BROOD BREAK-UP AND DISPERSAL OF JUVENILE GREATER PRAIRIE CHICKENS (TYMPANUCHUS CUPIDO PINNATUS) IN NORTHEASTERN KANSAS

by 5721

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Introduction

The greater prairie chicken (*Tympanuchus cupido pinnatus*) is an important game bird in eastern Kansas. In order for any species' number to be effectively maintained, a sound understanding of the ecology of that species is mandatory. To increase such understanding for the greater prairie chicken of Kansas, a 6-year study of its ecology was started in 1963 in the north-central portion of the Flint Hills region of Northeastern Kansas.

The objectives of the entire study were to determine: 1) seasonal and daily movement patterns, 2) behavioral patterns, and 3) habitat preferences of the greater prairie chicken. This report includes data gathered by the author during 1969-1970 plus some data obtained by previous investigators; Cebula (1966), Viers (1967), Silvy (1968), and Watt (1969).

The juvenile phase of the prairie chicken life cycle is critical because mortality is high. Therefore, the objective of this portion of the annual study was to gather information on juvenile mobility patterns, habitat preferences, mortality, brood movements, and brood break-up and dispersal.

Review of Literature

Radio Telemetry

Cebula (1966), Viers (1967), and Silvy (1968) have prepared extensive reviews of the radio-telemetry literature. Other general references and reviews of radio-telemetry techniques include Slater (1963), Ko (1965), Pienkowski (1965), Adams (1965), Siniff and Tester (1965), Tester and Siniff (1965), and Heezen and Tester (1967).

Home Range and Movements

Seton (1909:26) is generally credited with originating the concept of home range when he stated that "No wild animal roams at random over the country; each has a home region, even if it has no actual home." Home range was defined by Burt (1940:25) 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". A simpler definition of home range was given by Blair (1953:5) as "The area over which an individual travels in its normal daily activities".

Sanderson (1966:219) believed that investigators should concentrate more on the ecological aspects of an area, rather than the size and shape of the animal's home range, insofar as size and shape of a home range are of little importance when considered alone. Sanderson went on to point out that if all of the species requirements could be provided on a small area, its home range would be much smaller than the average for the species.

Brood Movements

Female prairie chickens and their broods were observed by Schwartz (1945:68) to stay in the vicinity of their nest for the first few days after hatching. These hens and their broods began to range out about 2 weeks later into higher areas and grain fields, cattle trails, paths, and other spots where the ground was bare. Baker (1953:71) believed that females stayed with their broods all summer, frequenting grasslands and cultivation. Attwater's prairie chicken (*Tympanuchus cupido attwateri*) also spent the first few weeks of life near the nest site (Lehmann, 1941:21). Lehmann postulated that in a favorable environment, the daily cruising radius of a brood was probably less than 300 yards for birds under 4 weeks of age. These movements, he believed, were restricted to the vicinity of surface water and shade. Copelin (1963:37) found that lesser prairie chicken (Tympanuchus pallidicinctus) broods in Oklahoma appeared to be more mobile in dry years when cover was sparse. Robel (1969:397) noted that gray hens (Lyrurus tetrix) and their broods were quite mobile for about 10 days after hatching. One hen and her brood moved 900 meters in less than 20 hours soon after hatching. Bendall and Elliot (1967:50) reported that the distance of brood movements of blue grouse (Dendragapus obscurus) was highly variable. Data based upon distances between initial sightings and final sightings of hens and their broods indicated movements of 1500 to 5000 feet between these sightings from June through August.

Jones (1963:772) believed that brood ranges generally had greater percentages of forbs than areas used for other activities. Cover most often used by prairie chicken broods was dominated by low weeds and annual lespedeza (Lespedeza sp.) with areas of tall weeds providing resting cover for small chicks. Briggs (1968:49) noted that moderate to heavy cover was required by greater prairie chickens in the Kansas Flint Hills region. Lehmann (1941:30) located a preponderance of Attwater's prairie chicken broods in light to medium cover in Texas. Sage Grouse (Centrocercus urophasionalus) broods in Idaho were always observed in areas of less than 31.00 percent shrubby cover (Klebenow 1969:649). As the summer progressed, broods moved to higher elevations following a gradient of green food plants. Peterson (1970:147) found that in Central Montana sage grouse broods 2 to 3 weeks of age moved from sagebrush or grassland benches to the bottomlands.

Juvenile Mortality

Many authors have reported high juvenile mortality in many tetraonids (Sandys 1902, Forbush 1913, Lehmann 1941, Yeatter 1943, Edminster 1947, Boag 1964, Pour 1967, and Bendall and Elliot 1967). Estimates of juvenile mortality of ruffed grouse (Bonasa umbellus) ranged from 50 percent (Forbush 1913) to 77 percent (Roberts 1932). Edminster (1947) believed that 25 to 50 percent of ruffed grouse chicks are lost in their first month of life, and that most of that loss occurs in the first 3 weeks. Bendall and Elliot (1967: 55) stated that while mortality of young blue grouse was high in their first month, enough escaped to increase the population if it were not for later mortality and dispersal. Yeatter (1943:414) observed an average loss of approximately 46 percent among juvenile greater prairie chickens in their first 5 weeks. The mortality rate of juvenile Attwater's prairie chickens was heaviest during the first 4 weeks after hatching (Lehmann 1941:20). Lehmann postulated that the actual survival of young prairie chickens was always probably well below the potential yield.

All of the proximal causes of juvenile grouse mortality are not known. Edmister (1947:304) thought that the guiding factor seemed to be "the relationship" of high population density to poor recovery and vice versa. He believed the most critical factor causing death of young chicks was inclement weather, and that as they grew older, the mortality factor that took precedence was predation. He believed that young grouse were more independent during the dispersal period and, therefore, were more susceptible to predation.

Dispersal

Concepts of Dispersal and Dispersion

"Population dispersal is the movement of individuals or their disseminules (seeds, spores, larvae, etc.) into or out of the population area"(Odum, 1953:201). Dispersal should not be confused with dispersion, which refers to an internal patterning of the population. Dispersal, when considering animals, refers only to movement, usually of young, from sites of birth to breeding. "Effective distance of dispersal refers to the least distance by air between site of birth and site or sites of subsequent breeding" (Johnston 1961:386). There is general agreement that the chief means of dispersal in birds consists of movements by young individuals (Grinnel 1922, Fisher 1955, Johnston 1956, Johnston 1961, and Pinowski 1965). Fisher (1955:44) and Howard (1960:152) suggested that dispersal in sedentary bird species is a result of the territorial system.

Dispersal of individuals, the lowest denominator which brings about dispersion in the population, can be very important to the perpetuation of the group through increased probability of individual genotypic survival (Godfrey and Marshall 1969:610). Alee et al. (1949:363) stressed that dispersion along with natality and mortality is one of the major factors controlling population growth form and behavior. Lack (1954:264) believed that dispersion is brought about mostly by young individuals. These tend to settle most densely in the most favorable areas up to a certain level, at which time they move elsewhere, even to less favorable habitats. Wynne-Edwards (1962:16) stated that while populations of birds and other animals are limited ultimately by food, this limit is not normally reached in nature because dispersion through behavior keeps animal numbers near the optimum. He described the process of regulation as "homeostatic", and believed that behavior which he termed "epidiectic" has evolved to reveal the density of the population.

<u>Grouse Dispersal</u>

The term "crazy flight" is usually attributed to grouse in the fall during times of high population density. Bump et al. (1947:256) stated that crazy flight is a characteristic of young birds seeking a territory and that the incidence of crazy flight probably tends to vary with fall population density. Many authors have reported increased dispersal movements of juvenile grouse in the fall of the year (Edminster 1947:43, Chambers and Sharp 1958:239, Hale and Dorney 1963:648, Bendall and Elliot 1967:55, Sullivan and Marshall 1968:143, Zwickel 1968:451, Godfrey and Marshall 1960:615, and Robel et al. 1970:302). Edminster (1947:43) explained that in October young ruffed grouse become more aggressive toward one another. Each time an individual chases another, one individual is less apt to return. He noted definite antagonism on the part of most birds for all other grouse, and, if after being driven off, they came into contact with other grouse, they were likely to be driven off again. Zwickel et al. (1968:465) observed that in late summer, brood bonds of juvenile blue grouse tend to disappear as maternal attachments weaken, and that juveniles wander until they find a suitable area or acceptable flock.

Juvenile ruffed grouse dispersal was characterized by Godfrey and Marshall (1969:616) as explosive and unidirectional in nature. They believed that the proximal stimulus for this dispersal could be photo-periodic control, meteorological changes, or age specific response. What had previously been construed as crazy flight by other investigators, they explained as resulting because of the unidirectional mode of dispersing juveniles.

Dispersal activities of juvenile ruffed grouse have two definite components (Godfrey and Marshall 1969:609); brood break-up followed by distinct dispersal movements. Brood break-up is a period of brood fragmentation and continued detachment with individual adherance to a relatively small and intact range, which is called the break-up range. Edminster (1947:43) reported a similar break-up period before actual dispersal.

Schwartz (1945:69) found that greater prairie chickens between 8 to 10 weeks of age are seldom found with the hen, and that dispersal of family groups gradually takes place at about that age. Baker (1953:17) observed that by early September, young greater prairie chickens were indistinguishable from adults, and, at that time, began to assemble into established flocks. Young Attwater's prairie chickens at the age of 6 weeks are as capable of foraging and resisting adverse conditions as are adults, and many young leave family groups at 6 to 8 weeks to fend for themselves (Lehmann 1941:19). Copelin (1963:46) reported that young lesser prairie chickens generally move greater distances their first year of life than thereafter. He believed that some, and perhaps most of the young birds use fall booming grounds in their first fall after hatching. Some occupied grounds within 0.25 to 0.50 mile of their brood range, while others moved more than 2 miles. He also found that additional movement and mixing of populations occurred in spring as juveniles moved from feeding grounds to display grounds and from one display area to another. Young females were usually more mobile than males.

Robel et al. (1970:302) observed extensive movements of juveniles in October and November. They believed that if increased movements of juvenile prairie chickens actually represent population dispersal, then it might reflect an internal population regulatory mechanism. They noted a possible high mortality for dispersing juveniles, and believed that if it was representative of the mortality for dispersing juveniles in the population, then dispersal was certainly an important regulatory force.

Materials and Methods

Study Areas

Most of the data presented in this thesis were obtained on the Simpson Ranch study area, located 22 miles south of Manhattan in T12S, R7E of Geary County, Kansas. The area consists of the 6000-acre Simpson Ranch and adjacent areas.

The area is typical of the western edge of the eastern Kansas Flint Hills bluestem prairie which extends from the Nebraska border on the north to Oklahoma on the south. Topography of the area is characterized by a series of gently rounded ridges fringed with limestone outcrops and separated by wooded draws with intermittant streams and small drainages. Detailed descriptions of this area are presented by Cebula (1966), Viers (1967), Briggs (1968), Silvy (1968), and Watt (1969).

Until 1968, grazing practices on the area included moderate year-round grazing of cow-calf units with a limited amount of season-long grazing by steers and rotation of pasture use. These land use practices were altered in 1968 when the ranch was leased for season-long grazing by steers and some year-round grazing by cow-calf units.

In April of 1968, the northern half of the Simpson Ranch was intentionaly burned along with adjacent grassland acreages with the cooperation of neighboring landowners. This began the annual practice of alternately burning the north and south portions of the study area.

Three traditional booming grounds, designated: the north, central, and south booming grounds (Fig. 1), were utilized by prairie chickens from 1964 to 1967. Silvy, (1968:23) observed on the study area an additional "territorial" booming ground (Hamerstrom and Hamerstrom 1949:327) in the spring of 1967. A booming ground designated the "South-2" booming ground, approximately 1.25 miles to the south southwest of the south booming ground was well established by the spring of 1967.

During the 1969-1970 phase of the study, an additional study area was used. This new study area is situated 12 miles south and 2 miles east of Manhattan in T13, R8, S13 of Waubuansee County, Kansas. The area was typical of the bluestem prairie and was leased for season-long steer grazing. Grazing pressure was light to moderate, and the pasture was bordered on the north, south, and east by pasturelands and on the west by cultivation. Cultivated crops included winter wheat (Triticum aestivum), sorghum (Sorghum bicolor), and alfalfa (Medicago sativa)-brome (Bromus inermis) meadows. Much of the pasture was mowed annually for prairie hay. Sorghum was interspersed with strips of hay meadow

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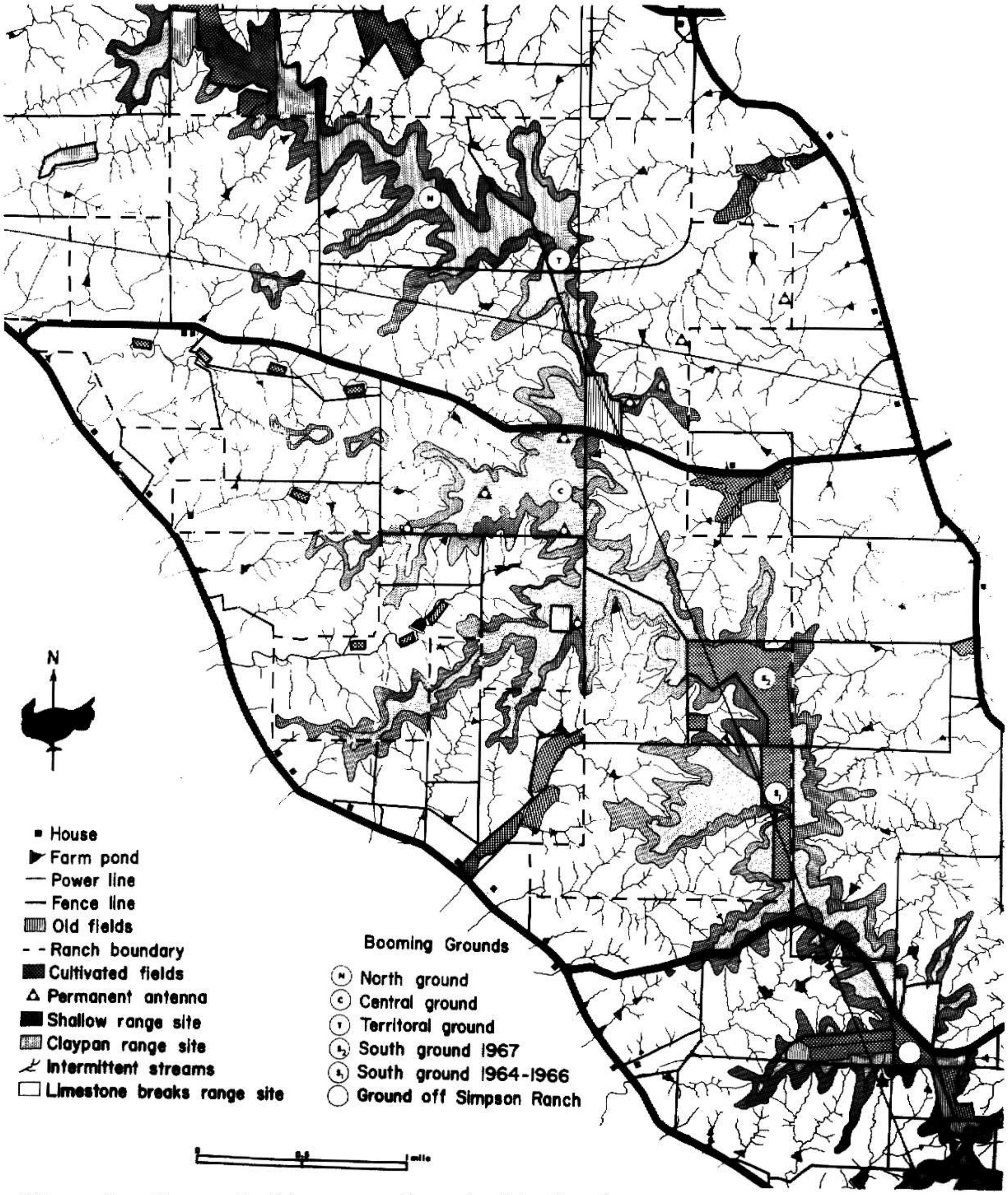

Fig. 1. Map of Simpson Ranch Study Area.

and shallow grassy waterways, and was bordered in late summer and early fall by tall stands of sunflowers (Helianthus annuus) which were used by prairie chickens for shade and dusting areas.

Live-trapping and Banding

Prairie chickens were live-trapped by two principle means during the study. Cannon nets projected by three "composite" cannons (Smith 1962:3) were used on the booming grounds to live-trap prairie chickens in the fall and spring. More detailed descriptions can be found in Silvy (1968:25) and Watt (1969:32).

Throughout the entire study, funnel-type walk-in traps of various sizes and baited in different ways were used to live-trap prairie chickens during late fall, winter, early spring, and mid to late summer. Large (6 x 10 x 4 feet) traps and smaller single funnel (4 x 4 x 2 feet) traps were described by Watt (1969:34). Two sizes of funnel-type walk-in traps were used in mid to late summer of 1969-1970 to capture juvenile birds. The smaller two-funnel traps measured 4 x 4 x 2 feet, and the larger four-funnel traps measured 8 x 8 x 2 feet.

All traps were constructed from 2 x 4-inch welded wire mesh, and covered by 2-inch mesh nylon fish netting to prevent injury to captured birds. Funnels were 18 to 20 inches deep and constructed from 1-inch mesh chicken wire with the outer opening 12 inches in diameter and the inner opening 4 inches in diameter. The edge of the inner opening of each funnel was snipped off so that wire prongs projected inward and downward to make it difficult for captured birds to exit once they were in the trap.

Funnel traps were placed in prairie chicken feeding and dusting areas along an edge between feed (grain sorghum, wheat, oats, alfalfa, and clover) and pasture. Leads constructed from 12-inch high 1-inch mesh chicken wire were sometimes used to funnel birds to the traps. Mature sorghum heads, grain of grain sorghum, oats, wheat, whole kernel and cracked corn and soybeans were used during the study as bait. Watt (1969:34) used a 1:1:1 ratio of grain sorghum, oats, and wheat during summer trapping. It was necessary to use large quantities of bait to capture prairie chickens during the summers of 1969-1970. Approximately 50 pounds of grain sorghum, 25 pounds of scratch grain, and 25 pounds of shelled corn were used to bait the 4 x 4 x 2 foot traps. Approximately 100 pounds of grain sorghum, 50 pounds of scratch grain, and 50 pounds of shelled corn were used for the 8 x 8 x 2 foot traps.

In the 1969 and 1970 phase of the study, hand-held directional antennas were used exclusively for the monitoring of brood and juvenile movements. Attempts were made to locate each transmitter equipped juvenile prairie chicken two or three times a day at different times each day to determine daily and seasonal movements. Occasional continuous monitoring of birds for extended periods of time supplemented data on daily movement patterns. All radio determined locations were plotted on base maps to provide a history of individual prairie chicken movements. The outer most points were then connected to determine monthly ranges for each bird (Mohr, 1947). In order to correct for a possible bias due to a 2- to 3-day sedentary period just after trapping, only birds for which 15 or more locations had been made were used.

Distance in yards between each successive daily location was used as an index to bird mobility. A table of random numbers was utilized to determine which location was to represent a given day if more than one had been recorded.

Ranges and distances of movement for each juvenile prairie chicken were stratified into monthly categories. Movements overlapping successive months were recorded as belonging to the preceding month. Standard errors were calculated for both ranges and distances for each month class using the method described by Snedecor (1956). Distance between capture site and the last location was used as the "effective distance of dispersal" (Johnston 1961:386).

Aerial Searches for Lost Transmitters

During the 1969 and 1970 phase of the study a new technique was utilized to locate transmitters which the investigator believed to be still operable but out of range of the receiving equipment. A handheld directional antenna was attached to the wing brace of a Cessna 120 aircraft. A piece of polystyrene foam was cut and formed to fit over the wing brace and the handle of the antenna was pressed into the polystyrene with the filaments perpendicular to the ground. Both the foam and the antenna were then lashed to the wing brace with $\frac{1}{4}$-inch nylon cord, and covered with tape. The lead from the antenna was then threaded through an open window, the window forced closed over it, latched, and the lead connected to the receiver (Fig. 2).

A functioning transmitter was left on the ground each time before take-off so that equipment could be tested just after take-off by circling the airport. The signal from a test radio could be received from a distance of 8 miles at an altitude

EXPLANATION OF FIGURE 2.

Fig. 2. Attachment of antenna to aircraft wing brace.

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of 1000 feet above ground. A spare receiver was available in the airplane in case one receiver failed to function properly.

The search began by flying around the periphery of the study area at an altitude of approximately 1000 feet at a flight speed of approximately 100 mph. Once this was done, the plane would descend to 500 feet and fly parallel to the main drainages. If the transmitter was functioning on the study area, it could normally be located in this manner. If the bird was not located on the study area, the plane would resume an altitude of 1000 feet and fly several wide circles around the study area to locate transmitter equipped birds which had possibly moved off the study area.

When a signal was located, the plane was flown in a grid pattern at an altitude of about 500 feet. Where 2 flight lines bisected one another and a maximum signal strength was found, its tentative location was plotted on a base map in the plane. Following the tentative aerial location of transmitter-equipped birds, the investigator returned to the airport and returned to the study area to confirm the location by standard techniques on the ground.

If the radio signal could not be found by this method, it was assumed that the transmitter was no longer functional, and further ground searches were discontinued.

Habitat Preference Indices

Habitat preference indices as described by Watt (1969:67) were calculated on the basis of all (834) transmitter locations obtained for juvenile birds on the Simpson Ranch study area throughout the entire prairie chicken project. Three major range sites (Bidwell, 1960); limestone breaks, claypan, and shallows, as well as two crop types; wheat and oats, and sorghum were the habitat types considered. By dividing the percentage of bird locations found in a particular habitat type by the percentage of the study area covered by that type, an index of relative utilization was obtained. No such indices were calculated for the Lutheran pasture study area, because all juvenile movement was within loamy uplands and associated cultivation.

Results

Live-trapping

During the entire prairie chicken project (1964-1970), 242 greater prairie chickens were captured (Table 1). Sixty-six of the total were captured during the 1969-1970 phase of the study. Of the total birds captured, 49 (20.2 percent) were juveniles.

Aerial Search and Relocate Method

The aerial search and relocate technique described earlier was used four times. By using this technique, 2 out of 6 birds that could not be located by standard ground tracking techniques, were relocated. These were 2 adult males (AM141 and AM145) which had moved approximately 2.00 and 1.50 miles, respectively, from the point of their last location.

Mobility Studies

Sufficient numbers of locations were obtained to estimate 43 monthly ranges for the 24 juvenile greater prairie chickens monitored. A summary of radio-tracking data may be found in Table 2.

Mean monthly ranges for juvenile male prairie chickens were

Table 1 Summary of prairie chickens captured during the entire study and for the 1969-1970 phase of the study.

	TRAPPING METHOD					
	Mist Net	Cannon Net	Walk-in	Hand or dip-net	Bow Net	Totals
Entire Study						
Males	17	78	14	20	2	131
Females	12	21	6	23	0	62
Juveniles	7	7	14	20	1	49
Totals:	36	106	34	63	3	242
1969-1970						
Males	0	28*	9	2	0	39
Females	0	7*	1	2*	0	10
Juveniles	0	3	8	6	0	17
Totals:	0	38	18	10	0	66

*These data include trapping by Bowen and Ballard (Pers.Comm.) on the Simpson Ranch in 1970.

Table 2 Summary of radio-tracking data on 24 juvenile prairie chickens captured during the entire study.

Band Number	Brood Number	Sex	Number Days Transmitting	Last Record
24	1	unknown	24	unknown predator
28	1	unknown	29	hunter loss
30	single	female	3	unknown predator
31	single	female	55	signal off
33	single	female	35	signal off
34	single	male	43	signal off
58	single	female	78	signal off
61	single	male	30	signal off
62	single	male	14	bird lost radio
63	single	male	15	broken antennae
65	single	male	96	signal off
82	single	male	119	great horned owl
84	single	male	35	coyote
108	2	unknown	34	transmitter removed
112	2	unknown	27	transmitter removed
113	2	unknown	27	signal off
115	3	unknown	37	signal off
116	3	male	37	signal off
123	single	male	16	signal off
148	single	unknown	11	coyote
149	4	male	9	broken antennae
150	4	male	31	coyote
151	4	female	38	transmitter removed
153	4	male	10	coyote

calculated for the months of August through May (Table 3, Fig. 3). Mean monthly ranges were largest for juvenile males in December (918±123* acres) and March (938±242 acres) and smallest in September (45±7 acres). Monthly ranges for January, April, May, August, and October were calculated from movements based on one bird each month, so that they may not represent the actual monthly trends involved.

Mean monthly ranges for juvenile females were calculated for the months August through December (Table 3, Fig. 3). The trend was similar to that of the juvenile males for that same period. The largest monthly range occurred in November (1001** acres) while the smallest was in September. The monthly ranges for August and November were based on single birds each month.

Pooled juvenile monthly range data were calculated and did not deviate trend-wise from monthly ranges of both sexes. The trend was upward from September (106±31 acres) to an initial peak in December (760±123 acres), then decreased in January (440 acres), and increased to 938±242 acres in March. Sizes of monthly ranges then decreased sharply to a low in May (89 acres).

Sufficient data were obtained to calculate daily movement patterns for most birds tracked (Table 4). These mean daily movement trends followed closely the mean monthly ranges already calculated. The pooled trend line (Fig. 4) was upward from August (284±37 yards) to an initial peak in December (895±59 yards), down in January (624±107 yards) and up to a yearly high in March (1018±125 yards). Mean daily movements decrease sharply

*Mean±$S_{\bar{x}}$
**$S_{\bar{x}}$ not calculated

Table 3 Mean monthly ranges for 24 juvenile greater prairie chickens radio-tracked during the study. Numbers in parentheses represent one $S_{\bar{x}}$. Numbers underlined represent number of birds tracked during each month.

	Mean Locations for Monthly Ranges				Mean Area of Monthly Ranges in Acres			
Month	Juvenile Male	Juvenile Female	Unsexed Juveniles	Pooled Juveniles	Juvenile Males	Juvenile Females	Unsexed Juveniles	Pooled Juveniles
January	50 <u>1</u>	-- -	-- -	50 <u>1</u>	440*	-- --	-- --	440*
February	23 <u>9</u>	-- -	-- -	23 <u>9</u>	834(332)	-- --	-- --	834(332)
March	35 <u>2</u>	-- -	-- -	35 <u>2</u>	938(242)	-- --	-- --	938(242)
April	51 <u>1</u>	-- -	-- -	51 <u>1</u>	459*	-- --	-- --	459*
May	44 <u>1</u>	-- -	-- -	44 <u>1</u>	89*	-- --	-- --	89*
June								
July								
August	31 <u>1</u>	25 <u>1</u>	16 <u>5</u>	19 <u>7</u>	87*	171*	112(31)	117(23)
September	27 <u>4</u>	28 <u>2</u>	24 <u>2</u>	26 <u>8</u>	45(7)	151(94)	184(42)	106(31)
October	6 <u>1</u>	24 <u>2</u>	-- -	18 <u>3</u>	224*	422(188)	-- --	356(127)
November	12 <u>3</u>	34 <u>1</u>	-- -	18 <u>4</u>	409(278)	1001*	-- --	614(327)
December	24 <u>4</u>	17 <u>2</u>	-- -	22 <u>6</u>	918(123)	470(57)	-- --	768(123)

* $S_{\bar{x}}$ not calculated

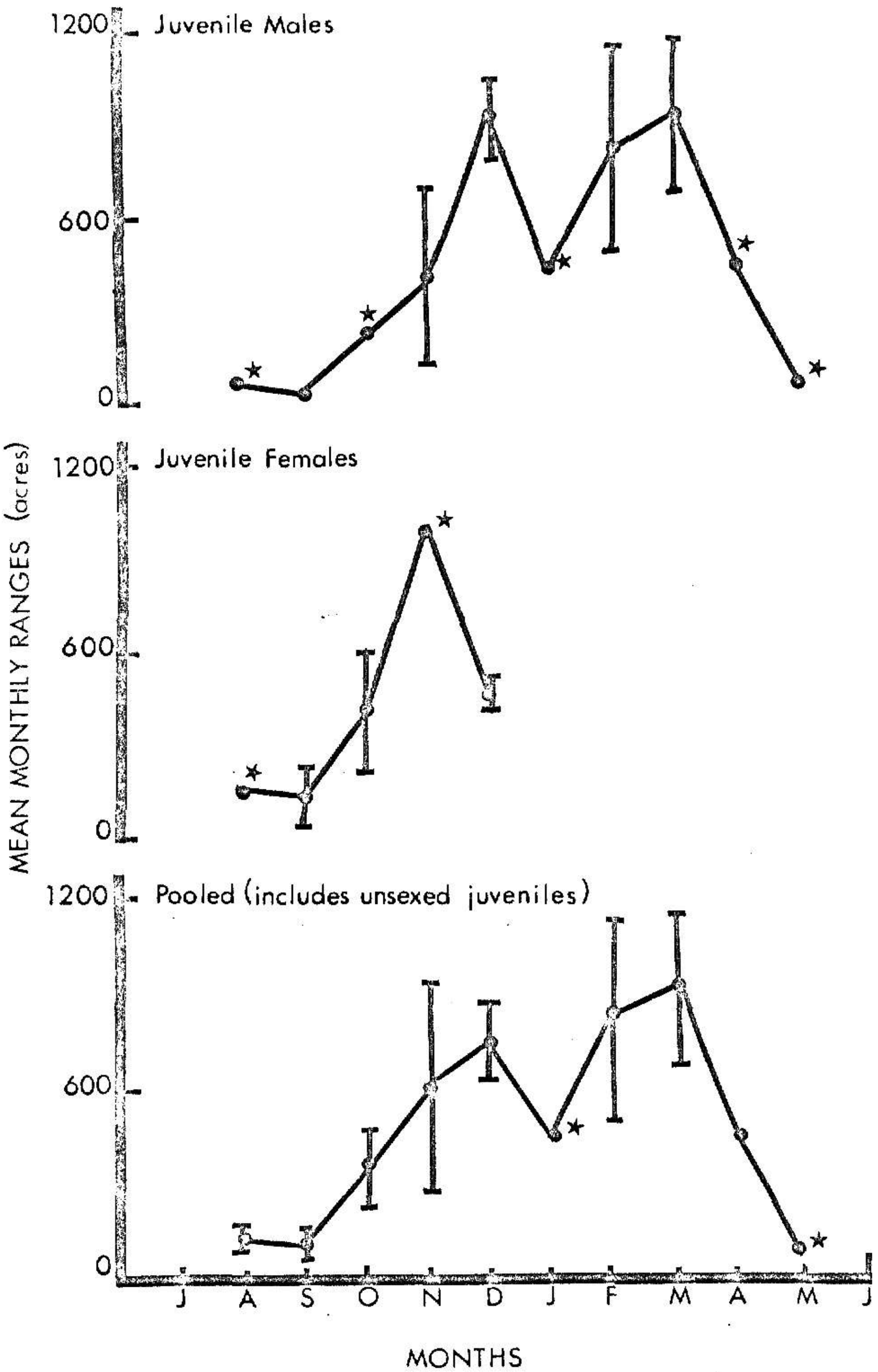


Fig. 3. Mean monthly ranges of 24 juvenile greater prairie chickens. Vertical lines represent $S_{\bar{x}}$.
*$S_{\bar{x}}$ not calculated.

Table 4 Mean daily movements, by month, for 24 juvenile greater prairie chickens radio-tracked during the entire prairie chicken project. Numbers underlined represent number of birds tracked during each month.

Month	Number of Movements				Mean Distance of Daily Movements			
	Juvenile Males	Juvenile Females	Unsexed Juveniles	Pooled	Juvenile Males	Juvenile Females	Unsexed Juveniles	Pooled
January	35 2	-- -	-- -	35 2	624(107)*	-- --	-- --	624(107)
February	68 4	-- -	-- -	68 4	969(100)	-- --	-- --	969(100)
March	50 2	-- -	-- -	50 2	1018(125)	-- --	-- --	1018(125)
April	24 1	-- -	-- -	24 1	499(102)	-- --	-- --	499(102)
May	21 1	-- -	-- -	21 1	298(73)	-- --	-- --	298)73)
June								
July								
August	21 1	15 1	69 7	106 9	341(68)	489(104)	226(19)	284(37)
September	58 4	54 2	28 2	140 8	333(26)	402(40)	299(50)	353(22)
October	5 1	46 3	-- -	51 4	316(114)	571(69)	-- --	548(64)
November	40 4	34 3	-- -	74 7	771(136)	939(144)	-- --	848(99)
December	75 4	26 2	-- -	101 6	926(73)	806(94)	-- --	895(59)

*All distances in yards; Means ± $S_{\bar{x}}$

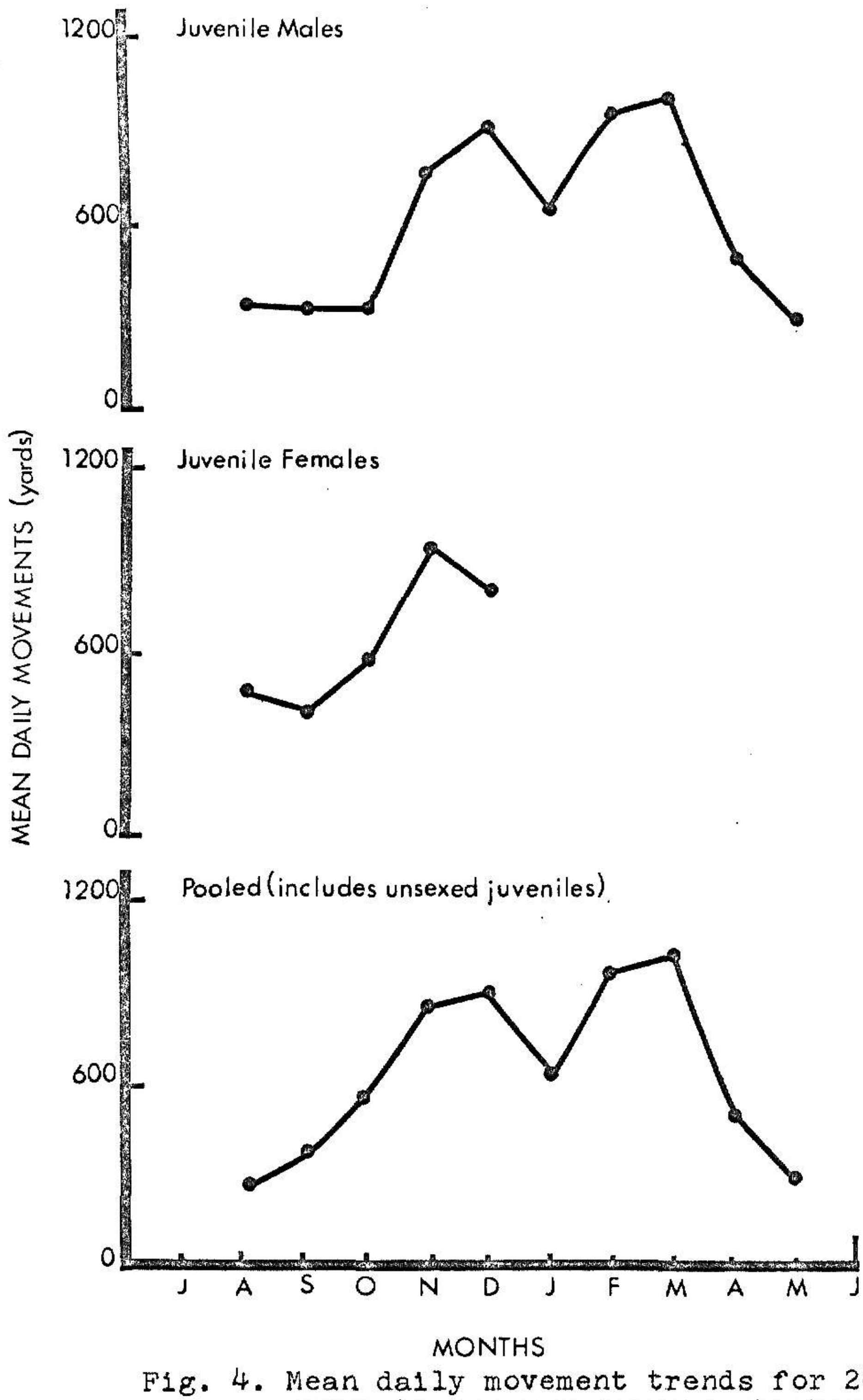


Fig. 4. Mean daily movement trends for 24 juvenile greater prairie chickens.

from March to May (298±73 yards). The pooled mean daily movement data of January to May consists of daily movements of juvenile males only, therefore, it may not be representative of juveniles as a whole.

A goodness of fit test (Ostle 1963:38) on day-to-day movement data was calculated and indicated that the data represented an exponential population distribution. Therefore, even though the standard errors are given it should be noted that the variability they represent is not symmetrical about the means.

Habitat Preference

A total of 834 radio-telemetry locations of 19 juvenile greater prairie chickens on the Simpson Ranch obtained throughout the study was used to calculate habitat preference indices (obtained by dividing percentage of locations by the percentage of the study area of each habitat type). Index values of 1.0 and larger indicate that use by prairie chickens was proportional or more proportional than would be expected based on habitat availability. Values of less than 1.0 indicate utilization was less proportional to availability. Habitat types used were the three major range sites (limestone breaks, shallows, and claypan), plus wheat and oats, and sorghum crop types, and booming grounds.

The shallow range site had consistantly higher preference indices than did other range sites. The average preference index was 1.48 during the entire study, and ranged from 0.76 in January to a high of 2.10 in February (Table 5).

The limestone break range site showed an average preference index of 0.64 and ranged from 0.00 in April and May to a high of 1.24 in September. No month other than September had a preference

Table 5 Monthly habitat preference indices calculated from 834 locations of 19 juvenile greater prairie chickens for the entire study on the Simpson Ranch study area.

Month	Habitat Preference Index* Lime-stone Breaks	Clay-Pan	Shallow	Wheat and Oats	Grain Sorg.	Booming Ground
January (2)[a] 63[b]	0.78	0.33	0.76	0.00	18.26	0.00
Juvenile males (2) 63	0.78	0.33	0.76	0.00	18.26	0.00
February (4) 93	0.34	0.06	2.10	0.00	6.57	12.90
Juvenile males (4) 93	0.34	0.06	2.10	0.00	6.57	12.90
March (2) 73	0.57	0.44	1.17	0.00	8.00	23.00
Juvenile males (2) 73	0.57	0.44	1.17	0.00	8.00	23.00
April (1) 51	0.00	0.21	1.87	0.00	0.54	55.00
Juvenile males (1) 51	0.00	0.21	1.87	0.00	0.54	55.00
May (1) 44	0.00	0.00	1.84	0.00	0.00	61.56
Juvenile males (1) 44	0.00	0.00	1.84	0.00	0.00	61.56
June	----	----	----	----	----	----
July	----	----	----	----	----	----
August (8) 144	0.71	0.44	1.62	7.52	0.58	0.00
Juvenile males (1) 31	0.12	0.51	2.30	10.75	2.69	0.00
Juvenile females (1) 25	0.23	0.00	3.24	8.33	0.00	0.00
Unsexed juveniles (6) 88	0.05	0.54	0.92	6.15	0.00	0.00
September (4) 94	1.24	0.50	1.06	0.44	0.29	0.00
Juvenile males (1) 13	0.00	3.64	1.47	0.00	0.00	0.00
Juvenile females (1) 34	0.83	0.00	2.38	1.22	0.82	0.00
Unsexed juveniles (2) 47	1.89	0.00	0.00	0.00	0.00	0.00
October (4) 60	0.44	1.40	1.98	1.39	0.46	3.33
Juvenile males (1) 6	0.00	0.00	3.17	0.00	0.00	33.33
Juvenile females (3) 54	0.49	1.56	1.85	1.54	0.51	0.00
November (8) 96	0.85	0.27	1.44	1.30	3.76	3.13
Juvenile males (5) 51	0.67	0.31	1.96	1.63	3.18	5.88
Juvenile females (3) 45	1.05	0.23	0.85	0.92	5.56	0.00
December (6) 116	0.73	0.27	1.15	3.23	6.71	0.00
Juvenile males (4) 81	0.75	0.32	1.12	0.00	8.57	0.00
Juvenile females (2) 35	0.70	0.15	1.22	10.71	2.38	0.00
JM Overall index (506) 9	0.43	0.32	1.61	0.83	5.00	8.90
JF Overall index (193) 4	0.53	0.53	1.76	3.75	1.94	0.00
Overall average preference index (834) 20	0.64	0.37	1.48	2.05	3.53	10.67

$$\text{* Habitat preference index} = \frac{\text{percent of bird locations}}{\text{percent of study area}}$$

a Numbers in parentheses are number of birds used to calculate index
b Numbers underlined are number of locations used to calculate index

index of greater than 1.00.

Preference indices for the claypan range site averaged 0.37, and ranged from 0.00 in May to 1.40 in October. All months except October showed preference indices of less than 1.00.

Habitat preference indices for the booming ground showed that these areas, even though proportionately quite small, accounted for high proportions of bird locations, especially during fall and spring months (Fig. 5). Insofar as no juvenile female locations were on the booming grounds, all preference indices on the booming grounds were due solely to juvenile male activity. The average throughout the year, for males only, was 17.59; 12.90 for February, 23.00 for March, 55.00 for April, and 61.56 for May. Juvenile male use of the booming grounds in the fall is reflected by preference indices of 33.33 and 5.88 for October and November, respectively.

Starting with lows of 0.58 and 0.29 in August and September, respectively, the indices for sorghum became progressively higher throughout the fall and winter months until a high of 18.26 was reached in January. Indices then declined to 0.00 in May. Preference was shown on an overall basis with an average index of 3.53.

The average preference index for the wheat and oats habitat type was 2.50. Utilization of this crop type began in August (preference index 7.52) and continued through December (preference index 3.23).

Many individual variations in habitat utilization exist. The index of 3.23 for wheat and oats in December denotes a high degree of preference for that crop type. This index was biased because one juvenile female prairie chicken frequented the wheat and oats

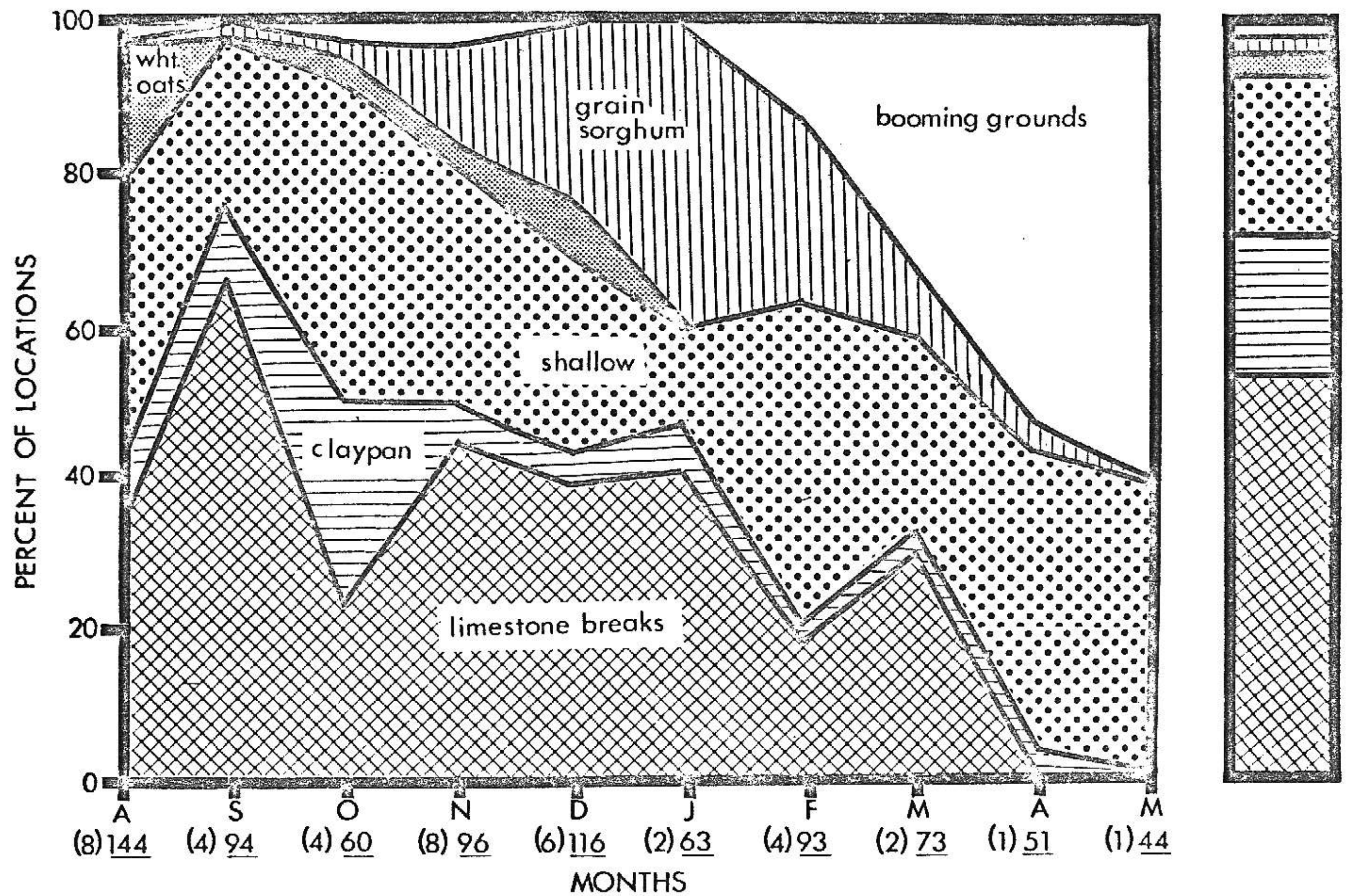


Fig. 5. Monthly site distribution of 834 radio-telemetry locations of juvenile greater prairie chickens tracked during the entire study. Numbers in parentheses are the number of birds tracked for that month. Numbers underlined are the number of locations used for that month.

crop type much oftener than might be expected. The same was true of the high index (18.26) for grain sorghum in January, because of a high utilization by a single juvenile male of the grain sorghum crop type during that month.

Juvenile Predation

During the entire study, a total of 92 greater prairie chickens were transmitter-equipped; 24 (26.1 percent) juveniles and 68 (73.9 percent) adults. During the entire study of the 92 transmitter-equipped birds, 22 (23.9 percent) were known to have been killed by predators. Of 22 predator-killed birds, 8 (36.4 percent) were adults. Five (57.0 percent) of the eight juvenile birds killed by predators were killed during September.

Brood Movements

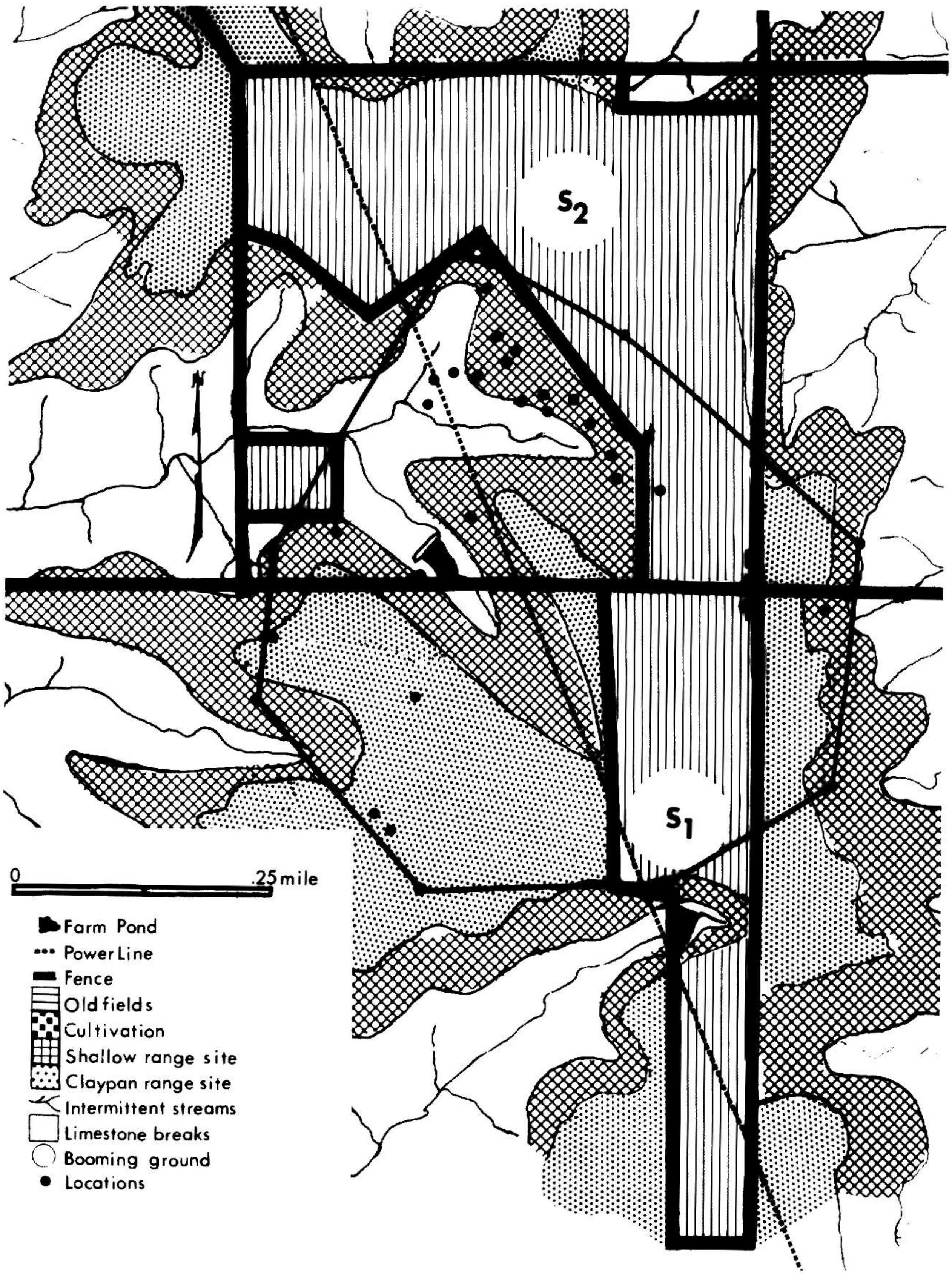
A description of selected individual brood movements is presented here as a foundation for comparison prior to presenting dispersal data.

Adult female number 54 (AF54) was captured on 16 June 1966, and was on her nest from then until 24 June 1966 at which time her clutch began to hatch and an unknown predator partially destroyed the nest. AF54 was successful in bringing off three chicks. The brood range (Fig.6) of AF54 and her brood, for the period of 24 June to 6 July 1966 was concentrated within a 174-acre area closely associated with an old field. The brood was most often found in shallow grassy draws of the shallow range site (preference index 2.44). Low preference indices of 0.78 and 0.39 occurred for the limestone break and claypan range sites, respectively.

On 12 August 1968, 3 members of a brood containing 6 chicks

EXPLANATION OF FIGURE 6.

Fig. 6. Brood range of AF54 and her brood from 24 June to 6 July 1966.


S2
S1
0
.25 mile
Farm Pond
Power Line
Fence
Old fields
Cultivation
Shallow range site
Claypan range site
Intermittent streams
Limestone breaks
Booming ground
Locations

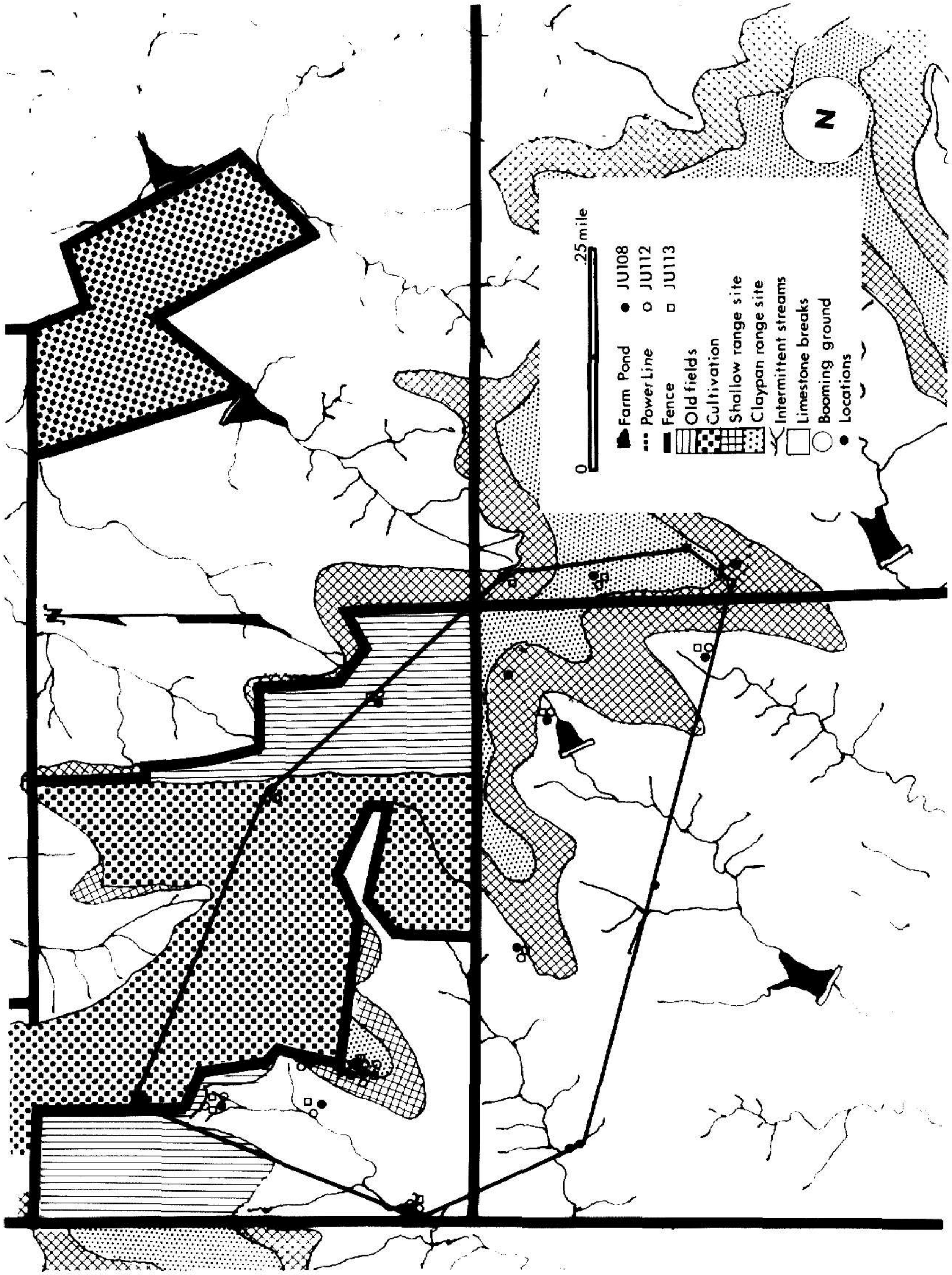
and the brood hen were captured. The brood range (Fig. 7) of this brood (Brood II) from 12 to 31 August covered 214 acres, and was closely associated with cultivation. A very high preference (preference index 21.20) was shown for the wheat and oats habitat type. Some preference (preference index 1.38) was shown for the shallow range site, while the limestone breaks and claypan range sites were frequented less than would be expected on the basis of availability (preference indices 0.66 and 0.79, respectively). The movements of Brood II were characterized by movements of the brood as an intact unit. Average distances between brood members had not yet begun to increase with time (Fig. 8).

On only four occasions during the study were two or more members of a brood captured simultaneously, and only on one of these occasions were all members of an intact brood radio-tagged. For this reason, it is difficult to present solid data on brood break-up. However, all four of these broods show similar behavioral tendencies and may represent brood break-up.

On 23 August 1965, a brood of five prairie chickens (Brood I) was captured in a walk-in trap on the Simpson Ranch. Two members (Ju24 and Ju28) of the brood were radio-tagged, and their movements monitored from 23 August to 20 September 1965 (Fig. 9). Until 5 September when Ju24 initiated an initial dispersal movement, and on 7 September, Ju28 did the same, Brood I was on its brood break-up range. The brood hen (AF14) was not with the brood at that time. The break-up range of Ju24 and Ju28 covered 109 acres and was almost exclusively associated with the limestone break range site. This was the only instance in which juvenile birds in late summer were not associated with some sort of cultivation

EXPLANATION OF FIGURE 7.

Fig. 7. Brood range of Brood II from 12 August 1968 to 31 August 1968.


N
0
.25 mile
Farm Pond
Power Line
Fence
Old fields
Cultivation
Shallow range site
Claypan range site
Intermittent streams
Limestone breaks
Booming ground
Locations
JU108
JU112
JU113

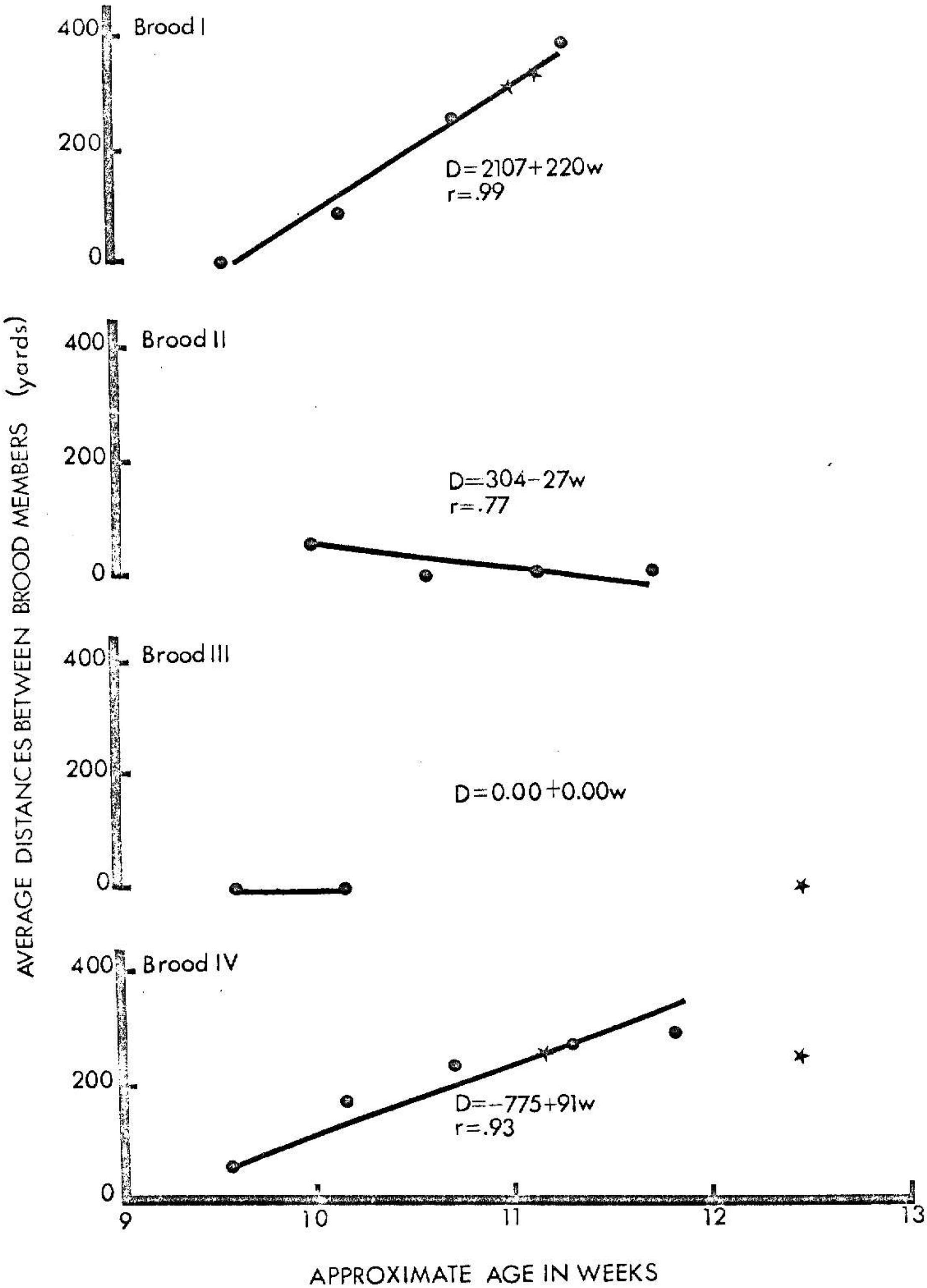
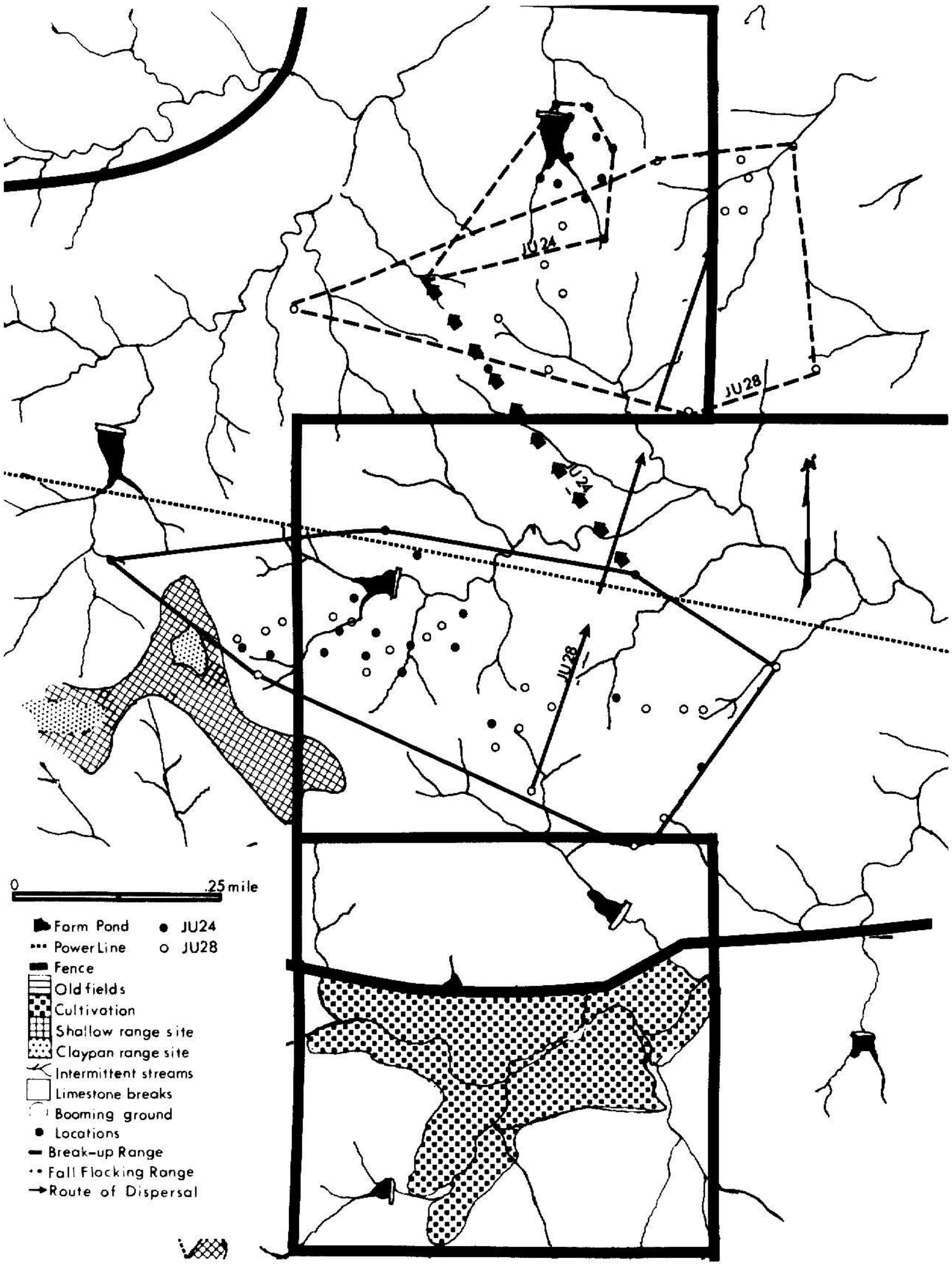


Fig. 8. Average distances between brood members from capture until initiation of dispersal.
*Initiation of dispersal of brood members
D= Distance
w= Week

EXPLANATION OF FIGURE 9.

Fig. 9. The break-up range (23 August to 5 September 1965) of JU24 and JU28, their dispersal movements (5 September and 7 September 1965, respectively), and their fall flocking ranges until 14 September 1965 (JU24) and 20 September 1965 (JU28).



JU24
JU28
JU24
JU28
0
.25 mile
Farm Pond
JU24
Power Line
JU28
Fence
Old fields
Cultivation
Shallow range site
Claypan range site
Intermittent streams
Limestone breaks
Booming ground
Locations
Break-up Range
Fall Flocking Range
Route of Dispersal

or old field habitat. While Ju24 and Ju28 were on their break-up range the average distances between them increased progressively until dispersal occurred (Fig. 8).

Two members of Brood III (Ju115 and JM116) were captured on 7 August 1969. Ju115 was lost due to radio failure on 13 August 1969. For this reason, break-up data for Brood III is lacking. Radio locations of two transmitter-equipped members of this brood, Ju115 and JM116, while both were still on the air indicate that break-up had not begun and at least those two brood members were moving as a unit.

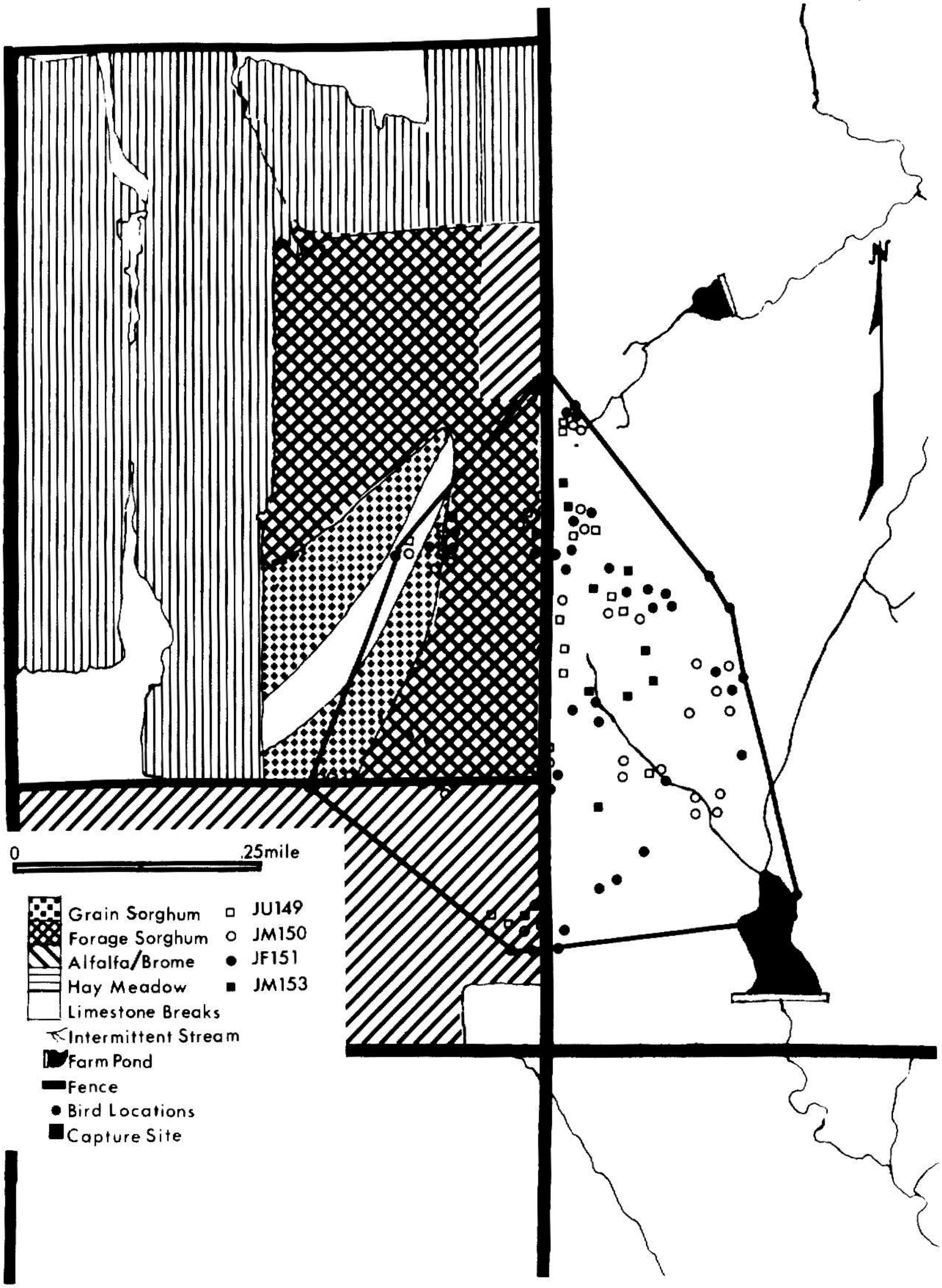
On 30 August 1970, three members of Brood IV were captured in a walk-in trap on the Lutheran pasture study area. On 7 September 1970, the fourth member of the brood was captured. The brood break-up range of Brood IV covered 94 acres and was exclusively within the loamy upland range site and associated cultivation (Fig. 10). The ranges of two members of Brood IV (JM150 and JM153), during the break-up period, are shown in Figs. 11 and 12. These ranges covered 81 acres and 39 acres, respectively. Note that during the break-up period the average distances between the members of Brood IV increased as time progressed (Fig. 8).

Initial Dispersal

Dispersal data of six juvenile greater prairie chickens are presented in Table 6. Four of the six moved from their break-up ranges to their early fall flocking ranges. One (Ju148) was approximately 10 weeks of age at the time of capture. After a period of inactivity following capture, Ju148 began to move east from the point of capture. It continued this movement for

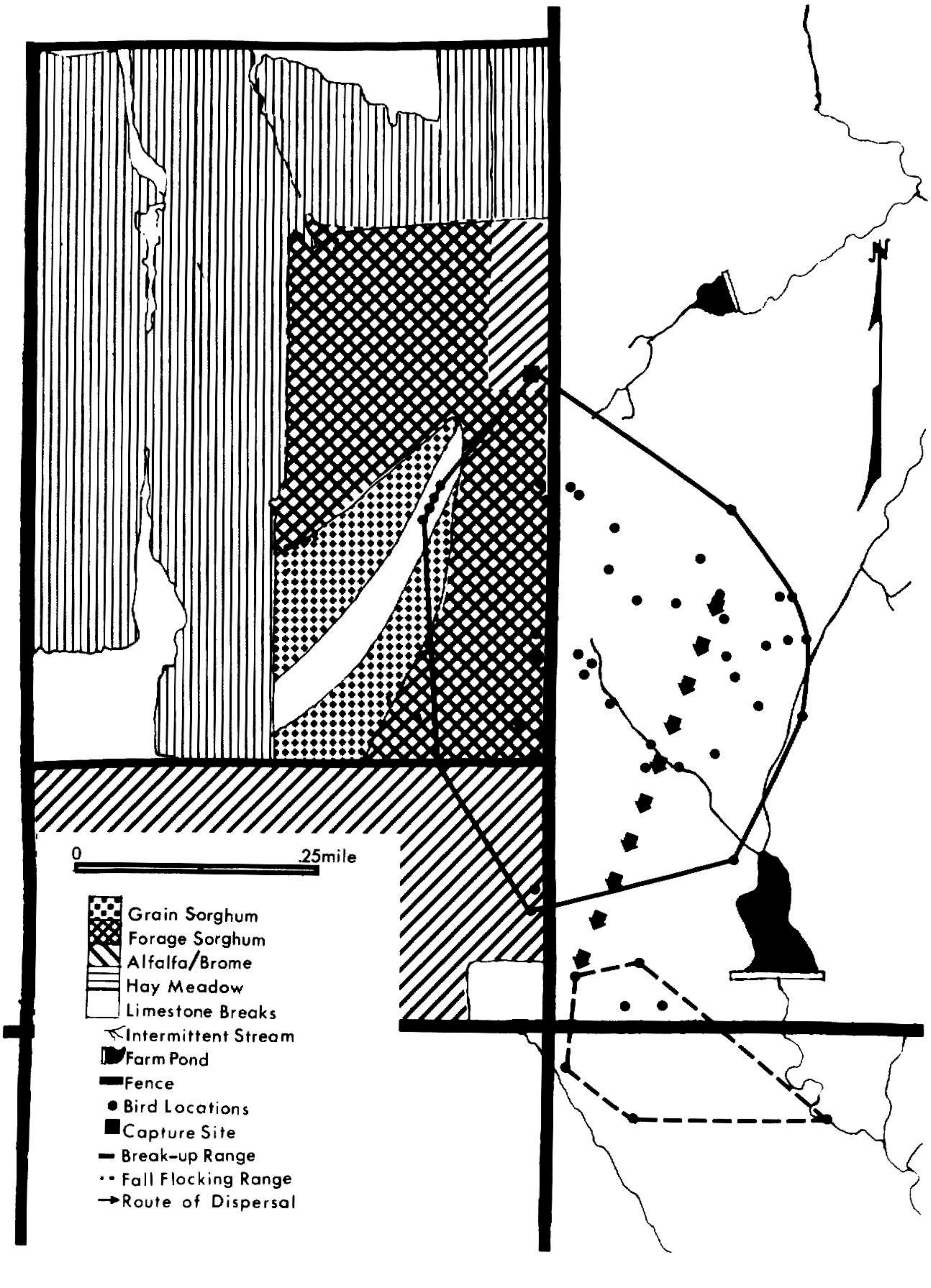
EXPLANATION OF FIGURE 10.

Fig. 10. Brood range and brood break-up range of Brood IV from 30 August to 8 October 1970.


N
0
.25mile
Grain Sorghum
Forage Sorghum
Alfalfa/Brome
Hay Meadow
Limestone Breaks
Intermittent Stream
Farm Pond
Fence
Bird Locations
Capture Site
JU149
JM150
JF151
JM153

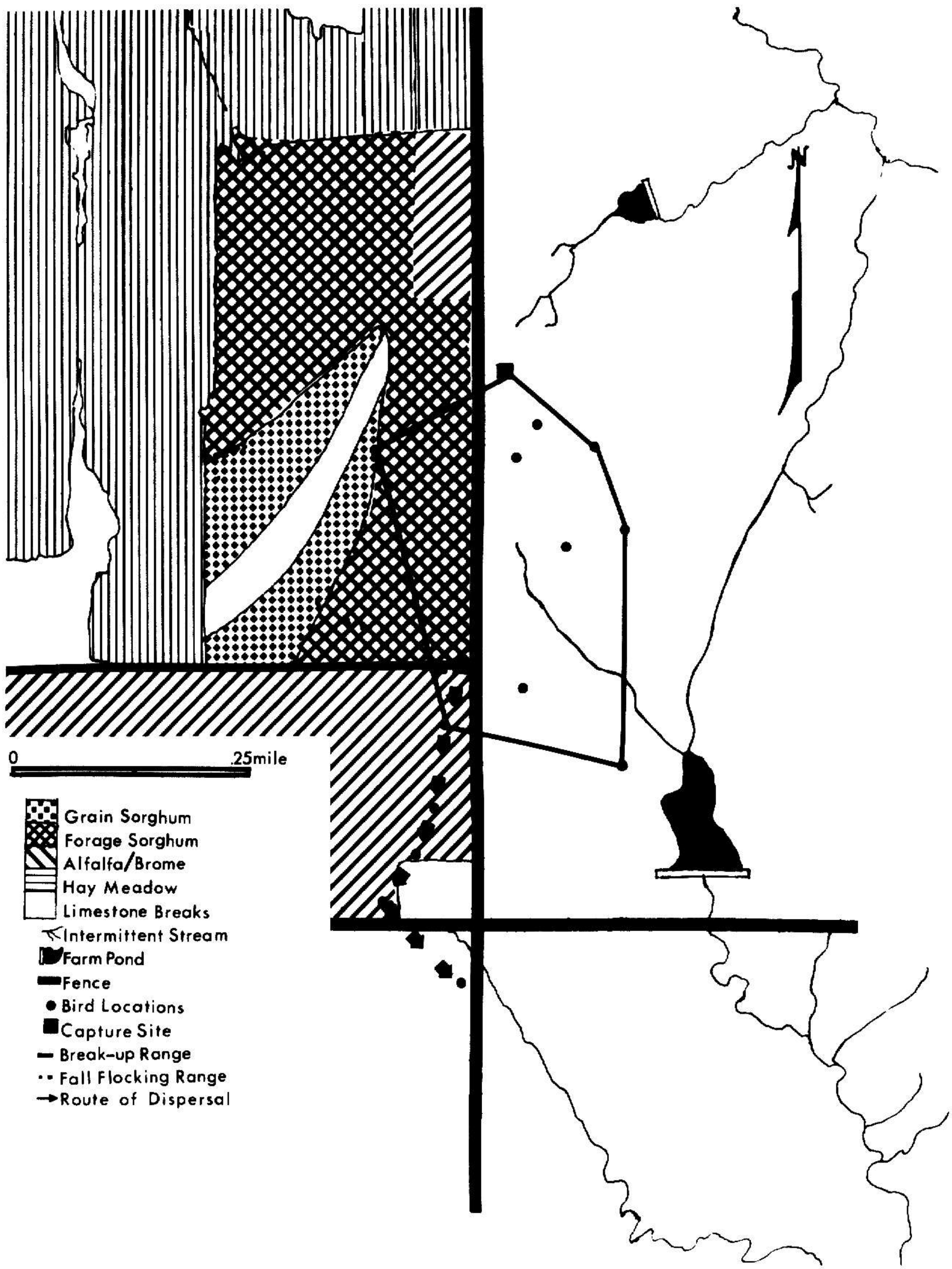
EXPLANATION OF FIGURE 11.

Fig. 11. Break-up range (30 August to 23 September 1970), dispersal movement (23 September 1970), and fall flocking range (24 September to 28 September 1970) of JM150.


N
0
.25mile
Grain Sorghum
Forage Sorghum
Alfalfa/Brome
Hay Meadow
Limestone Breaks
Intermittent Stream
Farm Pond
Fence
Bird Locations
Capture Site
Break-up Range
Fall Flocking Range
Route of Dispersal

EXPLANATION OF FIGURE 12.

Fig. 12. Break-up range of JM153 (7 September to 14 September 1970), and its subsequent dispersal movements (14 and 15 September 1970), prior to being killed by a predator on 15 September 1970.



N
0
.25mile
Grain Sorghum
Forage Sorghum
Alfalfa/Brome
Hay Meadow
Limestone Breaks
Intermittent Stream
Farm Pond
Fence
Bird Locations
Capture Site
Break-up Range
Fall Flocking Range
Route of Dispersal

Table 6 Dispersal of 6 transmitter-equipped greater prairie chickens.

	Prairie Chicken Number	Sex	Dispersal Period	Number of days involved	Daily Maximum (yds.)	Daily Average (yds.)	Total Linear Distance (yds.)
Simpson Ranch	JU24	unknown	5 Sept. to 7 Sept. 1965	3	564	394	1179
	JU28	unknown	6 Sept. 1965	1	1320	1320	1320
	JM116	male	30 Aug. to 1 Sept. 1969	3	550	431	1285
Lutheran Pasture	JU148*	unknown	27 Aug. to 30 Aug. 1970	3.5	440	291	1038
	JM150	male	23 Sept. 1970	1	1182	1182	1182
	JM153*	male	14 Sept. to 15 Sept. 1970	2	302	316	634

*Believed killed before end of dispersal movement.

about 0.41 mile until it was killed by a coyote (Canis latrans). Because of its age and because of its relatively long straight line movement, it is believed that Ju148 was captured during or just prior to its dispersal period. The sixth, JM153, was also killed by a coyote, either during or just after its dispersal period (Fig. 12).

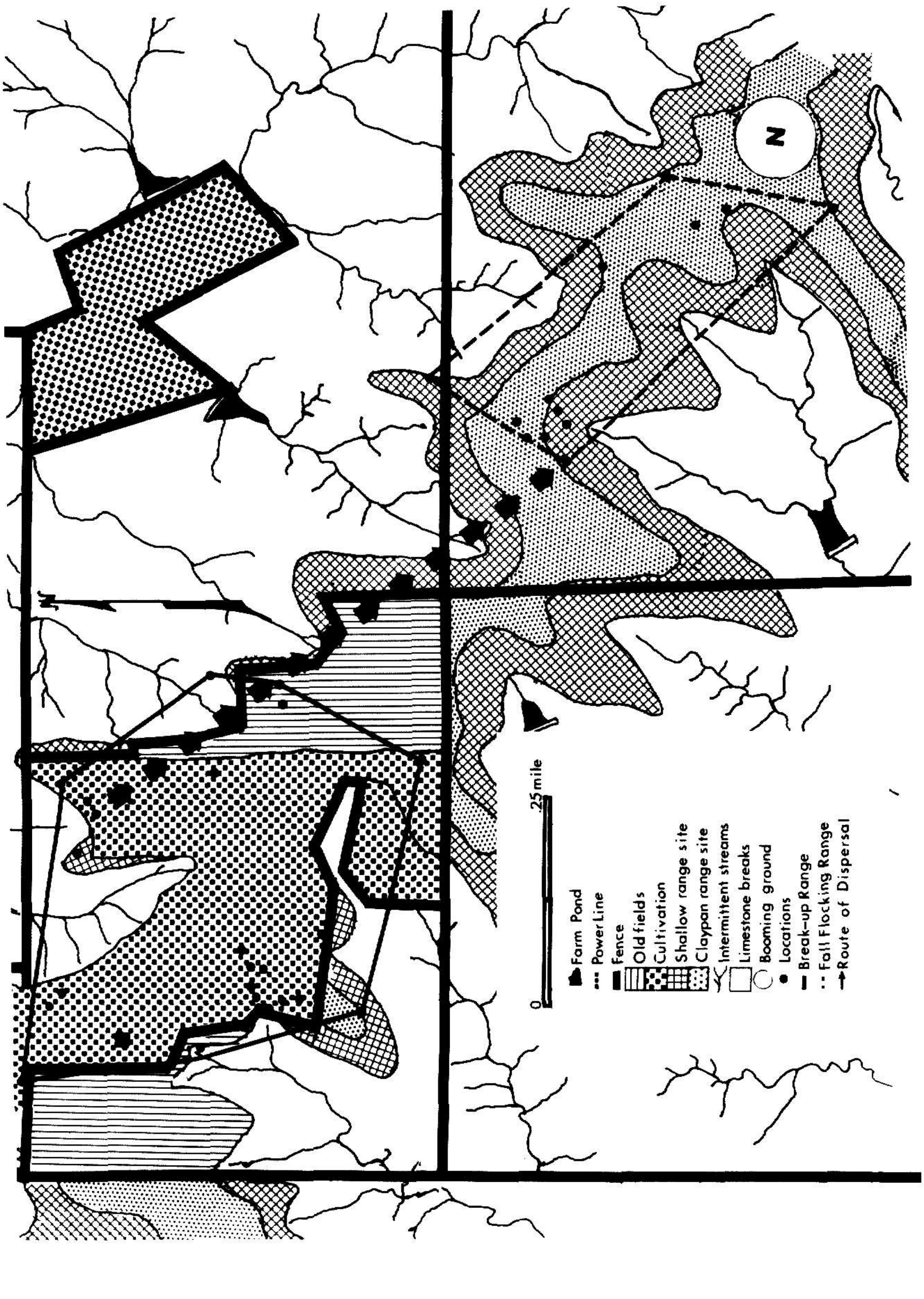
At 1400 on 5 September 1966, Ju24 initiated an early dispersal movement from the northeastern edge of its break-up range (Fig. 9). It was not located again until 7 September at 1420. It had moved 770 yards to the northwest where it joined an adult female. On 8 September, Ju24 had joined a flock of prairie chickens 385 yards east-northeast of its 7 September location. A brood mate (Ju28) was on the southern edge of its break-up range at 1130 on 6 September (Fig. 9). Ju28 was located 1320 yards to the northeast at 0845 on 7 September within the area that was to become its fall flocking range. Ju24 and Ju28 were seen together in the same flock in the fall. Ju24 was killed by a predator on 14 September, and Ju28 was killed by a hunter during the 1965 Kansas prairie chicken season.

JM116 (member of Brood III) was on the northern edge of its brood range in the edge of a grain sorghum field at 0145 hours on 30 August 1969 (Fig. 13). The bird was not located again until 0030 on 1 September, when it was located 1100 yards to the southeast. At 1400, the same day (1 September) JM116 had moved another 192 yards to the southeast to a point on the western tip of its fall flocking range. JM116 was seen on several occasions with other birds before its signal was lost on 8 September.

At 0700 on 22 September 1970, a member of Brood IV (JM150)

EXPLANATION OF FIGURE 13.

Fig. 13. Break-up range (7 August to 30 August 1969), dispersal movement (30 August to 1 September 1969), and fall flocking range (1 September to 8 September 1969) of JM116.


N
0
.25 mile
Farm Pond
Power Line
Fence
Old fields
Cultivation
Shallow range site
Claypan range site
Intermittent streams
Limestone breaks
Booming ground
Locations
Break-up Range
Fall Flocking Range
Route of Dispersal

was flushed from a forage sorghum field with a flock of 75 prairie chickens. Although two other remaining members of the brood were also in the same feeding area, they did not flush with the flock. On the night of 22 September, JM150 was back in the usual brood roosting spot with the rest of the brood. As it was monitored until after 2200 hours that night, it is believed that JM150 stayed there all night. At approximately 0800 the next morning (23 September), JM150 was with the large flock again, 688 yards away from where it had roosted with the brood the previous night. This bird was monitored most of the morning, and was observed to move to the southeast an additional 495 yards. The bird's movements then became those of the large flock until on 28 September when it was found dead in a deep eroded gully in the pasture corner (Fig. 11).

Late Fall and Early Winter Dispersal Movements

During the entire study, only four transmitter-equipped birds have been known to have left the study area; three of these were juveniles. The three juveniles leaving the study area were males (JM28, JM82, and JM84). Distances of movement from the original point of capture to their last known locations were 6.7, 2.7, and 4.3 miles, respectively. All three were killed in their first fall; JM82 by a great horned owl (Bubo virginianus), JM84 by an unknown predator, and JM28 by a hunter. Other fairly extensive movements from the original point of capture within the Simpson Ranch study area were those of JM34 (2.56 miles) and JM123 (1.78 miles). Most juvenile movements were not so extensive as the five examples just presented. Of the 24 juveniles monitored, only 2 (8 percent) moved 3.00 or more miles, 4 (17 percent) moved 2.00 or more miles, and 5 (21 percent) moved 1.00 or more miles from the point of capture to the last location point. Of the 24 juveniles, 19 (79 percent) were last located less than 1.0 mile from the original point of capture (Table 7). It should be noted that some bias may be involved here, because the bulk of the short distance movements were recorded only during short periods of time in summer, early fall, or spring. All long distance movements took place during the winter months and involved birds that had been monitored for relatively long periods of time.

Duration and Distance of Dispersal

Dispersal patterns of six juvenile greater prairie chickens which had been radio-tagged and monitored through their initial dispersal are found in Table 6. All dispersal movements took place during late August and September and were from 1.00 to 3.50 days in duration. The average distance of the initial dispersal moves was 0.68 mile, and the mean daily movement was 0.37 mile.

Non-dispersal

On two occasions, birds did not make dispersal movements (e.g. they did not move from a brood range to a flocking range or from one flock to another). Both were juvenile females. JF58 was monitored from 10 August 1966 to 4 November 1966, entirely on the original brood area. JF151, a member of Brood IV, was captured on 30 August 1970 and was last recorded on 8 October 1970 roosting in Brood IV's usual roosting spot, even though all other members of Brood IV had dispersed. This bird was often seen feeding with the flock which two other members of its brood had already joined, but never moved elsewhere with the flock.

Table 7 Distances between point of capture and last known location of 24 juvenile greater prairie chickens.

Band Number	Date of Initial Capture	Date of Last Record	Total Days Tracked	Effective Distance(mi.)
JM 82	21 Nov. 1967	31 Mar. 1968	131	2.70
JF 58	10 Aug. 1966	4 Nov. 1966	88	0.36
JM 61	8 Nov. 1966	1 Jan. 1967	55	0.87
JM 62	8 Feb. 1967	2 Apr. 1967	53	0.00
JF 31	17 Oct. 1965	10 Dec. 1965	52	0.32
JM 34	24 Nov. 1965	6 Jan. 1965	44	2.56
JM 65	13 Feb. 1967	25 May 1967	41	0.00
JF151	30 Aug. 1970	8 Oct. 1970	40	0.26
JM 84	28 Nov. 1967	1 Jan. 1968	36	4.32
JU108	12 Aug. 1968	14 Sept.1968	33	0.64
JM116	7 Aug. 1969	8 Sept.1969	33	1.00
JF 33	23 Nov. 1965	29 Dec. 1965	30	0.85
JM150	30 Aug. 1970	28 Sept.1970	30	0.63
JU 28	23 Aug. 1965	7 Nov. 1965	29	6.70
JU 24	23 Aug. 1965	15 Sept.1965	15	0.88
JM 63	8 Feb. 1967	1 Mar. 1967	22	0.00
JU112	12 Aug. 1968	7 Sept.1968	26	0.81
JU113	12 Aug. 1968	7 Sept.1968	26	0.84
JM123	25 Aug. 1969	9 Nov. 1969	15	1.78
JU148	22 Aug. 1970	31 Aug. 1970	10	0.41
JM149	30 Aug. 1970	27 Sept.1970	10	0.66
JM153	7 Sept.1970	16 Sept.1970	10	0.50
JU115	7 Aug. 1969	13 Aug. 1969	7	0.19
JF 30	17 Oct. 1965	6 Nov. 1965	4	0.30

All other birds monitored in the late summer and fall dispersed to become associated with flocks of prairie chickens, or were killed by predators during dispersal. Moves later in the fall and winter were always either with flocks or from one flock to another.

Association With Booming Grounds

Five juvenile males were captured in the fall and early winter. Four were captured on the central booming ground of the Simpson Ranch and one was captured in a walk-in trap in a pasture adjacent to the Simpson Ranch.

JM34 was trapped on the central booming ground in November 1965 and until late that December, associated closely with the flock of birds utilizing the central booming ground. In late December, the bird moved 0.74 mile south of the booming ground with several other birds and remained in that area until its signal was lost in early January 1966.

A juvenile male (JM82) captured on the central booming ground in November 1967, had moved to a grain sorghum field to the south with 19 other prairie chickens by early December. On 31 March 1968, it was killed by a great horned owl, 2.7 miles east of the point of capture. JM84 was captured on the central booming ground in November 1967 and was found dead 4.3 miles northwest of the point of capture on 31 March 1967. JM123 was captured on the central booming ground in October 1969, and associated with the local booming flock until November, at which time it left the flock and was last recorded 1.78 miles from the point of capture.

Three juvenile males were captured in February on the central booming ground on the Simpson Ranch. JM62 was trapped on the booming ground in February 1967 and although its signal was lost on 21 February, the bird was sighted on the central booming ground as late as 2 April 1967. A second juvenile male (JM63) was trapped on the central booming ground in February 1967 and was last seen on the central booming ground on 1 March 1967. JM65 was captured on the central booming ground in February 1967 and continued to visit the booming ground at least until 26 May 1967.

Throughout the study, there was no record of juvenile females visiting the fall booming ground, nor was there any record of juvenile females on the booming ground in their first spring.

Discussion

Materials and Methods

Little change in technique and methodology has been realized for the 1969-1970 phase of the study from that of past phases. For this reason, only those techniques which have been substantially changed or newly innovated will be discussed here.

Modifications made in walk-in traps used for late summer trapping in 1969 and 1970 are believed to have enhanced trapping success. However, it should be realized that not only were changes made in the traps, but a completely new study area was trapped. Pre-baiting the traps before installing the funnels, as well as periodic removal of funnels after first installing them, was important. The larger traps (I.E. those measuring 8 x 8 x 2 feet) were most successful because they were conspicuous and could be more heavily baited. Baiting with the current prevailing cultivated grain is probably requisite for trapping success. It was found that after the grain crop in the area being trapped was harvested and spillage occurred, trapping success on that area was radically reduced. Possibly trapping success would have increased as food became less abundant in late winter and early spring.

The aerial search and relocate technique proved to be highly valuable. Two adult males were relocated by this method, and their transmitters subsequently saved. The aerial search method was economically feasible, since the two transmitters recovered ($120.00 total value) exceeded the cost ($57.40 total value) of the four flights to attempt to locate six different birds during this phase of the study.

On one trip, an operating transmitter was placed on the study area prior to the search flight. The signal of that transmitter was picked up at well over 8 air miles from the study area. Thus, if the aerial technique is used correctly, it should be possible to locate any operating transmitter, if it is within 6 to 8 miles of the study area. This knowledge in itself is justification for a flight to relocate a lost bird. If during the aerial search the signal is not relocated, it can be assumed that the transmitter is no longer functioning. This allows the researcher to re-allocate time and effort that would otherwise be spent in gound searching for the lost bird.

Mobility Studies

Lack of data for certain parts of the year for juvenile prairie chickens was due to an inherent difficulty in trapping. Juvenile males could only occasionally be trapped on the fall and spring booming grounds, and females could virtually never be trapped on booming grounds until their second spring. Trapping at any other time of the year could only be done using walk-in traps, and this was successful only under the most optimum conditions.

Monthly Ranges

The term "monthly range" was used in this thesis because, as pointed out by Silvy (1968:84) and Watt (1969:87), it is more nearly correct when prairie chicken movements are considered than the term "monthly home range".

A short 2 to 3-day period of relatively low activity was exhibited by birds just after they were captured and transmitter equipped. Viers (1967:34), Silvy (1968:83), and Watt (1969:87) all had previously noted a similar period of low mobility. Marshall (1960) reported similar findings for juvenile ruffed grouse. For this reason, the stipulation of a minimum of 15 locations was made for delineating monthly ranges.

Mean monthly range of juvenile male greater prairie chickens showed an upward trend from August to an initial peak in December. This increase in monthly range size probably resulted from several causes. Birds became more and more mobile at that time and made more sallies farther from their initial center of activity. After initial dispersal in September and October, juvenile males joined flocks and their ranges became those of the flock they joined. A similar fall upward trend in monthly range size was reported by Watt (1969:88) for adult male greater prairie chickens. Because juvenile males joined adult male flocks, their ranges should show the same trends. From December to January, a sharp decrease in size of the mean monthly range was shown and then a second upward trend to a high point in March. This was to be expected because when conditions became more harsh and food more scarce, a wider foraging radius for the flock was necessary. Also, booming ground activity was on the upsweep in late February and March. The sharp decrease in size of mean monthly ranges for juvenile males after March could be due to increased food availability (succulent vegetation) near the booming ground at that time.

Mean monthly ranges of juvenile females exhibited an upward trend from August and September to a high in November. Because juvenile females do not join male flocks, and are seldom seen on booming grounds in the fall, their increased mean monthly range size cannot be explained in the same way that it was for juvenile males. The increase from September to November may have been due to restlessness to disperse, dispersal itself, and/or movements between feeding and roosting areas.

Mean Daily Movements

The author believes, as did Robel et al. (1970:300), that a much more meaningful insight to prairie chicken activity can be gained by using mean daily movements as an index to activity rather than monthly ranges. When dealing with daily movements, more data are available for analysis than when monthly ranges are delineated simply by connecting the outer location points on a base map.

Mean daily movements show an upward trend from August to a high in December. Juvenile males exhibited movements between the fall booming grounds and feeding, loafing, and roosting places during that time. However, the same sudden increase in daily movement patterns from August to November was also found for juvenile females, so that there is good evidence that other important factors cause this increased activity. Juvenile movements are consistently higher than those of adult birds (Robel et al. 1970:294). I believe that this increased activity in the late summer, fall, and early winter resulted from brood break-up and dispersal. This is not only true of initial dispersal, but also later in the fall and winter when juveniles are moving between flocks.

After the initial high mean daily movements of juvenile females and males in late fall and early winter, movements decreased. This probably reflected the reduced movements of the flocks the juvenile birds joined.

After January, increased daily activity was shown by juvenile males. In February and March, waste cultivated grain became more and more scarce, and the new growth of green vegetation was not yet available. It was probably necessary that flocks forage over a wider area to obtain sufficient food during the late winter period. This increased activity probably also reflected movements from feeding and roosting places to booming grounds, as well as movements between booming grounds for juvenile males.

A decline in magnitude of movements of juvenile males was observed after March. This probably reflected a more abundant food supply (an increase in the amount of succulent vegetation) as the season progressed. Also, as the booming season progressed and juvenile males were unable to establish themselves on a territory, they visited it less frequently and this may have reduced their mean daily movements.

Habitat Preference Index

A total of 834 radio telemetry locations for 19 juvenile greater prairie chickens was used to calculate habitat preference indices. Only birds monitored on the Simpson Ranch study area were used for this analysis.

Of the three major range sites, the shallow range site showed consistently higher preference indices than did the limestone breaks and claypan range site. The shallow range site is a gently sloping narrow transition zone near the crest of the Flint Hills between the limestone breaks range site below and the claypan range site above. Briggs (1968:47) believed that the relatively low density of vegetation on the shallow range site might most closely approximate the optimum cover requirement for greater prairie chickens. The location and slope of the shallow range site in relation to the other range sites may also account, in part, for its attractiveness to prairie chickens. Another important feature is a steady decrease in prairie chicken utilization of the shallow range site from October to January (Fig. 3). During the same period, a steady increase in utilization occurred in the sorghum crop type. This same trend was reported by Watt (1969:109). The decrease in use of the shallow site was probably due to an increased reliance upon the grain sorghum crop type.

Locations in the limestone breaks site accounted for 34 percent of the total locations for juvenile prairie chickens. On the study area, the limestone breaks range site was characterized by taller, more dense vegetation than in the shallow range site. Possibly, such dense vegetation does not constitute an optimum cover type. Only during September did the habitat preference index rise above 1.00 (1.24). September was the month of initial break-up and dispersal and there may have been increased utilization of the limestone breaks site because of the cover it afforded.

Consistently low preference indices for the claypan range site were recorded throughout the year. A single high preference index of 1.40 was recorded for October. That index, however, probably does not characterize the true situation, because the actual index was probably masked by the high preference shown by a single juvenile female for that range site.

Booming grounds provided an overall annual preference index of 10.61. This indicated an extremely high preference for that site. Juvenile males were active on the booming ground, during fall and spring. One possible function of fall booming may be to act as a form of "epidiectic display" (Wynne-Edwards, 1962:16) to further disperse juvenile males after they initially dispersed and joined a fall flock of males. On several occasions, juvenile males captured on the fall booming ground were known to move on from that booming flock while the season was not yet over. Possibly, they did so because of intolerance which manifests itself in aggression on the booming ground.

Wheat and oat fields accounted for 5.00 percent of all locations for juvenile prairie chickens throughout the study. The annual preference index was 2.05. The highest preference index (7.52) for the wheat and oats crop type occurred in August. This coincided with the harvest of these fields. Briggs (1968:45) noted that use of wheat and oats fields was high in summer and fall when waste grain was available. He also reported that utilization increased in winter when green wheat became available.

Grain sorghum accounted for 13.00 percent of all juvenile locations during the study (overall preference index 3.53). Juvenile prairie chickens showed greater preference for sorghum fields in winter and early spring. This was especially true from January through March. As winter progresses, natural foods become less abundant, necessitating greater utilization of available food on cultivated fields. When green succulent vegetation became available in April, prairie chickens utilized sorghum fields less.

Juvenile Mortality

The average clutch size on the Simpson Ranch study area, based upon 17 clutches, was 12 eggs (Watt 1969:60). During the study, 12 broods (10 weeks or older) were either transmitter equipped or observed in the field. The potential production of the 12 broods at the time of hatching was 144. The total number of juveniles observed in the 12 broods was 49. This reduction indicates a juvenile prairie chicken mortality during the first 10 weeks after hatching of approximately 66.0 percent. This mortality occurred prior to brood dispersal which occurred at about 11 to 13 weeks of age.

During the entire study, 22 prairie chickens were known to have been killed by predators. Eight (36.4 percent) were juveniles (26.0 percent of those killed) and 14 (63.6 percent) were adults (74.0 percent of those killed). Mortality due to predation was higher in juvenile greater prairie chickens than in adults. Note that over 57.0 percent of the known predation on juvenile greater prairie chickens occurred in September. September was the month in which most juvenile birds made their initial dispersal movements. Allee et al. (1949:363) considered dispersal to be a major factor in controlling population growth. If the mortality due to predation on juveniles making their initial dispersal movement is representative of that actually realized, then dispersal could, in this way, be an important population regulatory mechanism.

Brood Movements

During the 1969 and 1970 phase of the study, all brood activity prior to break-up was in close association with small grain cultivation and old fields. On two occasions in the summer of 1970, broods were observed, but not radio-tagged. On 22 June 1970, a brood, or part of a brood, of three chicks and the brood hen was flushed on the claypan range site on the Simpson Ranch, approximately 1.0 mile from the nearest cultivation. These chicks were approximately 3 weeks of age, and when flushed, did not leave the claypan range site. On 23 July 1970, a single 6-week old member of a brood was flushed from a grain sorghum pasture edge. There was evidence of dusting of several other birds in the same spot. Watt (1969:103) reported that 4-week or older broods were always observed in or near grain fields, field borders, or old fields. Viers (1967:33) speculated that the requirements of hens and broods less than 2 weeks of age were satisfied by revines. Schwartz (1945:68) noted that about 2 weeks after hatching, hens with broods began to range farther from the nesting vicinity to higher areas and fields of small grain; often visiting dusting spots in grain fields, cattle trails, paths, and other spots of bare ground.

Factors influencing brood movements are highly variable. Jones (1963:772) believed that areas in which broods were found generally had more forbs than occurred in areas utilized less by broods. He also found more broods in areas having large insect populations than in those areas where insects were not so abundant. Lehmann (1941:21) found that Attwater's prairie chicken broods moved toward areas with vegetation for shade. During this study, broods were found most often in or near cultivated areas with high insect populations. In the summers of 1969 and 1970, I observed prairie chickens of all sex and age groups dusting in the shade of large weed strips along field borders.

Brood Break-up and Dispersal

The terms brood break-up and dispersal have been used by several authors in the past, as synonomous activities when considered temporaly (Bump et al. 1947:256, Chambers and Sharp 1958:233, Eng 1959:50, Sullivan and Marshall 1960:53, Hale and Dorney 1963). These investigators were studying ruffed grouse and believed that juvenile grouse sporadically separated from the brood in September, probably initiated by juvenile males going to display centers. These sporadic movements from the brood range increased gradually until in early October, they decreased, and the juveniles no longer traveled far from a fall range.

Godfrey and Marshall (1969:615) showed evidence that break-up and dispersal rather than being two synonomous terms defining the same activity, were actually two specific behavioral activities. In the juvenile ruffed grouse, a definite brood break-up occurred and dispersal took place 2.5 weeks later. Zwickel (1968:465) reported similar findings for juvenile blue grouse.

I feel that there is a similar phenomenon exhibited in the greater prairie chicken. Brood break-up and dispersal were not so obviously separate for prairie chickens as they seem to have been for ruffed grouse, but they did appear as two distinct entities. In late August and early September, the individuals of a brood which had previously acted as a single unit tended to become more solitary and spread out over the brood range. The individuals of the brood then moved alone or in pairs on the break-up range. They would do this in the daytime, but at night the members of the brood would normally roost together in the usual roosting place. As the break-up period progressed, individuals of the brood spent less time together, until after about 2 weeks from initiation of break-up individuals began their early dispersal movements. During the break-up period, the break-up range remained relatively constant in size, and daily patterns for each individual became fairly predictable.

Godfrey and Marshall (1969:616) believed that photoperiodic control, meteorological changes, or age-specific response may be involved in the break down of the brood bond. It is possible that a mutual intolerance may have caused brood members to break away from the brood unit. On many occasions during routine monitoring of juvenile prairie chickens, two or more individuals moved together as a unit while other members of the brood remained solitary on the break-up range.

Initial Dispersal

The character of dispersal in juvenile greater prairie chickens is highly variable. Brood IV individuals initiated their dispersal movements throughout a 10-day period during September of 1970. Godfrey and Marshall (1969:616) characterized dispersal for ruffed grouse as "truly explosive, synchronized and rapid in character of the egress pattern away from the break-up ranges." Juvenile prairie chickens did not exhibit this explosiveness. Members of broods initiated their individual dispersal movements as much as 9 days apart.

The explosive nature of the dispersal of the ruffed grouse reported by Godfrey and Marshall (1969:616) resulted in a postulation that the proximal stimulus causing this dispersal was photoperiod. Although the same degree of synchrony was not attained in the dispersal of prairie chicken broods, a 10-day period is a fairly descrete period in time. Therefore, photoperiod cannot be ignored as a possible stimulus causing dispersal. Routine notes on prevailing weather conditions on the days which juvenile dispersal movements were initiated indicate that no marked meteorological changes (rainstorms, cold weather, etc.) were apparent at these times. Possibly, brood dispersal is an age specific phenomenon, and as broods mature a mutual intolerance between brood mates occurs, and a certain threshold of intolerance is reached causing the individuals to make their initial dispersal movements. Such a hypothesis may have been suggested by observations of Edminster (1947:43): "Juvenile ruffed grouse become more aggressive toward one another in October, coincidental with the birds leaving the brood."

Another possible stimulus for brood dispersal is that of local flocks. In every instance of known dispersal, the dispersing individual moved almost directly to the nearest local flock. Because of the short distances of most of these movements, it is possible the dispersing individual was aware of the flock's location. One juvenile male (JM150) of Brood IV was one day on the brood range and the next day with the local flock. It is possible that the dispersal movement did not entail an actual lone movement, but that the break-up range of the juvenile and the fall range of the flock overlapped, probably at a feed field, and the juvenile bird joined the flock there and remained with it when the flock left the feeding area.

Further Dispersal Movements

After the initial dispersal of juvenile greater prairie chickens from their break-up range to their first fall range, dispersal was not yet complete. In fact, dispersal of juvenile prairie chickens is not completed until they become established in a flock. This may not take place until they become part of a breeding flock. However, juveniles in this study normally became established in flocks before the end of winter. Dispersing juvenile prairie chickens are believed to be vulnerable and are often killed by predators before their dispersal is complete.

Johnston (1961:388) defined dispersal as "movement from the site of birth to site of breeding". If this definition of dispersal is used, then juvenile greater prairie chicken dispersal would include brood movements, initial brood dispersal and continued dispersal until juveniles mature and are established in a breeding population. Thus, dispersal may not be completed until the first or even second spring for many prairie chickens. Evidence that this is true was observed for many juveniles monitored in winter. They continued to move between flocks and to disperse to distances as far as 6.7 miles from the point of capture. This is not to say, however, that juvenile greater prairie chickens cannot become established with the first or any flock with which they come into contact. Possibly, a mechanism as described by Wynne-Edwards (1966:9) is involved in the dispersal of juvenile greater prairie chickens. Wynne-Edwards feels that when a juvenile joins a flock, the flock has "assessed" or will "assess" the potential carrying capacity of the flock habitat. The juvenile having just joined the flock will probably be very near the bottom of the social hierarchy and, therefore, if the carrying capacity of the habitat has not been exceeded the flock will accept the new bird. On the other hand, if the carrying capacity has been exceeded the juvenile may be forced to leave the flock and subsequently forced to move to another habitat in search of another flock. This may or may not involve active displacement of the juvenile. It may simply be that when feeding, a bird low on the flock social hierarchy is forced to the peripheral, less favorable feeding areas, or forced to less favorable cover when roosting. Such flock intolerance could force the juvenile to move from flock to flock until accepted.

In times of extreme weather or stresses of food shortage or high population, one would expect more "distributional accidentals". Population density could reach a point in favorable habitat at which time the habitat becomes less favorable and recruits move to marginal habitat that is favorable because of low density. In this way, the emigrants are able to avoid adversity due to over-population. Thus, the population is homeostatic due to social behavior.

Edminster (1947:43) hinted at a similar situation in juvenile ruffed grouse. He believed that in October, antagonism between brood mates reached a point at which they dispersed. If they came into contact with other birds they were met with varying degrees of aggression, until they reached a place where aggression was low and they could remain.

Conclusions

The following conclusions are believed justified on the basis of the data acquired throughout the entire study on juvenile movements:

1. Juvenile greater prairie chickens prefer the shallow range site throughout the year, more than would be expected on the basis of percent availability of that site.
2. Extensive movements of juveniles in the fall probably represent a segment of prairie chicken population dispersal, and, because of high juvenile mortality during that time of dispersal, it may act as an important population regulating mechanism.
3. Brood break-up and dispersal appear to be separate behavioral entities.
   a. Brood break-up: a period (2-3 weeks) characterized by prolonged periods of diurnal solitary movements of brood members.
   b. Initial dispersal: a period (1-3 days) of increased unidirectional movement of a single brood member, usually to the nearest local flock.
4. Maturation, manifesting itself through antagonism within

the brood, and the drawing force of local flocks may be important factors leading to the initiation of brood break-up and dispersal.

5. Extensive movements occur in the winter months, and dispersal probably continues until the dispersing juvenile becomes established in a flock.

6. Continued dispersal of juveniles until they reach adult status is probably dependant upon acceptance by a flock. If carrying capacity is high enough, the new recruits will be accepted. If carrying capacity is low, the juvenile may, in some way, be forced to move on.

7. More behavioral research is needed to assess 1) Interaction within the brood, 2) Interaction within the flock, 3) Changes in behavior when food is plentiful as opposed to when food is scarce.

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BROOD BREAK-UP AND DISPERSAL OF JUVENILE
GREATER PRAIRIE CHICKENS (*TYMPANUCHUS CUPIDO PINNATUS*)
IN NORTHEASTERN KANSAS

by

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In 1963, a 6-year study of greater prairie chicken (*Tympanuchus cupido pinnatus*) ecology was initiated on the 6000-acre Simpson Ranch in Northeastern Kansas. The main objectives of the over-all study were to determine: 1) seasonal and daily movement patterns, 2) behavioral patterns, and 3) habitat preferences of the greater prairie chicken. This portion (1969-1970) of the study deals with juvenile greater prairie chickens. Radio telemetry techniques developed by Marshall (1965) were used throughout the study.

Juvenile greater prairie chickens were captured in late summer and early fall in baited walk-in traps. Some juvenile males were captured on booming grounds with cannon nets. Miniature radio transmitters were attached to the trapped birds and their subsequent movements were monitored with portable receivers. A new aerial search and relocate method of finding lost transmitter equipped prairie chickens was devised in 1969.

Sufficient data were obtained throughout the entire study to calculate mean monthly ranges and mean daily movements for 24 juvenile greater prairie chickens. These data indicate that variations in mobility of juvenile greater prairie chickens during the year are closely correlated to habitat requirements and juvenile dispersal.

Habitat preference indices for 19 juvenile greater prairie chickens were calculated for 834 locations obtained during the entire study. Consistently higher preference indices were obtained for the shallow range site throughout the year than for the claypan and limestone breaks range site. As would be expected, high seasonal preferences were found for the wheat/oats, grain sorghum, and booming ground habitat types.

Data indicate that a mortality of as high as 66.0 percent may occur in juvenile greater prairie chickens in their first 10 weeks. In the month of September, when juvenile greater prairie chickens are about 11 to 13 weeks of age, 57.0 percent of all known predation on juveniles took place. September was the period of brood dispersal. Dispersal, therefore, may act as an important population regulatory mechanism.

Brood break-up and dispersal appear to be separate behavioral entities. Brood break-up is a 2 to 3 week period just prior to dispersal, characterized by prolonged periods of diurnal solitary movements of brood members. Initial dispersal occurs when juveniles are 11 to 13 weeks of age. It is a 1 to 3 day period of increased linear movement of single brood members, usually to the nearest local flock. Maturation and the drawing force of local flocks may be important factors leading to the initiation of brood break-up and dispersal. Continued dispersal of juveniles until they reach adult status is probably dependent upon acceptance by a flock, which may be a function of carrying capacity.