MOVEMENTS, MONTHLY RANGES, REPRODUCTIVE BEHAVIOR, AND MORTALITY OF RADIO-TAGGED GREATER PRAIRIE CHICKENS (*TYMPANUCHUS CUPIDO PINNATUS*)

by

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INTRODUCTION

Basic to the management of a wildlife species, it is necessary to have a thorough understanding of the ecology, population dynamics, and behavior of the species. These aspects must be intensively investigated before a management program can be fully effective.

Radio telemetry, a relatively new but already widely used tool, can enable biologists to gather more accurate information concerning ecology, population dynamics, and behavior of a species. Previously unobtainable data on secretive and secluded species are made readily available with telemetry instruments.

In 1963, a 6-year study of greater prairie chicken (*Tympanuchus cupido pinnatus*) ecology was initiated in the Flint Hills region of northeastern Kansas. The objectives of the study were to determine: (1) daily and seasonal movement patterns, (2) behavioral patterns, (3) incidence of endoparasitic helminths and (4) habitat preferences. This thesis covers work during the 1966-1967 phase of the study and follows studies by Cebula (1966) and Viers (1967).

The primary objectives for the 1966-1967 phase of the study were to supplement data obtained by Cebula (1966) and Viers (1967) on home range and daily and seasonal movement patterns of prairie chickens plus gather information on: (1) reproductive behavior of males and females, (2) daily activities of nesting females, (3) nesting success and (4) brood movements.

REVIEW OF LITERATURE

Radio Telemetry

A review of literature covering the use of radio telemetry reveals that general references to the technique are gradually becoming available. Slater (1963) and contributing authors of Bio-Telemetry reported on many aspects of radio telemetry. Pienkowski (1965) presented formulae for predicting transmitter range and life while Ko (1965) presented data on the evolution of miniaturization of transmitters. Slater (1965) discussed progress and problems associated with radio tracking. Adams (1965) gave an evaluation of radio telemetry and reported on applications for ecological research. The use of digital computers to process and accumulate telemetry information was described by Siniff and Tester (1965) and Tester and Siniff (1965). Heezen and Tester (1967), using an automatic tracking system and a digital computer, reported on an evaluation of radio-tracking by triangulation.

An early use of telemetry for ecological research was employed by Busser and Mayer (1957) for obtaining information from incubating penquin eggs. LeMunyan *et al*. (1959) designed a transmitter for use in studying the ecology of woodchucks (*Marmota monax*). Cochran and Lord (1963) found this transmitter unsuitable for studying movements of mammals due to its restricted range of transmission and developed units with greater capabilities. Their equipment was used on cottontail rabbits (*Sylvilagus floridanus*), striped skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*). Pheasants (*Phasianus colchicus*) were also tracked using this equipment (Lord and Cochran, 1963). Lord *et al*. (1962) and Cochran *et al*. (1963) used this system for monitoring the movements of mallard ducks (Anas platyrhunchos) and Canada geese (Branta canadensis), respectively. Modifications were made in the Cochran and Lord (1963) transmitters for tracking white-tailed deer (Odecoileus virginianus) by Cochran and Hagen (1963). Improvements to the portable receiver were described by Cochran and Nelson (1963).

Tester (1963) used radio transmitters that were similar to those described by Cochran and Lord (1963). To allow for differences in the methods of attachment, modifications were made in the design of the transmitters for each of the three species tracked, blue-winged teal (Anas discors), white-tailed deer and American toad (Bufo americanus). Tester et al. (1963, 1964) reported in more detail on the movements of white-tailed deer. Modifications were made of the transmitter, including a pulsing circuit. A light-weight transistorized tracking receiver was also developed. Verts (1963) used the radio-tracking system described by Cochran and Lord (1963) and modified it for use with striped skunks. Sanderson and Sanderson (1964) used similar equipment to study movements of rats (Rattus spp.) in Malaya. Ellis (1964) adopted equipment similar to that used by Verts (1963) for monitoring the movements of raccoons. Southern (1963a) incorporated the system designed by Cochran and Lord (1963) for radio-tracking herring gulls (Larus argentatus) and bald eagles (Haliaeetus leucocephalus). Bald eagle movement data were presented by Southern (1963b and 1964). Southern (1965) also developed this equipment for use on mallards, bobwhite quail (Colinus virginianus), rough-legged hawks (Buteo lagopus) and gray partridges (Perdis perdix). Storm (1965) using the design described by Verts (1963) with certain modifications, monitored the movements of red foxes (Vulpes fulva). Graber and Wunderle (1966) using improved versions of the equipment designed by Cochran and Lord (1963), studied movements of a robin (Turdus migratorius). Low-weight transmitters or imitations thereof were also placed on common grackles (Quiscalus quiscula), house sparrows (Passer domesticus) and starlings (Sturnus vulgaris). Kobriger (1965) monitored the movements of one female sharptail grouse (Pedioecetes phasianellus) from dancing ground to nest site using equipment similar to Cochran and Lord (1963). One sharptail male was followed through the summer months by the same method. Storm and Verts (1966) monitored the movements of a rabid striped skunk prior to its death. Mech et al. (1965), using transmitters similar to those of Cochran and Lord (1963), developed a durable, water proof transmitter-collar made of dental acrylic for use on cottontail rabbits, snowshoe hares, and raccoons. Beal (1967) adapted self-locking, 11-inch adjustable plastic hospital ID bracelets for use as transmitter-collars suitable for gray squirrels (Sciurus carolinenis) and fox squirrels (Sciurus niger).

Cochran et al. (1964) and Cochran et al. (1965) reported the development of an automatic tracking system for use in tracking red foxes, white-tailed deer, raccoons, cottontail rabbits and snowshoe hares (Lepus americanus) and badgers (Taxidea taxus). Tester and Heezen (1965) used this system to test a white-tailed deer drive census. Mech et al. (1966a) used the automatic tracking system developed by Cochran et al. (1964) to study the onset and cessation of activity in cottontail rabbits and snowshoe hares in relation to sunset and sunrise. The fall daytime resting habits of raccoons were determined by Mech et al. (1966b) using the automatic tracking system developed by Cochran et al. (1964). Mech (1967) presented a report on the use of telemetry as a technique to study predation of snowshoe hares and cottontail rabbits.

Independent of the previously described system, Singer (1963) designed a transmitter for use on pigeons (Columba livia) while Merriam (1963) designed a transmitter to study the movements of woodchucks. Slagle (1965) designed an electronic system for studying the movements of raccoons, wild turkey (Meleagris gallopavo) and feral pigeons. Ellis and Lewis (1967) reported on the use of equipment developed by Slagle (1965) for studying the annual range and daily and seasonal movements of the eastern wild turkey in Missouri. Another system designed by Craighead et al. (1963) was used by Craighead and Craighead (1965) to track grizzly bears (Ursus arctos horribilus).

Another independently developed system, first reported by Marshall (1960), was used by Marshall et al. (1962) for determining the summer activities of porcupines (Erethizon dorsatum). This system was modified for use on ruffed grouse (Bonasa umbellus) (Marshall, 1962; Marshall and Kupa, 1963). Studies of movements, behavior and activities of ruffed grouse were reported by Marshall (1963). In a later report the equipment was also modified for use on snowshoe hares (Marshall, 1964). Slade et al. (1965) discussed the accuracy and reliability of biotelemetry equipment which was used in ruffed grouse behavioral studies by Marshall (1965) and greater prairie chicken movement studies by Cebula (1966). Kuck (1966a) used equipment, similar to equipment used by Marshall et al. (1962), for movement studies of pheasants. Kuck (1966b) discussed an improved battery attachment for his radio telemetry studies. To study the effects of the toxicity of pesticides on wild sharptailed grouse, McEwen and Brown (1966) used equipment similar to that described by Marshall (1965). Viers (1967) used the equipment described by Cebula (1966) to study home range, movements and activities of greater prairie chickens.

Movements

Techniques for studying the migration, movements and home ranges of birds are similar to and have evolved concurrently with mammalian methods (Viers, 1967:1). The concept of home range was initiated by Seton (1909:26) who pointed out that, "No wild animal roams at random over the country; each has a home region, even if it has not an actual home." Burt (1940:25) defined home range as, "that area about its established home which is traversed by the animal in its normal activities of food gathering, mating and caring for young." Sanderson (1966) presented a detailed review of methods used to study and evaluate mammalian home ranges and movements. Before the advent of radio telemetry the usual method used to study the movements and home ranges of various birds was by direct observation and band returns. A considerable amount of information for greater prairie chickens had been obtained by using these methods.

The first reports of prairie chicken movements involved observations of migrational tendencies. Cook (1888:105) observed large flocks of greater prairie chickens migrating from Minnesota and Iowa to southern Iowa and northern Missouri. In the early 1900's migration of the greater prairie chicken was a regular phenomenon and was most evident in the northernmost regions (Schorger, 1943:8). Bennitt and Nagel (1937:47) noted an influx of greater prairie chickens into northern Missouri during fall months. Gross (Bent, 1932:261) stated that, in the "Northern States," prairie chickens made flights of considerable length. He considered such flights migratory in character. Mohler (1952:13) seeing a flock of greater prairie chickens that "appeared nervous", thought it probable they were migrating to a winter feeding area and had stopped in Nebraska to feed and rest.

Cook (1888:105) and Schmidt (1936:197) stated that only female prairie chickens migrated, not males. Schmidt attributed this to different requirements of the two sexes for food and cover. Hamerstrom (1941:100) suspected that some prairie chickens migrated and that most were females, but not all females migrated. Schmidt (1936:197) stated that female prairie chickens in Wisconsin wintered in the southern half of the State.

Hamerstrom and Hamerstrom (1949:329) reported there was still some migration in the "Lake States" at the time of their study, but almost none in Wisconsin. Schwartz (1945:84) noted greater prairie chickens in Missouri spent their entire lives in the same area if their food requirements were satisfied. Ammann (1957:77) stated there was little definite evidence of long migrations or emigrations by prairie chickens during recent years. Hamerstrom (1941:90) reported that his banding records have given no positive evidence of migrations.

Summer was thought by Hamerstrom and Hamerstrom (1949:315) to be the season of least movement for greater prairie chickens. Schwartz (1945:83) stated the daily movements of both males and females were very limited during the summer, probably to an area of 0.5 square mile or less, and that the birds were more scattered and harder to find than in the spring.

Schwartz (1945:82) noted that, as the booming season drew to a close, the males spent more time alone and showed a reduced tendency to flock. Yeatter (1943:386) noted that in southeastern Illinois during the summer months, after the booming season, certain groups of adult males tended to stay together in the vicinity of the booming grounds. A similar tendency was noted by Hamerstrom (1939:108) in Wisconsin.

In Missouri, Schwartz (1945:68) found female prairie chickens with young stayed in the vicinity of the nest for the first few days after hatching and gradually moved toward swales if any were nearby. He also reported that two weeks after hatching, the female and chicks ranged farther, and a marked tendency for movement toward higher areas and fields of small grain was noted. Hamerstrom and Hamerstrom (1949:315) stated that in Wisconsin, broods of prairie chickens did not move far during the rearing period. Yeatter (1943:387) noted there was a tendency for broods to combine loosely in midsummer. He also reported it was not uncommon in late summer to see two or more females together with young of different sizes.

In contrast to summer, Hamerstrom and Hamerstrom (1949:315) found fall was a time of considerable movement when small flocks and individuals gathered to form large packs. Once autumn packs were formed they remained in definite areas (Hamerstrom and Hamerstrom, 1949:318). Hamerstrom (1941:120) found fall packs of greater prairie chickens formed as close to the breeding grounds as food supply permitted.

In general, the daily cruising radius of flocks were found by Hamerstrom and Hamerstrom (1949:320) to be 1 to 1.5 mile. Baker (1953:21) reported the fall range for one flock to be approximately 1 square mile. Mohler (1952:19) never observed a flock during the fall alighting more than 0.75 mile from a take-off point. Schwartz (1945:83) found daily movements of flocks during the fall varied with the type of range; some restricting themselves to an area 0.25 square mile, while others ranged over 1 square mile or even 2; the size depended upon the proximity of the fall booming grounds, feeding, roosting and loofing areas. Hamerstrom (1941:127) thought hunting had no effect on movements of autumn packs and stated that the various packs stayed in their individual ranges during this period.

Schwartz (1945:83) and Ammann (1957:77) found that during the fall, flocks were of separate sexes; each flock including both adults and young birds of the year. Baker (1953:23) found that in all instances, when flocks were seen during the winter, males predominated. He therefore concluded the daily routine of females involved fewer conspicuous movements by flight than did those of males. Baker (1953:20) and Schwartz (1945:59) reported daily visits to the booming grounds, both morning and evening, in the fall. Hamerstrom (1939:107) and Mohler (1952:18) also reported fall booming ground activity. Hamerstrom and Hamerstrom (1949:320) saw no regular daily movements to the booming grounds and found no reason to believe flocks were wholly or even largely of one sex.

Ammann (1957:76) found prairie chicken populations were considerably more mobile during late fall and winter; population shifts were most likely to take place during this period. Schwartz (1945:83) found that the area traversed in a day by a large flock was often less than 1 square mile, depending upon the availability of food and good roosting cover. He stated that in a week, a large flock covered the entire area (5 square miles or so) formerly occupied by its component parts. Baker (1953:22) found different flocks shared the same feeding area, but acted as a distinct unit at other times. He also stated that the daily and seasonal ranges of flocks and individuals were limited to a cruising radius of approximately 0.5 mile. The home range of winter flocks in Nebraska was approximately 3 square miles (Mohler, 1952:22).

During periods of severe weather, Schwartz (1945:83) found flocks of males and females united to form large bisexual packs. Baker (1953:17) stated that flocks assembled and functioned as a unit in their daily movements throughout the winter and that packs may be all of one sex or of both sexes. Though some shifting occurred among individuals of different flocks while they were together in the large packs, the size of each remained fairly constant (Hamerstrom, 1941:100). Hamerstrom and Hamerstrom (1949: 321) found winter packs to be aggregations of varying degrees of tightness. They found packs became progressively tighter and less mobile as winter progressed. Hamerstrom and Hamerstrom (1949:322) reported that large winter packs were usually rather unstable.

Hamerstrom and Hamerstrom (1949:322) found small flocks feeding at unexpected places at times other than during the most severe weather. These flocks were found over a wider area during unusually moderate periods and did not join the large packs. Hamerstrom and Hamerstrom thought that such movements might be the result of increased cruising radius or might be oriented moves of small flocks back toward their breeding places.

Schwartz (1945:84) stated that the daily activities during the winter were similar to the fall, except no booming-ground performances took place. Schmidt (1936:197) stated male prairie chickens wintered within a few miles of their booming grounds, and sought whatever grain was available. Schwartz (1945:58) found that during periods of mild weather, following the cessation of their regular fall visits, some cocks occasionally returned to the booming ground. Hamerstrom and Hamerstrom (1949:324) stated prairie chickens often displayed in winter, long before the main booming season. Baker (1953:22) stated that he observed prairie chickens on the booming grounds whenever he visited the grounds during the winter. Hamerstrom and

Hamerstrom (1949:326), Yeatter (1943:384) and Baker (1953:17) noted that movements in the spring were characterized by a return of males to the booming grounds. Kobriger (1965:793) found two marked prairie chicken males moved only 100 yards from a feeding station trap site to their spring breeding grounds. Hamerstrom (1941:17), Schwartz (1945:45) and Hamerstrom and Hamerstrom (1949:327) found males visited the booming ground every morning and nearly every afternoon during the spring booming season.

Hamerstrom and Hamerstrom (1949:328) stated that during the booming season, prairie chickens showed a strong tendency to stay within a rather small area, and, in the case of males at least, the spring range was close to or part of the winter range. Hamerstrom and Hamerstrom (1949:327) stated that most birds stayed within 1 mile or less of their booming grounds during the spring. They also found males often spent the night on their booming ground or at its edge and fed close by, sometimes within a few hundred yards. Hamerstrom and Hamerstrom (1949:327) reported males tended to stay together during the time they were away from the booming ground.

Hamerstrom and Hamerstrom (1945:327) reported hens were seen coming to booming grounds from distances of 0.3 to 0.5 mile and sometimes further.

Hamerstrom and Hamerstrom (1949:327) found males on different booming grounds during different years. Hamerstrom and Hamerstrom (1949:328) stated that males seldom moved from one booming ground to another within the same season. Observation by Schwartz (1945:41), Hamerstrom and Hamerstrom (1949:327) and Robel (1967:112) showed occasional movements of male greater prairie chickens from one booming ground to another in the same spring. Robel (1967:112) observed movements of males between different booming grounds to occur within the same morning. Although use of a single booming ground by two separate flocks of greater prairie chickens was not common, Robel (1964:709) found two different flocks using the same ground, one during the normal booming season and one after the regular season had ceased.

Leopold (1931:176) stated that greater prairie chickens were more mobile than any other gallinaceous game bird and that mobility data were of obvious importance to its management.

Reproductive Behavior

Schwartz (1945:48) believed that each booming ground had a sphere of influence within its portion of the range and that the limits of this sphere of influence was determined by the distances and directions from which booming was audible. Schwartz (1945:49) also believed there was a flock of females within the sphere of influence of each booming ground and those females were attracted by males using the booming ground. He further believed that the entire flock of females visited the booming ground regularly at the height of the season.

Schwartz (1945:51), Baker (1953:29) and Hamerstrom and Hamerstrom (1954:464) stated that the principle use of the booming ground was for courting and mating, though those activities also occurred elsewhere. Robel (1966:331) stated that the function of the booming ground was only indirectly one of mating, and its direct function appeared to be one of female attraction and concentration.

Studies by Hamerstrom (1941:42), Hamerstrom and Hamerstrom (1954:464) and Main (1937:40) indicated that the bulk of mating activity took place off the main booming grounds. Robel (1967:112) found no evidence of mating off a booming ground. Both Robel (1967:112) and Schwartz (1945:53) observed numerous successful matings on the main booming grounds.

Hamerstrom (1941:33), Yeatter (1943:385) and Anderson (1965:8) found evidence that males, and probably females, did not all arrive at the breeding stage at the same time, but rather showed a spread of several weeks in the stage of sexual cycle development.

Hamerstrom (1941:24), Schwartz (1945:43), and Robel (1967:111) found the number of males occupying a booming ground to fluctuate. Schwartz (1945:53) found that the maximum number of males using a booming ground was during the height of the booming season, while Robel (1967:111) and Hamerstrom (1941:24) observed the number of males to be greatest early in the booming season. Schwartz (1945:43) noted that the attendance at the morning booming period was always more regular than during the evening period, except at the height of the season. He also found daily booming periods had less regular attendance early and late in the season. Hamerstrom (1941:25) thought some males left the booming grounds on their own accord to possibly set up "nesting territories".

Early in the spring, booming activity began gradually, reached its peak during the height of the season and then declined steadily until the end of the season (Schwartz, 1945:45). A gradual disappearance of the males from the booming grounds was also reported by Yeatter (1943:385) and Hamerstrom (1939:108; 1941:22).

Activities of greater prairie chickens on booming grounds have been described by Breckenridge (1929), Schwartz (1945), Hamerstrom and Hamerstrom (1960) and Robel (1964).

During the early part of the spring season the principle activities on the booming ground were territorial disputes and booming (Schwartz, 1945:51).

Hamerstrom (1939:106) reported that early in the spring, males boomed and fought over the whole booming ground, but once the boundaries were established there was much less fighting. Robel (1964:710) found territories to be well established early in the spring and to remain so throughout the booming season.

Hamerstrom (1941:22) and Robel (1964:709; 1967:111) reported that in the spring when females visited the booming ground, a great increase in activity of the booming males resulted. Robel (1964:710) observed the fixed territory system broke down when females visited the booming ground. This was also observed by Breckenridge (1929:543) and Hamerstrom (1941:41). Schwartz (1945:51) stated that in the presence of females, at the height of the season, males stayed especially close to their territories. He found almost no territorial fighting at this time. Both Hamerstrom (1941:17) and Schwartz (1945:50) found that if an "intruder", a male with no apparent territory on the booming ground, should cross the ground, he was quickly driven off if he showed any indications of display. If the "intruder" was a "subdued male", he was treated as a female.

Schwartz (1945:43) stated that only the males occupied the booming ground daily throughout the season. The females were regularly present for only about a week at the height of the season. He found that before and after the climax of the booming season the females were present only occasionally, and then only for short periods and in small numbers. Hamerstrom (1941:26), Hamerstrom and Hamerstrom (1954:463) and Robel (1967:111) found the number of females visiting a booming ground on a given morning and the number of female visits for a given period was greatest early in the booming season. Schwartz (1945:51) found that the arrival of females on the booming ground to be about 15 minutes after the first males.

Schwartz (1954:53) found matings were not restricted to the height of the season and males attempted to mate whenever the female appeared receptive. Hamerstrom (1941:36) found as the season progressed, females were more apt to accept the male, but that unready females would appear at any time. Hamerstrom (1941:37) stated that he had not recognized the lessening of readiness with the onset of broodiness, but the less receptive behavior of females seen toward the end of the season reflected this condition.

Hamerstrom and Hamerstrom (1954:464) reported individual females came to a booming ground over a period of days before they were ready to accept a male, and copulation generally marked the end of their visits, at least for some time. Schwartz (1945:52) found females to be most receptive during the height of the spring booming season and stated at other times they wandered at random over the booming ground. During the height of the season, the females remained in a loose flock near the center of the booming ground for most of the morning (Schwartz, 1945:51).

Robel (1967:112) found a direct correlation between size of territory and number of copulations. Males with large territories were involved in the most copulations. Robel (1966:330) found evidence that the size of the "primary territory" (that area including the central 50 per cent of use) was directly correlated to mating success, at least more so than the peripheral portions. Robel (1967:113) also reported the greatest number of matings to be by adult males 2.7 years or older. Schwartz (1945:51) and Robel (1967: 113) observed most matings were with males whose territories adjoined the area where the females flocked.

The actual mating of the greater prairie chicken has been described in detail by Schwartz (1945:52). After mating, the females wandered through the booming ground; possibly mated again, once or several times, or joined the flock of females nearby (Schwartz, 1945:52). Hamerstrom and Hamerstrom (1954:463) thought it possible that an individual female may leave and then return again during the same morning. Schwartz (1945:53) reported that females moved from one territory to another and mated with successive males.

Schwartz (1945:54) and Hamerstrom (1939:112) thought it probable that almost the entire population of females was mated during the height of the season. Other than at the height of the season, most mating attempts were interrupted by nearby males (Hamerstrom, 1941:41; Schwartz, 1945:53; Hamerstrom and Hamerstrom, 1954:463). Both Hamerstrom (1941:36) and Schwartz (1945:52) observed some competition among females. The females were found to raise their pinnae and oppose each other; cackling as males did in their territorial disputes. Females who had assumed the mating position were driven away by other females, or the reverse was found.

Robel (1967:112) observed that matings on the booming grounds were restricted primarily to two periods, one at the height of the season and another approximately a month later. Baker (1953:24) and Schwartz (1945:54) stated that few matings took place after the height of the season. Baker (1953:24) observed matings over at least a 6-week period and stated both sexes seemed to become physiologically incapable of breeding shortly after the first of June.

Schwartz (1945:61) found males paid little attention to females that came to the booming grounds in the fall of the year. He stated that the females were not receptive at this time, and neither matings nor attempted matings took place. Anderson (1965:8) found males responded sexually to decoys mounted in a receptive position during the fall booming season. Schwartz (1945:61), after measuring the testes of 15 male prairie chickens taken during different periods of the year, concluded that males were probably incapable of breeding in the fall.

Yeatter (1943:391) found nests of Illinois prairie chickens to have a definite tendency to be grouped close to booming grounds. He found most nests were within a radius of 0.25 mile from the nearest booming ground, and a number of nests were found between 150 and 330 yards from a booming ground. Hamerstrom (1939:115) stated that grouping of nests was not chance distribution and indicated this was because females tended to nest near the booming ground on which they were mated. Hamerstrom (1941:53) reported that most nests were found between 0.5 and 1.25 miles from a booming ground.

Yeatter (1943:389) found the distance of nesting cover from booming grounds apparently influenced the choice of nest site. Schwartz (1945:63) reported the cover immediately around the nest was variable, but a preference was shown for grassy sites. Hamerstrom (1941:54) found most nests to be in open herbaceous cover with cover plants being a mixture rather than pure stands. Yeatter (1943:391) reported there appeared to be a definite tendency for prairie chicken nests to be situated within a few feet of field margins, hedges, small trees or near streams. Schwartz (1945:63) found most nests located on slopes with no apparent preference for any direction of slope.

Schwartz's (1945:64) description of nest structure agreed closely with those of Gross (Bent, 1932:246) and Hamerstrom (1939:117; 1941:53). Schwartz (1945:64) found nests were rather flimsily built, and lined with dead grass found at the nest location. The nests were located in natural hollows of the ground or slight excavations made by the females. The vegetation about the nest was usually very thick and provided concealment by arching high over the nest.

Gross (Bent, 1932:248) found eggs of captive greater prairie chickens and that one nest of a wild bird were laid at the rate of one egg every other day. He also stated that egg laying was not necessarly on alternate days, but more apt to be very irregular. Baker (1953:25) presented indirect evidence that eggs were laid one per day until the clutch was completed.

The data of Hamerstrom (1941:50) and Ammann (1957:97) and others indicated that the average full clutch size for greater prairie chickens averaged between 11 and 13 eggs with a range of 5 to 26 eggs. Hamerstrom (1939: 113) and Baker (1953:28) believed the largest clutches were begun during the height of the booming season, and, as the season advanced, the size became progressively smaller. The very large clutches were thought by Gross (Bent, 1932:248) to be products of two or more female prairie chickens. The largest clutch of a single female prairie chicken reported by Hamerstrom (1941:52) had 17 eggs, while the largest clutch reported by Yeatter (1943: 391) contained 16 eggs. Schwartz (1945:65) and Yeatter (1943:392) found that one or two eggs early in the season were sometimes "dropped" and did not represent nesting attempts.

Little data were given for size and weight of individual eggs. Gross (Bent, 1932:247) gave the average long diameter as 44.86 millimeters and the average short diameter as 33.59 millimeters for 100 eggs measured.

Gross (Bent, 1932:249) found the incubation period for one greater prairie chicken nest to be 23 days. Schwartz (1945:66) observed two clutches of which the first date of incubation was known and found hatching occurred after 23 and 24 days. Gross (Bent, 1932:248) found evidence that incubation started before all eggs were laid.

Schwartz (1945:66) stated that the protective coloration of the female made it difficult to locate nests. He found that as incubation advanced, the females were more reluctant to flush. One female was seen displaying a "broken-wing" act when leaving the nest while another female, on two occasions, flew directly away for about 0.25 mile, then made a wide circle and alighted about 100 yards behind the nest where she could be seen watching the observer. Gross (Bent, 1932:250) seldom saw females feign a "broken-wing" and stated that most would fly directly away from the nest.

Schwartz (1945:67) and Hamerstrom (1941:53) noted females did not cover the nest when they were away feeding during the incubation period. Gross (Bent, 1932:248) stated that no attempt was made to cover the eggs during the incubation period, but one female was observed to cover a nest of rather exposed eggs with nesting material before she left the nest during the laying period.

Gross (Bent, 1932:250) reported one female continuously shifted her position during the course of the day and at times would reach far out of the nest to get an insect. Schwartz (1945:67) found that a female usually faced down the slope as she sat on the eggs.

Schwartz (1945:67) and Gross (Bent, 1932:248) found females regularly left the nest to feed during both the early morning and late evening, walking several yards before flying. Gross (Bent, 1932:249) observed females usually were away from the nest for periods of approximately 50 minutes.

Schwartz (1945:66) stated that fertility of greater prairie chicken eggs appeared to be high; all 60 eggs hatched in five nests under observation. Yeatter (1943:392), Hamerstrom (1941:52) and Ammann (1957:97) also found fertility of greater prairie chicken eggs to be very high.

Schwartz (1945:67) found the time required for chicks to emerge from the eggs after pipping started was from 0.5 to 24 hours, while from 8 to 24 hours were required for all chicks to emerge and leave the nest. Gross (Bent, 1932:252) stated that the first eggs were pipped on about 22 days after incubation started. He also found the time required for all chicks to emerge from the eggs was, at times, less than 1 hour.

Gross (Bent, 1932:252) stated that in cases where incubation started before the last one or two eggs were laid, one or two eggs failed to hatch before the female left the nest. Schwartz (1945:68) stated that no nests were observed during the hatching period in which the female left the nest before all the eggs hatched. Gross (Bent, 1932:252) and Yeatter (1943:396) reported broods left the nest a few hours after hatching, but if the hatching took place late in the afternoon the female, unless disturbed, brooded them on the nest during the first night and left the next morning as soon as temperature and weather conditions were suitable for the chicks to move. He also stated that eggshells were never removed from the nest by the females.

As with most gallinaceous birds, many prairie chicken nests were unsuccessful (Hamerstrom, 1941:52). Ammann (1957:99) summarized his data and data from other investigators and found approximately 52 percent of all greater prairie chicken nests were unsuccessful. Yeatter (1943:392) found clutches laid early in the season suffered high losses from predators (35 percent), while those laid later in the nesting season had fewer losses. He thought this was due to better vegetative cover later in the season. Yeatter (1943:393) also found females deserted nests early in the season when only a small number of eggs were laid and that later, when the incubation period was well under way, nest desertion was less likely to occur. He found plowing and burning to be the chief hazard to prairie chicken nests in Illinois. Schwartz (1945:67) found that heavy rainfall and flooding was, at times, of major importance in nest destruction. Schwartz (1945:66) also reported cases in which horses and cattle stepped on nests and crushed eggs, but that this was thought to be of minor importance.

Hamerstrom (1939:112) found most greater prairie chicken nests were begun during the height of the mating season. Baker (1953:28) found two distinct groupings of dates on which the first eggs were laid and suggested this was due to renesting. Yeatter (1943:385) and Robel (1967:112) also thought the late nests to be products of renesting. Hamerstrom (1939:115) believed that the greater prairie chickens renested but to a lesser extent than quail, Hungarian partridges, and pheasants. Yeatter (1943:392) believed a comparatively high percentage of female greater prairie chickens in southeastern Illinois finally brought off broods successfully because of renesting.

Ammann (1957:101) stated that it seemed unlikely any females could renest after their first clutches were destroyed during the latter part of the incubation period. Both Hamerstrom (1941:56) and Schwartz (1945:54) stated that although they thought greater prairie chickens renested, there was no direct evidence of renesting. The only direct evidence of renesting by prairie chickens was a report by Lehmann (1941:15) for Attwater's prairie chickens (Tympanuchus cupido attwateri). He found that some Attwater's prairie chickens renested as many as two times, after failures, for a total of three nesting efforts.

MATERIALS AND METHODS

Study Area

The study area was located 22 miles south of Manhattan in T12S, R7E of Geary County, Kansas and was enclosed almost entirely by the 6000-acre Simpson Ranch (Fig. 1). During the fall and winter, a portion of the study was conducted east and south of the Simpson Ranch. The topography of the area was characterized by branched, rounded ridges fringed with limestone rock outcrops and intersected with small drainages. The elevation varied from 1180 feet in the lowland drainages to over 1400 feet on the highest ridge tops.[1]

Vegetation of the area was characteristic of the Flint Hills region in northeastern Kansas as described by Herbel and Anderson (1959) with the exception that some ridge tops were in cultivation in the late 1920's and have an abundant growth of annuals. Vegetation was a mixture of both tall and short grasses with the dominants being little bluestem (*Andropogon scoparius*),[2] big bluestem (*Andropogon gerardi*), tall dropseed (*Sporobolus asper*), western wheatgrass (*Agropyron smithii*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), and buffalo grass (*Buchloe dactyloides*). Other grasses and forbs occurring were slimflower scurfpea (*Psoralea tenuiflora*), three-awn grass (*Artistida spp.*), Japanese brome (*Bromus japonicus*), downy brome (*Bromus tectorum*), western ragweed (*Ambrosia psilostachya*), western yarrow (*Achillea millefolium*), green milkweed

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[1] United States Dept. of Int. Geol. Survey Contour Map, 1955.

[2] Common and scientific names follow Anderson (1961).

(Asclepias viridiflora), broomweed (Gutierrezia dracunculoides), purple prairieclover (Petalostemum purpureum), and Louisiana sagewort (Artemesia ludoviciana).

Trees and shrubs were the dominant plants in the lowlands and along the creeks.

Species found in the cultivated and old fields included sorghum (Sorghum vulgare), alfalfa (Medicago sativa), yellow sweetclover (Melilotus officinalis), wheat (Triticum spp.) and smooth brome (Bromus inermis). Vegetation analysis presented by Robel (1964) for the northern portion of the study area was descriptive of most of the area. A detailed vegetational analysis of the study area was conducted by Briggs (1968) during the 1966-1967 phase of the study.

Moderate grazing pressure coupled with pasture rotation was experienced by most of the study area throughout the year. The area was not burned but prairie hay was baled and removed from some hillsides during the period 1964-1966. The northern area (25 acres) designated as an old field was heavily grazed and part of it was mowed during the summer of 1965 and 1966 but the southern tract (7 acres) was unmowed and grazed only during the winter of 1966-1967. Wheat (75 acres) and grain sorghum (65 acres) were grown on the cropland of the study area. The wheat and grain sorghum fields were seeded to native grasses during the summer and fall of 1966, respectively.

Three permanent and one "territoral" (Hamerstrom and Hamerstrom, 1949: 327) booming grounds were located on the study area during the 1966-1967 phase of the study. Following the plowing and planting (spring of 1966) to grain sorghum of the area on which the south booming ground was located, the south ground was relocated 0.5 mile to the north of the old ground. The new south ground was located 1.4 miles southeast of the central ground, 2.75 miles southeast of the north ground and 1.9 miles northwest of a booming ground off the southeast end of the study area. The central booming ground was located 1.5 miles southeast of the north booming ground and the territorial booming ground was located 1.04 miles north of the central ground and 0.65 mile southeast of the north booming ground.

Spring censuses of birds on the three permanent booming grounds during the height of the booming season, showed approximately 31 to 35 displaying males during 1964 and 1965 (Cebula, 1966:7), with 35 and 30 during the spring of 1966 and 1967, respectively. The territorial booming ground had from one to four males present during the spring of 1967. Prairie chickens were numerous throughout the study area and were observed in greatest abundance during the winter when flocks utilized the grain fields on the area.

Live-trapping and Banding

Prairie chickens were live-trapped throughout the study period to facilitate attachment of leg bands, patagial markers and radio transmitters. A cannon net was the most extensively used trapping device during this study. The cannon net consisted of a 40- x 60-foot woven nylon net having a 2-inch mesh and was projected by three "composite cannons" (Smith, 1962: 3). The cannons were loaded with commercially prepared black powder charges and detonated by a 50-cap blasting machine. This trap was employed exclusively on the booming grounds.

Japanese mist nets were also employed to capture prairie chickens on booming grounds (Plate I, Fig. 1). The nets[1] were 2-ply, 4-inch mesh black nylon with three shelfstrings and measured 7 x 60 feet. The nets were inclined at ground level with the distal edge to the booming ground being elevated approximately 30 inches above the ground. The proximal edge was anchored to the ground. Steel rods were used to anchor the ends of each net. Mist nets were erected on the booming ground before dawn each morning they were used and were constantly tended during each trapping period from a blind erected on the edge of the booming ground. At times only one mist net was used, but normally two were employed to form a "V", the open end facing the path of approaching birds.

A mirror trap (Bendell and Fowle, 1950) was also used for trapping male prairie chickens on booming grounds. The trap was a rectangular box, 20(h) x 20(w) x 42(l) inches, constructed of 0.5-inch mesh hardware cloth over a 1- x 1-inch wooden frame. Three inches below the wire fabric roof, a 1-inch mesh cotton net was stretched rather loosely across the top of the trap to prevent captured birds from seriously injuring themselves in efforts to escape. The trapping mechanism consisted of a drop-door of solid 0.5- x 18- x 20-inch plyboard, triggered by a mousetrap-treadle apparatus.

In conjunction with cannon-net, mist-net and mirror-trap operations, a portable electric fence was erected around the booming grounds to prevent cattle from interfering with trapping activities. Tape recorded vocalizations of booming prairie chickens were also used to expedite trapping of male prairie chickens on booming grounds. Recordings were placed on Scotch

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[1]Mist nets were of Japanese manufacture obtained from Bleitz Wildlife Foundation, Hollywood, California. A special permit from the U. S. Fish and Wildlife Service is required for use of mist nets to capture migratory birds in the United States.

III plastic magnetic tape at a speed of 7.5 ips and were broadcast by a battery-powered Wollensack 1700 tape recorder. Broadcasts were made from blinds at the edge of booming grounds with either the internal speaker of the recorder or a Lafayette SK-128, 8-inch biaxial speaker. The SK-128 speaker was oriented upward in a plywood box 2 x 2 x 0.8 feet, usually located in the center of the booming ground, and concealed with vegetation.

Similar to the technique employed by Anderson and Hamerstrom (1967), female decoys mounted in a receptive position were used during this study to increase trapping success. Decoys were used during all seasons in connection with cannon-net and mist-net trapping on booming grounds. At times decoys mounted both in receptive and standing positions were employed with walk-in traps during winter trapping. Decoys were placed either in, on or close to the walk-in traps.

A drive trap (Patterson, 1952) was used during the summer of 1965 to trap female greater prairie chickens with broods. The trap was constructed using 2-inch mesh cotton fish netting made into a rectangular enclosure 3 x 20 x 30 feet. Two wings of 2- x 150-foot poultry netting formed a 60° angle at the mouth of the trap and joined to form a funnel approximately 10 feet inside the mouth. Females with broods were driven toward the mouth of the trap with the aid of vehicles.

A 5-foot diameter dip-net suspended by one or two 10-foot lengths of 1-inch aluminum poles was used for night recaptures of transmitter-equipped birds and to capture incubating females on nests. During night recaptures, the bird was first located, blinded with 7-cell flashlight, and then netted by the investigator or by an assistant who approached the bird from the same direction.

Equipment for night-lighting, similar to that described by Labisky (1959), was employed to trap greater prairie chickens during this study. The basic equipment consisted of a 2500-watt, 110-volt AC, gasoline generator mounted in the rear of a pickup truck. A floodlight cluster made of five 150-watt flood lamps held by a wiring trough, was mounted at the apex of a tripod made from three 3-foot lengths of 1-inch metal conduit, welded together at the top and bolted at the bottom to a metal car-top carrier. The tripod was mounted above the cab of a pickup truck when in use. The floodlights produced a semicircle of light extending about 10 yards on either side of the truck and 15 yards forward. The individual flood lamps were adjustable so the area of projected light could be controlled. A 110-volt master switch box with a 10-amp fuse was mounted between the floodlight cluster and the generator to protect the operator from shorts in the electrical wiring. To trap birds, fields of relatively flat terrain and grain stubble were systematically cruised to locate roosting prairie chickens. When a bird was located, a hand-held spotlight was used to "blind" the bird and the floodlights were immediately switched off. The bird was then trapped by using the dip-net described above.

Three types of traps were constructed to capture greater prairie chickens at fall and winter feeding areas. A funnel-type walk-in trap was constructed by arranging three 3- x 15-foot sections of 2- x 4-inch mesh welded fencing wire in an elongated oval arrangement with the ends directed in to form funnels. A bob-type trap (Taber and Cowan, 1963) was constructed using a 3- x 16-foot section of 2- x 4-inch mesh welded fencing wire connected to form a square with swinging wire bobs placed in a 24- x 18-inch opening at the bottom portion of one side of the trap. Two single-funnel walk-in traps were constructed using 6- x 10-foot sections of 2- x 4-inch mesh welded fencing wire to form a rectangle with a single funnel at one end. Cotton fish netting was used to cover the tops of these wire traps. Ear corn and whole milo were used to bait the traps. Bait stations were established prior to placement of the traps in the fall and winter feeding areas. All baited traps were inspected daily to prevent escape and reduce injury of captured birds.

Other equipment used included; (1) black cotton stockings which were placed over the heads of captured birds to calm them, (2) numbered aluminum leg bands, (3) colored plastic bands (Hamerstrom and Mattson, 1964) and (4) patagial tags (Anderson, 1963). All captured prairie chickens were released immediately at the capture site after banding, marking and attachment of transmitters.

Radio Telemetry

The telemetry materials and techniques used in this study were developed by Marshall (1960), described by Cebula (1966) and Viers (1967) and constructed for this study by Sidney L. Markusen of Esko, Minnesota. The transmitters measured 0.5 x 1.25 inches, weighed 6 to 7 grams and were encased in nylon tape coated with epoxy (Plate I, Fig. 2). The transmitters were of the continuous broadcasting type and operated at discrete frequencies between 150.815 and 151.085 megacycles/second with a power output of 0.01 watts. A crystal oscillator circuit transistor and an 11-inch spring wire antenna comprised each transmitter. Transmitters were powered by either one or two mercury batteries, each weighing 12 grams (Mallory RM401).

Harnesses fashioned from 0.1-inch diameter plastic tubing were used to attach the transmitters to prairie chickens. Two 10-inch lengths of the tubing containing wire leads were built onto the front of each transmitter. For attachment to prairie chickens, a loop large enough to fit around the neck of a prairie chicken was formed. Slits were made in the tubing at approximately 4 inches below the point where the tubing was attached to the transmitter. The wire leads were extracted and clipped leaving about 0.5 inches of wire lead extending beyond the slit. Each end was then run through the center of a plastic "snap cap" and soldered to a 0.25-inch square piece of sheet brass. The snap caps were then fitted over both ends of a plastic vial consisting of the top 0.5-inch of two 5-cubic centimeter artificial inseminating bottles cemented together, thereby producing a vial with snap caps at both ends. The snap caps supplied enough pressure to make a strong connection between the brass contacts and the battery. The battery package was then taped with plastic electrical tape to seal out moisture. Occasionally two battery packs were connected to the transmitter in parallel and then taped together as a single unit (Plate I, Fig. 2).

Attachment to a prairie chicken was accomplished by placing the loop over the head of the bird so that the battery was suspended over the bird's crop. The ends of the tubing were passed under each wing and both ends threaded through an opening in the rear of the transmitter and tied with a square knot (Plate II, Fig. 1). The excess tubing was clipped and the ends were taped to the transmitter with plastic electrical tape.

Biotelemetry receiving equipment consisted of three portable receivers specifically designed for radio tracking. The receivers were 12-channel, transistorized, crystal controlled, double conversion superheterodyne mechanisms. Two of the receivers were powered by 10 size "C" flashlight batteries and the other was powered by 10 size "D" flashlight batteries. The components were contained in an aluminum case 6 x 7 x 12 inches and weighed 4.5 pounds. Padded canvas carrying bags were constructed for each receiver for protection and ease of handling (Plate III, Fig. 2). The receivers were equipped with earphones for audible detection of transmitter signals. A signal strength meter permitted visual detection of transmitter signals. Receiver controls consisted of an on-off switch and volume control, channel selector, battery test, circuit switch, sensitivity control, beat frequency oscillator (BFO) switch and control, meter gain and vernier tuner. Various directional antennas were connected to the receivers by coaxial fittings.

Receiver operation was accomplished by turning the set on and selecting the desired channel for receiving a specified transmitter. The vernier tuner was slowly adjusted and the antenna was rotated until a tone was audibly detected. Vernier tuning was continued to obtain maximum volume of the signal. Finer tuning was obtained by adjusting the BFO and sensitivity controls. The antenna was then rotated to determine the null points on either side of the maximum signal reception. The azimuth of the signal was calculated by bisecting the arc between and null points. This procedure was repeated at another antenna to obtain a second azimuth on the same transmitter and both azimuths were plotted to determine the location of the transmitter.

Three different designs of directional receiving antennas were used in combination with the portable receivers. They consisted of eight permanent receiving stations, two mobile receiving stations and three hand held directional antennas. Each hand held directional antenna consisted of a tubular conduit handle supporting two 30-inch heavy wire elements at right angles to the handle. A lead-in cable about 2 feet long connected the antennas to the portable receivers (Plate IV, Fig. 1). Use of the hand held antennas was confined to night recaptures, for determining locations on prairie chickens beyond the range of permanent antennas and where vehicular travel was not practicable. Radio-tagged prairie chickens were located by circling the position of the bird and obtaining several bearings from different locations. The locations of radio-tagged birds were noted in relation to visible landmarks and later plotted on aerial photographs. The hand held antennas were also used to flush transmitter equipped birds to check on their physical condition, to locate nesting females and to determine precise locations.

The permanent and mobile antennas were 8-element yagi type directional antennas constructed by inserting heavy wire elements of the proper length through a 10-foot length of 0.5-inch diameter electrical conduit and soldering them in place (Fig. 2). The seventh or driven element was composed of heavy wire connected to the conduit by three 0.25-inch bolts and a 3-inch bakelite insulator. A coaxial balun loop 27.75-inches long was attached to each driven element. The lead-in cables were RG 58 A/U coaxial cable extending from the driven element to the mast, through a cork stopper in the top of the mast and out a hole above the base and ending in a coaxial fitting (Fig. 3).

Each permanent antenna was supported by a 20-foot mast constructed from two 10-foot lengths of 1.25-inch diameter galvinized steel conduit. A 1.5-inch muffler clamp was used to attach the yagi antenna to the masts. A 30-inch base with metal wings welded to the sides and buried 24 inches in the ground supported each mast. Welded to the top of each base was an 8-inch metal flange which was used for attachment of the compass cards. The compass cards were originally 8-inch photographs of a circular protractor which were glued to masonite discs, covered with transparent acetate and glued to the metal flanges. Later in the study, the compass cards were replaced with 8-inch clear plastic circular protractors (Plate III, Fig. 2). These were bolted through painted masonite discs to the metal flanges. Pointers were constructed by modifying television insulator standoffs and attaching them to the antenna masts. Support for the mast was furnished by four guy wires attached to a slip-ring retained by a collar bolted through the mast 48 inches from the top. After replacement of the compass cards with plastic protractors, the use of canvas covers for weather protection was discontinued. Barbed wire fences approximately 20 feet square were erected around the antennas to exclude cattle and to anchor the guy wires (Plate III, Fig. 1).

The permanent antennas were erected in a gridlike pattern along the ridge tops of the study area approximately 0.5 mile apart. The antennas were aligned true north. Alignment was accomplished by compass readings and periodically checked to insure accuracy. An evaluation of the accuracy of the permanent antennas by Slade _et al_. (1965) revealed a mean error of 96 feet for two azimuth locations at distances of about 0.5 mile. The mean error in feet was positively correlated with the distance from the receiver to the transmitter (Slade _et al_., 1965).

The mobile receiving stations were constructed by mounting a directional yagi antenna on the rear bed of a pickup truck. A compass card was secured to the bed of the truck and a pointer was inserted through a hole in the mast. The lead-in cable extended from the yagi to the bed of the truck where the receiver was located (Plate IV, Fig. 2). Azimuths were recorded as degrees deviation from imaginary base lines connecting the mobile station with visible landmarks.

Attempts were made to locate each radio equipped prairie chicken once or twice a day at different hours to determine the daily and seasonal movements. Continuous tracking periods, consisting of radio location of birds at 30-minute intervals for extended periods, supplemented determinations of daily movements. All radio determined locations were plotted on base maps to provide a history of each individual prairie chicken tracked.

By joining outermost location points (Mohr, 1947), monthly ranges in acres were calculated for each individual prairie chicken with 15 or more total locations per month.

Distance in yards between each successive daily location was determined by measurement from a base map. Ranges and distances of movement for each individual prairie chicken for this phase of the study and for the entire study were stratified into monthly categories. A table of random numbers was utilized to determine which location was to represent a given day if more than one had been recorded. When four or more locations were recorded for a given day the first was used. Movements overlapping successive months were recorded as belonging to the preceding month. Standard errors were calculated for both mean ranges and distances for each month-class using the method described by Snedecor (1956).

Reproductive Studies

Greater prairie chicken behavioral and reproductive data were collected on booming grounds during both the spring and fall booming seasons. Observation periods began approximately 1 hour before sunrise and continued for 2 hours. Late afternoon observations beginning 2 to 3 hours before sunset were also conducted when time permitted. Blinds erected at the edge of the three booming grounds on the study area facilitated observation of bird activity. The majority of the observations for the entire study were conducted on the central booming ground (Fig. 1).

Reproductive and behavioral data of nesting female prairie chickens were collected on all nests found. Nests of female prairie chickens were located by one of four methods; (1) flushing radio-tagged birds when nesting was suspected, (2) direct observation of females making flights from nests to feeding areas, (3) covering areas of suspected nest habitat with a dog to find nests by scent and (4) use of a flusing device made from rock-filled cans tied to a 100-foot rope at 2-foot intervals.

For recording reproductive and behavioral data of nesting greater prairie chicken females during the 1966-1967 phase of the study, two Rustrak model 133, dual channel, thermistor probe recorders were used (Plate V, Fig. 1). Similar electronic equipment was used by Baldwin and Kendeigh (1927) for measuring nesting activities of the house wren (*Troglodytes aedon*) and Kessler (1960) to measure egg temperatures of the ring-necked pheasant.

Each recorder was powered by a 12-volt auto battery and had a temperature range of 20° to 120°F. Two model 1333 banjo-type probes equipped with either 60 or 110-foot lead cables with phone plug terminals were used to record both air and nest temperatures.

Nest temperature was recorded by placing one probe inside a prairie chicken nest (Plate V, Fig. 2). The sensor end of the probe was placed in the center of the nest at a height of 1.25 inches and held there by a wire protruding from the bottom of the nest. Air temperature was measured in the same manner from an "artificial nest" located within 5 yards of, and constructed to resemble, the prairie chicken nest. The leads of both probes were camouflaged using natural vegetation. An 8- x 13- x 20-inch plastic container, used to house each auto battery and recorder, was placed in tall vegetation as far from the nest as the leads would allow. The plastic container was surrounded by rocks and the front covered with clear plastic sheeting to protect the instruments.

A canine repellent[1] and red pepper were spread around prairie chicken nests to protect them from mammalian predators. A 25-foot square, 2-foot high poultry netting fence was constructed around one nest for additional protection. Occasionally, a portable electric fence was erected around prairie chicken nests to protect them from cattle.

Weights and measurements of greater prairie chicken eggs were obtained from clutches partly destroyed or deserted. Length and width measurements were made to 0.01 centimeter with a Helios vernier caliper. Intact eggs were weighed to 0.01 gram on a H6T Mettler balance.

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[1]Active ingredients; Naphthalene (98.5 percent) and cresylic acid (0.1 percent).

RESULTS

Trapping and Banding

During the entire study, a total of 131 greater prairie chickens was trapped with 47 of these being trapped in the 1966-1967 phase of the study (Table 1). A total of 83 prairie chickens was banded for the entire study with 25 banded during the 1966-1967 phase of the study. Forty-eight prairie chickens were recaptured during the entire study and 22 were recaptured during the 1966-1967 phase of the study. Thirty-eight radio-tagged prairie chickens were recaptured during the entire study and 17 of these were recaptured during the 1966-1967 study. Two prairie chickens were killed during the 1966-1967 phase of the study. One male prairie chicken died after being hit with a cannon-net projectile and a female died as a result of injuries received while attempting to escape from a mist net.

Tape recorded vocalizations of displaying prairie chickens aided in the trapping of 52 prairie chickens during the entire study and 20 for the 1966-1967 phase of the study. Female decoys posed in a receptive position aided in trapping eight male prairie chickens on booming grounds during the 1966-1967 phase of the study.

Radio Telemetry

All telemetry equipment performed satisfactory during the 1966-1967 phase of the study. During the entire study, a total of 75 transmitters were placed on 58 different prairie chickens. Thirty were placed on 27 prairie chickens during the 1966-1967 phase of the study. Thirty-nine transmitters were recovered during the entire study and 31 were lost.

Table 1. Summary of prairie chickens trapped by all methods for the entire study and for the 1966-1967 phase of the study.

	Number Trapped	Trapping Method			
		cannon-net	walk-in	hand drop-net	mist-net
Entire study					
Males	74	49	2	13	10
Females	40	14	1	18	7
Juveniles	17	4	2	10	1
Totals	131	67	5	41	18
1966-1967 phase					
Males	22	5	0	8	9
Females	15	1	0	7	7
Juveniles	10	4	0	5*	1
Totals	47	10	0	20	17

*Includes one bird caught by hand.

Eleven transmitters were recovered, 14 were lost during the 1966-1967 phase of the study and 5 were still transmitting when the study terminated on 15 June 1967. A total of 1902 "bird days" of location data was collected with 873 collected during the 1966-1967 phase of the study. An average of 33 days of location data per prairie chicken was obtained for the entire study and 32 days per prairie chicken during the 1966-1967 segment. A total of 2818 locations was recorded on 58 birds resulting in 49 locations per bird for the entire study. In the 1966-1967 phase, 1234 locations on 27 prairie chickens were obtained; an average of 46 locations per prairie chicken.

Two prairie chickens were equipped with radio transmitters powered by two batteries during the 1966-1967 phase of the study. One transmitted 106 days before the signal was lost. The other was attached to a prairie chicken on 18 May 1967 and was still transmitting 15 June 1967 when this phase of the study terminated.

During the entire study 3 radios were known to have been lost from prairie chickens. Male AM23[1] was radio-tagged on 4 June 1965 but when retrapped on the central booming ground on 7 May 1966, only a radio harness and battery remained around his neck. The radio transmitter of another male (AM11) was replaced on the night of 4 August 1965. When retrapped 7 November 1966 on the central booming ground, bird AM11 was not carrying a radio. On 23 September 1965, when an attempt was made to recapture male AM11 for radio replacement, he flushed and flew into a power line. He was later

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[1]Numbers with the prefix A are adults, J are juveniles, M are males, F are females, U are unsexed birds and N are non-banded birds. Numbers are metal band numbers with the exception of numbers following the prefix N. The numbers following the prefix N were systematically assigned to distinguish between non-banded birds.

flushed and found able to fly but his radio was no longer transmitting. While observing prairie chickens on the central booming ground on 2 April 1967, a radio attached to male JM62 on 8 February 1967 was noticed to have a loose harness. On numerous occasions his feet became entangled in the harness. During an encounter with another male (AM40), the radio was lost from the back of JM62. Examination of the radio disclosed that its antenna was missing and the harness broken. The radio was also damaged, indicating that bird JM62 had hit something with force.

In general, little physical discomfort to the birds was caused by equipping the birds with transmitters. Inspection of retrapped radio-tagged prairie chickens revealed only one case of apparent adverse physical effects caused by the harness arrangement. A radio was attached to an adult male (AM66) on 18 November 1966. On 20 April 1967, bird AM44 was retrapped on the central booming ground and found to have areas under both wings rubbed raw due to a loose transmitter harness. The transmitter was removed from male AM44 at this time. On several occasions, both before and after the transmitter was removed, male AM44 was observed to display normally (Plate II, Fig. 2). The death of a 7-week old juvenile prairie chicken (JU55) was attributed to its being radio-tagged (for details see page 68).

Mean Monthly Ranges

Of 27 prairie chickens radio-tracked during the 1966-1967 phase of the study, a sufficient number of locations was obtained to estimate 33 individual monthly ranges.

The mean monthly range of male prairie chickens varied from a low of 105 acres in May to a high of 2337 acres in March (Table 2). Mean monthly

Table 2. Summary of 1966-1967 phase mean monthly range areas for male, female and juvenile prairie chickens. Number in parentheses represents the number of prairie chickens radio-tracked.

Month	Mean Locations for Monthly Ranges				Mean Area of Monthly Ranges*			
	Male	Female	Juvenile	Pooled	Male	Female	Juvenile	Pooled
January	----	----	----	----	----	----	----	----
February	18(1)	----	22(3)	21(4)	1087 ± **	----	1042 ± 366	1054 ± 259
March	41(1)	----	41(1)	41(2)	2337 ± **	----	1179 ± **	1758 ± 579
April	----	42(2)	51(1)	45(3)	----	810 ± 18	459 ± **	693 ± 118
May	18(1)	36(2)	44(1)	33(4)	105 ± **	822 ± 23	89 ± **	459 ± 211
June	----	25(4)	----	25(4)	----	469 ± 220	----	469 ± 218
July	15(1)	28(2)	----	24(3)	122 ± **	415 ± 154	----	317 ± 132
August	34(2)	----	25(1)	31(3)	190 ± 111	----	153 ± **	177 ± 65
September	34(3)	----	34(1)	34(4)	253 ± 81	----	230 ± **	247 ± 57
October	32(2)	----	31(1)	32(3)	387 ± 64	----	609 ± **	461 ± 83
November	20(1)	----	17(1)	19(2)	1128 ± **	----	962 ± **	1045 ± 83
December	----	----	17(1)	17(1)	----	----	879 ± **	879 ± **

*All ranges in acres; mean ± one standard error.

**Standard error not calculated.

ranges were below 400 acres during the period of May through October and over 100 acres during November, February and March. Sufficient data for calculation of mean ranges of male prairie chickens during the months of January, April, June, and December were not obtained.

Sufficient data for calculation of mean ranges of female prairie chickens were obtained only for the months of April through July (Table 2). Female mean monthly ranges varied from a low of 415 ± 154[1] acres in July to a high of 822 ± 23 acres in May.

Sufficient data for calculation of juvenile mean ranges were obtained for all months except January, June, and July. The juvenile mean monthly range varied from a low of 89 acres in May to a high of 1179 acres in March. The mean ranges were below 250 acres during the period of May through September, over 875 acres from November through March for months with calculated mean ranges, and 459 and 609 acres for the months of April and October, respectively.

Mean monthly ranges obtained by pooling all sex and age classes varied from a low of 177 ± 65 acres for August to a high of 1758 ± 579 acres for March. There were sufficient data for calculation of mean ranges for all months with the exception of January. The mean monthly ranges varied from a low of 177 ± 65 to a high of 469 ± 218 acres during the period May through October. Mean ranges were over 875 acres for all months during the period of November through March. The mean monthly range for April was 693 ± 118 acres.

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[1] Standard errors are given for all mean ranges when sufficient data allowed their calculation.

Movements

The mean daily movements for male prairie chickens varied from a low of 88 yards in April to a high of 1533 ± 274 yards in March (Table 3). Mean movements between successive daily locations for the months of May through September were under 430 yards. Mean daily movements for the period from January through March were over 1300 yards. Male prairie chicken's mean daily movements for October, November and December were 599 ± 53, 957 ± 97 and 701 ± 137 yards, respectively.

Female mean daily movements varied from a low of 521 ± 55 yards during July to a high of 1056 ± 133 yards during March. During the period of May through August, mean daily movements were between 521 ± 55 yards and 615 ± 73 yards. The mean movements between successive daily locations for the month of April averaged 838 ± 76 yards. No females were radio-tracked during the period September through February.

The mean daily movements for juvenile prairie chickens varied from a low of 298 ± 231 yards for May to a high of 1423 ± 226 yards for March. No juveniles were radio-tracked during the months of January, June, and July. The mean daily movement for the period of November through March was over 900 yards, while all mean daily movements for other months were under 500 yards except October (776 ± 97 yards).

Mean daily movements obtained by pooling all age and sex classes varied from a low of 414 ± 34 yards for September to a high of 1452 yards for January. Mean daily movements were over 860 yards during the period from November through March, under 550 yards from May through September, and 736 ± 66 and 650 ± 48 yards for the months of April and October, respectively.

Sufficient data were obtained to determine seasonal and daily movement

Table 3. Summary of 1966-1967 phase mean monthly movement distances between successive daily locations for male, female and juvenile prairie chickens. Number in parentheses represents the number of prairie chickens radio-tracked.

Month	Number of Movements				Mean Distance of Daily Movements*			
	Male	Female	Juvenile	Pooled	Male	Female	Juvenile	Pooled
January	1(1)	----	----	1(1)	1452 ± **	----	----	1452 ± **
February	13(1)	----	43(3)	56(4)	1533 ± 274	----	1234 ± 139	1303 ± 124
March	25(1)	3(3)	26(1)	54(5)	1335 ± 232	1056 ± 133	1423 ± 226	1362 ± 158
April	1(1)	62(5)	24(1)	87(7)	88 ± **	838 ± 76	499 ± 124	736 ± 66
May	14(1)	61(2)	21(1)	96(4)	355 ± 100	615 ± 73	298 ± 231	508 ± 53
June	16(2)	61(5)	----	77(7)	429 ± 100	580 ± 101	----	549 ± 82
July	12(2)	36(2)	----	48(4)	337 ± 71	521 ± 55	----	475 ± 45
August	47(3)	11(2)	15(1)	73(6)	424 ± 52	586 ± 265	489 ± 101	462 ± 94
September	74(3)	----	25(1)	99(4)	402 ± 39	----	467 ± 74	414 ± 34
October	62(3)	----	25(1)	87(4)	599 ± 53	----	776 ± 97	650 ± 48
November	34(5)	----	15(2)	49(6)	958 ± 123	----	955 ± 157	957 ± 97
December	14(2)	----	7(1)	21(3)	701 ± 137	----	1182 ± 948	861 ± 171

*All distance movements in yards; mean ± one standard error.

**Standard error not calculated.

and movement patterns of several radio-tracked birds. Portions from the histories of selected individual prairie chickens are presented herein to exemplify these movements and activities.

Movements of interest include the movements from one booming ground to another. Prairie chicken AM66 was observed on three permanent and one territorial booming ground during the period 28 February to 2 June 1967. Bird AM66 was on the central booming ground (Fig. 1) on 21 March then moved 1.5 miles north to the north booming ground on 24 March. On 30 March he was located on a territorial booming ground 0.65 mile to the southeast. The next morning he was located on the south booming ground, over 2 miles south of the territorial booming ground. Two days after his visit to the south ground, male AM66 was again located on the north booming ground, 2.75 miles north of the south booming ground (Fig. 1). Bird AM66 was also credited with the longest movement during any single 24-hour period; a distance of 2.85 miles between 1600 hours[1] on 30 March and 1000 hours on 31 March 1967.

Movements between booming ground were also observed for female prairie chickens during the 1966-1967 phase of the study. Female AF71 was first observed on the central booming ground on 31 March 1967. On 14 May 1967, one day following destruction of her first nest, female AF71 was located on the north booming ground. Another female (AF70), trapped 31 March 1967 on the central booming ground before nesting, moved to the south booming ground the day following destruction of her first nest on 12 May 1967. Four days after destruction of her second nest on 1 June 1967, female AF70 was located on a booming ground off the Simpson Ranch, 1.9 miles south of the south booming

[1]Military time.

ground (Fig. 1). Later, during the same morning, bird AF70 returned to the south booming ground.

A female prairie chicken (AF54) with a brood was tracked continuously for daily periods from 26 June through 5 July 1966. Bird AF54 moved at a rate of 93 ± 9.3 yards per 0.5 hour during periods of movement. During the continuous tracking of AF54, no movement was detected between 18 of the 74 successive 0.5-hour locations determined. Periods of no movement were usually from 1100 hours to 1530 hours. Bird AF54 and her brood did not move during a 1-hour light rain on 27 June 1966. Following the rain, under overcast skies, female AF54 and her brood moved almost continually for the remainder of the day. Within 6 days after hatching, AF54 and her brood were located 2 miles from the nest site.

Flocks of prairie chickens were observed during all months of the year for the 1966-1967 phase of the study. An adult female (AF52) joined a flock of approximately 20 birds at a wheat field after cattle had destroyed her nest 19 June 1966. Female AF54, after loss of her brood, was observed with this flock on 6 July. Birds AF52 and AF54 fed with the flock on waste grain and roosted next to or in the wheat field. Movements of both birds were confined to an area in close proximity to the wheat field. Occasionally both birds were found feeding and roosting with the flock but this was not predictable as numerous times they were found alone or with small numbers of other birds.

On 13 July an adult male (AM56) was captured in the wheat field at night with the hand drop net and flashlight after radio-tagged female AF54 was located with the roosting flock. Another male (AM57) was radio-tagged using this method on 29 July 1966. AM56 was never observed with the flock again before his death on 24 July 1966. Bird AM57 was found with this and other flocks numerous times during the fall. After the first week of August, AM56 was observed to roost in areas of tall grass within 0.25 mile of the wheat field. On 10 August 1966 a juvenile female (JF58) was captured with AM57 in a roosting area. Another male (AM59) was trapped with AM57 on 19 August near the same location.

During the fall season, birds AM57, JF58 and AM59 were observed with small flocks (10-15 birds) on numerous occasions. These three birds were never found together at one time but each was observed with one other radio-tagged bird on several occasions.

An adult male (AM60) trapped on the central booming ground 4 November 1966, was 1 of 15 males that visited the ground. Bird AM60, after his capture, moved to the area of the feed fields and was not relocated on the central booming ground. Male AM60 joined with a flock of prairie chickens that ranged in size from 10 to 35 birds during the month of December. A juvenile male (JM61) was trapped with bird AM60 on the night of 8 November 1966. Both birds were found together on several occasions but were usually in different flocks or were occasionally by themselves. Both birds fed in grain sorghum fields on the study area and would either fly or walk into the fields to feed.

Birds JM63, JM65 and AM66 were trapped on the central booming ground in early February 1967 and were part of a flock of up to 16 males visiting the ground. Movements of these birds during February and March were from feeding areas to the booming ground. All birds were found together on several occasions but usually were found by themselves or with small groups of other birds.

During the height of the booming season in early April 1967, birds AM40, JM65 and AM77 and eight other males were found together during most periods of the day. Mornings and evenings were spent on the central booming ground and midday was spent about 0.25 mile west of the ground. This flock of males gradually "broke-up" and the males began to spend more time by themselves. Male AM77, until the study terminated on 15 June 1967, was usually found alone within 100 yards of and occasionally on the central booming ground. Adult male AM40 moved to an area near the north booming ground and made few long movements thereafter.

Reproductive Behavior

Observations of greater prairie chickens on booming grounds were conducted for over 160 morning and 15 evening display periods during the spring of 1965, 1966 and 1967. In addition, observations were conducted for over 30 mornings during the fall display periods of 1965 and 1966.

Arrival of males on the central booming ground for the 1966 spring booming season was first observed on 10 March 1966. On 5 February 1967, fourteen males appeared on the central booming ground following the broadcast of recorded vocalizations. These males continued to visit the ground when recorded vocalizations were used but were not observed to use the ground without the aid of the recorder until 6 March 1967.

The number of males on the central booming ground during the spring of 1966 ranged from 26 males in early March to 3 males on 9 June the last day males were observed on the ground. Thirteen males were usually found on the central booming ground during the height of the season (the first half of April). The number of males on the central booming ground during 1967 ranged from 14 on 5 February to 4 on 15 June when this phase of the study ended. During March and until 27 April 1967, eleven males were usually found on the central booming ground. On 27 April only nine males were observed. During the month of May, eight males were usually found although when females appeared on the ground, another male usually appeared also. After 24 May, the number of males varied between four and six until this phase of the study terminated on 15 June 1967. In 1965, males were last observed on the central booming ground 25 May; although, when tape recorded vocalizations were used, one male continued to appear on the ground until 28 July 1965.

During the fall of 1965, males were first observed on the central booming ground on 10 October when 15 males were seen. The number of males visiting the ground varied greatly during this period. On 7 November 1965, thirty-five males were seen on the central booming ground and on 23 November, 42 males were found on the ground. During 1966, males were first observed on the central booming ground during the fall period on 9 October. Fifteen males were observed at all times on this ground from 9 October to 7 November. Air sacks were noted to be a pink color and not orange as they were in the spring. No females were found on fall display grounds during 1965 or 1966.

Exact dates for the spring arrival of female prairie chickens were not determined for the central booming ground for either 1966 or 1967. The arrival date in 1966 was between 15 March and 20 March. No observations were made on the central booming ground in 1967 from 10 March through 21 March. No females were observed before 10 March but four were on the ground 22 March 1967.

The spring booming period was stratified into seven, 15-day intervals and the percent of days females were present on the central booming ground determined for 1966 and 1967 (Fig. 4). During the period 16 March to 15 April, females were seen on the central booming ground during 17 (89 percent) of the 19 days under observation. During the period of 15 to 30 April, 50 percent of the 12 days under observation had females present. Only three females were observed on the central booming ground between 22 April and 15 May during 17 days of observation. During the period 15 to 30 May, females were observed on 40 percent of the 15 days under observation. After 30 May no females were observed on the central booming ground during either 1966 or 1967.

In 1965 the last female observed on the central booming ground was during the late afternoon of 2 June when tape recorded vocalizations of displaying prairie chickens were used. During the 1966 spring booming season, females were last observed on the central booming ground on 24 May when two females were present. The last female to be observed on the central booming ground during 1967 was seen on 22 May. The latest observed date for a female on any booming ground was a radio-tagged female (AF70), observed on the south booming ground during the late morning of 4 June 1967.

The largest number of females observed at one time on the central booming ground was six (6 April 1966). Four females were the largest number observed at any one time during 1967, occurring on eight separate occasions between 22 March and 17 April 1967.

Males were observed to arrive at the booming ground in the morning, between 1 and 1.5 hours before sunrise. Females usually arrived within 0.20 to 0.5 hour after males were on the ground. Females usually left the booming ground within a few minutes after mating, or remained on the booming ground 1 or 2 hours if not mated. After 15 May, females tended to stay on or near the booming ground for much longer periods, occasionally for most of the morning. It was during the last half of May that a female was observed on the central booming ground in the evening.

Early in the season, males stayed on the booming ground for periods of 1.5 to 2 hours after sunrise but during the height of the season and on cool cloudy days thereafter, males were frequently found on the booming ground during all hours of the day. During this period most males were observed to roost on or within 100 yards of the ground if not flushed during the evening booming period. At other times they roosted within 0.25 to 0.5 mile of the booming ground.

Arrival of males during the evening booming period was less predictable than during the morning period. Males usually arrived between 1 and 1.5 hours before sunset. With the aid of recorded vocalizations, males were attracted to the booming grounds approximately 3 hours before sunset.

The daily arrival and departure of males during the fall booming season was similar to that of the spring booming period but less predictable. Both the duration of the morning and evening periods were shorter and the evening periods utilized only occasionally.

Males that roosted away from the booming grounds usually flew to the ground singly or in small flocks. When they had roosted nearby they were observed to move onto the ground as a group. Flocks of males flying to the ground usually landed 50 to 75 yards from the ground in tall vegetation and would then walk to the ground. Males usually hurried to their territories but would stop occasionally to cackle and boom. When arriving to the ground after the majority of males were on the ground, males usually flew directly to their territories. Females were seldom observed to fly directly to the ground but would land a short distance away and walk to the ground.

Males in the center of the booming ground each held a well established booming territory during both the spring and fall booming seasons while the territory of each male at the edge of the booming ground was less permanent. The territory system broke down when females were on booming grounds both during and after the height of the booming season. Males normally did not leave their booming territory during the booming period unless females were present. However, male AM40 controlled one territory near the center of the central booming ground and another on the south edge of the ground and was observed to fly occasionally between the territories, even when females were not present. Male AM40 was observed to be a breeding male on the central booming ground in 1967.

Twice during the 1966 spring booming season an "intruder" male was observed on the central booming ground. In 1967 an intruder male was observed on 4 different mornings during the spring booming period. When crossing the edge of the booming ground, these males were usually driven off but if driven into the center of the booming ground they were treated as females if they showed no indications of display.

Activities of male prairie chickens on booming grounds involved ritualistic stamping of feet, vocalizations, fighting, flutter-jumps, other aggressive and display behavior and mating.

The nuptial bow, a display behavior, was observed on only five occasions during the 1966-1967 phase of the study. The nuptial bow was first observed by the author during the fall booming period of 1966. On 23 October 1966 a male prairie chicken attempted to mate with a female prairie chicken decoy posed in a receptive position. He attempted to mount the female decoy six times within a period of 5 minutes. Between attempts three and four of mounting the decoy, the male made a full nuptial bow. Although over 35 attempted matings were observed during the next 2 days no additional nuptial bows were observed until 26 October 1966. At this time a male prairie chicken decoy mounted in an alert position was placed on the booming ground where the female decoy had been located. After numerous attempts by a male prairie chicken to mount the decoy (all efforts to complete "copulation" failed when the male prairie chicken slid from the inclined back of the decoy), the male proceeded with two nuptial bows interspaced with other attempts at mounting.

During the spring of 1967, the nuptial bow was observed on two occasions. On 23 March 1967 four females were observed on the central booming ground. None of the females appeared ready to mate although one female (AF68) on several occasions displayed the receptive position. Attempts by male JM62 to mount female AF68 failed as she would pull away before he could mount. After several attempts at mounting, bird JM62 performed a nuptial bow. Female AF68, as though a male, stepped up on the male's back. An instant later, male JM62 stood up knocking female AF68 from his back. On 28 March, three females were observed on the central booming ground and a similar occurrence was observed. Only on this occasions, male JM62 pulled out of the nuptial bow as the female was attempting to mount.

Flutter-jumps by male prairie chickens were observed on many occasions throughout the booming season but were more frequent during and after the height of the season. Flutter-jumps usually occurred when new arrivals (male or female) appeared on or near the booming ground. From 22 March through 28 March 1967, females on the central booming ground were observed on eight different occasions to do a "flutter dance". Females would jump 1 or 2 feet in the air with wings beating rapidly. This was usually followed by a few steps with then another jump. Between jumps a female would make a series of half or complete turns as she "flutter danced" for distances of up to 20 feet across the booming ground. Half or complete turns were made very rapidly usually while the female was in mid air or on the ground just before or after completing a jump. "Flutter dancing" was observed only on mornings when more than one female was present on the ground.

Few matings were observed on the central booming ground during the seasons under observation. Five matings were observed after 1 May 1965, four during 1966 and only three were observed during 1967 when 55 females were observed on the central booming ground. Of the 12 matings observed, 11 were with males whose territories adjoined the center area of the booming ground. During 1965 and 1966 only two males were known breeders on the central booming ground. In 1967, of three matings observed, all were by different males. The earliest known mating in 1966 was on 4 April. During 1967 the first observed mating was on 15 April. The last observed mating for the booming seasons under observation was 24 May 1966.

Before the last week of May, no matings were observed to be interrupted by nearby males. After this period, males were frequently interrupted by other males when attempting to mount a female. With persistent efforts, mating was usually accomplished before the female left the booming ground.

Aggression between females was observed on the central booming ground during the spring season of 1966 and 1967. On 6 April 1966 six females, including AF42, were observed on the central booming ground. Five of the six females on several occasions approached the territory of the known breeding male (AM43) only to be driven away by female AF42. For 2 days previous, female AF42 had kept females away from the breeding male. On 7 April 1966, female AF42 mated with male AM43 and did not return to the ground, after which aggression between females was no longer observed. On 25 March 1967, a female was observed running another female away from the center of the central booming ground. The pursued female had been performing a flutter dance and was moving near the center of the booming ground. On 28 March 1967, a female was observed to raise her pinnae and pursue another female that had approached too near a breeding male's territory. On 31 March 1967, one female (AF71) chased another female (AF69) into a mist net and both were captured.

After the first week of April, females would appear on the central booming ground and stay for short periods only. Females usually went directly to the dominant male's territory and, if mated, left the ground within a few minutes, usually by walking to the edge of the ground and flying. Females not receptive would wander over the booming ground, at times leaving and then returning to the booming ground later the same morning. One female was observed to leave and return to the ground on three different occasions during the same morning without mating. After the last week of April, females appeared to be less receptive; often visiting the booming ground for 2 or 3 days in succession before mating. Once mated radio-tagged females were never observed on booming grounds again unless nesting attempts had failed.

Of 20 nests located during the entire study, 11 were nests of radio-tagged females, 5 were accidentally discovered, 2 were found while observing females flying from feeding areas to nests and 2 were brought to the attention of the author by other persons.

The average distance of nests from the nearest booming ground was 1199 ± 108 yards, with a range of 330 to 1980 yards. Fifteen of the 20 nests observed were located on shallow range sites (Briggs, 1968) and 4 were on limestone breaks sites. Twelve nests were located on north facing slopes of ridges, 3 on south facing slopes, 3 on ridge tops and 1 nest was found on an island in a creek bed. Two nests were located within 8.5 feet of each other.

Nests, when completed, were shallow saucer-shaped depressions placed in hollows 2 to 3 inches deep made by the females. The lining was of dead grass and forbs found near the nest location. Two nests were observed early in the laying period, one with a single egg and another with two eggs. At this stage of nesting, no lining was found in the bottom of the nest and very little along the sides. Eggs were laid on the bare soil surface in slight excavations made by the females. As the females laid more eggs, the nests were gradually lined both along sides and bottom. Nests were usually placed in dead grass clumps of the previous year's growth. One female (AF83) was observed on two occasions to cover her nest with plant material before she left during the laying period.

Eggs in four nests under observation in 1967 during the laying period, were laid at the rate of one egg per day with one exception. A nest found on 25 May 1967 contained one egg. The second egg was not laid until 27 May, but thereafter eggs were laid at a rate of one egg per day until the clutch of 12 eggs was completed.

The average full clutch size for nests during the entire study was 12 eggs with a range of 7 to 15 eggs. The number of eggs in nests where the estimated first egg was laid before 1 May ranged from 13 to 15 eggs, while

Table 4. Summary of data gathered from 20 prairie chicken nests located during the entire study period.

Bird Number	Nest Location			Nest History			
	Distance from Nearest Booming Ground (yards)	Range Site	Slope	Number of Eggs	Date of First Egg (est.)	Fate of Nest	Number of Eggs Hatched
AF14	1298	LB*	N**	13	4-26-65	hatched 6-3-65	13
AF22	1430	S	SE	15	4-19-65	hatched 5-27-65	15
AF41	1694	S	N	9	5-4-66	DP*** 5-13-66	0
AF41	1364	S	N	7	5-28-66	DP 6-25-66	0
NAF1	1364	S	N	12	---	deserted 6-18-66	0
AF42	1298	LB	N	13	4-20-66	hatched 5-29-66	13
AF51	1298	LB	S	15	4-18-66	hatched 5-26-66	15
AF52	1804	S	T	9	5-19-66	DC 6-19-66	0
AF53	704	S	N	8	5-25-66	DP 6-10-66	0
NAF2	1980	S	T	---	---	D 1966	0
AF54	638	S	N	13	5-19-66	PDP 6-24-66	3
AF70	1848	S	NW	14	4-23-67	DP 5-12-67	0

Table 4. (cont.).

Bird Number	Nest Location: Distance from Nearest Booming Ground (yards)	Range Site	Slope	Nest History: Number of Eggs	Date of First Egg (est.)	Fate of Nest	Number of Eggs Hatched
AF70	1650	S	N	11	5-20-67	DP 6-1-67	0
AF70	946	S	N	9	6-7-67	NTP 6-15-67	0
AF71	1100	LB	B	13	4-27-67	DP 5-13-67	0
AF71	924	S	N	11	5-21-67	DP 6-9-67	0
NAF3	1320	LB	E	14	---	DP 5-21-67	0
NAF4	330	S	T	11	5-21-67	DP 6-10-67	0
NAF5	462	S	S	10	---	NR 5-20-67	---
AF83	528	S	N	12	5-26-67	deserted 6-9-67	0

* LB = limestone breaks, S = shallow (Briggs, 1968).

** N = north facing, S = south facing, E = east facing, W = west facing, T = top of ridge, B = bottom of draw.

*** DP = destroyed by predator, DC = destroyed by cattle, D = destroyed cause unknown,
PDP = partly destroyed by predator, NTP = nesting at termination of project 15 June 1967,
NR = non-relocated presumed destroyed.

those started after 1 May ranged from 7 to 13 eggs. The number of eggs making up complete clutches of known renesting females became progressively smaller with each renesting attempt.

Table 5 presents a summary of lengths, widths, and weights of greater prairie chicken eggs measured during the 1966-1967 phase of the study. For 60 eggs measured, the average length was 4.17 ± 0.02 centimeters and the average width was 3.20 ± 0.01 centimeters. The average weight was 23.73 ± 0.10 grams for 23 eggs measured during early stages of incubation. Eggs from the second and third nests of female AF70 and the second nest of female AF71 did not vary significantly in size from eggs in their first nests.

During the late incubation period, females were more reluctant to flush. Females AF51 and AF14 were retrapped on their nests for replacement of radio batteries during the 14th and 19th day of incubation, respectively. Both females had to be pushed from their nests before they would flush. Female AF51 tried to peck at the author's hand as he attempted to push her from the nest. Renesting females early in incubation were more apt to flush than were females with first nests. Female AF70 could be approached to within 2 or 3 feet without flushing during early incubation of her first nest but would flush readily when approached to within 20 feet during her second renesting attempt. Females were never observed to perform a "broken-wing" act when flushed from eggs but if chicks were in the nest or with a female at the time of flushing, the "broken-wing" act was usually observed.

The known incubation period was obtained for two nests during this study. Female AF14 started incubation on 11 May 1965 and the full clutch of 13 eggs hatched on 3 June, a period of 23 days. Another female (AF42) started incubation on 5 May 1966 and her eggs hatched on 29 May, a period of

Table 5. Summary of mean lengths, widths, and weights of greater prairie chicken eggs examined during this study.

Bird Number	Number of Eggs	Mean Measurements (cm.)[a] Length	Width	Mean Weight (gm.)[a]	Date of First Egg (est.)
NAF3	5	4.27 ± 0.05	3.24 ± 0.02	----	unknown
NAF4	7	4.27 ± 0.05	3.19 ± 0.01	22.30 ± 0.17*	5-21-67
AF83	10	4.35 ± 0.03	3.30 ± 0.02	25.12 ± 0.10	5-26-67
AF70	8	4.01 ± 0.02	3.16 ± 0.02	----	4-21-67
AF70	8	4.03 ± 0.01	3.18 ± 0.02	----	5-20-67
AF70	6	3.97 ± 0.02	3.18 ± 0.02	----	6-07-67
AF71	11	4.25 ± 0.03	3.18 ± 0.02	23.10 ± 0.26**	4-27-67
AF71	5	4.14 ± 0.03	3.19 ± 0.02	----	5-21-67
Total	60	4.17 ± 0.02	3.20 ± 0.01	23.73 ± 0.10***	

[a] Means ± one standard error.

*Measurements on 6 eggs only.

**Measurements on 7 eggs only.

***Measurements on 23 eggs only.

twenty-four days. Tables 6, 7 and 8 show that three renesting female prairie chickens started incubation before their clutches were completed. Females AF70 and AF71 started incubation before laying their last egg and female AF83 started before the last two eggs were laid.

During the 1966-1967 phase of the study, over 738 hours of data were collected on three renesting female prairie chickens using Rustrak recording thermistors. Tables 6, 7 and 8 present data on the arrival and departure of female prairie chickens during both egg laying and incubation. The average time spent on the nest during laying was 3.25 hours with a range of 1.5 to 8.75 hours. The average arrival and departure times were 1134 and 1450 hours, respectively. The arrival time during egg laying for the three females under observation ranged from 0921 hours to 1234 hours. Departure time ranged from 1236 hours to 1807 hours.

During the incubation period, females were observed to leave their nest both morning and evening for feeding. Female AF70 was observed to miss a morning feeding period on 31 June 1967 and female AF71 was observed to leave twice during the evenings of 2 June and 5 June 1967 and twice during the morning of 3 June. The average period off the nest for the morning feeding period was 1.35 hours and for the evening feeding period 1 hour. The average time of departure in the morning for the three renesting females was 0803 hours and the average time of return was 0924 hours. For the evening feeding period, the average time of departure was 1829 hours and the average time of return was 1931 hours. On several occasions, female prairie chickens were observed to fly from their nest to feeding areas. Female prairie chickens continuously shifted their positions during the laying and incubation periods (Plate VI, Fig. 1). Observations of nesting females disclosed

Table 6. Nesting activity determined from changes in nest temperatures during egg laying and incubating periods for renest of female AF71 during 1967.

Date	Egg No.	Laying Period		Incubating Period			
				Morning		Evening	
		Arrival	Departure	Departure	Arrival	Departure	Arrival
May 24	4	1125*	1301				
25	5	1202	1422				
26	6	1220	1432				
27	7	1201	1505				
28	8	1148	1547				
29	9	1135	1320				
30	10**	1108	1236				1950
31				0618			1925
June 1				1000	1202	1918	2001
2				0906	1020	1641	1751
						1911	1933
3				0901	1000	1756	1940
4				0547	0617		
				0958	1030	1846	1925
5				0810	0902	1552	1700
						1930	2001
6				0830	0918	1858	1940
7				0910	1000	1827	1917
8				0822	0905	1913	2001

*Military time.

**Final clutch size 11 eggs.

Table 7. Nesting activity determined from changes in nest temperatures during egg laying and incubating periods for renest of female AF83 during 1967.

Date	Egg. No.	Laying Period		Incubating Period			
				Morning		Evening	
		Arrival	Departure	Departure	Arrival	Departure	Arrival
June 2	7	1047*	1601				
3	8**	0921	1807				2008
4				0617	0911	1851	1941
5				0718	0925	1900	1959
6				0803	0853	1914	1947
7				0847	0937	1851	1920
8				0758	0835	1902	1942
9				0809	0846		

*Military time.

**Final clutch size 10 eggs.

Table 8. Nesting activity determined from changes in nest temperatures during egg laying and incubating periods for first renest of female AF70 during 1967.

Date	Egg. No.	Laying Period		Incubating Period			
				Morning		Evening	
		Arrival	Departure	Departure	Arrival	Departure	Arrival
May 28	9	1234*	1420				
29	10**	1157	1603				1900
30				0552	0924	1738	2031
31						1607	1951

*Military time.

**Final clutch size 11 eggs.

no preference for facing a specific direction when setting on nests.

Fertility of greater prairie chicken eggs under observation was 100 percent. All 56 eggs hatched in 4 nests under observation. In addition, three eggs were known to have hatched from a nest partly destroyed by a predator during hatching. On 24 June 1966, the nest of a radio-tagged female AF54 was found destroyed. All evidence indicated that female AF54 had been killed on the nest and that her eggs had been destroyed. Holes in one side of the seven eggs found scattered about the nest indicated the possible work of a striped skunk. Female AF54 was located with the radio receiver and retrapped at 2200 hours on 24 June to check for possible injuries. Three chicks were observed with her at this time indicating that she had been attacked during the hatching period.

Only one nest was observed during hatching. The eggs in the nest of female AF42 were observed to be pipped during the late afternoon of 28 May 1966. At 0900 hours on the morning of 29 May, nine chicks were observed hatched. Female AF42 had not left the nest by 1830 hours on the 29 May. By 1630 hours on 30 May all 13 eggs had hatched and the female and brood had left the nest. No chicks were observed to be left behind in nests observed during this study.

Of the 20 nests observed during this study, 12 were known to have been destroyed, one was not relocated after its discovery and was also suspected as being destroyed, one was partly destroyed during hatching and two nests were abandoned due to human disturbance. Of the 4 nests that hatched, one female (AF42) and her brood of 13 were killed by a predator 2 days following hatching. The signals from two radio-tagged females (AF22 and AF51) were lost within a week following hatching of their eggs. It was suspected that these two females (AF22 and AF51) and their broods fell victim to predators. Only female (AF14) was known to have survived until her young were of age to fend for themselves. All 13 eggs of female AF14 hatched on 3 June 1965. Her signal was lost 24 June 1965 and was not relocated until 23 August 1965. Bird AF14 was retrapped along with five of her remaining brood of eight at this time. One of her brood (JU28) was later killed by a hunter during the 1965 Kansas prairie chicken season and another JU24 fell prey to a predator on 15 September 1965.

Of the 12 known destroyed nests and 1 partly destroyed, the striped skunk was the suspected predator for 8 nests, the coyote for 2 nests, the raccoon for 1 nest, 1 nest was trampled by cattle and the egg shells in 1 nest (estimated to be almost a year old when found) were too badly crushed to be of use in identification of the cause of destruction. A canine repellent and red pepper placed around one and five nests, respectively, during the 1966-1967 phase of the study, were found to be of little value as all six nests were later destroyed. No females during the entire study were known to have been killed while on nests.

Female prairie chickens were known to have deserted two nests during the entire study. One female (NAF1) deserted her nest after seven attempts were made to capture her on the nest during a period of early incubation. Another female (AF83) deserted her nest after she was trapped and radio-tagged on her nest during the 6th day of incubation. Female AF83 had returned to her nest within a few hours after trapping but would not fly across a predator proof fence which was placed around her nest at the time of capture. The next day AF83 was found within 30 feet of the fence. She was then flushed and the fence removed but she did not return to her nest.

During the entire study three radio-tagged female prairie chickens renested. On 12 May 1966, the first nest of female AF41 was found containing nine eggs. This nest was destroyed 13 May 1966 by a mammalian predator. The bird was not relocated until 19 May 1966 when female AF41 was recaptured at night and equipped with a new transmitter. Following the recapture, female AF41 visited the central booming ground twice and was apparently mated. On 4 June 1966 her second nest was located 1276 yards from her first nest. This renesting attempt contained seven eggs and was destroyed by a mammalian predator 25 June 1966. The radio signal of female AF41 was not relocated after this date.

Radio-tagged female AF71 had her first nest of 13 eggs destroyed by a mammalian predator during the 2nd day of incubation, 13 May 1967. On 23 May, following two visits to the north booming ground, female AF71 was located on her second nest containing two eggs, 528 yards from the first nest. Final clutch size of the second nest was 11 eggs. The second nest was destroyed 9 June 1967 by a mammalian predator. As of 15 June 1967 when this phase of the study ended, female AF71 was not observed to visit another booming ground and was not expected to renest a second time.

Female prairie chicken AF70 was observed to renest twice during the 1967 season. On 6 May 1967, female AF70's first nest was located containing 14 eggs. This nest was destroyed 12 May by a mammalian predator. After female AF70 visited the south booming ground, her second nest (2486 yards from the first nest) was discovered on 27 May 1967. On 1 June, the entire clutch of 11 eggs was destroyed by a mammalian predator. Following visits to both the south booming ground and a ground 1.9 miles south of the south ground, female AF70 was located on her third nest 13 June 1967. By 15 June

1967, when this phase of the study terminated the clutch of nine eggs was completed.

Mortality

Table 9 presents data on mortality observed for 20 greater prairie chickens during the entire study. The coyote was the suspected killer of six birds, hawks of three and an owl and a skunk of one bird each. Hunters shot three birds, trapping operations caused the death of two birds, a power line one, and three were killed by unknown or miscellaneous causes described below.

An adult female (AF15) was captured 5 February 1965 in a walk-in trap. During the nights of 26 March and 10 May 1965, female AF15 was recaptured and different transmitters were placed on the bird. After release on 10 May 1965, female AF15 flew into a barbed wire fence. 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. On 13 May this bird was found dead, apparently prey to a coyote. It was suspected that female AF15 could no longer fly after hitting the fence.

An adult male (AM16), originally trapped in a walk-in trap 7 February 1965, was retrapped on 7 April 1965 on the central booming ground with a cannon net. The bird was unable to fly when released and was presumed to have been injured by the cannon net when trapped. Observations of male AM16 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 13 April 1965, male AM16 was found dead on the booming

Table 9. Summary of prairie chicken mortality observed during the entire study.

Bird Number	Date Trapped	Date of Death	Suspected Cause of Death
AM01	4-21-64	7-26-66	coyote
AF15	2-4-65	5-13-65	coyote*
AM16	2-7-65	4-13-65	hawk*
AM11	4-7-65	11-11-66	hunter*
AM17	4-17-65	4-25-65	hawk
JU24	6-3-65**	9-13-65	coyote
JU28	6-3-65**	11-7-65	hunter
JF30	10-17-65	10-21-65	coyote
AM29	3-10-66	3-16-66	unknown*
AM36	3-12-66	11-7-66	cannon net
AF42	4-6-66	5-31-66	coyote
AF46	4-17-66	5-2-66	hawk
AF52	5-17-66	8-5-66	owl
JU55	6-27-66	6-30-66	unknown*
AM56	7-13-66	7-24-66	unknown*
AM57	7-29-66	11-8-66	hunter
AF74	4-11-67	4-11-67	mist net
AF75	4-14-67	4-18-67	skunk
AM76	5-24-67	5-27-67	coyote
NAM6	----	3-8-67	power line*

*See text for details of death.

**Hatched date--radio-tagged on 8-23-65.

ground. Evidence indicated that a hawk had killed the bird.

Male AM11, banded 7 February 1965, was the victim of a hunter on 11 November 1966. After receiving a steady signal from bird AM11 for three successive days, a hand held antenna was used to locate the bird. Male AM11 was found dead 0.25 mile east of the grain sorghum field on the south end of the Simpson Ranch. Hunters had been in the field during the 9-day Kansas prairie chicken season beginning 5 November 1966. Bird AM11 was apparently shot while flying over the field. After being shot he presumably continued flying until he fell 0.25 mile to the east.

On 10 March 1966 a male prairie chicken AM29 was found on the central booming ground with a broken wing. As no trapping had been conducted on the ground since November of 1965, bird AM29 was suspected to have broken the wing by hitting a power line near the booming ground. After being radio-tagged male AM29 moved to an area 0.5 mile southeast of the booming ground. On 16 March male AM29 was recaptured and was found to be in poor condition. His broken wing had begun to "rot" and was in a "pussy" state. Bird AM29 was released but was not relocated again. It was suspected that bird AM29 fell prey to a predator.

A 7-week old juvenile bird (JU55) was caught by hand 27 June 1966. Juvenile JU55 was found alone and could fly for distances of up to 100 yards. After being radio-tagged, bird JU55 flew only about 10 yards. On 30 June 1966, bird JU55 was found dead 300 yards from his point of capture. It was suspected that the added weight of the radio and high temperatures during the tracking period coupled with separation from the brood resulted in the bird's death.

An adult male (AM57) was trapped on the night of 13 July 1966 while roosting in a wheat field. Before his capture bird AM57 was observed to fly for distances of only 20 to 30 yards. After being radio-tagged, male AM57 was not observed to fly and was found dead on 24 July 1966. An examination by the Kansas State University Veterinary Diagnostic Laboratory revealed peritonitis. Cheesy pus covered the duodenum, gizzard, proventriculis, and cecal areas. The crop and gizzard were filled with grain. No fractures were detected, and bone marrow culture was negative for pathogenic bacteria. There was no evidence that the bird had been killed by predatory animals.

An adult male (NAM6) was flushed at 1730 hours with a flock of 30 birds, 0.5 mile west of the feed fields at the southeast end of the Simpson Ranch on 8 March 1967. The flock flew toward the feed fields and as they passed over a power line near the west edge of the feed fields, bird NAM6 fell from the flock. After 20 minutes of searching, bird NAM6 was found with its head completely severed from its body below the air sacs. The power line had broken both clavicles which then cut through the breast muscles. The sternum was broken and parts of it were pushed into the breast muscles. NAM6's back was also broken and the body cavity filled with blood. The bird's weight was 1012 grams and the crop was empty.

DISCUSSION

Materials and Methods

The use of the cannon net to trap greater prairie chickens on booming grounds has been thoroughly discussed and evaluated by Viers (1967:31). He found cannon nets were a reliable method for trapping prairie chickens on booming grounds. Moderate use of cannon nets did not result in any apparent changes in behavioral characteristics of participating birds (Robel, 1964 and 1965); however, excessive use of cannon nets resulted in alterations of behavioral characteristics (Viers, 1967:31; F. N. Hamerstrom, Jr., personal communication). Viers (1967:31) found it necessary to fire a cannon net over the dominant male several times during the course of the 1966 spring trapping period when attempts were made to capture female prairie chickens. Such repeated firings (three days in succession) resulted in the dominant male shifting his territory and finally assuming a less dominant role on the booming ground (Viers, 1967:31). To avoid such behavioral effects, alternative means of trapping booming prairie chickens were developed during the spring display period of 1967.

The use of Japanese mist nets proved useful in capturing prairie chickens on booming grounds and caused less disturbance to the displaying birds. During the 1966-1967 phase of the study, females never reappeared on the booming ground during the same morning after the cannon net was fired even though males were easily lured back with recorded vocalizations. Removing a prairie chicken from a mist net caused the others to flush; however, the disturbance was only temporary and both males and females would be on the ground shortly after recorded vocalizations were used. Compared to cannon nets, mist nets had several other advantages.

During this study of prairie chicken nesting, behavioral and movement patterns, once a bird was captured and marked or equipped with a radio transmitter, it was seldom of value to recapture the bird on the booming ground. Therefore, recaptures mainly resulted in wasted time and effort. During the 1966 trapping period, cannon nets recaptured 6 of 14 birds while mist nets recaptured only 1 of 14 birds in 1967. This one recapture in 1967 was purposeful, to replace a battery on a male equipped with a radio transmitter. This male was lured into a mist net by placing a stuffed female prairie chicken decoy directly under the inclined mist net. He became entangled when he attempted to mount the decoy.

Once a bird became entangled in a mist net, it seldom became entangled in its meshes again unless lured into it by a stuffed decoy. This avoidance reaction indirectly accounted for a selectivity for females by the mist nets. By placing mist nets adjacent to the primary territory (Robel, 1966: 329) of the dominant male, he could be captured and marked. He would then become wary of the net and avoid future contact with mist nets. Females visiting the booming ground and courted by the dominant male would likely become ensnarled in the mist nets placed adjacent to his territory.

During the trapping period, the additional time required to set and disassemble mist nets each morning about equalled the time required to clean and reset cannon nets after they had been fired. Placing and changing the locations of mist nets can easily be done by one person, whereas setting and changing the location of a cannon net is accomplished more readily by two individuals.

Winds decreased the effectiveness of both the cannon net and mist nets. Cannon nets were much less effective when fired into winds exceeding 15 mph. When strong winds whipped the mist nets, prairie chickens were hesitant to walk under them.

A disadvantage of mist nets is their inability to capture more than one bird at a time. On one occasion, one female prairie chicken chased another female into the mist net and both became entangled. Except for this one incident, all mist net captures were single captures. On the other hand, cannon nets were able to capture several prairie chickens with a single firing. The disadvantage of the single-capture feature of mist nets was lessened somewhat; however, since birds return quickly to the booming ground and therefore offer several opportunities for mist netting in a single morning. During this study, the maximum number of birds captured in a single morning was four and six in the mist nets and cannon nets, respectively.

Another method employed to trap male prairie chickens on booming grounds, the mirror trap, proved to be ineffective. The trap was placed on the central booming ground on 18 May 1965 and left for the remainder of the season. It was thought that a male seeing his reflection would attempt to drive the "intruder" from his territory and thereby be trapped. Males tended to shy away from the trap when it was first employed on the booming ground. This might have been due to its large size and bulky appearance. Later when the birds adjusted to the trap they tended to ignore it. It was thought that if the trap had been employed early in the season and reduced in size, the trap might have been effective. This trap was abandoned in favor of mist nets which were much easier to acquire and operate.

Tape recorded vocalizations of displaying prairie chickens aided in the trapping of 52 prairie chickens during the entire study and 20 for the 1966-1967 phase of the study. Because this technique was so far superior to trapping without the aid of broadcasts, trapping attempts subsequent to its first use, usually incorporated recorded vocalizations. Thus, no data were available to compare trapping success with and without the aid of recordings. The following experiences exemplify how recorded vocalizations were used to assist in trapping greater prairie chickens on booming grounds.

The effective trapping period during the spring booming season was extended when recorded vocalizations were broadcast on booming grounds.

Male greater prairie chickens usually stopped using the booming grounds by the first week of June (Baker, 1953:23; Robel, 1966:328; Viers, 1967:26). On 31 May 1965 four males appeared on a booming ground following the broadcast of recorded vocalizations. Previous to this date, males had failed to appear on the ground for six consecutive mornings. During the following week, all four of these birds were captured with the aid of recorded vocalizations. Continued use of the recordings on the booming ground elicited positive responses by these males as late as 28 July. The latest activity observed on booming grounds in Kansas was 12 June by Baker (1953:23) and 25 May by Viers (1967:24).

Greater prairie chickens visit their booming grounds sporadically during fall and winter. Although recorded vocalizations were used infrequently during this time, greater prairie chickens were attracted to the booming grounds when the tape was played. On 5 February 1967, fourteen males appeared on the central booming ground following the broadcast of recorded vocalizations. These males continued to visit the ground when recorded vocalizations were used but were not observed to use the ground without the aid of the recorder until 6 March 1967. Hence, the use of recorded vocalizations provided a stimulus for display activity of greater prairie chickens and thereby increased the likelihood of trapping birds lured to booming grounds during the fall and winter.

Greater prairie chickens, both males and females, usually responded to the playback of vocalizations by moving slowly toward the speaker as if seeking the source of the vocalizations. Occasionally birds were observed to run toward and, at times, to circle the speaker. To take advantage of this response, the cannon net or mist nets were placed at the edge of the booming ground or primary territory (Robel, 1964:705) of the individual bird desired and oriented toward the area of activity. The remote speaker was placed directly behind the nets and birds were trapped as they moved toward the speaker. Sometimes it was advantageous to place the nets perpendicular to the angle of the blind. When this was done, the remote speaker was placed at the end of the net farthest from the blind to attract birds to the trapping area and then the internal speaker of the recorder was used to draw birds into trapping position. By shifting broadcasts between the remote and internal speaker, birds could be manipulated into a favorable trapping location.

Schwartz (1945:46) noted that the appearance of greater prairie chickens on booming grounds in the evening was less predictable than during the early morning hours. Broadcasts of recorded vocalizations attracted birds to booming grounds earlier than they normally arrived. By broadcasting booming vocalizations, it was possible to attract birds and begin to trap on the booming grounds approximately 3 hours before sunset. In addition to providing a longer evening trapping period, this also avoided visual problems often associated with trapping at dusk.

Birds returned quickly to the booming ground after being disturbed. Two hours before sundown on 7 April 1966, recorded vocalizations were broadcast at a booming ground, and within 5 minutes, nine male greater prairie chickens appeared. The cannon net was fired and three of the birds were captured. After handling the birds and resetting the net, vocalizations were again broadcasted. Within 15 minutes, several birds appeared. Two of them bore patagial markers which had been placed on them less than 0.5 hour before. One of these birds was recaptured when the cannon net was fired the second time. Birds often were called back to the booming ground two or three times following a disturbance.

Greater prairie chickens were flushed from the booming ground three times during trapping attempts on the morning of 14 March 1966. Following each disturbance, the birds quickly returned when the recorded vocalizations were broadcast. Occasionally, if the recorder was not turned off, untrapped birds remained on the booming ground after cannon nets were fired. Also, if the recorder was left playing, birds often repeatedly flew around the booming ground even when the author was out in the open, handling trapped birds.

Extensive use of recorded vocalizations may have possible behavioral influences on the sexual cycle of prairie chickens. It was noted that the central booming ground, on which recorded vocalizations were used extensively since the spring of 1965, became sexually active almost a week before the other grounds on the study area. Although no matings were observed during this time, females appeared on the ground before they normally did on the other grounds. Individual territories or whole booming grounds might be shifted if extensive use of recorded vocalizations were used. Moderate use of recorded vocalizations early in the spring season, to aid in trapping males before females were present, had no apparent effect on displaying birds (Robel, 1964 and 1967). Extensive use of recorded vocalizations on booming grounds is not recommended when behavioral studies are undertaken. For mobility studies, tape recorded vocalizations offer a considerable advantage for trapping large numbers of birds during many seasons of the year.

Female decoys posed in a receptive position, used in conjunction with tape recorded vocalizations, aided considerably in trapping male prairie chickens on booming grounds. Males lured to booming grounds with recorded vocalizations were easily lured into trapping position when female decoys were placed in front of cannon nets or directly under inclined mist nets. Males demonstrated sexual ability and willingness for female decoys during both spring, fall and winter display periods. Although different species were not tested during this study, it was found that males responded to decoys of both sexes and different poses. A male decoy mounted in an alert pose attracted similar responses from male prairie chickens as did female decoys mounted in a receptive pose. Anderson (1965:8) found it was the immobility and pose of the decoy rather than the sex or species that determined whether or not copulation attempts occurred.

During this study, males responded to female decoys to a greater extent during periods other than the height of the booming season. During the height of the season, males tended to ignore female decoys when live females were present on the booming ground. Toward the end of the spring booming season, when females came to the ground only occasionally, males again showed an increased interest in the female decoys. Anderson (1965:8) found males responded sexually to decoys during the fall booming season but to a lesser degree than in the spring.

Decoys placed around or in walk-in traps during the winter months received no response from males feeding nearby, although males lured to booming grounds during this period were very responsive to the decoys. This might have been due to the added stimulus of the recorded vocalizations which were used on booming grounds but not with walk-in traps.

A drive trap (Patterson, 1956) used during the summer of 1965 proved ineffective. Two attempts to drive an adult male (AM1) into the trap failed. Bird AM1 could not be driven as the bird would hold until approached to within a few feet and then would flush. Similar responses were noted for females with broods.

Equipment for night-lighting, similar to that described by Labisky (1959) and used successfully for capturing pheasants, proved to be ineffective for capturing roosting prairie chickens. Noise produced by the generator in the back of the pickup truck seemed to frighten the birds as they could be approached to within only 50 yards when the generator was running. When using only the headlights from the truck, birds could be approached to within 20 or 30 feet. Light from the bank of floodlights produced a "daylight" effect. This caused the birds to flush as they could easily locate new roosting areas. This system was abandoned in favor of using the truck headlights and a hand-held spotlight. Later when radio-tagged birds were observed with flocks, birds were trapped by first "zeroing" on a radio-tagged bird and then searching the immediate area for non-radio-tagged birds roosting nearby. When found, a bird was blinded with a 7-cell flashlight and then netted by the investigator or an assistant who approached the bird from the same direction. It was necessary, at all times, to keep the light between the bird and the netter. If the semicircle of light produced by the flashlight should expose the netter, the bird was likely to flush.

The hand drop-net described by Cebula (1966:8) and used by Viers (1967:11) for night recaptures, was replaced during this study with a hand dip-net. The dip-net made it possible to trap birds at a greater distance, up to 20 feet compared to less than 10 feet for the hand drop-net. By using the dip-net, it was also possible for the investigator to locate, blind with flashlight and net birds without the aid of an assistant.

Abundant food and lack of snow hampered winter trapping during the 1966-1967 phase of the study. Due to drought conditions during this period, the grain sorghum field at the southeast corner of the Simpson Ranch (Fig. 1) was not harvested. Although the sorghum field did not produce a sufficient crop to harvest, there was more than sufficient grain for birds during the winter of 1966-1967. A heavy snow (11 inches) during the month of December only made it easier for birds to reach the sorghum heads that were left standing. Walk-in traps placed in this field and baited with ear corn were not utilized. Ear corn was ignored during the winter of 1965-1966 and 1966-1967. Prairie chickens were observed to walk over stations prebaited with shelled and ear corn. Jones and Sullivan (1962:273), studying food plot utilization by prairie chickens on an area 9 miles northwest of the Simpson Ranch, found prairie chickens preferred corn to grain sorghum. As corn had been grown on their study area for many years prior to their investigation, the birds may have been accustomed to utilizing corn, but on the Simpson Ranch, corn had not been grown for many years. Therefore, prairie chickens on the Simpson Ranch may not have ingested corn for lack of previous experience with it. Jones and Sullivan (1962:273) suggested that grain sorghum might be easier for prairie chickens to ingest than corn. The physical size of the shelled corn may also have effected its utilization. Leopold (1931:165) reported that prairie chickens had to "learn" to use corn when it was first introduced into the northern states.

Both Cebula (1966:33) and Viers (1967:31) found trapping greater prairie chickens for mobility studies to be a major problem. Viers found prairie chickens were easily trapped during the spring booming season using the cannon net trap at booming grounds. He found prairie chickens were erratic in their visits to the fall booming grounds which caused considerable difficulty in trapping during this period. Baker (1953:21) and Horak and Peabody (1966:3) likewise experienced difficulty in trapping during this season.

During the 1966-1967 phase of the study, although considerable time was required to trap prairie chickens, sufficient numbers of prairie chickens were available for mobility studies with the exception of the period following the fall hunting season. From this period until the first of February, when birds were lured to booming grounds with the aid of recorded vocalizations, radio-tagged birds were quite "spooky" and were very difficult to night-light. During this winter period, radio-tagged birds were retrapped only on nights with strong winds and rainy weather. Trapping during periods when snow was present proved ineffective as reflected moonlight made it impossible to approach birds close enough for netting. During the last week of December and the month of January, birds with transmitters needing new batteries could not be recaptured; thereby causing a period when sufficient birds were unavailable for mobility studies. It is thought that with the aid of double battery packs, developed during the last half of this study, birds might be carried through this period without a need for battery replacement. The use of radio-tagged prairie chickens to locate non-radioed birds might provide sufficient birds to replace those lost during this period. The use of tape recorded vocalizations on stable booming grounds during this period might also provide birds.

The major problem encountered during this phase of the study was not a supply of prairie chickens but a supply of birds of the right age and sex when needed. Males when needed could usually be taken on booming grounds during most periods of the year, but females, both juvenile and adults, were much more difficult to obtain. Adult females were taken easily only during the height of the spring booming season. Juvenile birds large enough to carry a radio transmitter were nonexistent during the months of June and July. Only juvenile males trapped on the fall booming grounds and juveniles captured with radio-tagged birds during the fall and winter were available.

The radio telemetry equipment used in this study has been thoroughly discussed and evaluated by Cebula (1966). Only telemetry techniques developed during this phase of the study are discussed herein.

The use of a plastic vial with "snap caps" at both ends, as a method of battery hookup, was used exclusively during this phase of the study. This non-solder method eliminated decreased battery life due to battery overheating which commonly occurred when leads were formerly attached to the battery by solder.

Attachment of the transmitter package to the bird's back was also slightly modified. As the plastic tubing was passed under each wing, both ends instead of one (Viers, 1967:13), were threaded through a hole in the posterior end of the transmitter, secured with a square knot and the ends taped to the transmitter. This eliminated the need for tying the knot under one wing which was not only a cumbersome operation but more apt to cause wing abrasion.

The use of two batteries to power a single transmitter, although used only on two male prairie chickens, showed much promise for extending transmitter life. The extra 15 grams of weight (total weight 37 grams) added to the transmitter package was not considered to be of excessive weight for adult male prairie chickens. Kuck (1966a:5) used a transmitter package weighing slightly over 57 grams for pheasant mobility studies with no apparent effects on movements.

Compass cards on the permanent antennas were replaced with 8-inch plastic circular protractors. Errors in azimuth readings due to weather-damaged compass cards were eliminated. The use of canvas covers, originally attached to the masts above the compass cards for protection, were no longer needed when plastic protractors replaced the compass cards.

Early in this study, locating nests of radio-tagged female prairie chickens was attempted as soon as incubation was suspected. After a female was located in a given area for over 2 days, the bird was flushed using a hand-held antenna and receiver. Later during this study females were flushed from suspected nests during the laying period. Females were flushed during the midday period (1130 hours to 1500 hours) when no movement was observed with the receiver.

Two nests were located by watching and interpreting the early morning activities of nesting females. This consisted of posting an observer at a particular vantage point on the study area and noting the locations when females "dropped" down into the grass following flights from feeding areas. Important in this technique was the time of day required for watching. During this study, females usually left their nests between 0800 hours and 0930 hours during the incubation period. After the approximate location of a nest was determined and a reliable landmark noted, it was then located by a systematic search of the immediate area. This method was found to be practical only for nests laid early in the season. After new growth vegetation became of sufficient height to conceal the females, it was suspected that they walked from and fed close to their nests.

During this study, locating nests with the aid of a bird dog proved to be ineffective. It was suspected that females on nests did not produce enough scent to be detected readily by a dog.

A flushing device made from rock-filled cans tied to a 100-foot rope at 2-foot intervals was also ineffective for locating greater prairie chicken nests. The rope was either dragged between two investigators or two vehicles. Over 18 hours of rope dragging during the entire study produced no prairie chicken nests, although nests of meadowlarks (Sturnella spp.), mourning doves (Zenaidura macroura) and upland plovers (Bartramia longicauda) were found. Nests of prairie chickens found in areas that had previously been dragged with the rope indicated that female prairie chickens "held" on their nests as the cans passed over them. Sowls (1950) found dogs, rope dragging and early morning watching useful for locating nests of waterfowl.

Rustrak recording thermistor charts were interpreted to obtain information on activities of nesting female prairie chickens during both the laying and incubating periods. Comparisons between nest and artificial nest temperatures were made to obtain these data. During periods when females were present on the nests, the nest temperatures usually held at a somewhat constant level (approximately 104°F); whereas, temperatures of artificial nests varied with the time of day. After a female arrived at or left the nest, the nest temperature would tend to follow the temperature of the artificial nest; thereby, producing a sharp break in the chart's tracing (Plate VI, Fig. 1). These breaks were then used to determine when females had arrived and departed from nests.

Early in this study, probes were placed under the eggs instead of at egg height. This produced a nest temperature that was "masked" by a cooling effect of the soil surface and an insulation effect produced by the eggs above the probe. Probes placed under eggs early in the laying period were usually covered with nesting material by the female when the nests were later lined during laying. This added another insulating effect. These difficulties were lessened by placing the probes in the nests at egg height; thereby, keeping insulation effects to a minimum. Nests were visited during periods when females were away to check the accuracy of interpretations made from the chart tracings.

Both a canine repellent and red pepper placed around prairie chicken nests, to protect them from mammalian predators, proved to be ineffective. Red pepper might have been effective if it had not been for frequent rains and heavy dew during the nesting season. Once the red pepper became wet it appeared to lose its effectiveness.

Monthly Ranges

The monthly ranges in acres were calculated for each individual radio-tagged prairie chicken for which there were 15 or more total locations per month. Viers (1967:34) found radio-tagged juvenile prairie chickens to exhibit a period of low mobility immediately following attachment of radio transmitters. Data presented by Marshall (1964) suggested that juvenile ruffed grouse behaved in a similar manner. Viers (1967:34) also noted male prairie chickens did not return to fall booming grounds following capture and radio-tagging. With the exception of males during the height of the booming season, prairie chickens during this study usually exhibited a period of little or no movement for as much as 3 days after being trapped and radio-tagged. Therefore, to deemphasize the effects of trapping on bird movements, only those birds for which 15 or more locations were available during any one month, were used in monthly range determinations.

The term mean monthly range was preferred over mean monthly home range; for, as defined by Burt (1940:25), home range can be determined only when all area traversed by an animal during its normal activities of food gathering, mating and caring for young are known. With prairie chickens these activities encompass, at the least, a period of one year; therefore, mean monthly range has been used to designate the area known to have been traversed by a prairie chicken during a given month.

To make comparisons possible, the original home range data of Cebula (1966) and Viers (1967) were recalculated by joining the outermost points to show the range (Mohr, 1947). These data were then combined with data for the 1966-1967 phase of the study to give mean monthly ranges for the entire study (Table 10).

Mean monthly ranges obtained during the 1966-1967 phase of the study were in all cases equal to or slightly larger than combined ranges for the entire study. The larger mean ranges for the 1966-1967 phase of the study may have been caused by droughty conditions which existed during this phase of the study. Under conditions of drought, birds may have had to travel farther to obtain food and locate suitable roosting and loafing habitat.

The adult male mean range for the month of March during the 1966-1967 phase of the study was 755 acres (Table 2) larger than the combined mean range for the entire study (Table 10). This large difference was the result of movements of male AM66, the only adult male radio-tracked during March of the 1966-1967 phase of the study. Male AM66 was observed to move between three permanent and one territorial booming ground during this period in an

Table 10. Summary of entire study mean monthly range areas for male, female and juvenile prairie chickens. Number in parentheses represents the number of prairie chickens radio-tracked.

Month	Mean Locations for Monthly Ranges				Mean Area of Monthly Ranges*			
	Male	Female	Juvenile	Pooled	Male	Female	Juvenile	Pooled
January	----	----	----	----	----	----	----	----
February	18(1)	----	22(3)	21(4)	1087 ± **	----	1042 ± 366	1054 ± 259
March	31(2)	29(1)	41(1)	33(4)	1582 ± 755	407 ± **	1179 ± **	1187 ± 414
April	32(1)	26(7)	51(1)	30(9)	161 ± **	475 ± 99	459 ± **	438 ± 83
May	20(3)	30(8)	44(1)	29(12)	91 ± 37	331 ± 113	89 ± **	251 ± 81
June	28(5)	25(6)	----	27(11)	115 ± 23	368 ± 157	----	253 ± 92
July	39(4)	28(2)	----	35(6)	97 ± 23	415 ± 155	----	203 ± 80
August	39(5)	17(1)	20(2)	32(8)	145 ± 51	96 ± **	97 ± 56	127 ± 33
September	33(4)	22(1)	27(3)	29(8)	200 ± 78	21 ± **	178 ± 39	169 ± 44
October	32(2)	----	25(2)	28(4)	387 ± 64	----	444 ± 165	415 ± 74
November	20(1)	----	26(2)	24(3)	1128 ± **	----	935 ± 38	999 ± 66
December	----	----	21(3)	21(3)	----	----	601 ± 150	601 ± 150

*All ranges in acres; means ± one standard error.

**Standard error not calculated.

attempt to establish a mating territory.

Adult female mean ranges for the months of April and May during the 1966-1967 phase were almost twice as large as the April and May mean ranges for the entire study. Both females radio-tracked during the 1966-1967 phase of the study had early nests destroyed and movements back to booming grounds increased the ranges of these birds.

In general, mean monthly ranges for the four seasons of the year were similar for both the entire study and the 1966-1967 phase of the study. Due to more complete data, the mean monthly ranges from the pooled prairie chicken data by months are used in comparisons with results reported by other investigators.

The mean monthly ranges for radio-tracked prairie chickens during the summer period of June through August were smaller than those of other seasons. Mean ranges varied from 127 $\pm$ 33 acres in August to 252 $\pm$ 92 acres in June. This is in agreement with observations reported by other investigations. Hamerstrom and Hamerstrom (1949:315) suspected the summer cruising radius was 1 mile or less for males. Schwartz (1945:83) found male and female prairie chickens stayed in an area of 320 acres or less during the summer months.

Mean monthly ranges for the fall season of September through November varied from a low of 169 $\pm$ 44 acres in September to a high of 999 $\pm$ 66 acres in November for prairie chickens radio-tracked during this study. The mean range for November was larger than the fall range of approximately 640 acres reported for one flock by Baker (1953:21).

During this study the mean winter ranges for radio-tagged prairie chickens varied from a low of 601 $\pm$ 150 acres in December to a high of 1054 ± 259 acres in February. Sufficient data for calculation of a mean range for January were not obtained. The range of winter flocks in Nebraska was approximately 3 square miles (Mohler, 1952:22). In Missouri, Schwartz (1945:83) reported large flocks may cover 5 square miles or so in a week during the winter.

Prairie chicken movements in the spring were characterized by large ranges during the month of March (1187 ± 414 acres) and much smaller mean ranges during April and May (438 ± 83 and 251 ± 81 acres, respectively). This was in agreement with Hamerstrom and Hamerstrom (1949:327), who found most birds stayed within 1 mile or less of their spring booming grounds.

In general, the pooled mean monthly range of radio-tagged prairie chickens was found to decrease gradually from May (251 ± 81 acres) through August (127 ± 33 acres) followed by a slight increase between August and September (127 ± 33 and 169 ± 44, respectively). Mean range more than doubled between September and October (169 ± 44 and 415 ± 74 acres, respectively) and again increased between October and November (415 ± 74 and 999 ± 66 acres, respectively). Mean range during December (601 ± 150 acres) was less than that for February (1054 ± 259 acres) and March (1187 ± 414 acres). The April mean range (438 ± 83 acres) was substantially below the winter mean. The large November mean range may have been caused by the annual Kansas prairie chicken hunting season held during this month, although Hamerstrom (1941:127) thought hunting had no effect on movements of autumn packs.

Movements

For more complete data on monthly movement distances between successive daily locations, the original data compiled by Cebula (1966) and Viers (1967) has been combined with data for the 1966-1967 phase of the study (Table 11).

Mean monthly distances from successive daily locations during the 1966-1967 phase of the study were usually equal to or slightly larger than distances for combined data of the entire study. As with mean monthly ranges, this may have been caused by less abundant food and suitable habitat produced by droughty conditions existing during the 1966-1967 phase of the study.

When few movements were recorded (mean movements for males during April and females during March of the 1966-1967 phase of the study), the results were highly erratic and may not have been indicative of the true movement patterns for the month. Even though the mean monthly movements of females during the entire study for the month of February (391 ± 66 yards) and March (525 ± 94 yards) were based on only one bird, it may by chance be representative of the true movements since Baker (1953:23) also noted females did little flying during the winter period.

The summer mean monthly movement distances between successive daily locations for prairie chickens during the entire study ranged from 322 ± 24 yards in August to 357 ± 33 yards in June. This was in agreement with Schwartz (1945:83) who reported the summer daily movements for prairie chickens were over an area of 0.5 square mile or less. Likewise, Hamerstrom and Hamerstrom (1949:315) thought summer was probably the season of least movement for greater prairie chickens.

Fall mean movement distances during this study ranged from 370 ± 25 yards in September to 928 ± 74 yards in November. Mohler (1952:19) observed similar movements; a flock during the fall was never observed alighting more

Table 11. Summary of entire study mean monthly movement distances between successive daily locations for male, female and juvenile prairie chickens. Number in parentheses represents the number of prairie chickens radio-tracked.

	Number of Movements				Mean Distance of Daily Movements*			
Month	Male	Female	Juvenile	Pooled	Male	Female	Juvenile	Pooled
January	1(1)	----	4(1)	5(2)	1452 ± **	----	1639 ± 585	1602 ± 455
February	24(2)	8(1)	43(3)	75(6)	1447 ± 206	391 ± 66	1234 ± 139	1212 ± 108
March	68(7)	29(5)	26(1)	123(13)	983 ± 127	525 ± 94	1423 ± 226	968 ± 90
April	41(5)	142(12)	24(1)	207(18)	662 ± 124	704 ± 46	499 ± 124	672 ± 43
May	85(5)	177(10)	21(1)	283(16)	428 ± 43	398 ± 36	298 ± 231	400 ± 26
June	96(10)	126(11)	----	222(21)	343 ± 27	368 ± 55	----	357 ± 33
July	80(5)	36(2)	----	116(7)	281 ± 66	521 ± 55	----	355 ± 36
August	128(6)	18(3)	31(3)	177(12)	298 ± 28	510 ± 70	314 ± 69	322 ± 24
September	91(4)	12(1)	53(3)	156(8)	378 ± 34	271 ± 57	378 ± 45	370 ± 25
October	71(4)	----	38(3)	109(7)	614 ± 59	----	638 ± 77	622 ± 47
November	48(7)	----	56(5)	104(12)	955 ± 110	----	905 ± 100	928 ± 74
December	14(2)	----	55(4)	69(6)	701 ± 137	----	920 ± 82	876 ± 71

*All distance movements in yards; mean ± one standard error.

**Standard error not calculated.

than 0.75 mile from a take-off point. However, Hamerstrom and Hamerstrom (1949:320) reported the fall daily cruising radius of flocks in Wisconsin was from 1 to 1.5 miles. Schwartz (1945:83) found daily movements of flocks during the fall varied with the type of range.

During the winter months, prairie chicken mean daily movements ranged from 876 ± 71 yards during December to 1602 ± 455 yards during January. Ammann (1957:76) found prairie chicken populations were considerably more mobile during late fall and winter than during any other period of the year. Schwartz (1943:83) reported the area traversed in a day by a large flock was often less than 1 square mile, depending upon the availability of food and roosting cover. Baker (1953:22) found the daily range of both flocks and individuals were limited to a cruising radius of approximately 0.5 mile during the winter.

Spring movements were characterized by a return to the booming grounds. Mean daily movements ranged from 400 ± 26 yards in May to 968 ± 90 yards during March. Similar movements were observed by Hamerstrom and Hamerstrom (1949:327). They found birds stayed within a mile or less of their booming grounds during the spring. They also reported to have seen females coming to or flying away from booming grounds from distances of a 0.3 to 1.0 mile. However, Kobriger (1965:793) found two marked males moved only 100 yards from a winter trap site to their spring breeding grounds.

In general, mean distances of radio-tracked prairie chickens between successive daily locations were found to decrease gradually from May (400 ± 26 yards) through August (322 ± 24 yards). Movements then increased abruptly from September (370 ± 25 yards) to January (1602 ± 455 yards). Mean daily movements then began an abrupt decrease as birds tended to spend more time near booming grounds; a mean movement of 968 ± 90 yards in March to 400 ± 26 yards in May.

Seasonal and daily movement patterns were evident for several radio-tracked birds during this study.

An adult male prairie chicken (AM66) was observed on three permanent and one territorial booming grounds during the spring of 1967. Movements from one booming ground to different booming grounds have been recorded by Hamerstrom and Hamerstrom (1949:327); but no explanation was offered for this behavior. Viers (1967:37) considered the interbooming ground movement he observed to have resulted from a high population density during his study. Robel (1967:112) suggested movement by males from one booming ground to another appeared to be caused by severe competition for mating territories on booming grounds.

The movements between booming grounds by male AM66 during this study may have resulted from the plowing and planting to grain sorghum of the south booming ground during the summer of 1966. During the following spring (1967) males gathered at several locations before setting up a booming ground 0.5 mile north of the south booming ground (Fig. 1). It was not known whether male AM66 had been associated with the old south ground, but several males observed on the new south ground were found to visit other grounds early in the spring of 1967 before the new south ground was well established. It was therefore possible that AM66, having been divested of a mating territory, attempted to establish a mating territory on other grounds; thereby, accounting for his many visits to other grounds. Evidence reported by Robel (1967:113), that males with similar movement patterns were 1-year old males may further support this. Robel reported that of four marked males which unsuccessfully attempted to establish mating territories at two different booming grounds, all were 1-year olds. If this were the usual case, then the interbooming ground movement by adult male AM66 (2.7 years or older) might have been performed under exceptional circumstances, *i.e.*, the loss of a mating territory due to plowing of the booming ground area.

Movements between booming grounds by females observed during this phase of the study has not been recorded in the literature before. These movements may have resulted from disturbances caused during trapping operations; however, female AF71 observed first on the south booming ground, moved to a ground 1.9 miles south of this ground (Fig. 1) and then back again to the original ground during a period when no trapping was conducted on either ground. Further, female AF71 was never approached to within 0.25 mile during this period. The theory purposed by Schwartz (1945:48), that each booming ground had a sphere of influence within its portion of the range and that flocks of hens within the sphere of influence of each booming ground came to these booming grounds might be challenged by the activities of female AF71 and a second female (AF70), which was also observed to visit more than one booming ground.

Female AF54 and her brood were observed to move a distance of 2 miles from her nest site within a period of 6 days. The movements for prairie chicken AF54 were more extensive than reported by earlier investigators. Hamerstrom and Hamerstrom (1949:315) thought the summer movements of female greater prairie chickens with broods were not extensive. In Missouri, females with young stayed in the vicinity of the nest for the first few days after hatching and gradually moved toward swales if any were nearby

(Schwartz, 1945:68). However, a radio-tracked female (AF14), was observed to move her brood nearly 2 miles overland during a period of 7 days (Viers, 1967:33).

Flocks of prairie chickens were observed during all months of the year in the 1966-1967 phase of the study. Early in the summer (June), males showed a reduced tendency to flock and would spend more time by themselves. Similar observations were reported by Schwartz (1945:82). However, Yeatter (1943:386) and Hamerstrom (1939:108) reported that during the summer months, certain groups of adult males tended to stay together in the vicinity of the booming ground.

During this study, females with broods were observed to combine into large flocks during August. A similar tendency was noted by Yeatter (1943: 387). He reported it was not uncommon in late summer to see two or more females together with young of different sizes. Radio-tagged females that had either lost broods or had nests destroyed were observed with flocks that had gathered near freshly harvested wheat fields during the first week in July. These flocks were of both sex and age groups. Hamerstrom and Hamerstrom (1949:316) found prairie chickens well distributed in numerous small flocks of up to a dozen or so birds during late summer but made no mention of flocking before this period. Schwartz (1945:83) reported prairie chickens were more scattered and harder to find during summer months.

During the summer period, flocks combined loosely and mixing of flocks was common. Radio-tagged birds were found feeding and roosting with various flocks of up to 20 birds, but this was not predictable as numerous times they were found alone or with small numbers of birds. Flocks of prairie chickens tended to spend most of the day in or near the wheat fields, and on numerous occasions would roost there during the night. After the first week of August, flocks were observed to roost most often in areas of tall grass within 0.5 mile of the wheat fields. Schwartz (1945:71) reported that during the late spring, summer, and early fall, prairie chickens usually roosted alone, though occasionally a few males were found together.

During the fall season, radio-tagged prairie chickens were observed with small flocks (10-15 birds) on numerous occasions. Flocks during this study consisted of birds of all sex and age groups and were held together rather loosely. Exchange of individuals between flocks was common and on numerous occasions radio-tagged birds were found alone. These data were in contrast to observations reported by other investigators. Hamerstrom and Hamerstrom (1949:315) reported that during the fall, small flocks and individuals gathered together to form large packs. Schwartz (1945:83), Baker (1953:21) and Ammann (1957:77) reported that although flocks included both adults and young birds of the year, they were of separate sexes.

Flocks of both adult and juvenile male birds were observed on booming grounds during fall periods; however, all males did not return to booming grounds during the fall. An adult male (AM23), observed on the central booming ground during the spring booming season, was never located on a booming ground during the fall. Male AM23 was usually found alone or with small groups of birds of both sexes during this period in close proximity to the wheat and grain sorghum fields.

During the winter period, flocks ranged from a few individuals to over 40 birds. Similar to summer and fall periods, flocks during the winter were usually small (10-20 birds) but flocks of up to 40 birds were observed on days with severe weather. However, even during severe weather, smaller and even individual birds were observed feeding in grain sorghum fields on the study area. Similar large flocking was found by Schwartz (1945:83) during periods of severe weather in Missouri.

As no females were radio-tracked during the winter months of this study, it was not known whether flocks were of both sexes. However, observations made during the winter of 1966-1967 were in agreement with Baker (1953:23), who found that in all instances, when flocks were seen, males predominated. He therefore concluded that the daily routine of females involved fewer conspicuous movements by flight than did that of males. Cebula (1966:24) reported a radio-tagged female prairie chicken tracked during February and March was never located with the large winter flocks that frequented the same general area. Cebula (1966:25) also reported that another adult female prairie chicken was trapped with this female on the night of 26 March 1965. This may indicate that females were of separate flocks during the winter period. However, Hamerstrom and Hamerstrom (1949:320) found no reason to believe that large flocks were wholly or even largely of one sex.

During the month of February 1967, flocks of males were observed to visit the central booming ground. This indicated that at least some flocks are of one sex during this period. Flocks visiting the spring booming grounds were always of one sex, males. Females were observed to visit the ground as single birds or in groups of two or three birds. This may indicate that females during the early spring (March) are found alone or in small groups. After visits to spring booming grounds, radio-tagged females were usually found alone, but occasionally with one or two other females. Their flocking behavior remained similar until the start of the incubation period.

Reproduction

In general, observations of greater prairie chickens on booming grounds were similar to those reported by other investigators. Robel's (1964, 1966 and 1967) observations and discussions of greater prairie chicken behavior for the north booming ground of this study area were descriptive for those observed during this study. Therefore, only those observations not reported, discussed or those in direct disagreement with studies by Robel and other investigators are discussed herein.

With the exception of the booming ground edge, territories were found to be well established during both the spring and fall booming seasons. The territory system was observed to break down when females were on booming grounds both during and after the height of the spring booming season. Similar observations were reported by Robel (1964:710); however, Hamerstrom (1939:106) and Schwartz (1945:51) reported the early part of the spring season consisted of territorial disputes. Schwartz also found males to stay close to their territories during the height of the season when females were present. Although Robel (1964:710) reported similar observations he gave no reason for the well established territories during early spring observations. Observations made by the author indicate males return to booming grounds in winter during warm periods. Most territorial disputes may be settled during these periods. Males may then have mating territories well established before the main spring booming season commences. Similar visits to booming grounds during the winter were observed by Baker (1953:22) and Hamerstrom and Hamerstrom (1949:324).

The nuptial bow was observed on five occasions during the 1966-1967 phase of the study; twice during the spring of 1967 and three times during the fall of 1966. The nuptial bow has been reported by numerous investigators for the spring booming seasons. Schwartz (1945:52) reported that the nuptial bow was usually, but not always, followed by mating. Hamerstrom (1940) suggested that the nuptial bow was the climax to a perfect mating display. Observations made by the author indicate that the nuptial bow might be a display directed toward a female to induce receptiveness. Both nuptial bows during the fall were performed after several attempts at copulation with mounted decoys. One decoy was a male posed in an alert position while the second was a female in a receptive position. Even though in a receptive position, the female decoy was "unreceptive" to the male's attempt to complete copulation. All attempts at mounting the male decoy failed when the mounting male slid from the inclined back of the decoy. It was possible that the nuptial bow was directed toward the decoys to induce "receptiveness". Nuptial bows during the spring occurred after several attempts to mount unreceptive females early in the spring booming season. The mounting of a male in full nuptial bow by a female further suggests that males might be imitating a female in a receptive position. The female, unreceptive early in the spring booming season, may have been stimulated by the nuptial bow and then took the initiative by mounting the male.

Flutter-jumps by male prairie chickens were observed on many occasions throughout the booming season but were more frequent during and after the height of the season. Flutter-jumps usually occurred when new arrivals (male or female) appeared on or near the booming ground. Hamerstrom and Hamerstrom (1960:283) reported there was general agreement, "if no real proof", that flutter jumping served to advertise display grounds. Hamerstrom and Hamerstrom (1960:284) suspected flutter jumping was probably both stimulus and response. They found flutter jumping was most commonly released by the visual stimulus of one or more prairie chickens flying or walking into view; however, they found males promptly responded to whoops by flutter jumping when no other bird was present. As observed during this study, Hamerstrom and Hamerstrom (1960:284) reported that even when no new bird was arriving and when a female or females were on one part of a large booming ground, the males which were not close to the females often flutter jumped. Hamerstrom and Hamerstrom thought this was "a clear attempt to draw hens to them" (the males).

Observations during this study have indicated flutter jumping may serve two purposes; one of attraction and one of obtaining a better view of females approaching the ground. On the morning of 14 April 1966, a female prairie chicken flew to an area 50 yards south of the central booming ground. The males began immediately to flutter jump. As the female approached the ground, the flutter jumping ceased except for males at the north edge of the ground. One male, so excited by the "whooping", flew and lit atop a blind on the north edge of the booming ground and began a vigorous booming and strutting display. Although this male had earlier been performing flutter jumps persistently before his flight to the top of the blind, he was not observed to flutter jump while on the blind. It would therefore seem likely that if flutter jumping was only an attraction display, the male would have continued to jump as the female was still over 30 yards from his position at this time.

The "flutter dance" by female prairie chickens observed during this study has not been reported previously in the literature. The "dance" was similar to a "waltz" and seemed to have no attraction value. Males paid little or no attention to such females; however, one female was observed to chase a female seen performing a "flutter dance". This may have been in response to the approaching nearness of the "flutter dancing" female to the dominant male's territory and not a reaction to the display itself. Both Hamerstrom (1941:36) and Schwartz (1945:52) observed some competition among females. There seemed to be no apparent reason for this display, although it was observed on eight separate occasions.

The small number of matings observed on the central booming ground during this study may have resulted from disturbances caused by trapping operations. In an effort to obtain as many females as possible for nesting studies, attempts were made to capture all non-radio-tagged females visiting the central booming ground. Such continued disturbance may have resulted in females visiting other grounds or visiting the central booming ground after early morning trapping operations had been completed. Robel (1967:112) conducting observations on the north booming ground, where trapping disturbances were kept to a minimum, observed 28 matings during the 1966 spring season. Only four matings were observed on the central booming ground during the same period with approximately the same observation time. During the 1967 season, only 3 matings were observed on the central booming ground while 24 were observed on the north ground (Robel, personal communication).

Observations during this study and those by other investigators (Hamerstrom, 1941:36; Baker, 1953:24; Schwartz, 1945:54 and Robel, 1967:112) indicated the reproductive period for greater prairie chickens occurred during the spring booming season. However, the use of female decoys posed in a receptive position during this study and the study by Anderson (1965:8), showed males were, at least physically and psychologically capable of mating if they were not physiologically capable of breeding. Schwartz (1945:61), after measuring the testes of 15 male prairie chickens taken during different periods of the year, concluded males were probably incapable of breeding in the fall. Schwartz suggested that both physiological experiments and histological examinations were needed to verify this observation.

The average distance of nests from the nearest booming ground during this study was 1199 ± 108 yards with a range of 330 to 1980 yards. Yeatter (1943:389) found the distance of nesting cover from booming grounds apparently influences the choice of nest sites. Yeatter (1943:391) found nests of Illinois prairie chickens have a definite tendency to be grouped close to booming grounds. He found most nests were within a radius of a 0.25 mile from the nearest booming ground. Hamerstrom (1939:115) stated that grouping of nests was not chance distribution and indicated this was because females tended to nest near the booming grounds on which they were mated.

At first glance it would appear that the findings during this study suggest nests were not chance distributions and females tended to nest close to booming grounds; however, one must first consider the distribution of the booming grounds themselves. Booming grounds on the study area were approximately 1.5 miles apart. Therefore nests would usually be within 0.75 mile of a booming ground. Only nests to the far end of the study area were outside of this range and may actually have been closer to booming grounds off the study area. Other booming grounds were known to exist off the study area, but their exact locations have not as yet been determined. Observations of radio-tagged females have shown that females do not always nest nearest the booming ground on which they were mated.

Female AF41, observed to visit the central booming ground before nesting, had her first observed nest located 2332 yards from the central booming ground but only 1694 yards from the south booming ground. Observations of females visiting more than one booming ground during this study may also indicate some females do not always nest near any ground in particular.

Four renests of radio-tagged prairie chickens averaged 1293 ± 416 yards from preceding nests with a range of 616 to 2462 yards. The first nest of female AF70 was 2462 yards from her second nest and 2222 yards from her third nest. Lehmann (1941:15) observed that Attwater's prairie chickens placed renests 5 to 20 yards from first nests.

Eggs in four nests under observation in 1967 during the laying period, were laid at the rate of one egg per day with one exception. A nest found on 25 May 1967 contained one egg. The second egg was not laid until 27 May, but thereafter eggs were laid at a rate of one egg per day until the clutch of 12 eggs was completed. This nest was found after the author had spent most of the day trying to relocate a nest in the same area. It might have been possible that the author had kept the female away from this nest during this period; whereas, she may have laid in the nest if given a chance. It was also possible that the egg was "dropped" at another location during this period of disturbance. Both Schwartz (1945:65) and Yeatter (1943:392) found that one or two eggs early in the season were sometimes "dropped" and did not represent nesting attempts. Eggs laid at a rate of one egg a day was in agreement with Baker (1953:25); however, Gross (Bent, 1932:248) reported eggs of captive prairie chickens and one nest of a wild bird were laid at the rate of one egg every other day. He also stated that egg laying was not necessarily on alternate days, but more apt to be very irregular.

Heavy rains during the egg laying period were found not to affect the rate of egg laying for nests under observation during this study. However, Gross (Bent, 1932:248) found that the time required to complete a set of eggs depended on a number of factors, such as the weather, the health of the bird, and availability of food.

Nest success of 20 nests observed during this study was only 20 percent. This was considerably lower than nesting success reported by other investigators. Ammann (1957:99) summarized his data and data from other investigators and found approximately 52 percent of all greater prairie chicken nests were unsuccessful. During the 1966-1967 phase of the study all nine nests under observation were unsuccessful.

All possible care was taken to protect nests from predators including the use of a canine repellent and red pepper. Nests were visited only when necessary and all possible effort was taken not to leave trails for predators to follow. The nests of a non-radio-tagged female (NAF3), was never approached closer than 0.25 mile before the nest was found destroyed. Female NAF3 had been under observation as she departed from and return to her nest. After 2 days of observations the nest site was located to within a 100-foot square area, but it was decided to make observations for another day before attempting to locate the nest. The next morning female NAF3 was not observed to leave the nest area. Upon approaching the area, the nest was found with all eggs destroyed. Although nest predation on the study area appeared to be quite high, populations of prairie chickens on the study area remained stable during this study. Therefore, predator control measures are not recommended, although attempts were made to protect nests which hopefully would produce birds for brood movement studies.

During this study, three radio-tagged female prairie chickens were found to renest. One female was observed to renest twice during the 1967 season. Of the 20 nests observed during this study, the estimated date on which the first egg was laid could be calculated for 16 nests. Nine of these 16 nests were suspected or known to be renests. Of these nine nests, four were known renest attempts, two were started after females were trapped on the central booming ground during late May with brood patches, and three were suspected of being renests because of the late date on which the estimated first eggs were laid. Both Hamerstrom (1941:56) and Schwartz (1945:54) stated that although they thought greater prairie chickens renested, there was no direct evidence of renesting. Ammann (1957:101) stated that it seemed unlikely any females could renest after their first clutches were destroyed during the late part of the incubation period. However, Yeatter (1943:385), Baker (1953:28) and Robel (1967:112) thought the late nests were products of renesting. The only direct evidence of renesting by prairie chickens reported in the literature was a report by Lehmann (1941:15) for Attwater's prairie chickens. He found some Attwater's prairie chickens renested as many as two times, after failures, for a total of three nesting efforts.

The dates on which the estimated first egg was laid were grouped into three periods. The first period contained nests in which the first egg was laid before 1 May and were probably all first nesting attempts. The second period extended from 1 May to 1 June and contained the two known first renesting attempts. Nests in which the first egg was laid after 1 June were probably second attempts at renesting. It must be noted that if nests were destroyed early in the laying period when only a few eggs (1-5) were laid, females could renest with or without first re-visiting a booming ground. This may cause some overlap in the above estimated groupings for first, second and third nests. Indeed this may have been the case of female AF41 (Table 4). The estimated date of the first egg of the first located nest of female AF41 was 4 May 1966. The estimated date of the first egg for two other radio-tracked female prairie chickens during this same period was 18 and 20 April 1966. Since this nest of female AF41 was initiated approximately 2 weeks after the other two nests, it may be possible that female AF41 had lost a previous nest. Baker (1953:28) also found distinct groupings of dates on which the first eggs were laid and suggested this was due to renesting.

The number of suspected renests plus the number of late matings observed on the north booming ground; 15 in late May 1966 (Robel, 1967:112) and 10 in mid May 1967 (Robel, personal communication) suggested that renesting may have more effect on the overall population than was previously suspected. Yeatter (1943:392) believed a comparatively high percentage of female greater prairie chickens in southeastern Illinois finally brought off broods successfully because of renesting. However, Baker (1953:28) suggested that early clutches were larger, more successful, and produced most of the young. Lehmann (1941:15), reporting on the Attwater's prairie chicken, stated, "A successful season depends largely on the fate of the early nests, so that a primary objective of management should be to safeguard these attempts."

After destruction of a nest, radio-tagged females were observed to visit a booming ground and lay the first egg of a succeeding nest within a very short period. Three of the four renesting attempts observed during this study were begun within a period of a week or less after destruction of a previous nest. The fourth female (AF41) did not start to lay her second clutch until 2 weeks after destruction of her first nest. This female (AF41) was recaptured and the transmitter replaced during the period between the two nesting attempts. As noted previously, trapping may have an effect on movements of prairie chickens for short periods; therefore, it may be possible that trapping had a delaying effect on the initiation of this bird's (AF41) renesting attempt.

Between nesting attempts, females visiting the booming grounds were usually unreceptive for periods of 2 or 3 days. During late May, females visiting the booming grounds would stay on the grounds as long as males were present. One female on 2 June 1965 was also located on the central booming ground during the late afternoon display period. It may be that unreceptive females at this time were still "broody" after a recent loss of a nesting attempt. Hamerstrom (1941:36) found as the season progressed unready females would appear at any time and (Hamerstrom, 1941:37) the less receptive behavior of females observed toward the end of the season reflected a broody condition.

Mortality

Twenty known prairie chicken fatalities were observed during the entire study. Of the 58 individual prairie chickens radio-tagged during this study, 18 (31 percent) were known to have died. This was less than the mortality observed for radio-tagged ruffed grouse in Minnesota (Marshall, 1964); of 20 radio-tagged ruffed grouse, 12 (60 percent) were known to have died.

Of the 20 fatalities observed during the entire study, 11 (55 percent) instances of predation were known to have occurred. The coyote was the suspected killer of six birds, hawks of three and an owl and a skunk accounted for one each. Without the aid of the radio telemetry equipment, 10 instances of predation probably would have been missed. Doubtless other cases of predation on radio-tagged prairie chickens occurred but transmitters were possibly destroyed and therefore, the evidence not discovered. Schwartz (1945:87) found no direct evidence of predation on prairie chickens during his study in Missouri. Schwartz (1945:87) thought that if predation had been heavy, "much more information would have been obtained during the three years spent in the field." He therefore concluded that predation was relatively unimportant.

A non-radio-tagged male (NAM6) was killed after hitting a power line and a radio-tagged female (AF15), later killed by a mammalian predator, was seriously injured by flying into a fence. In addition, three other prairie chickens were known to have hit either fences or power lines. Leopold (1931:185) referring to losses from accidents due to flying into overhead wires, stated; "The pinnated grouse is more prone to do this than any other game bird." He also reported that prairie chickens were found dead which had flown into "an ordinary barbed wire fence". Schorgen (1943:7) found that when telegraph wires were first installed in the Chicago area, prairie chickens were killed "frequently" by striking them. Five birds from one flock were killed in this manner. Schwartz (1945:89) stated that occasionally prairie chickens were injured or killed by flying into telephone wire or fences.

Three radio-tagged prairie chickens were killed by hunters during the entire study. One of these birds was an apparent hunter loss due to crippling. Marshall (1964:9) reported the loss of a radio-tagged ruffed grouse due to hunter crippling. Radio telemetry techniques may be valuable in determining such losses in the future.

Injuries and mortality are always problems facing biologists when live trapping birds. Of 131 total prairie chickens trapped during the entire study only 2 birds were killed and 2 seriously injured by trapping operations. Although undesirable, deaths due to trapping operations were not considered to be of major importance.

During this study, two prairie chickens died from causes other than predation, accidents and legal hunting. An adult male (AM56), in poor condition when captured, died from unknown causes. The death of a 7-week old juvenile (JU55) was attributed to the added weight of a transmitter. The minimum age at which a juvenile prairie chicken can successfully carry a transmitter has not as yet been determined. It is suspected that a bird 10 to 11 weeks old might carry a transmitter with little difficulty. Two juvenile birds (JU24 and JU28), almost 12 weeks of age when radio-tagged, exhibited normal movement behavior. Further investigations are needed to determine the minimum age at which juvenile prairie chickens can successfully carry a radio transmitter without impairment of normal movement and behavioral habits.

SUMMARY

In 1963, a 6-year study of greater prairie chicken ecology was initiated in the Flint Hills region of northeastern Kansas. This paper reports

aspects of daily and seasonal movements, monthly ranges and reproduction of the greater prairie chicken during the 1966-1967 phase of the study. Data were obtained using a radio-telemetry system developed by Marshall (1960) and adopted for greater prairie chicken mobility studies by Cebula (1966).

Trapping methods utilized included cannon nets, mist nets, a mirror trap, a drive trap, walk-in traps and a hand dip-net. Tape recorded vocalizations and female decoys mounted in a receptive position aided trapping success. Telemetry equipment consisted of miniature radio transmitters, portable receivers, and portable, mobile and permanent receiving antennas. Reproduction data were collected with two Rustrak thermistor probe recorders and by direct observations from blinds erected on three booming grounds.

A total of 131 prairie chickens was trapped during the entire study and 47 were trapped during the 1966-1967 study. Eighty-three prairie chickens were banded during the entire study and 25 banded during the 1966-1967 phase of the study. A total of 48 prairie chickens was recaptured during the entire study and 22 recaptured during the 1966-1967 phase of the study.

During the entire study a total of 75 transmitters was placed on 58 different prairie chickens. Thirty were placed on 27 prairie chickens during the 1966-1967 study. A total of 1902 "bird days" of location data was collected with 873 collected during the 1966-1967 phase of the study. Averages of 33 location days per bird for the entire study and 32 per bird for the 1966-1967 phase of the study were obtained. A total of 2818 locations was recorded on 58 birds resulting in 49 locations per bird for the entire study. In the 1966-1967 phase, 1234 locations on 27 prairie chickens were obtained; an average of 46 locations per prairie chicken.

Sufficient locations were obtained to evaluate 72 and 33 individual monthly ranges for prairie chickens radio-tracked during the entire study and the 1966-1967 phase, respectively. Mean monthly ranges of radio-tagged prairie chickens were found to decrease gradually from May (251 ± 81 acres) through August (127 ± 37 acres), followed by a slight increase for September (169 ± 44 acres). The mean range for October (415 ± 74 acres) was more than double the mean range for September. A similar increase was found between October (415 ± 74 acres) and November (999 ± 66 acres). Mean range during December (601 ± 150 acres) was less than the mean ranges of February (1054 ± 259 acres) and March (1187 ± 414 acres). The mean range for April (693 ± 118 acres) was midway between the mean ranges of March and May. Sufficient data were not obtained to calculate a mean range for birds during January.

Mean distances between successive daily locations of radio-tagged prairie chickens were found to decrease gradually from May (400 ± 26 yards) through August (322 ± 24 yards). Movements then increased abruptly from September (370 ± 25 yards) to January (1602 ± 455 yards). Mean daily movements decreased between January and May (400 ± 26 yards).

Both male and female prairie chickens were observed to move between booming grounds during the spring booming season of 1967.

Flocks of prairie chickens were observed during all months of the year for the 1966-1967 phase of the study. The largest flocks (up to 40 birds) were observed during the winter on days with severe weather.

Prairie chicken behavioral and reproductive data were collected both spring and fall on booming grounds. Observations of greater prairie chickens on booming grounds were conducted for over 160 morning and 15 evening display periods during the spring of 1965, 1966 and 1967. Fall display ground observations were conducted for over 30 mornings in 1965 and 1966.

Twenty nests found during the entire study were located 1199 ± 108 yards from the nearest booming ground. Eggs in nests under observation were laid at a rate of one egg per day. The average clutch size was 12 eggs with a range of 7 to 15 eggs. For 60 eggs measured, the average length was 4.17 ± 0.02 centimeters and the average width was 3.20 ± 0.01 centimeters. The average weight of 23 eggs was 23.73 ± 0.10 grams.

During the 1966-1967 phase of the study, over 738 hours of data were collected on three female prairie chicken nests using two Rustrak thermistor temperature recorders. The average time a female spent on the nest during laying was 3.25 hours. The average arrival and departure times during laying were 1134 and 1450 hours, respectively. The average period for morning feeding during incubation was 1.35 hours and 1 hour for the evening feeding period. The average time of departure in the morning was 0803 hours and the average time of return was 0924 hours during the incubation period. For the evening feeding period, the average time of departure was 1829 hours and the average time of return was 1931 hours.

Fertility of greater prairie chicken eggs was observed to be 100 percent. Nest success during the entire study was 20 percent. Predation was the primary cause of nest failures.

Three females were known to renest during the entire study and five others were suspected of renesting. One female was observed to renest a second time after two nest failures for a total of three nesting attempts.

Twenty known prairie chicken fatalities were observed during the entire study. Eighteen of the 58 individual prairie chickens radio-tagged during the entire study were known to have died. Of 131 total prairie chickens trapped during the entire study, only 2 birds were killed and 2 seriously injured by trapping operations.

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APPENDIX

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

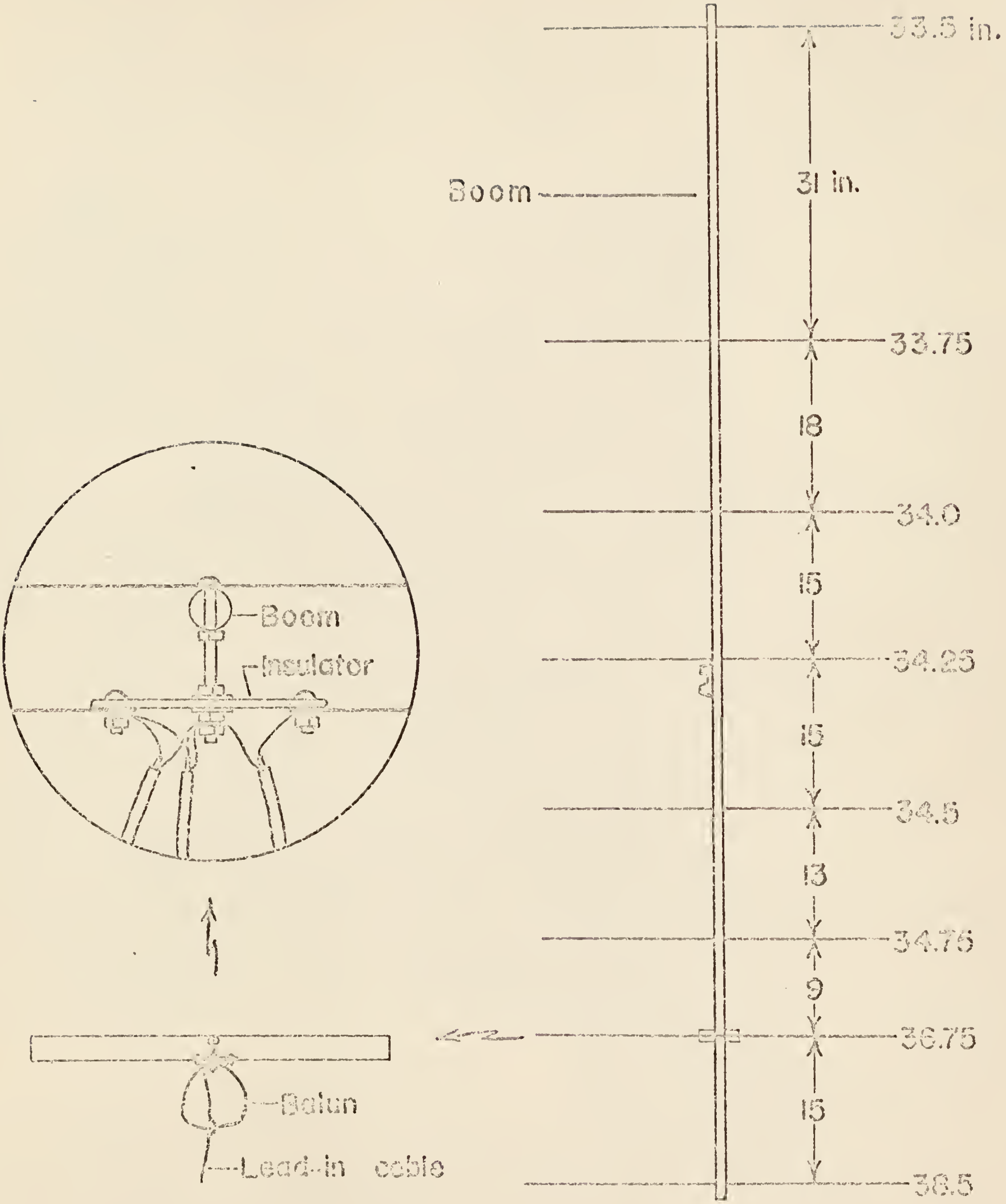


Fig. 2. Construction details of directional yagi receiving antenna utilized in both permanent and mobile stations.

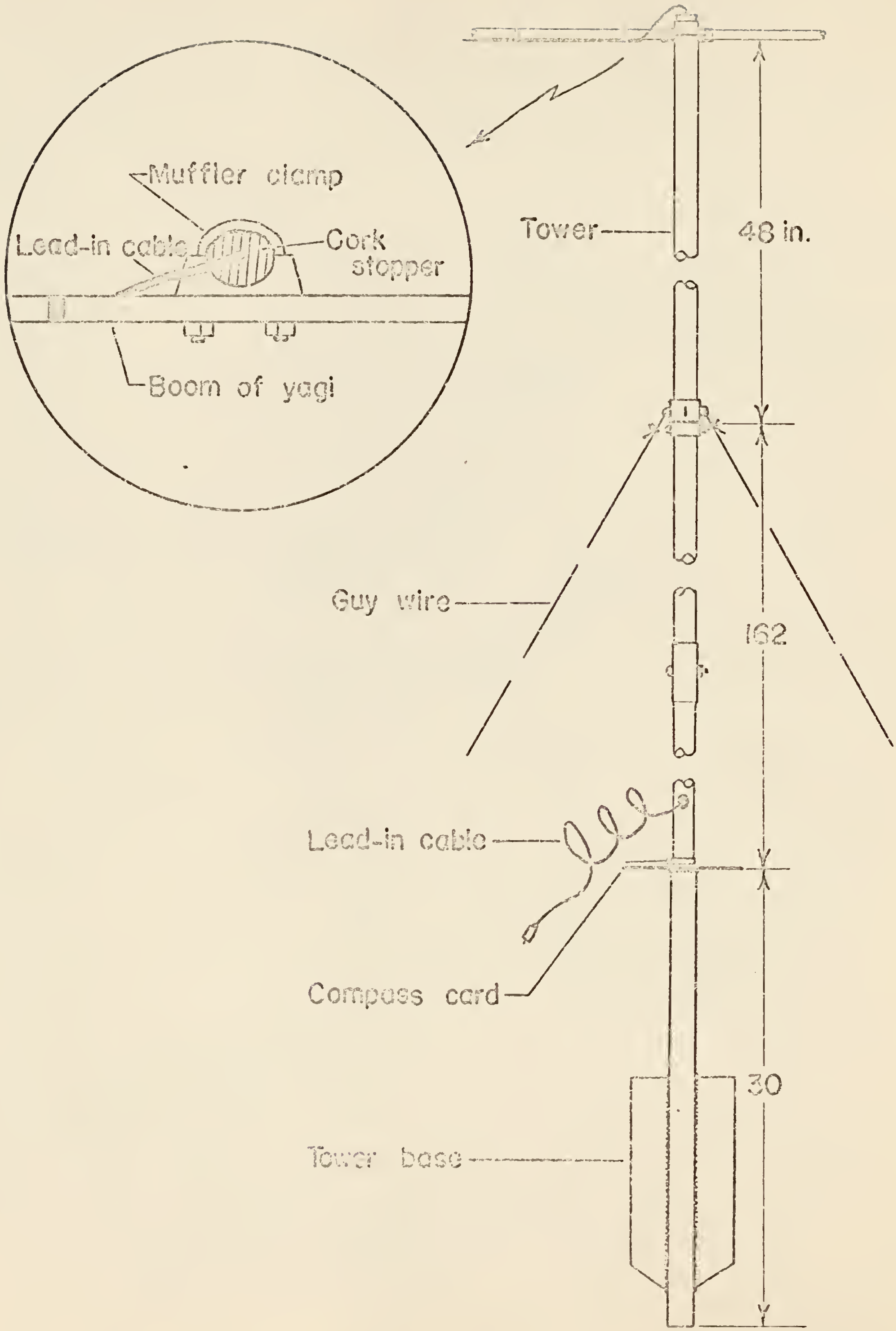


Fig. 3. Construction details of a permanent station.

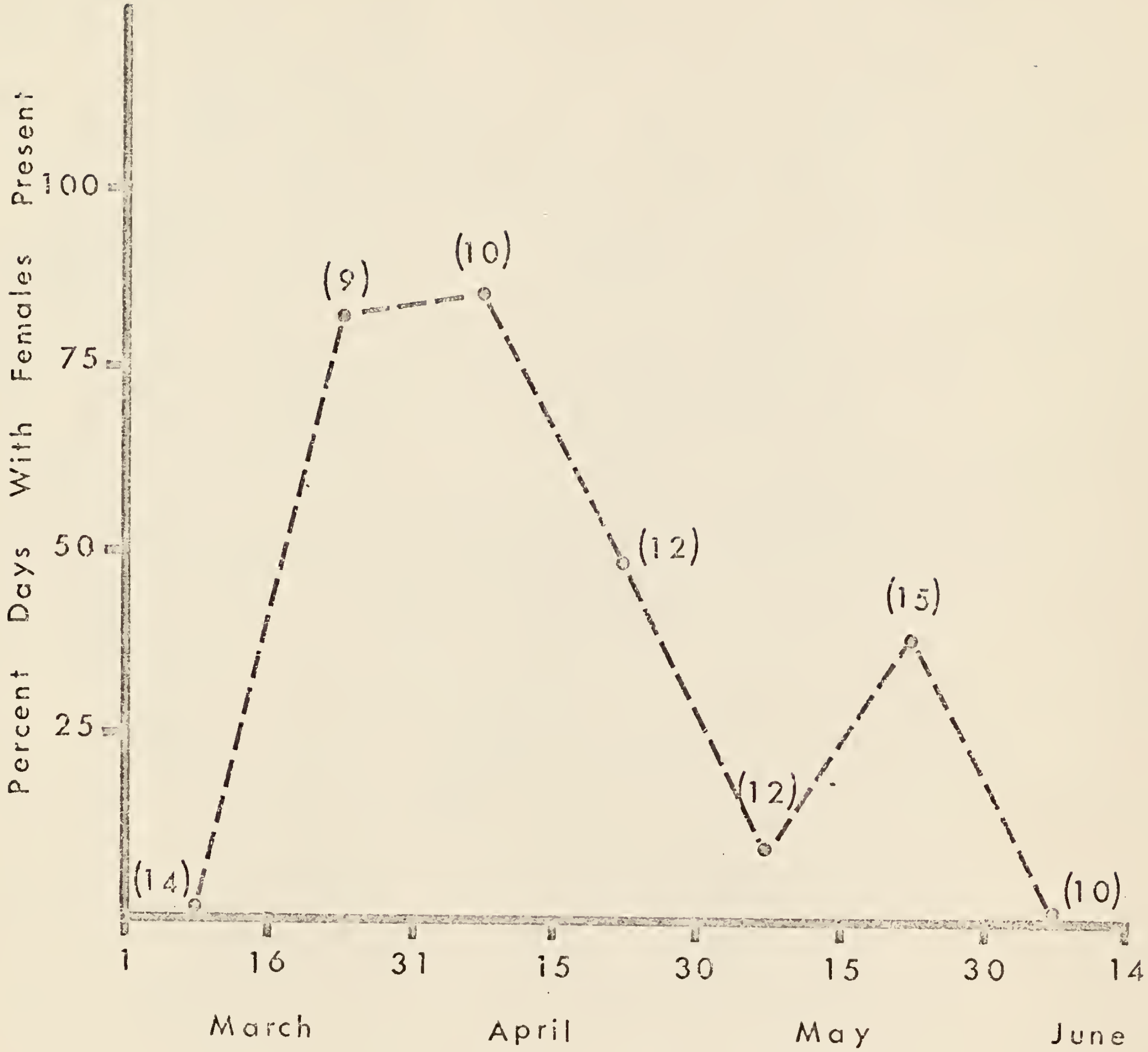


Fig. 4. The percent of days that females were present on the central booming ground for 15-day intervals during the spring booming season of 1966 and 1967. Number in parentheses represents the number of days under observation.

EXPLANATION OF PLATE I

Fig. 1. Diagrammatic sketch of erected mist net. Supports (A) and (A') are 14-inch surveyor's arrows and (B) is a standard electric wire fence post. The elevated edge of the net should face the main path of approaching birds.

Fig. 2. A view of transmitters with both single and double battery packs. Note plastic "snap cap" with center brass contact.

PLATE I

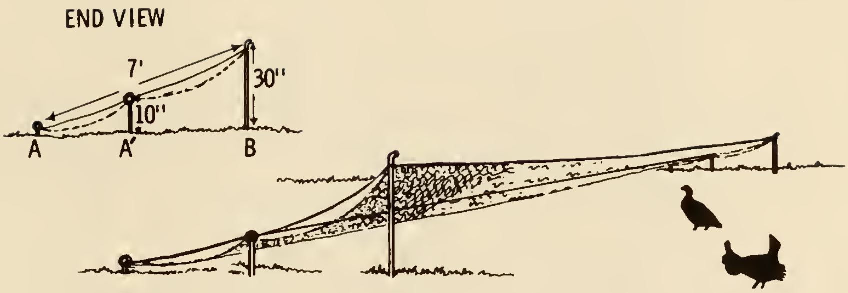


Figure 1.

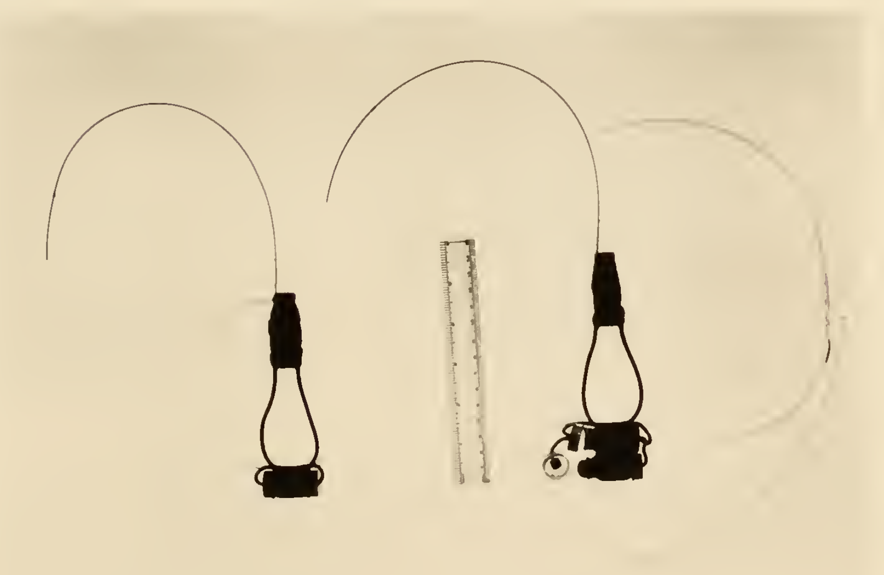


Figure 2.

EXPLANATION OF PLATE II

Fig. 1. A radio-tagged female prairie chicken ready to be released. Transmitter is visible on bird's back.

Fig. 2. A radio-tagged male prairie chicken displaying in a normal manner. Note aluminum band on bird's left leg.

PLATE II

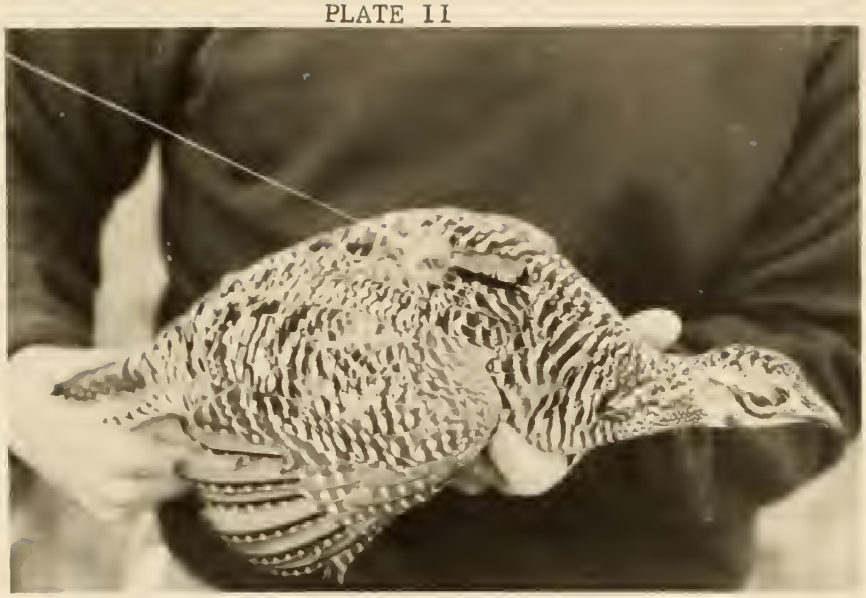


Figure 1.

Figure 2.

EXPLANATION OF PLATE III

Fig. 1. Rotating directional yagi antenna atop 20-foot tower of permanent station.

Fig. 2. Closeup of base of permanent station, portable receiver and plastic protractor compass card.

PLATE III

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. The mobile receiving antenna mounted on a pickup truck.

PLATE IV

Figure 1.

Figure 2.

EXPLANATION OF PLATE V

Fig. 1. Closeup of Rustrak recorder housed in plastic container.

Fig. 2. View of prairie chicken nest showing Rustrak thermistor probe.

PLATE V

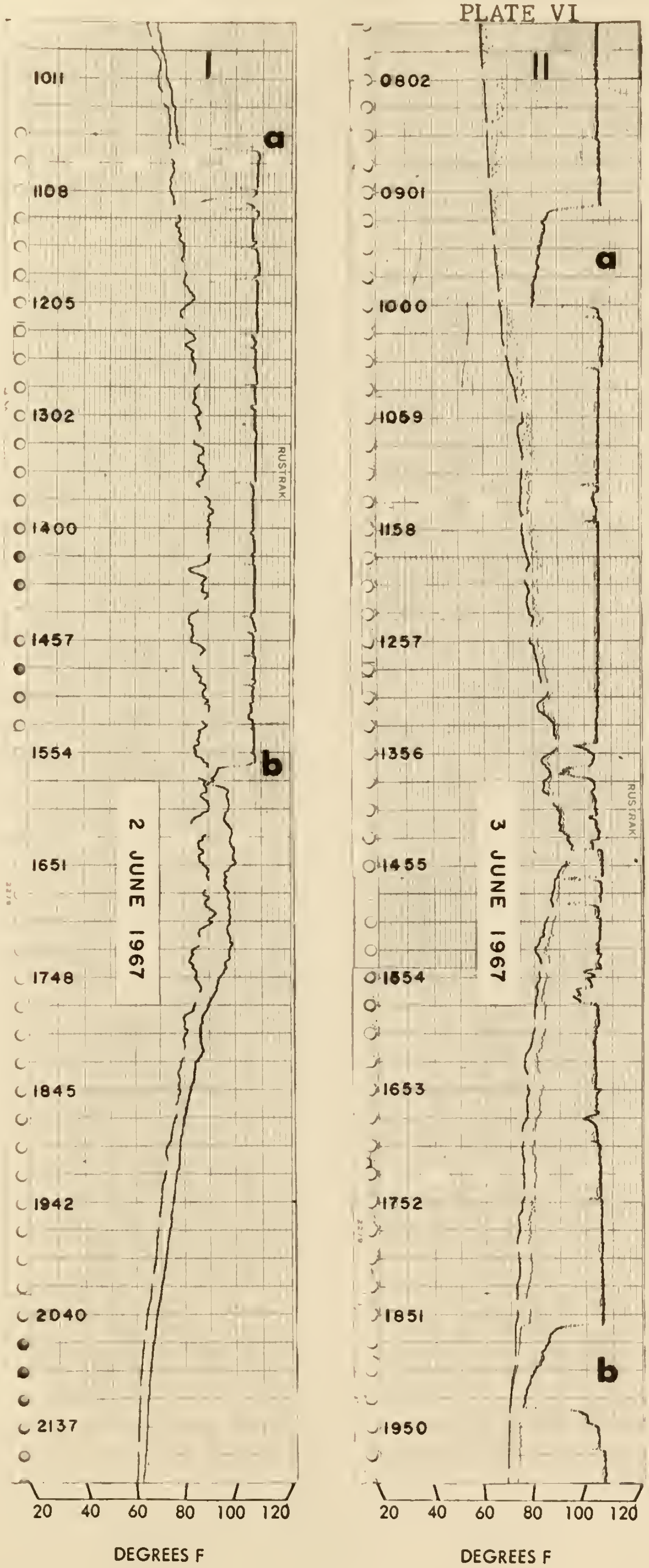
Figure 1.

Figure 2.

EXPLANATION OF PLATE VI

Fig. 1. View of three Rustrak chart tracings. Dashed line recorded artificial nest temperature and solid line recorded nest temperature. Chart I shows the arrival to (a) and departure from (b) a nest by a female prairie chicken during a morning laying period. Chart II shows morning (a) and evening (b) feeding periods of an incubating female. Chart III shows time female was flushed from nest prior to nest destruction (a) and two subsequent revisits (b) by the female prairie chicken before nest abandonment.

PLATE VI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RUSTRAK

MOVEMENTS, MONTHLY RANGES, REPRODUCTIVE BEHAVIOR, AND MORTALITY OF RADIO-TAGGED GREATER PRAIRIE CHICKENS (*TYMPANUCHUS CUPIDO PINNATUS*)

by

NOVA J. SILVY

B. S., Kansas State University, 1964

AN ABSTRACT OF A MASTER'S THESIS

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In 1963, a 6-year study of greater prairie chicken (Tympanuchus cupido pinnatus) ecology was initiated in the Flint Hills region of northeastern Kansas. During the period 16 June 1966 through 15 June 1967 an intensive study of the daily and seasonal movements, monthly ranges and reproduction of the greater prairie chicken was conducted using radio-telemetry. Telemetry equipment consisted of miniature radio transmitters, portable receivers, and portable, mobile and permanent receiving antennas. Additional reproduction data were collected with two Rustrak thermistor probe recorders and by direct observations from blinds erected on three booming grounds.

Trapping methods utilized included cannon nets, mist nets, a mirror trap, a drive trap, walk-in traps and a hand dip-net. Tape recorded vocalizations and female decoys mounted in a receptive position aided trapping success.

One hundred thirty-one prairie chickens were trapped during the entire study and 47 were trapped during the 1966-1967 study. During the entire study, 75 transmitters were placed on 58 different prairie chickens. Thirty were placed on 27 prairie chickens during the 1966-1967 study. A total of 1902 "bird days" of location data was collected with 873 collected during the 1966-1967 phase of the study. A total of 2818 locations was recorded on 58 birds during the entire study with 1234 locations on 27 prairie chickens collected during the 1966-1967 study.

Sufficient locations were obtained to evaluate 72 and 33 individual monthly ranges for prairie chickens radio-tracked during the entire study and the 1966-1967 phase, respectively. Mean monthly ranges were under 450 acres during the period April through October and over 990 acres during the period November through March. The mean range of prairie chickens for

December was 601 ± 150 acres.

Mean distances between successive daily locations of radio-tagged prairie chickens were found to decrease gradually from May (400 ± 26 yards) through August (322 ± 24 yards). Movements then increased abruptly from September (370 ± 25 yards) to January (1602 ± 455 yards). Mean daily movements decreased between January and May (400 ± 26 yards).

Both male and female prairie chickens were observed to move between booming grounds during the spring booming season of 1967.

Flocks of prairie chickens were observed during all months of the year for the 1966-1967 phase of the study. The largest flocks (up to 40 birds) were observed during the winter on days with severe weather.

Prairie chicken behavioral and reproductive data were collected both spring and fall on booming grounds. Observations of greater prairie chickens on booming grounds were conducted for over 160 morning and 15 evening display periods during the spring of 1965, 1966 and 1967. Fall display ground observations were conducted for over 30 mornings in 1965 and 1966.

Twenty nests found during the entire study were located 1199 ± 108 yards from the nearest booming ground. Eggs in nests under observation were laid at a rate of one egg per day. The average clutch size was 12 eggs with a range of 7 to 15 eggs. For 60 eggs measured, the average length was 4.17 ± 0.02 centimeters and the average width was 3.20 ± 0.01 centimeters. The average weight of 23 eggs was 23.73 ± 0.10 grams.

During the 1966-1967 phase of the study, over 738 hours of data were collected on three female prairie chicken nests using two Rustrak thermistor temperature recorders. The average time a female spent on the nest during laying was 3.25 hours. The average period for morning feeding during incubation was 1.35 hours and 1 hour for the evening feeding period.

Fertility of greater prairie chicken eggs was observed to be 100 percent. Nest success during the entire study was 20 percent. Predation was the primary cause of nest failures.

Three females were known to renest during the entire study and five others were suspected of renesting. One female was observed to renest a second time after two nest failures for a total of three nesting attempts.

Twenty known prairie chicken fatalities were observed during the entire study. Eighteen of the 58 individual prairie chickens radio-tagged during the entire study were known to have died. Of 131 total prairie chickens trapped during the entire study, only 2 birds were killed and 2 seriously injured by trapping operations.