsh near the corn and made trips to
the patch two successive nights. The patch was on the north side of
a highway where he had not traveled previously.

When sweet corn was not available, field corn adjacent to the
river was heavily used by raccoons in autumn and spring. Giles (1939)
and (1940) and Hendrickson (1943) re-orted corn as a major food item
of raccoons in Iowa. Raccoons living under an abandoned house on the
study area fed nightly in cornfields between the house and river in
autumn of 1965. Raccoon 63 spent several nights in the same fields
during May, 1965. Night spotlighting revealed raccoons feeding in
picked cornfields in late fall and early spring. The animals took
advantage of corn left on the ground from normal picking operations.
Crayfish and frogs were generally abundant along river banks and in marsh areas from April to October. High incidences of crayfish remains in scats, high numbers of tracks around shorelines, direct observations, and radio-tracking data showed that summer foraging activities of raccoons centered around shorelines of available water. They did not have to move far because crayfish were abundant. Studies of scats collected along marsh and drainage areas in Iowa (Giles, 1940) and Minnesota (Schoonover and Marshall, 1951) showed crayfish were important food items in summer. Frogs were not noted in raccoon scats during this study. Hamilton (1940) and Dorney (1954) could not explain the low incidence of frogs in scats on marsh areas where frogs were abundant. As the small pools dried up in late summer, raccoons foraged mainly along the river and around the more permanent waterholes.

Raccoons commonly ate plums in mid-September. Animal 74 was tracked to plum thickets several times in September and other raccoons were chased from the thickets during the same period. Plum pits were found in scats collected from nearly all sections of the area. Such remains were observed in scats from along the north marsh area even though the nearest plum thicket was almost a mile away. Raccoons traveled considerable distances for this preferred food.

Scat analyses showed insects, especially grasshoppers, to be important food in autumn. Grasshoppers were abundant everywhere and probably were easily caught by raccoons.
It is believed that seasonal availability and palatability of food were major factors influencing raccoon activities. It also appears that raccoons are selective feeders when many foods are abundant.

Weather Conditions

Cold winter temperatures seem to be the major weather condition that affect behavior, although high temperatures in summer may affect a raccoon's choice of day retreats. Raccoons spent much time resting in marsh vegetation; hence, there is a possibility that marsh areas offer a cool retreat during warm periods. Since they have a period of semi-dormancy during extreme cold weather, an abandoned farmstead used by raccoons was investigated during December, January, and February, 1965-66 to learn about periods of activity and inactivity of the animals. Activity was noted by fresh tracks in snow near the house and around a large scat station on the farm lot. Activity generally ceased after temperatures dropped below 0 F. During one cold period with temperatures as low as -25 F no activity was noted for at least 6 days. Four days after the cold period fresh tracks were seen around the house, at a scat station, and near six tree dens along a mile of the river.

Sharp and Sharp (1956) pointed out that temperature and winds limited nocturnal activity. They stated that populations of raccoons in Nebraska were active throughout the winter during mild weather, but thermometer readings of 24 F or below caused adult populations to
"lay up"; and winds stronger than 10 mph curtailed raccoon activity. Stains (1956), working in Kansas, did not believe wind velocity was important, but stated that temperatures, more than any other factor, influenced activity in colder months. Both Cabalka et al. (1953) and Sharp and Sharp (1956) found that raccoons were generally intolerant to snow. Whitney and Underwood (1952) stated that the animals may become sluggish and remain quiet in a protective den during cold weather.

Activities of three radio-equipped raccoons increased in late summer and autumn regardless of lowering temperatures. However, two of the animals were juveniles which seemingly range farther as they grow older.

Rain or wind had no noticeable influence on movements of four radio-equipped raccoons. Slagel (1963) also noted that rain had no effect on movements of a radio-equipped raccoon in Missouri.

Denning Habits

Various dens were utilized by raccoons according to season. Abandoned farm buildings and trees were used during late autumn, winter, and early spring while heavy marsh vegetation was used mostly in summer and early autumn.

Buildings of an abandoned farmstead apparently offered better shelter than most trees in winter, and being on higher ground away from the river, provided refuge sites during spring floods. Adult
male 63 lived under the house in May, 1965 but used tree dens and a
ground den by the river from June 1-17. It appeared he had lived
under the house before the tracking period prior to May 8, 1965. A
female with a litter was reported living in a shed on the farm lot
June 2, 1965, after which she moved her litter to the nearby barn for
a week before leaving the vicinity. Raccoons occupied the house in
autumn and winter of 1965-66 by gaining entrance under a porch and
through a basement window. Buildings were not extensively used in
warm months, but a few scats found in the barn in summer of 1965 in-
dicated that buildings offered resting sites and possibly day retreats
for a few individual raccoons.

Many trees with cavities, mostly willows along the river, were
primarily used for winter dens. Surveys revealed that the larger den
trees had been occupied during December, January, and February. In
two half-mile stretches of the river, six of nine such trees showed
use in January and February, 1966. Trees were not important for day
retreats in summer. Adult male 63 was radio-tracked to seven trees in
May and early June but started resting in a ground den in mid-June.
Adult female 65 and a young male which accompanied her were located in
a limb depression on 6 days in June. Shortly afterwards she spent
many days in a marsh. Two radio-equipped juvenile males did not use
tree dens in summer. Only two raccoons were captured near tree dens;
however, tracks around several tree dens showed that raccoons visited
them regularly.

Marsh vegetation was the most important denning habitat in
summer. Eighteen of 19 day retreats of four radio-tracked animals were in marsh vegetation. High numbers of scats found in the dry parts of the marsh indicated that marsh areas were common resting places in summer and early autumn. Marsh areas offered a denning area close to abundant supplies of crayfish, the summer staple food.

Beaver and badger dens were available, but only two raccoons utilized them. Raccoon 63 used a ground den in mid-June and a yearling male was taken from a ground den in November, 1965. If trees and heavy vegetation were lacking, utilization of ground and bank dens might have been more noticeable.

Radio-tracking data revealed that raccoons used several dens in a relatively short period; thus the animals returned regularly to familiar den sites.

It is difficult to evaluate the part den sites had in influencing movement activities of raccoons on the study area. Steuwer (1943) assumed that lack of tree dens limits raccoon populations. According to Dorney (1954), widespread use of ground dens on Horicon Marsh, Wisconsin, and increasing raccoon populations in other parts of the country would indicate that tree dens are not essential for high raccoon populations. New federal farm programs have promoted abandonment of farmsteads, creating new denning sites that are utilized by raccoons. As a result, empty houses, barns, and sheds are common in eastern South Dakota. Raccoons in areas of South Dakota lacking permanent streams, other water areas, and trees may find these buildings and ground dens their only available retreat. It is believed that
Fig. 9. Denning habitat. (A) and (B) Typical tree dens. (C) and (D) Marsh areas utilized for day retreats.
activities in dry areas may differ from those of the study area.

Mobility might be greater in these areas because a raccoon may have to range farther to find preferred foods. Raccoons in South Dakota have shown their adaptability by living in the ground, buildings, and heavy cover when tree dens are scarce.

Competition

Striped skunks and red foxes might compete with raccoons for den space, especially in winter months. Twenty-six skunks were taken from the study area, nine near buildings once occupied by raccoons. Two were captured at entrances of dens occupied by raccoons at the time of capture. Raccoons continued using all 11 dens. A family of red foxes was reported living under a shed at one abandoned farmstead. No reports of raccoon encounters with skunks or foxes were noted.

Raccoons are gregarious in their feeding and denning habits. Feeding in packs (sometimes well defined family groups) in late fall and winter was noted by Sharp and Sharp (1956). They point out that the packs broke up and animals became more intolerant of each other at the onset of the breeding season. It was evident by frequent trips to the study area at night that in spring raccoons were often encountered foraging alone, while later in the season, packs of three or four (possible family groups) were common. Incidents of numerous raccoons taken from a single den are not rare in eastern South Dakota.

Physical Barriers

The river, railroad, and roads constituted the only physical
barriers on the study area. Radio-equipped raccoons crossed the river on foraging trips and released raccoons readily crossed the river to escape the observer. Raccoons followed and crossed roads frequently. Since raccoons follow these barriers, their range may be affected, causing it to be linear in shape. Otherwise, highway mortality was the noticeable effect of these barriers.

Range and Dispersion

Raccoon range was studied by telemetry and capture-recapture methods. Sixty-five raccoons including 3 adult males, 7 adult females, 29 juvenile males, and 26 juvenile females were captured (Table 4). Of 23 animals recovered, 12 were found or reported killed on the highway or taken by hunters and trappers. Thirty-one percent of the recovered animals were recaptured an average of 3.4 days after release.

Summer ranges of four radio-tagged animals suggest that raccoons have seasonal ranges that are influenced by availability of certain food. Also, there was a noticeable difference of summer ranges between sex and age groups. An intensive evaluation of range was not attempted in this study because of too few data.

During May, an adult male (63) foraged in cornfields and outlying potholes within an area less than 2 square miles (Fig. 5). He shifted his range to the river and a creek during June where he foraged (presumably for crayfish) within another area of the same dimension.
Table 4. Distances traveled by recovered ear-tagged raccoons during 1964 and 1965.

<table>
<thead>
<tr>
<th>Number</th>
<th>Age</th>
<th>Sex</th>
<th>Initial Capture</th>
<th>Recovery</th>
<th>Airline Miles Between Captures</th>
</tr>
</thead>
<tbody>
<tr>
<td>21*</td>
<td>Adult</td>
<td>F</td>
<td>May 18, 1964</td>
<td>July 10, 1964</td>
<td>0.8</td>
</tr>
<tr>
<td>24*</td>
<td>Juvenile</td>
<td>F</td>
<td>June 18, 1964</td>
<td>Oct. 17, 1964</td>
<td>0.5</td>
</tr>
<tr>
<td>25</td>
<td>Juvenile</td>
<td>M</td>
<td>June 18, 1964</td>
<td>Oct. 5, 1964</td>
<td>0.7</td>
</tr>
<tr>
<td>26</td>
<td>Juvenile</td>
<td>F</td>
<td>June 19, 1964</td>
<td>Aug. 12, 1964</td>
<td>0.5</td>
</tr>
<tr>
<td>29*</td>
<td>Juvenile</td>
<td>M</td>
<td>June 23, 1964</td>
<td>July 13, 1964</td>
<td>0.6</td>
</tr>
<tr>
<td>30*</td>
<td>Juvenile</td>
<td>F</td>
<td>June 24, 1964</td>
<td>Aug. 2, 1964</td>
<td>1.0</td>
</tr>
<tr>
<td>32*</td>
<td>Juvenile</td>
<td>F</td>
<td>July 4, 1964</td>
<td>July 28, 1964</td>
<td>0.3</td>
</tr>
<tr>
<td>39</td>
<td>Juvenile</td>
<td>F</td>
<td>July 20, 1964</td>
<td>Nov. 5, 1964</td>
<td>0.8</td>
</tr>
<tr>
<td>41**</td>
<td>Juvenile</td>
<td>F</td>
<td>Aug. 12, 1964</td>
<td>July 2, 1965</td>
<td>0.5</td>
</tr>
<tr>
<td>44</td>
<td>Juvenile</td>
<td>F</td>
<td>Aug. 16, 1964</td>
<td>Aug. 22, 1964</td>
<td>0.8</td>
</tr>
<tr>
<td>45*</td>
<td>Juvenile</td>
<td>M</td>
<td>Aug. 17, 1964</td>
<td>Nov. 8, 1965</td>
<td>2.8</td>
</tr>
<tr>
<td>50**</td>
<td>Adult</td>
<td>F</td>
<td>Aug. 25, 1964</td>
<td>Aug. 2, 1965</td>
<td>0.8</td>
</tr>
<tr>
<td>60**</td>
<td>Juvenile</td>
<td>F</td>
<td>Oct. 9, 1964</td>
<td>Oct. 15, 1964</td>
<td>0.3</td>
</tr>
<tr>
<td>63**</td>
<td>Adult</td>
<td>M</td>
<td>May 8, 1965</td>
<td>July 1, 1965</td>
<td>0.0</td>
</tr>
<tr>
<td>64*</td>
<td>Juvenile</td>
<td>M</td>
<td>July 1, 1965</td>
<td>Aug. 5, 1965</td>
<td>1.0</td>
</tr>
<tr>
<td>65**</td>
<td>Adult</td>
<td>F</td>
<td>July 2, 1965</td>
<td>Feb. 3, 1966</td>
<td>1.0</td>
</tr>
<tr>
<td>74**</td>
<td>Juvenile</td>
<td>M</td>
<td>Aug. 18, 1965</td>
<td>Aug. 21, 1965</td>
<td>0.5</td>
</tr>
<tr>
<td>75**</td>
<td>Juvenile</td>
<td>M</td>
<td>Aug. 16, 1965</td>
<td>Sept. 17, 1965</td>
<td>0.8</td>
</tr>
<tr>
<td>79*</td>
<td>Juvenile</td>
<td>M</td>
<td>Aug. 23, 1965</td>
<td>Nov. 15, 1965</td>
<td>0.6</td>
</tr>
<tr>
<td>80</td>
<td>Juvenile</td>
<td>F</td>
<td>Aug. 26, 1965</td>
<td>Sept. 22, 1965</td>
<td>0.1</td>
</tr>
<tr>
<td>81</td>
<td>Juvenile</td>
<td>F</td>
<td>Aug. 26, 1965</td>
<td>Sept. 2, 1965</td>
<td>0.0</td>
</tr>
<tr>
<td>83*</td>
<td>Juvenile</td>
<td>M</td>
<td>Aug. 29, 1965</td>
<td>Nov. 17, 1965</td>
<td>1.3</td>
</tr>
<tr>
<td>85**</td>
<td>Adult</td>
<td>M</td>
<td>Sept. 22, 1965</td>
<td>Oct. 8, 1965</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Animals Killed
** Radio-Tagged Animals
This suggests that he was influenced by crayfish abundance near permanent water areas because outlying potholes were drying.

An adult female (65), accompanied by a juvenile, ranged within a 1/4-section area during July and August, 1965 (Fig. 6). Crayfish were also abundant in this area so she did not have to travel far for summer preferred food. This animal probably spent much time caring for her young. Her range and activity increased about 200 yards in late August. This could be influenced by the fact that her kit was older and could forage for itself, therefore requiring less attention.

The distance between initial capture and last recapture for 14 juvenile raccoons suggests a small range for the first few months. Airline distances between captures of juveniles ranged up to 1 1/4 miles and averaged approximately 1/2 mile (Table 4). Radio-tracking of two juvenile male raccoons, possibly offspring of a lactating female killed on the study area in June, confirmed such movements as they traveled within a 1/2-section area during August (Fig. 7 and 8). They also increased their range as certain foods became available (Table 2). It was not known if these animals were with an adult. Their range was somewhat larger than that of the adult female (65) with one juvenile.

Evidence of some dispersal was shown by juvenile male 45, tagged August, 1964, when he was recaptured November, 1965 nearly 3 miles from release. Another juvenile male, found about a year after release, was killed on the highway almost a mile from initial capture,
and juvenile male 83 was recaptured in November, about 2 months after release, approximately 1 1/4 miles down stream from the release site.

Juvenile female 41 was recaptured about 1/2 mile from release one year after being tagged, and another juvenile female, tagged in 1964, was found dead in May, 1965, in the middle of the study area within 1/4 mile from point of capture. It is suspected that juvenile females do not disperse as far as juvenile males.
CONCLUSIONS

Radio telemetry was superior to the trapping-observation method for studying raccoon behavior. Miniature collar-type transmitters seemingly had no effect on animals or their movements. They were retained by raccoons for periods ranging from 1 to 8 months.

Data from four radio-equipped animals suggest small summer ranges for raccoons and movement variation between sex and age groups. Range of an adult male in May and June was less than 2 square miles. An adult female with a juvenile ranged within a 1/4-section area in mid-summer and two juvenile males had summer ranges of about 1/2 section. Availability of food affected movements in spring, summer, and autumn. Summer activities were near water areas where crayfish were abundant. Spring and autumn activities centered in cornfields where the animals fed on corn. Depredation of sweet corn in the milk stage was a problem. When natural foods are scarce or lacking other depredation by raccoons might result. Temperatures of 0 F generally caused raccoons to "den up" in abandoned buildings and hollow trees during winter. Raccoons denned in heavy marsh vegetation during summer and autumn.

Control of raccoons, if necessary, should be on a local complaint basis rather than by indiscriminate killing programs over broad areas because individual animals have a small range.
LITERATURE CITED


