

RADIO-TELEMETRY AS A TECHNIQUE USED IN GREATER
PRAIRIE CHICKEN (TYMPANUCHUS CUPIDO PINNATUS) MOBILITY STUDIES

by

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INTRODUCTION AND REVIEW OF LITERATURE

A review of numerous studies of greater prairie chicken (Tympanuchus cupido pinnatus) ecology, population dynamics, and behavior reveals a scarcity of data on daily and seasonal movements (Bent, 1932; Yeatter, 1943; Schwartz, 1945; Hammerstrom and Hammerstrom, 1949; Mohler, 1952; Baker, 1953). An extensive research program was initiated in September, 1963 at Kansas State University to determine the behavior and movements of greater prairie chickens on a study area in northeastern Kansas. The objectives of the initial phase of the study which was terminated in June, 1965 were: (1) to obtain and construct necessary radio-telemetry equipment for radio-position finding of unconfined prairie chickens, (2) to determine and evaluate the accuracy and limits of the radio-telemetry system, (3) to radio-tag and monitor daily and seasonal movement patterns of prairie chickens, and (4) to evaluate the application and feasibility of the technique as developed during the study.

Migrations and movements of birds have intrigued man for centuries, consequently many different methods of marking birds as individuals have evolved to facilitate study of these movements. Cottam (1956) reviewed the development of bird marking methods beginning with the earliest record of bird banding in 1710. He stated that Audubon marked birds with silver wire in 1803 and that numbered aluminum bands were first used in 1899 in Denmark and by 1920 in the United States. Some of the more recent techniques mentioned by Cottam included neck bands, dyeing of plumage, and various attachments of colored plastics. Early markers were designed for identification of individuals at close range, therefore a means was needed

which would enable identification at greater distances. Some recent developments in markers designed to solve this problem include colored anodized aluminum leg bands (Hammerstrom and Mattson, 1964) and button tags inserted through the patagium of the wing (Knowlton, Michael, and Glazener, 1964). The habits of many birds make observations extremely difficult without disturbing the animals, hence inadequate observations have often resulted in sketchy evaluations of movement patterns.

Recent advancements in the miniaturization of radio transmitter components have inspired the imagination of many biologists and ecologists concerned with the problem of animal movements. As a result of this interest, radio transmitters were first incorporated in wildlife research in 1957 (Busser and Mayer, 1957). This event spawned a new interdisciplinary technique termed biotelemetry or ecotelemetry by Adams (1965). Biotelemetry was defined by Slater (1965) as the instrumental technique for gaining and transmitting information from a living organism and its environment to a remote observer. Biotelemetry involves the attachment of a radio transmitting device to a study animal and the recording of signals received from the animal as it reacts to its environment. It is assumed that animals should be able to adapt to carrying small devices attached to their bodies and behave in a normal manner. Slagle (1965) stated that the basis for such an assumption lies in the fact that wild animals do incur injury and partial impairment of various faculties but continue to live apparently normal lives.

Space and medical technology have been responsible for much of the fast growth that has characterized biotelemetry, especially the phase of physiological telemetry (Adams, 1965). Physiological telemetry is however

somewhat removed from ecological telemetry because it usually involves short transmitter range and life as compared to the long range and life required of ecological telemetering equipment.

Some of the first ecological telemetering apparatus was designed and built by LeMonyan et al. (1959). Their transmitter weighed 123 grams, had a range of approximately 25 yards, and was used to track small mammals. Cochran and Lord (1963) found this early equipment unsuitable for their purposes and therefore developed a more refined system consisting of transmitters employing a loop antenna incorporated into an attachment collar, and a suitable portable receiver. Modifications of the Cochran and Lord transmitter have been utilized in studies of cottontail rabbits (Sylvilagus floridanus), striped skunks (Mephitis mephitis), raccoons (Procyon lotor), mallards (Anas platyrhynchos), Canada geese (Branta canadensis), and pheasants (Phasianus colchicus) (Lord, Bellrose and Cochran, 1962; Cochran, Warner and Raveling, No Date; Lord and Cochran, 1963). Jeter and Marghinton (1964) constructed and used radio instruments to track white-tailed deer (Odocoileus virginianus) at distances up to 1.5 miles for periods of six months. Craighead, Craighead and Davies (1963) reported on the testing of a prototype transmitter for use in tracking grizzly bears (Ursus horribilis) and subsequent modifications of this transmitter that were used to monitor bear movements at distances up to 12 miles over rugged mountain terrain. Added benefits of this system were stated to be the ability to place an observer at a vantage point without disturbing the bears (Craighead and Craighead, 1965). Singer (1963) reported on the construction of a 70-gram transmitter used in homing pigeon (Columba livia) research. The pigeons required a period of training to adjust to carrying this heavy package.

The development and use of low frequency transmitters for tracking woodchucks (Marmota monax) underground were disclosed by Merriam (1963). Equipment and techniques for radio-tracking striped skunks were reported by Verts (1963). The movements of rats (Rattus spp.) in Malaya was the subject of a radio-tracking study conducted by Sanderson and Sanderson (1964) in which transmitters weighing between 16 and 32 grams and having a range of 50 to 350 yards were employed. Ellis (1964) used a modification of the Cochran and Lord transmitter to study movements and habits of raccoons. Storm (1965) described the use of radio devices for studying the movements and activities of red foxes (Vulpes fulva) while Southern (1965) has used various radio transmitters in research concerned with bald eagles (Haliaeetus leucoccephalus), herring gulls (Larus argentatus), bobwhite quail (Colinus virginianus), rough-legged hawks (Buteo lagopus), and gray partridges (Perdix perdix).

Marshall and Kupa (1963) discussed the development of radio telemetry equipment for use in ruffed grouse (Bonasa umbellus) research. Their early transmitters were found to be too large for grouse to carry satisfactorily so they were employed in porcupine (Erethizon dorsatum) research (Marshall, Gullion and Schwab, 1962). Continued efforts by Marshall (1965) and a private contractor produced transmitters suitable for ruffed grouse application.

Biotelemetry is capable of providing large and sometimes overwhelming quantities of information. Cochran et al. (1965) developed an automatic radio-tracking system designed to receive and record a maximum of 1,920 locations on each of 52 different radio equipped animals every 24 hours. The complicated device has been used to monitor movements of red foxes,

white-tailed deer, raccoons, cottontail rabbits, and snowshoe hares (Lepus americanus). Tester and Heezen (1965) employed the automatic tracking system to test a deer drive census technique by tracking both deer and the human drivers. Siniff and Tester (1965) disclosed the use of a high speed digital computer to process the immense amount of data recorded by the automatic tracking equipment. Patric, Longacre and Doan (No Date) developed a new technique in radio position finding of white-tailed deer which incorporated unique features including location by bearing and range from one fixed station at 15 minute intervals, short pulse signal modulation, and field transmitter life of over one year. Radio telemetry is a relatively new but already widely used tool that can enable researchers to answer many questions concerning the movement of animals.

MATERIALS AND METHODS

The Study Area

The 6000-acre study area was located 9 miles east of Junction City in T12S, R7E of Geary County, Kansas and was almost entirely included within the Simpson Ranch. A portion of the study was conducted on land adjoining the south-central boundary of the Simpson Ranch. Topography of the region consists of branched, rounded ridges which are fringed with rock outcroppings and interlaced with drainages. The elevation varies from 1180 to over 1400 ft.¹ (Fig. 1).

¹United States Department of the Interior Geological Survey Contour Map, 1955.

Vegetation of the area averaged about 12 inches in height and was generally characteristic of the Kansas Flint Hills except on some of the ridges which were formerly cultivated. Dominant vegetation covering most of the ridges consisted of perennial grasses including little bluestem (Andropogon scoparius),¹ big bluestem (Andropogon gerardi), tall dropseed (Sporobolus asper), western wheatgrass (Agropyron smithii), sideoats grama (Bouteloua curtipendula), buffalo grass (Buchloe dactyloides), and blue grama (Bouteloua gracilis). Scattered throughout these dominant grasses were many forbs and less numerous grasses including slimflower scurfpea (Psoralea tenuiflora), Japanese brome (Bromus japonicus), western ragweed (Ambrosia psilostachya), western yarrow (Achillea millefolium), green milkweed (Asclepias viridiflora), broomweed (Gutierrezia dracunculoides), purple prairieclover (Petalosaeum purpureum), and Louisiana sagewort (Artemisia ludoviciana). Sedges (Carex spp.), rushes (Juncus spp.), and pricklypear (Opuntia spp.) were also present on occasional sites. Trees and shrubs were numerous in the bottoms of the drainages and annual vegetation was dominant on the formerly cultivated ridge tops. Additional important species found only in the cultivated and old fields included sorghum (Sorghum spp.), alfalfa (Medicago sativa), yellow sweetclover (Melilotus officinalis), wheat (Triticum spp.), and smooth brome (Bromus inermis). Robel (1964) described the vegetation of the northern portion of the study area and his list is descriptive of most of the area on which the study was conducted.

The study area was used predominately for year-around cattle grazing with light stocking rates and pasture rotation practiced. None of the area

¹Descriptive common and scientific names follow Anderson, 1961.

was burned during the study but some of the heavy grass on the hillsides was mowed and baled in the fall of 1964. Two tracts designated as old fields in Fig. 1 were ungrazed and unfarmed. The main crops cultivated in the small fields were wheat and grain sorghum.

Prairie chickens were numerous throughout the region with large numbers present on the study area during the winter when outside flocks fed in the cultivated fields. Censuses of the three known booming grounds located on the Simpson Ranch during 1964 and 1965 showed 9 to 10 males to be active on the north ground, 10 to 12 on the central, and 12 to 13 on the south. The total resident prairie chicken breeding population on the study area was estimated to be approximately 60 birds.

Live-trapping and Banding

Prairie chickens were live-trapped throughout the duration of the study to expedite attachment of leg bands and radio transmitters. A cannon-net trap consisting of a 40 X 60 ft. knotless nylon net having a 2-inch mesh and three composite type cannons utilizing 12 gauge factory charges was the trap most extensively used. The cannons were detonated by a 50-cap blasting machine which was located in a near-by blind and connected to the cannons with U.S. Army field communication wire. This trap was deployed on the booming grounds during the spring and fall and in the feed fields during the winter. Ear corn and whole milo were used for bait during winter trapping attempts. A portable electric fence was erected around the booming grounds during trapping operations to keep cattle away from the trap. A tape recording of booming prairie chickens was used to entice male prairie

chickens into trapping range in the late spring after regular booming activities had ceased.

Two funnel type walk-in traps were constructed for use in feed fields during the winter. Each trap was formed by arranging three 3 X 15 ft. sections of 2 X 4-inch welded wire fencing in an elongated oval shape with the ends of the fencing turned in toward the center to form funnels. The tops of these traps were covered with cotton fish netting and the traps were baited with ear corn and whole milo. These traps were inspected every evening when in use so that trapped birds would not be confined overnight.

An 8 X 10 ft. net suspended between two 12 ft. bamboo poles was also used to live trap prairie chickens. A portable receiver and a 5-cell flashlight were used to locate radio-tagged prairie chickens after dark and the hand net was deployed from the opposite direction to recapture these birds for replacement of radio transmitters. The hand net was also utilized to capture nesting hens while incubating on their nests.

Black cotton stockings were placed over the heads of prairie chickens as soon after trapping as possible to minimize escape attempts while the birds were detained. All prairie chickens captured during the study were banded on the left leg with numbered aluminum bands inscribed "Return to Dept. of Zool., KSU, Manhattan." Colored plastic bands were placed on the right leg in different color combinations to facilitate recognition of individuals. All banded and radio-tagged prairie chickens were immediately released as near to the capture site as possible.

Radio-telemetry

The radio-telemetric instruments used during the study were developed by Marshall (1965) and built for this study by Sidney L. Markusen, Cloquet, Minnesota. The transmitters were incased in a cylindrical epoxy package approximately 0.5 X 1.25 inches weighing 6 to 7 grams. These transmitters were of the continuous broadcasting type, had a maximum power output of 0.01 watt, and operated at discrete frequencies between 150.815 and 151.085 megacycles. Each transmitter employed a transistor in a crystal oscillator circuit and a fine spring wire whip antenna 11 to 12 inches long. The source of power for each transmitter was a mercury battery (Burgess or Mallory RM 401) which measured 0.45 X 1.1 inches and weighed 12 grams.

Harnesses were used to attach the transmitters to the prairie chickens and these were fashioned from 0.1 inch diameter plastic tubing. Two 10-inch lengths of this tubing were built into the anterior end of each epoxy transmitter package (Plate I). A harness was prepared by forming a loop with the tubing near the front end of the transmitter and attaching a mercury battery to the front of this loop with plastic tape. The loop was made just large enough to pass over a prairie chicken's head and the distance from the front of this loop to the posterior end of the transmitter was made equal to the distance from the front of a prairie chicken's neck to a point parallel to the trailing edge of the wings (Plate I). The wire battery leads were pulled through slits in the plastic tubing and were soldered to the battery and both the battery and the transmitter were covered with plastic tape before being attached to a prairie chicken. A transmitter was attached to a prairie chicken by slipping the neck loop

over the bird's head so that the battery was suspended over the bird's crop and the transmitter package held on the bird's back between the wings. The ends of the plastic tubing were then passed under each wing and one end threaded through a hole in the posterior end of the transmitter and secured to the other end of the plastic tubing with a square knot and plastic tape. The entire harness was then worked beneath the feathers so that only the posterior tip of the transmitter and the whip antenna were visible (Plate I). The transmitter, battery, and harness weighed approximately 21 grams when attached to a prairie chicken.

Two portable receivers specifically designed for use in tracking radio-equipped animals were employed to detect signals broadcast by the transmitters. These 10-channel, crystal controlled, double conversion, superheterodyne receivers were completely transistorized to minimize weight and battery drain. The power supply consisted of ten size "C" flashlight batteries and all components were contained in a 5 X 6 X 9 inch aluminum case weighing 4.5 pounds. Signals could be detected audibly by use of ear-phones and visually by use of a signal strength meter. Receiver controls included a master switch and volume control, channel selector, battery test, circuit switch, sensitivity control, BFO (Beat Frequency Oscillator) switch and control, meter gain, and vernier tuner. Various directional antennae were connected to the portable receivers by means of standard coaxial fittings. Padded canvas carrying bags were fabricated to encase each receiver for protection and ease of handling.

The portable receivers were operated by connecting a directional antenna, turning the set on, and selecting the proper channel for the reception of a specific transmitted signal. The vernier tuner was then

slowly adjusted while rotating the directional antenna until a tone was heard indicating the reception of a signal. Vernier tuning was then continued to obtain maximum volume and meter deflection. Finer tuning was accomplished by adjusting the BFO and sensitivity. The antenna was then swung back and forth in the direction of the signal to determine an arc of reception. A distinct null was detectable on either side of a zone of maximum reception and these null points were noted. The arc between the two null points was bisected to calculate a signal azimuth. Three azimuths were averaged to obtain the true bearing which was recorded. The entire procedure was then repeated at a different location to obtain another azimuth to the same transmitter and both bearings were then plotted to determine the location of the transmitter.

Three different types of directional receiving antennae were used in combination with the portable receivers. They consisted of eight permanent receiving stations, one mobile receiving station, and two hand held directional antennae. The permanent and mobile receiving stations employed 8-element yagi type directional antennae which were constructed by drilling holes through a 10 ft. length of 0.5 inch diameter electrical conduit, and inserting heavy wire elements of the proper length through these holes and soldering them in place (Fig. 2). The seventh or driven element was also fabricated from heavy wire but was connected to the boom by three 0.25 inch bolts and a bakelite insulator 3 inches long. The lead-in cables were RG 58 A/U coaxial cable extending from the driven element along the boom to the mast, through a cork stopper in the top of the mast, down the mast and out a hole above the base, and ending in a coaxial fitting (Fig. 3). A coaxial cable balun loop 25.75 inches long was attached to each driven

element.

Supporting masts for the permanent receiving stations were constructed from two 10 ft. sections of galvanized steel television mast 1.25 inches in diameter, bolted together to form a 20 ft. high tower. A directional yagi antenna was affixed to the top of each tower with a 1.5 inch muffler clamp after slightly flattening the end on the mast. This attachment prevented slipping as the mast was rotated in a 30-inch base which was buried to a depth of 24 inches in the ground. Steel wings were welded to the sides of the base to prevent it from rotating in the soil. A metal flange was welded to the upper end of each base to facilitate attachment of a compass card. The compass cards were 8-inch photographs of a circular protractor which were glued to masonite discs, covered with transparent acetate, and glued to the metal flanges. Television insulator stand-offs were modified by cutting off the insulator and sharpening the end and were fastened to the towers immediately above the compass cards to serve as pointers. Four guy wires were attached to a slip ring which was retained by a collar bolted through each mast 48 inches from the top. The guy wires supported the towers but allowed free rotation of the antennae (Fig. 3). Canvas covers were attached to the masts above the compass assemblies and protected the assemblies when not in use. Barbed wire fences approximately 20 ft. square were constructed around each permanent station to exclude cattle and were used to anchor the guy wires (Plate II).

A preliminary test showed that the maximum range of the transmitters was approximately 0.5 mile, therefore the permanent receiving stations were erected approximately 0.4 mile apart in a grid-like pattern along the ridge tops of the study area. The antennae were each aligned on imaginary base

lines extending between the permanent stations. Alignment was accomplished by two workers, one posted at the antenna (A) being aligned and the other at the station (B) being lined on. A spotting scope was set up at B and sighted on antenna A which was then oriented parallel to line AB with the open end pointing toward B. Antenna A was then held in this position and its pointer set to indicate "0" degrees on the compass card. This procedure was repeated periodically during the study to insure against changes in alignment.

The mobile receiving station consisted of a directional yagi antenna mounted at the top of a 10 ft. television mast which extended through the roof of a pickup truck and rotated in a base bolted to the floor of the cab (Plate III). An inverted compass card was secured to the roof of the cab and a heavy wire pointer inserted through a hole in the mast. The lead-in cable extended from the yagi to the mast, passed through a window into the cab, and connected to a portable receiver placed on the seat. The mobile station was operated from within the cab and was disassembled during transportation.

The mobile station was used to search large areas for radio-tagged birds outside the range of the permanent stations when ground conditions and terrain permitted vehicular travel. When used, the pickup was driven to a likely area and the antenna erected. The portable receiver was then employed in the usual manner to determine the azimuths for any given transmitter. Azimuths were recorded as degrees deviation from imaginary base lines connecting the mobile station with visible landmarks.

Each hand held directional antenna consisted of a tubular handle supporting two heavy wire elements at right angles. A lead-in cable about 18 inches long connected the antennas to the portable receivers (Plate IV).

These antennae were used to locate radio-tagged prairie chickens when it was impossible to use either the permanent or mobile antennae. Such instances included night retrapping operations and radio tracking outside the range of the permanent stations in areas where vehicular travel was impossible. Radio-tagged birds were located with the hand held antennae by walking in a wide circle around the position of the bird and obtaining several bearings on the signal from different points. The birds were not approached too closely as a precaution against disturbing or flushing them. The location of a radio-tagged bird was noted in relation to visible landmarks and later plotted on a base map with the aid of an aerial photograph. Hand held antennae were also used to flush radio-tagged birds to check their physical condition.

Research was conducted during the summer of 1964 to determine the accuracy of radio-position finding by use of the permanent stations. Attempts were made to locate transmitters placed in 66 different known locations determined by standard surveying techniques. The intersection of azimuths from two or three permanent stations was considered as the radio-location of a transmitter. The error of the method was measured as the difference between the radio-location of a transmitter and its actual location. Data were stratified into classes according to the distance from the transmitter to the permanent stations and analyzed by standard statistical procedures. The accuracy of two-azimuth locations was compared with that of three-azimuth determinations. Attempts were also made to determine the effects of vegetation and power lines on the transmission of signals.

Radio transmitters were attached to a total of twelve different prairie chickens and attempts were made to locate each bird once or twice

a day at different hours to determine the seasonal ranges of individual birds if possible. Continuous tracking, consisting of position-finding at 15 to 30 minute intervals for extended periods, was utilized as a method of determining daily mobility. The locations of prairie chickens were recorded on base maps and field notes were compiled to provide a history of each individual bird tracked.

RESULTS

Trapping and Banding

Fifteen male and 8 female prairie chickens were trapped and banded during the study. The cannon-net trap was used to capture 13 males and 5 females, a walk-in trap captured 2 males and a female, and the hand net was used to capture 2 nesting females. Three radio-tagged prairie chickens were recaptured with the cannon-net and three with the hand net. The cannon-net was responsible for the injury of two birds; one of which recovered and the other was later killed by a hawk. Only slight abrasions were noted on prairie chickens captured in the walk-in trap and no injuries resulted from the use of the hand net. The black stockings used to cover the birds' eyes probably prevented several injuries from occurring while handling the birds. Trapping attempts with the cannon-net trap during the winter were unsuccessful because prairie chickens failed to be attracted to the bait. A considerable amount of time was spent trying to capture prairie chickens during the late fall and early winter without success.

Radio-telemetry

The performance of the radio-telemetric equipment was satisfactory with few exceptions. Twelve different transmitters were employed in 17 separate attachments. Nine transmitters were recovered, three were lost, and five were still attached to prairie chickens and working when this phase of the study was terminated. One transmitter was lost after its battery had expended its full life and the other two transmitters were lost because of unknown causes. Antenna breakage and power failure were the two most common known causes of transmitter failure. Power failures could have been caused by poor connections, defective batteries, or excessive power drain by the transmitter. One transmitter failed to function properly when received from the manufacturer and was subsequently returned for repair. The transmitters functioned well at all temperatures encountered in the field, probably because of their close proximity to the bodies of the birds.

Inspection of retrapped radio-tagged prairie chickens revealed no apparent adverse physical effects caused by the harness arrangements. Balling of a few small feathers beneath the wings was noted on some individuals. None of the prairie chickens that were radio-tagged were seen to react violently to the transmitter or harness, even immediately after release.

The two portable receivers were used in excess of 150 hours during the study and required repairs three times. They were returned to the manufacturer by air express for maintenance and promptly repaired so research was never greatly hindered by receiver malfunction.

A loss in the efficiency of the receivers to obtain a signal was noted when they were operated at temperatures below 20° F for extended periods of time. The receivers were successfully used at temperatures below 0° F by leaving them in the heated vehicles except when actually in use. In extremely cold weather, hand warmers were placed in the padded carrying cases alongside the receivers in an attempt to maintain a higher operating temperature, however this practice was of little value because the hand warmers were often extinguished.

All three designs of directional antennae were successfully utilized during the study. The permanent stations were employed whenever possible because their use disturbed the prairie chickens least and their accuracy was known. Freezing of the antennae was a problem often encountered during winter use of the permanent stations. Moisture accumulated in the bases and on the guy rings and froze, making the antennae impossible to rotate. Because several of the permanent antennae were inoperative during the winter, hand held antennae were often used.

An evaluation of the accuracy of the telemetric instruments used in this study disclosed that the mean error in feet was positively correlated with the distance from the receiver to the transmitter but that the mean error in degrees was greatest in a mid-distance class (Table 1). Two errors of 6° each were encountered and were considered unusually large as compared to all other errors which were 4° or less. When these two errors were excluded, a significant positive correlation between distance and error in degrees was determined (t value = 2.915, df = 54; r = 0.764). The mean distance from actual transmitter locations and radio determined locations derived from three azimuths was 164 ft. as compared to a mean error of

Table 1. Accuracy and reliability of radio-position determinations stratified into six distance classes.¹

Distance class (feet)	Mean distance of trials (feet)	Number of attempts	Successful attempts	Percent success	Mean error (degrees)	Std. error of the mean (degrees)	Mean error (feet)
0-600	340	10	10	100.0	1.1	0.58	7.7
601-1200	881	11	11	100.0	0.6	0.20	9.0
1201-1800	1583	15	15	100.0	3.0	0.43	81.0
1801-2400	2134	14	12	85.7	1.3	0.35	48.1
2401-3000	2755	12	10	83.5	2.1	0.39	100.8
over 3000	3508	4	0	0.0	---	----	----

¹ (Slade, Cebula and Robel, 1965)

ninety-six ft. for two-azimuth locations. Bearings within 5° of a straight line between the antennae were excluded from the two-azimuth locations because slight errors in azimuth in this area may result in large linear errors.

No deflections or signal "bounce" was detected from the forms of vegetation present on the study area. The power lines caused deflections of up to 18° when bearings were nearly parallel to the lines but other bearings near the lines showed only normal errors. The results of the accuracy research are more thoroughly reported by Slade, Cebula and Robel (1965).

Seven male and five female prairie chickens were tagged with radio transmitters, released, and radio tracked for a total of 407 days. Attempts to locate these prairie chickens averaged 86.3 percent successful, yielding 546 locations. A summary of the tracking success is presented in Table 2. An "attempt" to locate the position of a radio-tagged prairie chicken involved a complete search for that bird using all tools available. The prairie chickens were numbered according to sex as they were radio-tagged, with the prefix "1" representing males and "2" representing females. The histories of individual radio marked birds are presented to facilitate summarization of the data obtained and to expose difficulties encountered.

An adult male (No. 11) was captured on the central booming ground with the aid of the cannon-net trap on 13 June 1964. Booming activities ceased for the spring on the central booming ground on that date. Number 11 confined his movements mostly to a 26-acre old field that had a heavy vegetative cover and was located 0.4 mile from the booming ground. The bird was not known to return to the booming ground during the summer.

Table 2. Summary of location determinations and field transmitter life for 12 unconfined radio-tagged prairie chickens.

Prairie Chicken number	Transmitter channel(s)	Success in locating bird (percent)	Number of locations	Transmitter duration (days in field)	Period of transmission	Cause of transmitter cessation
1964						
11	2	92.7	96	78	6/13-8/30	dead battery (lost)
1965						
12	2	37.1	18	37	2/7 -3/16	broken antenna
13	4	70.6	15	19	2/7 -2/26	broken antenna
	3	100.0	12	7	4/7 -4/14	bird killed
14	7	84.1	35	25	4/7 -5/2	dead battery
	6	95.7	22	13+	6/2 -6/15	still transmitting
15	3	86.9	33	23+	5/24-6/15	still transmitting
16	5	94.4	17	12+	6/4 -6/15	still transmitting
17	2	94.1	16	10+	6/6 -6/15	still transmitting
21	8	67.3	39	49	2/5 -3/26	replaced
	9	90.6	53	41	3/26-5/10	replaced
	10	100.0	5	3	5/10-5/13	bird killed
22	6	100.0	12	7	3/26-4/4	unknown (lost)
23	8	93.9	92	42	4/17-5/30	replaced
	1	96.2	24	17+	5/30-6/15	still transmitting
24	10	73.3	11	12	4/17-4/25	bird killed
25	9	90.4	42	12	5/24-6/5	unknown (lost)

Thirty-four radio positions of No. 11 were obtained at 15-30 minute intervals on 15 July from two permanent stations. The bird's movements for that day were calculated by measuring the distance between successive locations and totaled 0.45 mile, confined to an area of 4 acres. The known range of No. 11 as determined by 96 locations during a period of 78 days was 46 acres (Fig. 4). The only time No. 11 was known to leave this area was when the bird was deliberately flushed and then the bird returned to the area within one day. The bird appeared in good physical condition and flew well when flushed. Most of the failures to locate No. 11 occurred during rainy weather. The signal was lost on 30 August after the battery had presumably exhausted its power.

On 7 February 1965, an adult male (No. 12) was captured in a walk-in trap in an old field that contained a sparse stand of sorghum used as a feeding area by several prairie chickens. This bird was attracted by the bait after a period of stormy weather had left the ground covered with snow. Number 12 had been previously trapped and banded on a booming ground 2.2 miles north of the trap site the spring before. This bird was fitted with a transmitter and radio-tracked for a period of 37 days during which 14 locations were determined. Number 12 was observed on several occasions with flocks of prairie chickens wintering in the area. His known winter range covered 414 acres (Fig. 5). Number 12 returned to the northern booming ground on 14 March where tracks in the snow indicated that booming activities had begun. The transmitter went dead on 16 March but was later recovered and found to have a broken antenna. The transmitter was removed and the bird was released on the north booming ground in good condition.

A second adult male (No. 13) was trapped in the same walk-in trap as

No. 12 on 7 February 1965. This bird was equipped with a transmitter and radio-tracked for a period of 19 days and 12 radio locations were obtained. Number 13's known winter range encompassed 411 acres (Fig. 5). On 18 February, this bird was located on the central booming ground. Following a snowstorm on 24 February, No. 13 had joined a large flock of prairie chickens seen resting in the tops of some trees. This flock broke up two days later and No. 13 again returned to the booming ground. The transmitter went dead on 26 February and No. 13 was retrapped on 7 April on the central booming ground with the cannon-net. The dead transmitter was found to have a broken antenna and was replaced. The bird was unable to fly when released and was presumed to have been injured by the cannon-net when trapped. Observations of No. 13 on the booming ground on mornings following his release showed that although the bird walked to and from the booming ground, it maintained its booming territory. On 14 April, No. 13 was found dead on the booming ground by ranch workers. They said a hawk was eating the carcass when they first saw the dead prairie chicken. Evidence indicated that the hawk had killed the bird. The transmitter and harness were still intact when the dead bird was found and the transmitter was functioning well.

On 7 April 1965, an adult male (No. 14) was captured with the cannon-net on the central booming ground. This bird was tracked for 25 days and was located on the booming ground 10 times and 25 times in the near-by pastures. His known range covered 92 acres and included the central booming ground (Fig. 6). The males from this booming ground often arrived and departed as a group during this period of time and were often found with No. 14 during the day. Observations of No. 14 on the booming ground showed

that his behavior was similar to untagged males. He apparently had no difficulty fighting or displaying (Plate IV). On 2 May the signal was lost, apparently due to a power failure. On 2 June, near the end of the booming season, the cannon-net was again used to capture No. 14 on the booming ground. The old transmitter was removed and was found to be in working condition when a new battery was attached. A new transmitter was attached to No. 14 and the bird was tracked for an additional 13 days before this phase of the study terminated. Twenty-two locations showed that his known range had shifted since the height of the booming season and encompassed 83 acres adjacent to the booming ground. The males had become more solitary during this period and No. 14 was usually found alone.

The cannon-net trap was used on the central booming ground on 24 May 1965 to capture an adult male prairie chicken (No. 15). After tagging and release, this bird remained mostly solitary when away from the booming ground and stopped displaying on 1 June. Number 15 was radio tracked for 23 days and the 23 locations obtained showed this bird's range enveloped 74 acres (Fig. 8). Number 15 was observed to be one of only two breeding males on the central booming ground and was seen copulating once after being radio-tagged. The transmitter was still functioning on 15 June when tracking for this phase of the study was discontinued.

An adult male (No. 16) was trapped on 4 June 1965 on the central booming ground after regular displaying had ceased. The bird was lured onto his territory by a tape recording of booming prairie chickens played from within the blind. Number 16 was tracked until 15 June and the bird's position was determined 17 times. Number 16's known range included 103 acres near the central booming ground and overlapped that of No. 15. These

two birds were located together only twice and were usually found alone (Fig. 9).

On 6 June 1965, an adult male prairie chicken (No. 17) was captured at the central booming ground by the same method used for No. 16. Number 17 had been trapped and banded at this booming ground the year before. This bird was radio tracked until 15 June and was located 15 times. Number 17's known range covered 31 acres immediately adjacent to the booming ground (Fig. 9). Number 17 was observed to be an active breeder during the booming season and was the last male to leave the booming ground at the end of the season. The bird was often found near the booming ground during the day.

An adult female (No. 21) was captured on 5 February 1965 in a walk-in trap. Number 21's range was outside the area covered by the permanent antennae, therefore this bird was tracked entirely by use of the hand-held antennae. Thirty-nine locations showed that this bird covered a known area of 308 acres in 49 days (Fig. 10). Number 21 was often found a short distance from rock outcroppings and ranged at lower elevations than did No. 12 and No. 13 during the same period. Number 21 was never located with the large winter flocks of prairie chickens that frequented the same general area. During the night of 26 March, the bird was recaptured by use of the hand net and a flashlight. A different transmitter was installed and tracking continued for 39 more days. A slight change in range and a possible reaction toward a booming ground was noted during this second tracking period. Fifty-three locations showed No. 21's movements to be widely scattered with no apparent preferences toward a nesting site. The bird moved into a new region not previously occupied during the first two weeks of May (Fig. 11). Number 21 was again captured at night on 10 May but flew

into a barbed wire fence when released. The actual collision was audible and was also detected with a portable receiver. The bird refused to fly when found about 15 minutes after the accident, but examination showed no apparent injuries so the bird was released. Locations during the three days following the accident showed that No. 21 had returned to the formerly occupied range. On 13 May this bird was found dead, apparently the prey of a mammalian predator. It was suspected that No. 21 could no longer fly after hitting the fence. A total of 93 days of tracking produced 97 locations of prairie chicken No. 21.

The hand net was utilized for the capture of an adult female prairie chicken (No. 22) on the night of 26 March 1965. This bird was roosting very close to No. 21 and was thought to be the radio-tagged bird until captured. Number 22 was radio-tagged, released, and tracked for seven days when the signal was lost. An extensive search of the surrounding area was fruitless, indicating that the transmitter had probably failed. Twelve locations indicated that No. 22 ranged over a known area of 107 acres in seven days (Fig. 12). The bird was never located with No. 21 after the night of capture although both birds were in the same vicinity.

Prairie chicken No. 23, an adult female, was trapped with the cannon-net while visiting the central booming ground on 17 April 1965. Four other hens and a cock (No. 17) were also trapped at the same time. Tracking of No. 23 continued through nesting and incubation. Number 23's pre-nesting range was determined by 32 locations and was known to cover 206 acres including the nest site. The nest was found on 9 May and contained 13 eggs. Incubation began on 11 May and continued until 3 June when all 13 eggs hatched. Sixty-seven locations obtained during incubation revealed that a feeding

period of 0.5 to 1.0 hour occurred each morning and evening. The hen usually flew directly from the region of the nest to an old field 0.4 mile away to feed and returned in the same manner. The bird was never observed to walk from the nest to feed. On 30 May, No. 23 was captured with the hand net while on the nest to facilitate replacement of the transmitter before the eggs hatched. Seventeen locations were made after the eggs hatched and showed that No. 23 left the vicinity of the nest on the day the eggs hatched and traveled approximately 0.25 to 0.5 mile with her brood every two days until 15 June (Fig. 7). The hen was approached closely two times but only occasionally was a chick observed.

An adult female (No. 24) was trapped on the central booming ground on 17 April 1965 along with five other prairie chickens including No. 23. Number 24 was radio-tagged and was found to spend the first two days after release in the immediate vicinity of the booming ground. A steady signal was received on 28 April and when approached, the bird was found to have been killed. Evidence indicated that an avian predator probably caused the mortality. Eighteen locations prior to the death of No. 24 revealed that this hen's known range included 144 acres (Fig. 13). Several locations were obtained within a small area and indicated that No. 24 had spent more time in that area than elsewhere, but no nest was ever discovered. Number 24 was believed to be the victim of natural predation since the transmitter and harness were still intact and in place when found and probably contributed nothing to the cause of death.

An incubating adult female (No. 25) was captured with the hand net on 24 May 1965. The bird's nest had been discovered accidentally several days previously. On 27 May the entire clutch of 15 eggs hatched and No. 25 left

the nest with the brood. On 29 May, 24 locations taken at 30-minute intervals showed that the hen's movements covered 20 acres that day and that the bird had traveled over 1,700 yards. Number 25 began extensive travel two days later and was 2 miles away on 3 June. A large valley was crossed to reach this new area (Fig. 14). On 5 June the signal was lost and attempts to relocate it during the following week were unsuccessful.

DISCUSSION

Any new technique must be thoroughly tested and studied before it can be fully understood and utilized. Equipment and techniques similar to those used during this study were tested on ruffed grouse in forest habitats by Marshall (1965). He reported that the average field life of 24 transmitters powered by mercury 401 batteries was 31.4 days (Anon., 1964). The average field duration obtained during this study was 26.9 days but several of the transmitters were still functioning when this figure was calculated. A maximum field battery life of over 78 days was obtained in both studies. The antenna breakage problem was also reported by Marshall indicating that this was a weak feature of the transmitters (Anon., 1964). Improved transmitters that were built during the latter part of this study had heavier antennae and this improvement may have reduced the breakage problem.

Marshall's studies also revealed that the harness arrangement used had no apparent harmful effects on ruffed grouse. One instance of skin abrasion was noted by Marshall after a harness had been placed on an injured bird, but the wound had not been inflicted by the harness. An abnormal weight loss resulted when a transmitter was attached to an immature ruffed grouse that

was probably too small to properly carry the package (Anon., 1963 and 1964). Harnesses identical to those used by Marshall were utilized in this study with no observable physical injuries to the prairie chickens.

The psychological effect that a radio transmitter may have when attached to a bird has been discussed by several authors (Anon., 1963; Singer, 1963; Southern, 1965). Each of these workers believed that the small transmitters had no apparent effect on the behavior of birds when they were properly attached. A ruffed grouse was reported by Marshall to have been psychologically unsuited for carrying a transmitter but poor mounting of the apparatus was not precluded as the cause of the abnormal behavior observed (Anon., 1963). Comparisons of radio-tagged prairie chickens with other males on the booming ground during this study disclosed their behavior to be similar. Radio-tagged birds displayed and fought in what appeared to be a normal fashion. Further evidence of radio-tagged birds' normal behavior was obtained when two radio-tagged hens successfully incubated and hatched broods of prairie chickens.

A loss in the efficiency of the portable receivers to obtain a signal at low temperatures was encountered during this study and was also reported by Marshall (Anon., 1963). The use of insulated covers and hand warmers was recommended as a protective measure by Marshall when long exposure of the receivers at temperatures below 20° F are unavoidable. Handwarmers were found to be a nuisance during this study and were rejected in favor of leaving the receivers inside a heated vehicle until needed. The portable receivers functioned well for short periods of time at temperatures below 0° F using the latter procedure.

The accuracy of radio-locations obtained with the equipment used in

this study was similar to that reported by other workers. Ellis (1964) described the error of his system to be approximately 60 ft. at distances of 0.25 mile. Tester, Warner and Cochran (1964) obtained errors of 150 ft. at distances of 0.5 mile using portable receiving equipment. Deviations of less than 100 feet at distances between 0.125 and 0.25 mile over level terrain were reported by Storm (1965). He stated that errors increased to nearly 300 ft. over the same distances in rough terrain. Early research by Marshall indicated that he obtained greater inaccuracies than those reported by the other workers, but he attributed the increased error to a lack of operator experience. Later reports by the same author indicated that accuracy had been improved and was similar to the other studies (Anon., 1963). All of these workers reported maximum working ranges of their equipment to be approximately one mile.

Several possible causes of error in radio position finding are evident. These causes can be classified as either mechanical or biological. Mechanical errors originate in the equipment or may be inherent in the physics of the system used and include reflected signals, inaccurate maps, antenna misalignment, and unprecise instruments. Most of the biological errors are operator related. An operator's ability to procure correct azimuth readings is influenced by his experience, alertness, acuteness of senses, and comfort. Outside noises such as thunder and wind may also interfere and cause a worker to make mistakes. The radio-tagged bird may also cause biological errors if it moves during the time lapse between consecutive bearings on its position. This error can be minimized however by shortening the time lapse or by taking simultaneous bearings from two different antennae. All errors can be reduced by constant alertness and careful

procedures.

Many workers have utilized conventional methods such as banding and color-marking to study prairie chicken mobility. Most of these studies were concerned with flock relationships and movements with only supplementary data on individual prairie chicken mobility obtained by occasional observations of marked birds, band returns, and interpolation. The data obtained through radio-tracking prairie chickens during this study afford direct evaluations of the mobility of specific individuals. In some instances this information agrees with that reported by other authors but much of it has never before been acquired.

Hamerstrom and Hamerstrom (1949) suspected that summer was the season of least movement for male prairie chickens. They estimated the daily cruising radius to be less than one mile and that males remained solitary and near the general vicinity of the booming grounds. Research conducted by Schwartz (1945) and Baker (1953) also revealed that movements of male prairie chickens were minimal during the summer. The results obtained by radio tracking male prairie chickens during the summer agree with these authors.

Two male prairie chickens (No. 12 and No. 13) radio tracked during the winter displayed mobility patterns similar to those reported by Schwartz (1945), Hamerstrom and Hamerstrom (1949), and Mohler (1952). These authors reported that prairie chickens formed small flocks in the fall that banded together during severe winter weather. Movements of these flocks between feeding, loafing, and roosting sites were well documented but little data were reported about winter mobility of individual birds. Daily flock movements reported by earlier investigators (Schwartz, 1945; Hamerstrom

and Hamerstrom, 1949; and Mohler, 1952) ranged from 0.125 to over 1.0 mile each day. The winter ranges of most of the flocks observed by these workers covered less than one square mile.

A female prairie chicken (No. 21) radio-tracked during the winter displayed more solitary habits than the males during the same period. This hen was never known to have joined any of the large winter flocks but was occasionally found with up to seven other prairie chickens on certain days. The bird's habits were variable as this hen rarely spent over two days near the same location but seemed to roam between several favorite localities.

Schwartz (1945) stated that some prairie chickens moved up to 2 miles from wintering areas to booming grounds and Hamerstrom and Hamerstrom (1949) disclosed that most males do not travel over 2 miles during this shift. Movements of two radio-tagged males (No. 12 and No. 13) from wintering ranges to booming grounds spanned less than 2 miles in one case but slightly exceeded this distance in the other.

The range occupied by males during the spring booming season was reported by Schwartz (1945) to be approximately 1 square mile. The radio telemetric determined range for two males averaged 83 acres. The behavior of radio-tagged prairie chickens on the booming ground was similar to that reported by Schwartz (1945), Hamerstrom and Hamerstrom (1949), and other workers, and was classified as normal.

The average range of four male prairie chickens immediately after the spring booming season was 66 acres, indicating a slight reduction in mobility after booming activities had ceased. It was during this period that the males became solitary for the remainder of the summer.

The nests of two radio-tagged hens were found approximately 0.75 mile

from the central booming ground. One of these hens was trapped on this booming ground but it is not known whether the other hen visited the central booming ground. Hamerstrom and Hamerstrom (1949) and Trippensee (1953) stated that female prairie chickens nest within 1.25 miles of a booming ground. Rope dragging near the booming grounds during this study failed to locate any nests.

Lehman (1941) observed that female Attwater's prairie chickens (Tympanuchus cupido attwaterii) spent the first several weeks after hatching close to the nest site and had daily cruising ranges of less than 300 yards. He reported that extensive movements occurred when the chicks were three to five weeks old. Hamerstrom and Hamerstrom (1949) stated that greater prairie chicken broods do not move far during the summer. The summer range of a lesser prairie chicken (Tympanuchus pallidicinctus) hen and brood was reported by Copelin (1963) to be about 160 to 256 acres. The ranges determined for two female prairie chickens with broods in this study were more extensive than that reported by the above authors. These hens left their nests on the day of hatching and within two weeks had traveled to areas between 1.5 and 2.0 miles from the nests. An all day telemetry record of one of these hens revealed that the bird had traveled nearly 1,800 yards in an area of 20 acres with the brood in one day.

Comprehensive prairie chicken mobility data were previously inaccessible because direct observations were mandatory and impossible. Many of my attempts to observe unconfined radio-tagged prairie chickens were unsuccessful, even though the immediate locations of these birds were known. Such examples demonstrate the value of radio-telemetry as a tool that can enable researchers to accurately ascertain prairie chicken movements.

The radio telemetry system assembled during this study was operational but should not be considered as complete. Certain improvements will be necessary before more thorough research is attempted. A major problem encountered during the study was live trapping prairie chickens when needed. More reliable trapping techniques are needed to assure a ready supply of birds for telemetry applications. Longer field transmitter life would be a desirable feature that could also reduce the number of birds needed. More reliable antennae and increased battery life would serve to prolong the field transmitter life. Extended transmitting range would also be desirable but not absolutely necessary. More permanent stations should be built in areas where prairie chicken activity indicates them to be necessary and these stations should be modified for winter operation by either the addition of antifreeze or by structural modifications.

The application of automatic tracking equipment and computer analyses can not be overlooked as possibilities in future prairie chicken mobility research. These improvements would allow increased data through continuous tracking which may help to solve mobility as well as other problems such as inter-flock relationships and brood dispersal. Increased collaboration between biologists and electronics specialists will be necessary to advantageously utilize the full potentiality of this new research technique.

SUMMARY

A study was initiated in September, 1963, to determine the mobility and behavior of greater prairie chickens on a 6000-acre study area in north-eastern Kansas. This paper discusses the progress and results of the first

portion of that study which involved the construction, testing, application, and evaluation of radio-telemetric equipment.

An operational radio-telemetry system was assembled which consisted of miniature radio transmitters with harnesses; two portable receivers; and portable, mobile, and permanent receiving antennae.

Research was conducted during the summer of 1964 to determine the accuracy and reliability of the telemetric system. Sixty-six radio locations of known points were attempted of which 58 were successful. The data were stratified into distance classes and the mean error ranged from 7.7 feet for the shortest distance class to 100.8 feet for the longest class. The medium distance class had the greatest error in degrees. Two azimuth locations were compared with three azimuth locations and were found to be slightly more accurate if on-line bearings were avoided. The topography and vegetation had little effect on signal transmission but a power line caused deflections of up to 18° on azimuths parallel to the lines.

Twenty-three prairie chickens were live-trapped and banded during the study. Twelve of these birds were radio-tagged and tracked for a total of 407 days. Attempts made to locate the radio tagged birds averaged 86.3 percent successful, yielding 546 locations. No adverse physical or psychological effects were found to be caused by the transmitters or harnesses.

The efficiency of the portable receivers decreased at temperatures below 20° F but operation was possible at 0° F and lower if the receivers were left in the heated vehicles between readings. Handwarmers were found to be inefficient in heating the portable receivers.

Antennae breakage and power failures caused most of the known

transmitter malfunctions. Of the twelve transmitters used, nine were recovered, three were lost, and five were still attached to prairie chickens and transmitting on 15 June 1965 when this phase of the study was terminated. The average realized transmitter life was over 26.9 days.

The results obtained by radio-tracking prairie chickens revealed that the average summer range of the radio-tagged male prairie chickens was 66 acres, the average winter range was 413 acres, and the spring or breeding season range averaged 83 acres. The males were solitary during the summer but joined large flocks during severe winter weather. Unisexual flocks formed in the spring and the males traveled to and from the booming grounds as a unit.

Two female prairie chickens were radio-tracked during the nesting season and were found to feed twice daily during incubation. Extensive movements of the hens and broods were observed after hatching.

The winter range of one female was 308 acres or slightly smaller than that of the males.

More reliable trapping techniques were found to be necessary to assure a better supply of prairie chickens for radio-tagging during all seasons.

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APPENDIX

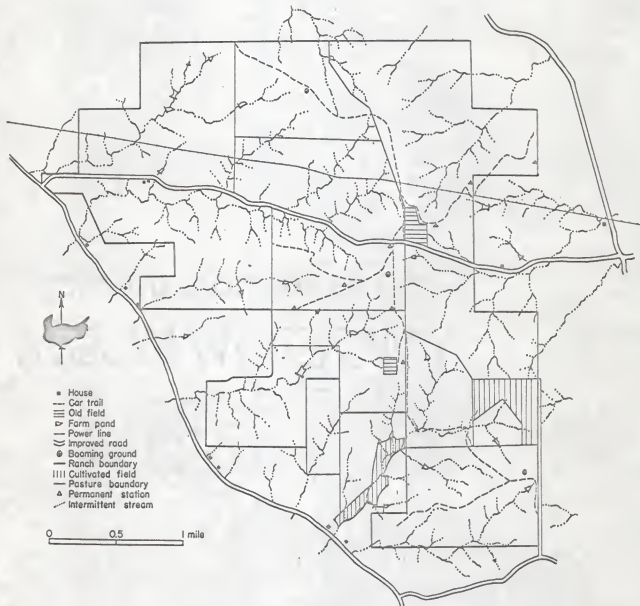


Fig. 1. Map of the Simpson Ranch-study area.

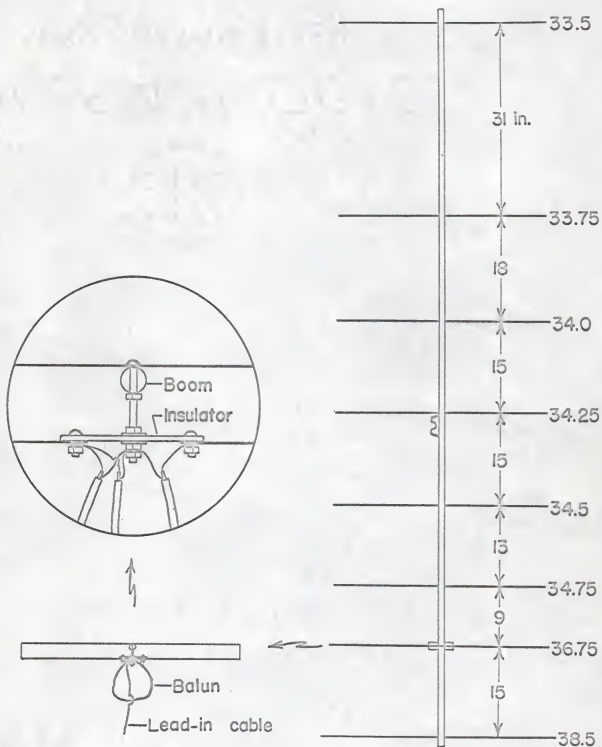


Fig. 2. Construction details of directional yagi receiving antenna utilized in both permanent and mobile stations.

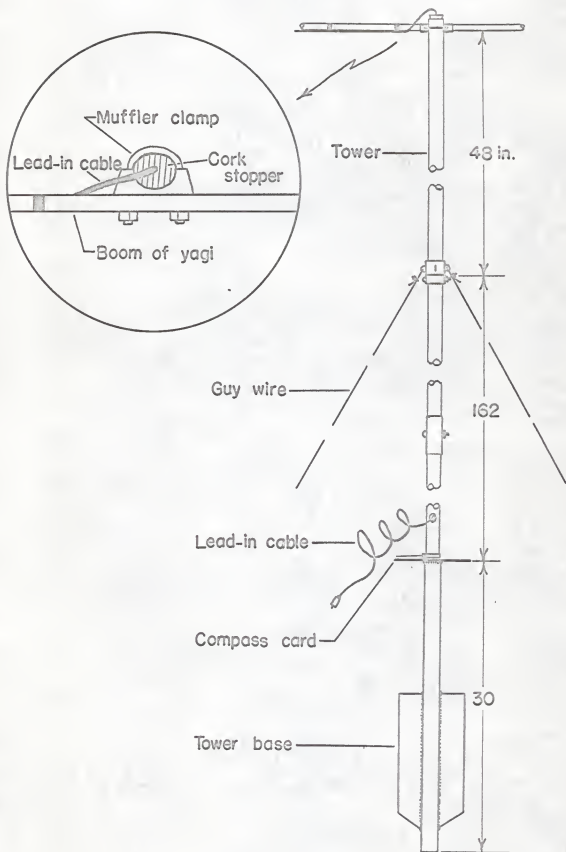


Fig. 3. Construction details of a permanent station.

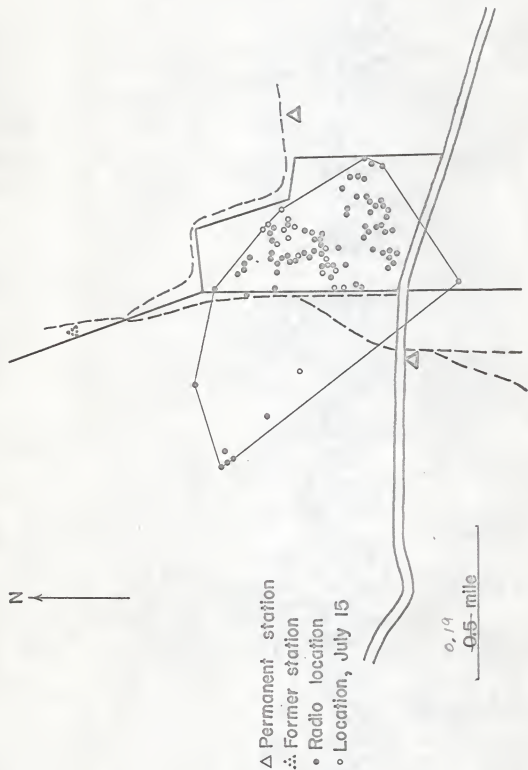


Fig. 4. Movements and range of prairie chicken No. 11 including locations obtained during continuous tracking on July 15. (Period of transmission: 6/13-8/30; 78 days, 96 locations.)

Fig. 5. (opposite) Known late winter ranges of prairie chickens No.12 and No.13 showing movements to respective booming grounds and number of locations on the booming grounds in parentheses. (Period of transmission of No. 12: 2/7-3/16; 37 days, 18 locations -- No. 13: 2/7-2/26, 4/7-4/14; 26 days, 27 locations.)

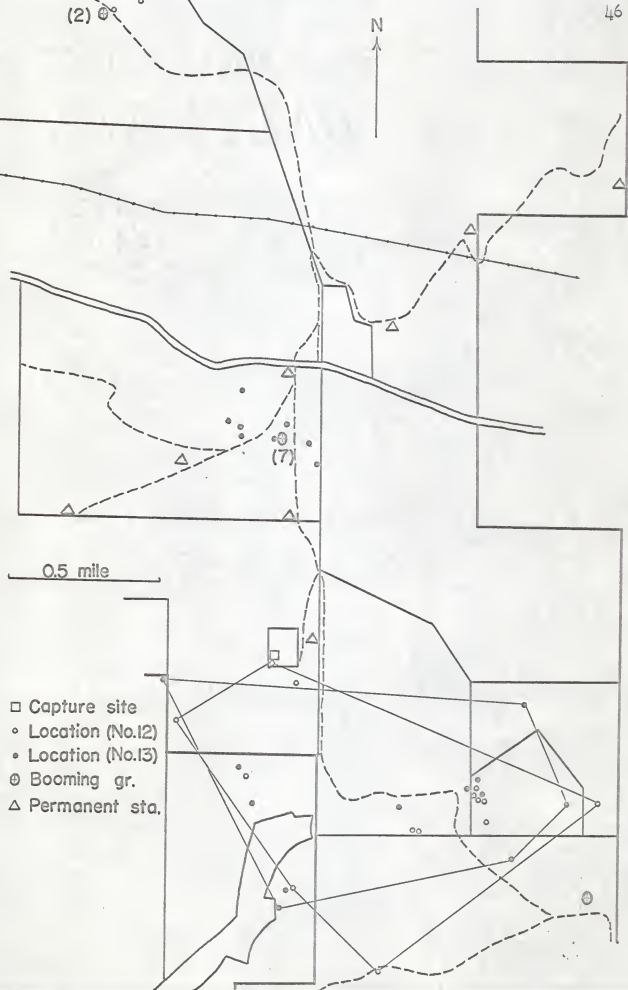




Fig. 6. Known range and movements of prairie chicken No. 14 during and after the spring booming season with the number of locations on the booming ground in parentheses. (Period of transmission; 4/7-5/2, 6/2-6/15; 38 days, 57 locations.)

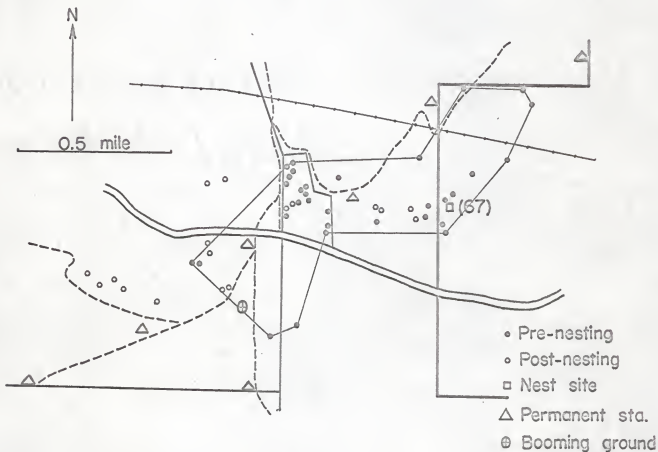


Fig. 7. The spring range of bird No. 23 showing the number of locations at the nest site and the movements of the hen and brood after hatching. (Period of transmission: 4/17-6/15; 59 days, 116 locations.)

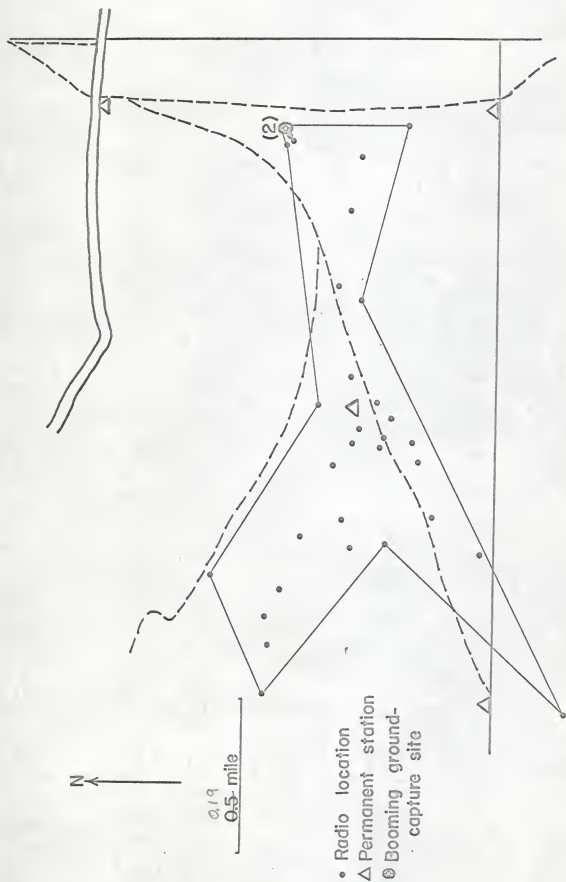


Fig. 8. Late spring movements of prairie chicken No. 15 including the number of locations on the booming ground in parentheses. (Period of transmission: 5/24-6/15; 23 days, 33 locations.)

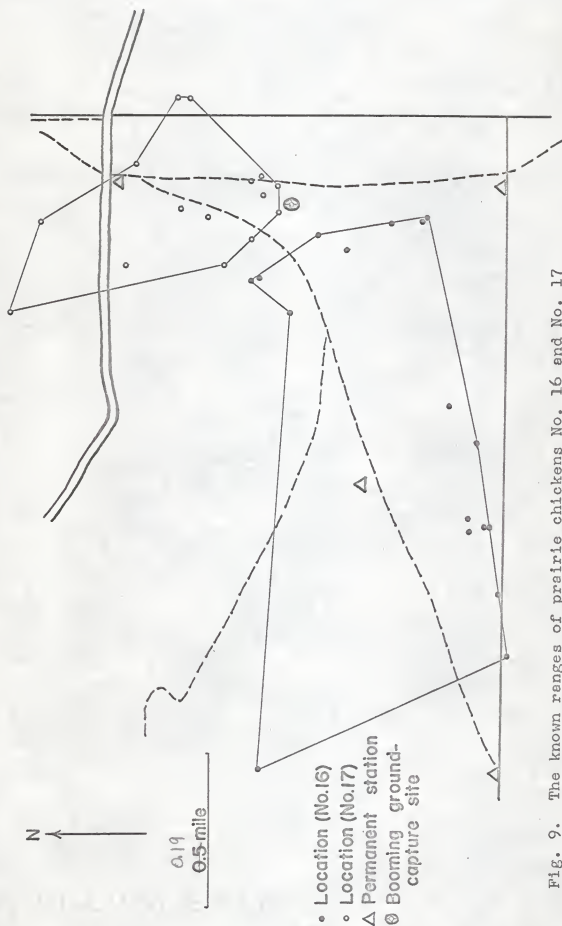


Fig. 9. The known ranges of prairie chickens No. 16 and No. 17 immediately following the spring booming season. (Period of transmission of No. 16: 6/4-6/15; 12 days, 17 locations -- No. 17: 6/6-6/15; 10 days, 16 locations.)

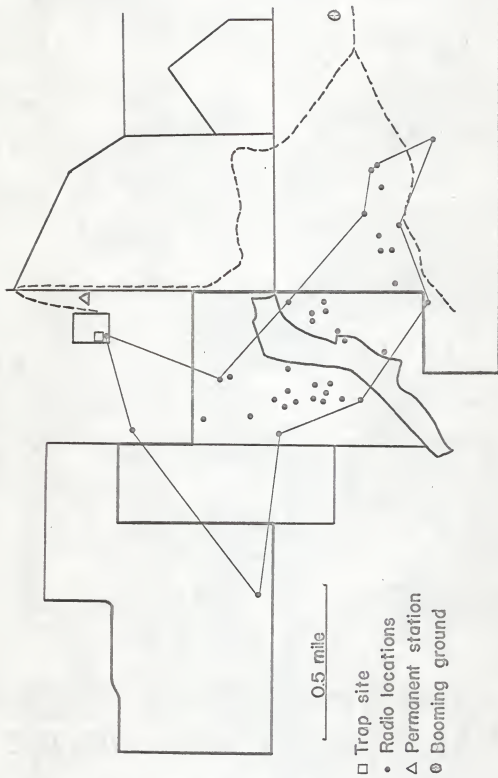


Fig. 10. Known late winter range of prairie chicken No. 21. (Period of transmission: 2/5-3/26; 49 days, 39 locations.)

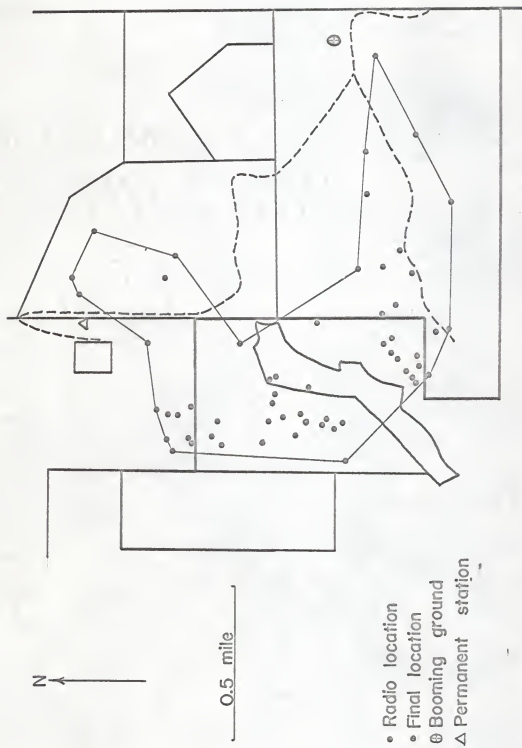


Fig. 11. Known early spring range of No. 21 indicating a movement toward a booming ground and an extension of the winter range to the north-east. (Period of transmission: 3/26-5/13; 44 days, 58 locations.)



Fig. 12. Known area traversed by prairie chicken No. 22 in seven days during late winter. (Period of transmission: 3/26-4/4; 12 locations.)

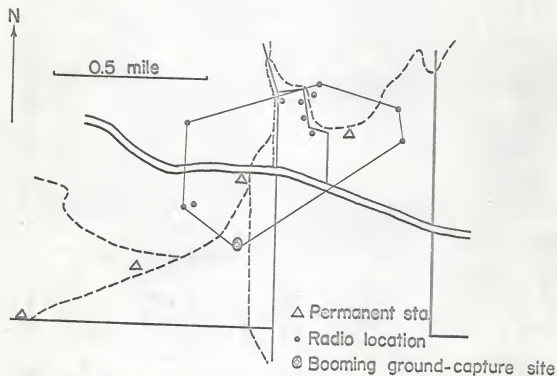


Fig. 13. Known range encompassed by prairie chicken No. 24 in 12 days during the spring booming season. (Period of transmission: 4/17-4/25; 11 locations.)

EXPLANATION OF PLATE I

Fig. 1. A view of transmitters, before and after harness is fashioned. Note size and shape of completed harness, battery package, and covering of plastic tape.

Fig. 2. A radio-tagged female prairie chicken ready to be released. Transmitter is visible on bird's back, battery is hidden beneath worker's left forefinger.

PLATE I

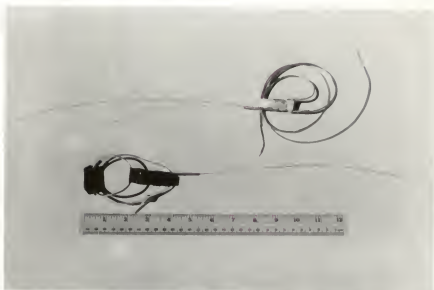


Figure 1.



Figure 2.

EXPLANATION OF PLATE II

Fig. 1. Worker shown rotating directional yagi antenna atop 20 ft. tower of permanent station to determine azimuth of signal.

Fig. 2. Close-up of base of permanent station showing the compass card assembly with cover removed and a portable receiver.

PLATE II



Figure 1.



Figure 2.

EXPLANATION OF PLATE III

Fig. 1. Mobile receiving antenna mounted on a pickup truck.

Fig. 2. Detail of mobile unit showing compass card, pointer, and worker rotating the directional antenna.



Figure 1.



Figure 2.

EXPLANATION OF PLATE IV

Fig. 1. The hand held directional antenna being used to pinpoint a radio-tagged prairie chicken.

Fig. 2. A radio-tagged male prairie chicken displaying or "booming" in a normal manner.



Figure 1.



Figure 2.

RADIO-TELEMETRY AS A TECHNIQUE USED IN GREATER
PRAIRIE CHICKEN (TYMPANUCHUS CUPIDO PINNATUS) MOBILITY STUDIES

by

JEROME J. CEBULA

B. S., Colorado State University, 1963

AN ABSTRACT OF A MASTER'S THESIS

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A study was initiated in September, 1963 to determine the mobility and behavior of greater prairie chickens on a 6000-acre study area in north-eastern Kansas. This paper discusses the first phase of that study which involved the construction, testing, application, and evaluation of radio telemetric equipment.

To expedite attachment of leg bands and radio transmitters, prairie chickens were live-trapped by means of a cannon-net trap, two walk-in traps, and a hand net. Radio transmitters powered by mercury batteries were attached to prairie chickens by means of plastic harnesses. A complete transmitter, battery, and harness weighed approximately 21 grams and had a maximum field range of about 0.5 mile.

Two 10-channel portable receivers were used in conjunction with portable, mobile, and permanent directional receiving antennae to locate radio-tagged prairie chickens. The accuracy and reliability of the bio-telemetry system were determined by obtaining radio locations of 66 known points and measuring the error of each attempt. Fifty-eight of the attempts were successful and when the data were stratified into distance classes, the mean error ranged from 7.7 ft. for the shortest distance class to 100.8 ft. for the longest class. A medium distance class had the greatest error in degrees. A comparison of two- and three-azimuth locations showed that two-azimuth locations were slightly more accurate if on-line bearings were avoided. Topography and vegetation had little effect on signal transmission, but deflections of up to 18° were obtained parallel to a power line.

Efficiency of the portable receivers decreased at temperatures below 20° F but operation was possible at 0° F and lower when the receivers were placed in heated vehicles between readings. Handwarmers were found to be

inefficient in heating the portable receivers as they easily became extinguished.

Antenna breakage and power failures caused most of the known transmitter malfunctions. Twelve different transmitters were used, nine of which were recovered, three lost, and five were still attached to prairie chickens and functioning when this portion of the study was discontinued. Maximum field transmitter life was 78 days, the minimum was 7 days, and the average was over 26.9 days as five transmitters were still functioning when the average was calculated.

Twenty-three prairie chickens were trapped and banded during the study, of which 12 were radio-tagged and tracked for a total of 407 days. Attempts to locate the radio-tagged birds averaged 86.3 percent successful and yielded 546 locations. The transmitters and harnesses were found to have little or no adverse physical or psychological effects on the tagged prairie chickens.

Results show that the average summer range of tagged males was 66 acres, the average winter range was 413 acres, and the spring range averaged 83 acres. Males formed unisexual flocks during the breeding season, gradually became solitary during the summer, and again formed flocks in the fall and winter.

Two female prairie chickens were radio-tracked during the nesting season and were found to feed twice daily during incubation. Extensive movements of these hens and broods were observed immediately after hatching.

The winter range of one female was 308 acres or slightly smaller than that of the males. This hen was also more solitary than the males during the winter and was never observed to join any of the large winter flocks.

More reliable trapping techniques were found to be necessary to assure a better supply of prairie chickens for radio transmitter application during all seasons.