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Winter and Spring Ecology of Gray Partridge in East Central South Dakota

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WINTER AND SPRING ECOLOGY OF GRAY PARTRIDGE IN EAST CENTRAL SOUTH DAKOTA

BY

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WINTER AND SPRING ECOLOGY OF GRAY PARTRIDGE

IN EAST CENTRAL SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head, Dept. of Wildlife
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WINTER AND SPRING ECOLOGY OF GRAY PARTRIDGE IN EAST CENTRAL SOUTH DAKOTA

Abstract

Loren M. Smith

Gray partridge (Perdix perdix) habitat utilization, home range, and food habits were studied in Brookings County, South Dakota during winter and spring of 1979 and 1980. Habitat utilization and food habits data were analyzed in 2-month periods; winter (December 22-February 21), early spring (February 22-April 21), and late spring (April 22-June 21). Habitat utilization was determined through radio telemetry, roadside surveys, and incidental observations. Chi-square analysis was used to determine habitat selection of partridge. Home range was determined via radio telemetry data. Food habits were analyzed with percent volume and frequency of occurrence methods.

In winter partridge utilized pasture in a year with deep snow (56 cm) and row crops in a year with less snow (4 cm). Partridge may have been able to locate food more easily in a pasture than in a stubble field in a year with deep snow. In early spring during dispersal, pair formation, and selection of nesting territories, partridge utilized a greater variety of habitat types. Partridge utilized row crops and idle areas for this period in 1980. Birds utilized idle areas in late spring during the nesting period in both years.

An unknown sex gray partridge had a home range of 60 ha during

early spring. Two paired birds had home ranges of 10 ha and 17 ha, and an unpaired male had a home range of 224 ha in late spring. Home range was studied in 1980 only. Avian predators accounted for the majority of identified depredations on radio-tagged birds.

Green vegetation and corn were the most important food items eaten by gray partridge according to percent volume and percent occurrence methods. Sunflower seeds and oats were also important. Green and yellow foxtail (Setaria viridis, S. lutescens) represented the highest volumes and percent occurrences for weed seeds. Insects were an important food in late spring. Ants (Hymenoptera) and beetles (Coleoptera) represented the most commonly utilized insects.

INTRODUCTION

The first introductions of gray partridge (Perdix perdix) to South Dakota were in Brown and Roberts Counties in the 1920's (Roth 1977). Partridge stocking by the South Dakota Department of Game, Fish and Parks concluded in 1941. Partridge expanded their range throughout most of the state by the 1940's and today hunting is allowed in all but a few south central and southeastern counties. Although hunting occurs in most of the state, only 2 areas are considered to have stable populations. One stable population occurs in the northern tier of counties from Corson to Roberts County, and the other extends from Grant County south along the Minnesota border to Lincoln County on the east and Hutchinson County on the west (Roth 1977).

Most gray partridge are harvested incidental to ring-necked pheasant (Phasianus colchicus) hunting (Roth 1975). With the decline of the ring-necked pheasant population in South Dakota and the associated loss of habitat (Dahlgren 1967), gray partridge are becoming increasingly important to hunters in the state (Roth 1979).

Little research has been conducted on gray partridge in South Dakota. Study of this species has been limited to rural mail carrier surveys, hunter questionaires and bag checks. My objectives were to (1) determine winter and spring habitat utilization; (2) estimate home range; and (3) analyze food habits. Establishing recommendations or drawing conclusions on aspects of partridge ecology from results of studies from other regions could result in faulty management

decisions. Mayr (1970:195) stated "local populations differ not only in morphological character but also in numerous genetically controlled adaptive features of habit, ecology, and physiology." The lack of gray partridge research and the increased hunter utilization of the species in South Dakota provided impetus for the project.

LITERATURE REVIEW

Previous studies have shown gray partridge prefer open agricultural land (Yeatter 1934, McCabe and Hawkins 1946). Murtha (1967) suggested partridge require at least 60% active agricultural land to maintain low population levels. These areas should contain small grains, row crops, rangelands, and hay fields. Mettler (1977) hypothesized that one reason for the recent increase in partridge populations and decrease in pheasant populations in Minnesota may be the reduction of heavy cover utilized by pheasants and less stringent cover requirements of partridge. However, the importance of idle and woody cover to partridge within intensive agricultural areas has also been reported for some regions (Hunt 1974, Weigand 1977a).

Studies have shown that partridge utilized different habitat types during different seasons (Yeatter 1934, Weigand 1977a). Reports of winter habitat utilization in Michigan showed intensive use of small grain and row crop stubbles (Yeatter 1934); winter habitat use in Montana included idle and woody areas with readily available feeding sites (Weigand 1977a). Gates (1973) noted that while pheasants abandoned upland areas during winter and concentrated in wetlands, partridge utilized open fields and idle areas. Yeatter (1934) noted that in early spring partridge dispersion was random and birds used all available habitat types. During late spring partridge utilized young grain, hay fields, and roadsides. In Montana partridge utilized rangelands, hay fields, and idle areas in spring (Weigand 1977a).

Gray partridge are a fairly sedentary species rarely ranging over a 0.4 km radius (Yeatter 1934, Green and Hendrickson 1938, Yocum 1943, Bishop et al. 1977). Weigand (1977a) reported that 59% of the partridge population in his study remained within 210 m of their winter trap location and 86% within 630 m. Adult and subadult males were the most mobile group while subadult females were least mobile. Weigand noted occasional movements of greater distances which he attributed to decreased food availability resulting from severe weather conditions. Recently, use of radio telemetry has provided more accurate home range data. Winter home ranges estimated from radio telemetry data in North Dakota yielded a mean home range size of 24.5 ha for 6 coveys (Schulz 1974). Pre-nesting home ranges in spring (late March to mid-April), using this method range from 2.2-13.9 ha. Home range of breeding pairs was considered by Jenkins (1961) and Hunt (1974) to be mutual spacing between pairs in suitable habitat, with no defense of specific boundaries.

Partridge usually initiate pair bonds in late January and early February (Yeatter 1934, Green and Hendrickson 1938, Yocum 1943, Blank and Ash 1956). "Spring breakup" (birds separating from winter coveys) occurs in mid-February and early March. Partridge pair with intra-and intercovey birds (Blank and Ash 1956, Jenkins 1961, Weigand 1977b). Individual recognition allows partridge to select mates from outside the covey and likely promotes heterozygosity (Weigand 1977b). Range expansion may occur from the period of "spring breakup" to nesting. Reductions in local partridge populations occur due to emmigration

(Jenkins 1957, Blank and Ash 1962). The spring period has received little study and research needs for this season were expressed at the Perdix I Conference (Kobriger 1977b).

Kelso (1932) noted that cultivated grains, weed seeds, and green herbage made up the major proportion of gray partridge foods. Studies have shown that partridge utilized different foods during different seasons (Yeatter 1934, Middleton and Chitty 1937). Middleton and Chitty (1937) reported an increase in utilization of green vegetation by partridge from December to May. Increased use of cultivated grains occured in winter and spring in North Dakota and Alberta (Westerkov 1965, Kobriger 1977a). Yeatter (1934) reported that during winter partridge feed on weed seeds and grain in stubble fields, however, when the ground was covered with snow food was obtained in corn fields. Yeatter also noted that as fields were plowed in spring some cultivated grains were still utilized along with green vegetation. Potts (1970a, 1970b) demonstrated preference for weed seeds in the diet of partridge and that modern farming practices decrease the availability of weed seeds. Most food habit studies have been conducted in conjunction with hunting seasons in order to obtain large numbers of crops and, aside from the studies previously cited, little information exists on late winter and spring food habits (Gullion 1966).

Gray partridge mortality in winter is considered to be insignificant by many authors due to the ability of birds to survive severe winter conditions (Green and Hendrickson 1938, Westerkov 1966,

Gates 1973, Bishop et al. 1977). With the exception of Weigand (1977a) and Middleton (1949), who suggested early spring may be a period of high mortality, little mortality data exist on this period. Nest destruction and adult mortality during nesting appear to be an important cause of mortality. Farming practices in some areas are considered to be major causes of these losses (Yeatter 1934, Knott et al. 1943, McCabe and Hawkins 1946, Gates 1973), however in South Dakota and Iowa agricultural mortality is considered to be minor (Bishop et al. 1977, Hupp et al. 1980). Raptors are the main predators of adult partridge, although red fox (Vulpes fulva), coyotes (Canis latrans), and weasels (Mustela spp.) also prey on adults (Blank and Ash 1956, Weigand 1977a). For those regions where data were available, hunting was considered to contribute little to total mortality of partridge populations (Bishop et al. 1977, Weigand 1977a).

STUDY AREA

My study area was located 10 km northeast of Brookings and 1 km west of White in north-central Brookings County, South Dakota. The 62 km^2 (24 mi^2) area was dominated by row crops and small grains (Table 1). Other land uses included hay fields, pastures and idle areas. Major small grains include oats, barley, rye, and flax. Corn, sunflowers, and soybeans were the major row crops. Hay fields were alfalfa or alfalfa-smooth brome (Bromus inermis) mixtures. Major plant species in pastures included smooth brome, red and sweet clover, and bluegrass (Poa pratensis). Roadsides, farmsteads, shelterbelts, and fencerows were classified as idle areas.

Soils of the study area lie in the Prairie Coteau region and are mostly loam, silt loam, and silty clay loam alluvial soils (Westin et al. 1951). Soils range from level, medium to fine textured to gently sloping medium textured soils of central uplands. Climate in winter is prolonged cold while in spring it is moist, cool, and windy. During these periods, the region experiences slow moving frontal precipitation. Average annual precipitation is 54 cm with weekly means ranging from 0.23 cm in December to 2.54 cm in May. Temperatures range from a mean of -10.0 C in January to a mean of 23.3 C in July (Westin 1959).

Table 1. Land use on the 62 km^2 study area in Brookings County, South Dakota in 1979 and 1980.

Land use	% of total area	
	1979	1980
Small grain	37.51	27.41
Row crop	27.02	42.59
Hay	11.28	9.99
Pasture	13.81	12.55
Idle	10.39	7.46

METHODS AND MATERIALS

Telemetry

Partridge were live-trapped using bait, decoy, brood, and nest trapping techniques (Smith et al. 1980a, 1980b). Solar or mercury-battery powered transmitters (Telemetry Systems, Inc., Box 187, Mequon, WI 53092; AVM Instrument Co., Champaign, IL 61820), were attached to birds using an elastic loop tied around each wing. Radio-tagged partridge were monitored with a mobile yagi null-peak antenna system. Locations were determined by triangulation. Weather conditions, land use, and time were recorded for each location. Species of predators were classified by examination of dead radio-tagged partridge and field observations (Dumke and Pils 1973).

Roadside Survey and Incidental Sightings

One 48 km (30 mi) roadside survey was conducted weekly. Surveys began at sunrise and were driven between 16 and 30 km/hr. The starting point of the survey was alternated between the beginning point and the end point of the route each week. Incidental observations were also recorded on the study area. Partridge observations were coded for the 1.6 km (1 mi) in which they occurred. Time, number of birds, and land use combinations were recorded for each observation (Table 2). Land use combinations were determined by noting the land use on each side of the road from the observation.

Food Habits

Gray partridge were collected in Brookings County from 22

Table 2. Land use combinations available on the Brookings, South Dakota study area.

Land use combination	Land use combination
1. Grain - grain	6. Hay - pasture
2. Grain - hay	7. Hay - idle
3. Grain - pasture	8. Pasture - pasture
4. Grain - idle	9. Pasture - idle
5. Hay - hay	10. Idle - idle

December-21 June 1979, 1980. Crops were removed and contents dried at 80 C for 12 hours. Seeds and fruits were identified to the lowest possible taxonomic unit. Animal matter was classified as insect or non-insect animal matter.

Percent volume and percent occurrence methods were used to represent food habits (Martin et al. 1946, Korschgen 1948). Volumes were measured to the nearest 0.1 ml and samples less than 0.1 ml were considered traces. Small seeds were settled in a graduated cylinder and volume was recorded. Large seed and animal matter volume was determined using fine sand to fill air spaces between food items. Amount of sand used was subtracted from the volume.

Statistical Analysis

Data for each field season (22 December-21 June 1979, 22 December-21 June 1980) were analyzed separately due to differences in land use and weather conditions between years. Data were pooled and analyzed in 3, 2-month (bimonthly) time periods corresponding to (1) winter (December 22-February 21), (2) early spring (February 22-April 21), and (3) late spring (April 22-June 21). Birds are in coveys in winter but in early spring they separate from coveys, select mates, and disperse. In late spring most birds are paired and engaged in nesting activities. I considered tests with $P \leq 0.05$ as significant throughout the text.

I used chi-square goodness of fit tests to determine habitat selection of radio-tagged partridge (Zar 1974). Expected frequencies

were calculated from the available proportions of habitat types (Table 1). Tests were conducted on significant chi-square goodness of fit tests to determine which habitat types were utilized beyond proportional availability (Neu et al. 1974). If a bird moved off the study area the habitat types for the quarter section in which it moved were added to the total. A habitat type was classified as the land use to which it was planted until a new habitat type could be distinguished (e.g. corn was considered a row crop after it was plowed until small grain plants began to emerge). If 2 radio-tagged birds occurred in a single covey, these were treated as a single observation due to behavioral dependance. Chi-square contingency tests were used to determine if habitat use differed during day time (diurnal) periods. Expected frequencies for contingency tests were calculated from the total number of observations. The day was divided into 3 periods from 0.5 hour before sunrise to 0.5 hour after sunset. No more than 1 location for each bird in each time period was considered in the analysis. Chi-square contingency tests were also used to determine if habitat use changed among each bimonthly time period.

Home range estimates of radio-tagged partridge followed methods described by Dunn and Gipson (1977). Each home range area was calculated from a minimum of 15 bursts. One burst was a series of 4 locations with each location occurring 2.5 hours apart.

Chi-square goodness of fit tests were used to determine habitat utilization of partridge observed incidentally and during roadside surveys. Expected frequencies for the roadside surveys were calculated

from the available proportions of land use combinations on the roadside route (Table 2). Expected frequencies for incidental observations were calculated from the available proportions of land use combinations in the 1.6 km (1 mi) section in which they occurred. Due to small sample sizes, non-grain associated land use combinations were combined for chi-square analysis to conform with expected frequency recommendations of Cochran (1954) and Roscoe and Byars (1971). Tests were conducted on significant chi-square goodness of fit tests as described for telemetry data. Chi-square contingency tests were used to determine if habitat use differed among the 3 diurnal time periods for incidental observations in each bimonthly period. Contingency tests were also used to determine if habitat use changed among bimonthly time periods for the roadside survey data and incidental observations.

Habitat utilization was tested using coveys and total number of birds observed prior to covey break-up. Analysis of coveys avoids utilization of dependent observations within a covey, but does not allow for consideration of larger, dominant coveys utilizing more preferred habitat. Two-way analysis of variance was used to test for covey size differences among land use combinations (Steel and Torrie 1960). When covey size differed among habitat types, chi-square goodness of fit tests were used to determine habitat selection by individual partridge.

RESULTS

Telemetry

Habitat utilization by radio-tagged gray partridge changed significantly over each bimonthly time period in 1979 and 1980 (Tables 3 and 4). Partridge did not utilize habitat in proportion to habitat occurrence during winter in 1979 or 1980 (Tables 5 and 6). Small grains and hay were used significantly less than expected in both years (Tables 7 and 8). Pasture was used significantly more than expected in 1979. Pasture was utilized less than expected and row crops were utilized significantly more than expected in 1980. Habitat use did not change significantly among the 3 diurnal time periods in winter (Tables 9 and 10).

Radio-tagged partridge did not utilize habitat in proportion to habitat occurrence during early spring in 1979 or 1980 (Tables 5 and 6). Hay was used significantly less than expected for both years (Tables 7 and 8). Small grains were used significantly less than expected with row crops and idle areas being used more than expected in 1980. Habitat use changed significantly across the 3 diurnal time periods in 1979 but not in 1980 during early spring (Tables 9 and 10). An unknown sex gray partridge had a home range of 60 ha during this period (Fig. 1). Sex could not be determined since the bird was radio-tagged as a juvenile. Movements of 1 male partridge did not fit the model (Dunn and Gipson 1977) and therefore did not have a definite home range.

Radio-tagged partridge did not utilize habitat in proportion to

Table 3. Bimonthly chi-square analysis of habitat use by radio-tagged gray partridge in 1979 on the Brookings, South Dakota study area. The table presents number of observations and (N) indicates number of radio-tagged birds during each bimonthly period.

Time period	Habitat type					Chi-square value	Probability
	Small grain	Row crop	Hay	Pasture	Idle		
December 22–February 21 (N=21)	21	26	3	55	12		
February 22–April 21 (N=13)	23	26	1	17	18		
April 22–June 21 (N=4)	9	7	8	2	49	110.71	P=0.0001

Table 4. Bimonthly chi-square analysis of habitat use by radio-tagged gray partridge in 1980 on the Brookings, South Dakota study area. The table presents number of observations and (N) indicates number of radio-tagged birds during each bimonthly period.

Time period	Habitat type					Chi-square value	Probability
	Small grain	Row crop	Hay	Pasture	Idle		
December 22-February 21 (N=3)	5	79	0	2	6		
February 22-April 21 (N=8)	33	151	1	22	39		
April 22-June 21 (N=8)	35	29	5	12	49	104.83	P=0.0001

Table 5. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use by radio-tagged gray partridge in 1979 on the Brookings, South Dakota study area.

Time period	Number of radio-tagged partridge		Habitat type: Small grain	Row crop	Hay	Pasture	Idle	Chi-square value	Probability
December 22-February 21	21	OBS	21	26	3	55	12		
		EXP	43.9	31.6	13.2	16.2	12.2	114.19	P=0.0001
February 22-April 21	13	OBS	23	26	1	17	18		
		EXP	31.9	23.0	9.6	11.7	8.8	22.44	P=0.0002
April 22-June 21	4	OBS	9	7	8	2	49		
		EXP	28.1	20.3	8.5	10.4	7.8	46.37	P=0.0001

Table 6. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use by radio-tagged gray partridge in 1980 on the Brookings, South Dakota study area.

Time period	Number of radio-tagged partridge		Habitat type: Small grain	Row crop	Hay	Pasture	Idle	Chi-square value	Probability
December 22-February 21	3	OBS	5	79	0	2	6		
		EXP	25.2	39.2	9.2	11.5	6.9	65.66	P=0.0001
February 22-April 21	8	OBS	33	151	1	22	39		
		EXP	67.3	104.0	24.8	31.7	18.2	88.36	P=0.0001
April 22-June 21	8	OBS	35	29	5	12	49		
		EXP	47.1	43.3	13.3	16.8	9.5	178.20	P=0.0001

Table 7. Bimonthly tests for significance of habitat use (Neu et al. 1974) by radio-tagged gray partridge from significant chi-square tests (Table 5) in 1979 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Habitat type				
		Small grain	Row crop	Hay	Pasture	Idle
December 22–February 21	Proportion of total area	0.375*	0.270	0.113*	0.138*	0.104
	95% confidence interval on proportion of occurrence	$0.088 \leq P_1 \leq 0.270$	$0.123 \leq P_2 \leq 0.321$	$-0.009 \leq P_3 \leq 0.061$	$0.351 \leq P_4 \leq 0.589$	$0.031 \leq P_5 \leq 0.175$
February 22–April 21	Proportion of total area	0.375	0.270	0.113*	0.138	0.104
	95% confidence interval on proportion of occurrence	$0.147 \leq P_1 \leq 0.395$	$0.177 \leq P_2 \leq 0.435$	$-0.018 \leq P_3 \leq 0.042$	$0.088 \leq P_4 \leq 0.312$	$0.098 \leq P_5 \leq 0.326$
April 22–June 21	Proportion of total area	0.375*	0.270*	0.113	0.138*	0.104*
	95% confidence interval on proportion of occurrence	$0.023 \leq P_1 \leq 0.217$	$0.007 \leq P_2 \leq 0.179$	$0.015 \leq P_3 \leq 0.199$	$-0.021 \leq P_4 \leq 0.075$	$0.511 \leq P_5 \leq 0.795$

Table 8. Bimonthly tests for significance of habitat use (Neu et al. 1974) by radio-tagged gray partridge from significant chi-square tests (Table 6) in 1980 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Habitat type				
		Small grain	Row crop	Hay	Pasture	Idle
December 22-February 21	Proportion of total area	0,274*	0.426*	0.100*	0.126*	0.075
	95% confidence interval on proportion of occurrence	$-0.007 \leq P_1 \leq 0.115$	$0.766 \leq P_2 \leq 0.952$	$-0.014 \leq P_3 \leq 0.024$	$-0.017 \leq P_4 \leq 0.061$	$-0.001 \leq P_5 \leq 0.131$
February 22-April 21	Proportion of total area	0.274*	0.423*	0.101*	0.129	0.074*
	95% confidence interval on proportion of occurrence	$0.078 \leq P_1 \leq 0.190$	$0.534 \leq P_2 \leq 0.694$	$-0.006 \leq P_3 \leq 0.014$	$0.042 \leq P_4 \leq 0.136$	$0.098 \leq P_5 \leq 0.218$
April 22-June 21	Proportion of total area	0.362	0.333*	0.102*	0.129	0.073*
	95% confidence interval on proportion of occurrence	$0.169 \leq P_1 \leq 0.369$	$0.129 \leq P_2 \leq 0.317$	$-0.005 \leq P_3 \leq 0.081$	$0.027 \leq P_4 \leq 0.157$	$0.268 \leq P_5 \leq 0.486$

Table 9. Bimonthly chi-square analysis of habitat use by radio-tagged gray partridge according to day time periods in 1979 on the Brookings, South Dakota study area. The day was divided into 3 equal periods beginning 0.5 hours before sunrise and ending 0.5 hours after sunset. The table presents number of observations and (N) indicates number of radio-tagged birds during each bimonthly period.

Time period	Day time period	Habitat type					Chi-square value	Probability
		Small grain	Row crop	Hay	Pasture	Idle		
December 22-February 21 (N=21)	1	9	6	2	24	5		
	2	6	5	0	17	3		
	3	6	15	1	14	4	10.05	P=0.2618
February 22-April 21 (N=13)	1	9	12	1	9	5		
	2	6	10	1	6	13		
	3	8	4	0	1	0	16.87	P=0.0315
April 22-June 21 (N=4)	1	7	4	4	2	20		
	2	1	2	4	0	18		
	3	1	1	0	0	14	10.37	P=0.2402

Table 10. Bimonthly chi-square analysis of habitat use by radio-tagged gray partridge according to day time periods in 1980 on the Brookings, South Dakota study area. The day was divided into 3 equal periods beginning 0.5 hours before sunrise and ending 0.5 hours after sunset. The table presents number of observations and (N) indicates number of radio-tagged birds during each bimonthly period.

Time period	Day time period	Habitat type					Chi-square value	Probability
		Small grain	Row crop	Hay	Pasture	Idle		
December 22-February 21 (N=3)	1	1	25	0	0	3		
	2	2	26	0	2	2		
	3	2	28	0	0	1	5.38	P=0.4961
February 22-April 21 (N=8)	1	10	47	0	11	17		
	2	15	64	1	7	13		
	3	8	40	0	4	9	6.44	P=0.5986
April 22-June 21 (N=8)	1	13	10	1	5	18		
	2	14	13	3	4	20		
	3	8	6	1	3	11	1.29	P=0.9956

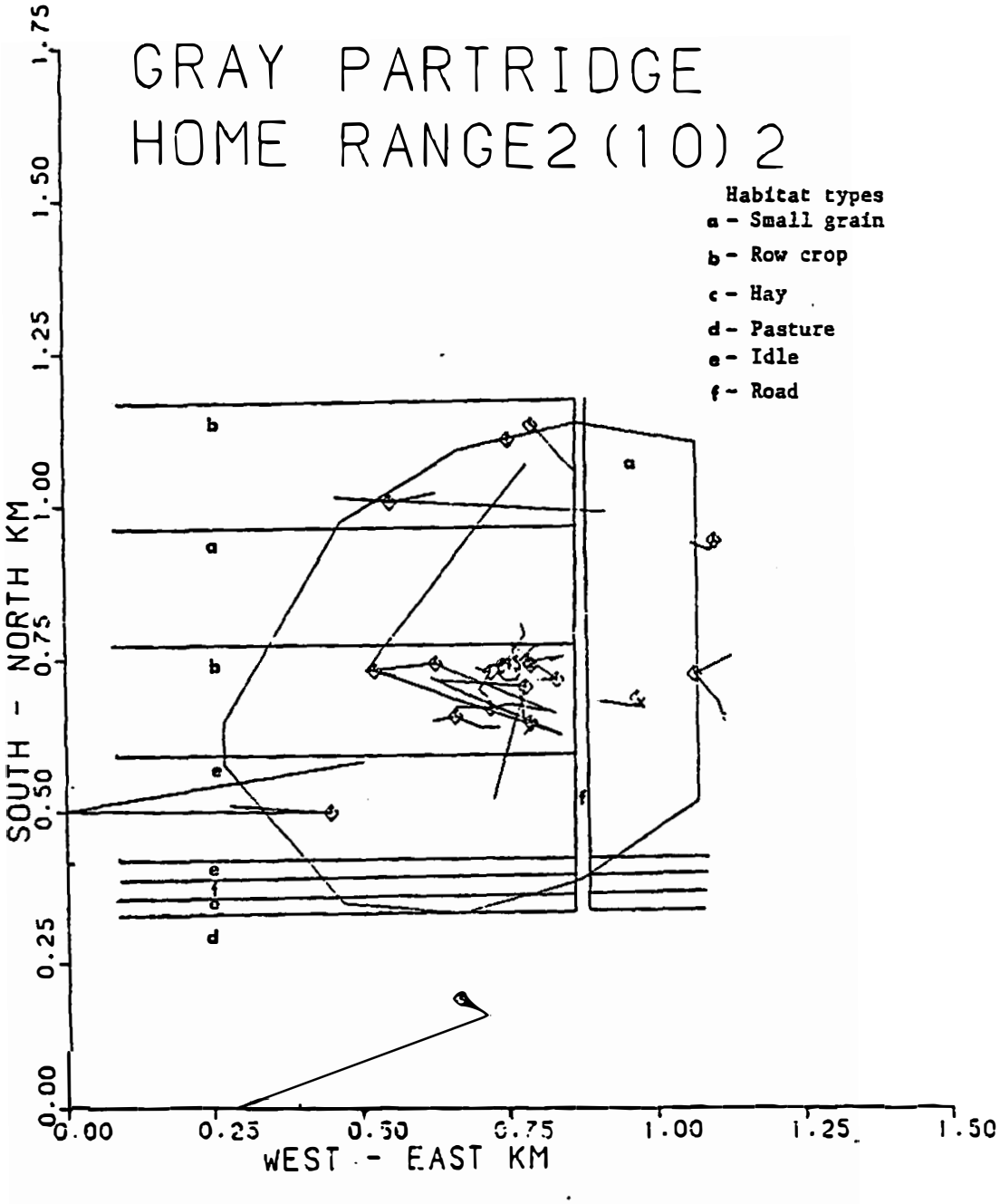

Fig. 1. Computer generated 95% confidence ellipse of home range (Dunn and Gipson 1977) for an unknown sex gray partridge on the Brookings, South Dakota study area, February 19, 1980 - April 1, 1980. ◇-lines are movements during 1 day. The area within the ellipse is 60 ha.

habitat occurrence during late spring in 1979 or 1980 (Tables 5 and 6). Row crops and pasture were used significantly less than expected and idle areas were used more than expected for both years (Tables 7 and 8). Small grain was used significantly less than expected in 1979 as was hay in 1980. Habitat use did not change significantly among the 3 diurnal time periods in 1979 or 1980 for the late spring period (Tables 9 and 10). A paired unknown sex partridge had a home range of 10 ha in late spring (Fig. 2). A paired male bird had a home range of 17 ha and an unpaired male had a home range of 224 ha for the same period (Figs. 3 and 4).

Roadside Survey

Gray partridge utilization of land use combinations changed significantly over each bimonthly time period in 1979 and 1980 (Tables 11 and 12). Partridge did not utilize land use combinations in proportion to land use combination occurrence during winter in 1979 or 1980 (Tables 13 and 14). Grain-grain was used significantly more than expected for both years (Tables 15 and 16). Grain-hay was used significantly less than expected for both years. Grain-pasture, grain-idle, and combined non-grain associated combinations were used significantly less than expected in 1980.

Partridge utilized land use combinations in proportion to land use combination occurrence during early and late spring in 1980 (Table 14). Partridge did not utilize land use combinations in proportion to land use combination occurrence in 1979 for these periods (Table 13). However significant deviations from expected

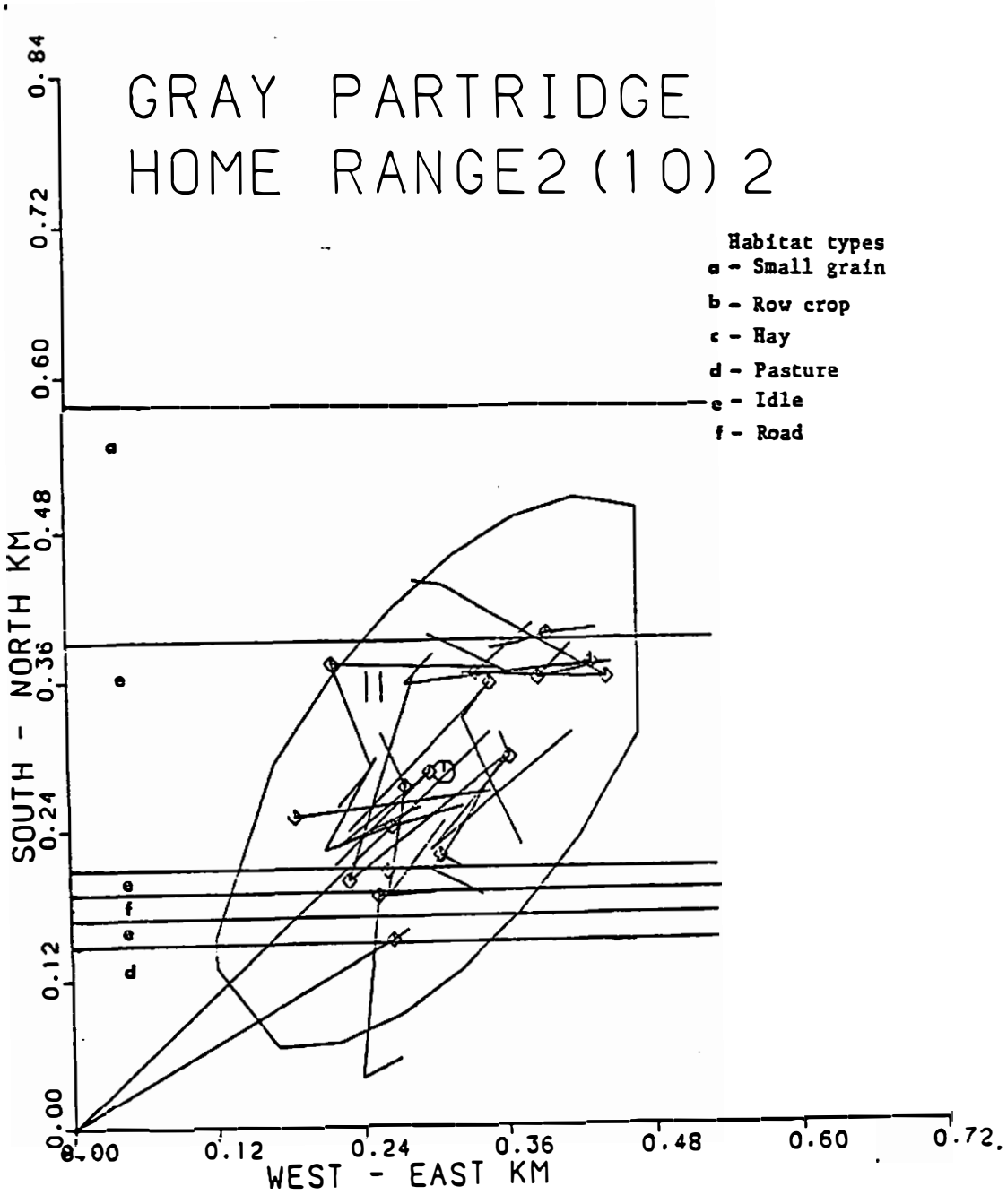

Fig. 2. Computer generated 95% confidence ellipse of home range (Dunn and Gipson 1977) for a paired unknown sex gray partridge on the Brookings, South Dakota study area, April 29, 1980 - May 22, 1980. ◇-lines are movements during 1 day. The area within the ellipse is 10 ha.

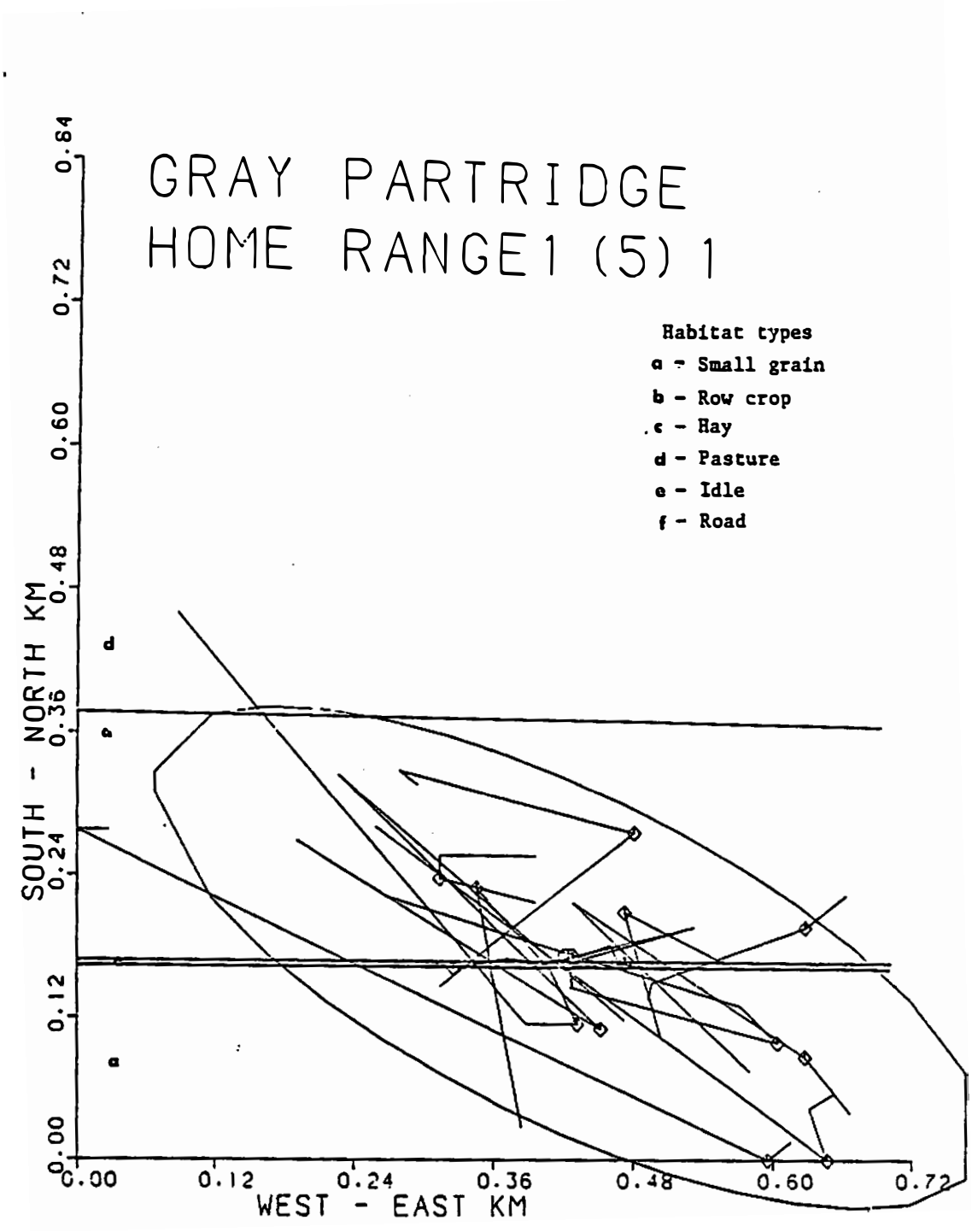

Fig 3. Computer generated 95% confidence ellipse of home range (Dunn and Gipson 1977) for a paired male gray partridge on the Brookings, South Dakota study area, April 29, 1980 - May 20, 1980. ◇-lines are movements during 1 day. The area within the ellipse is 17 ha.

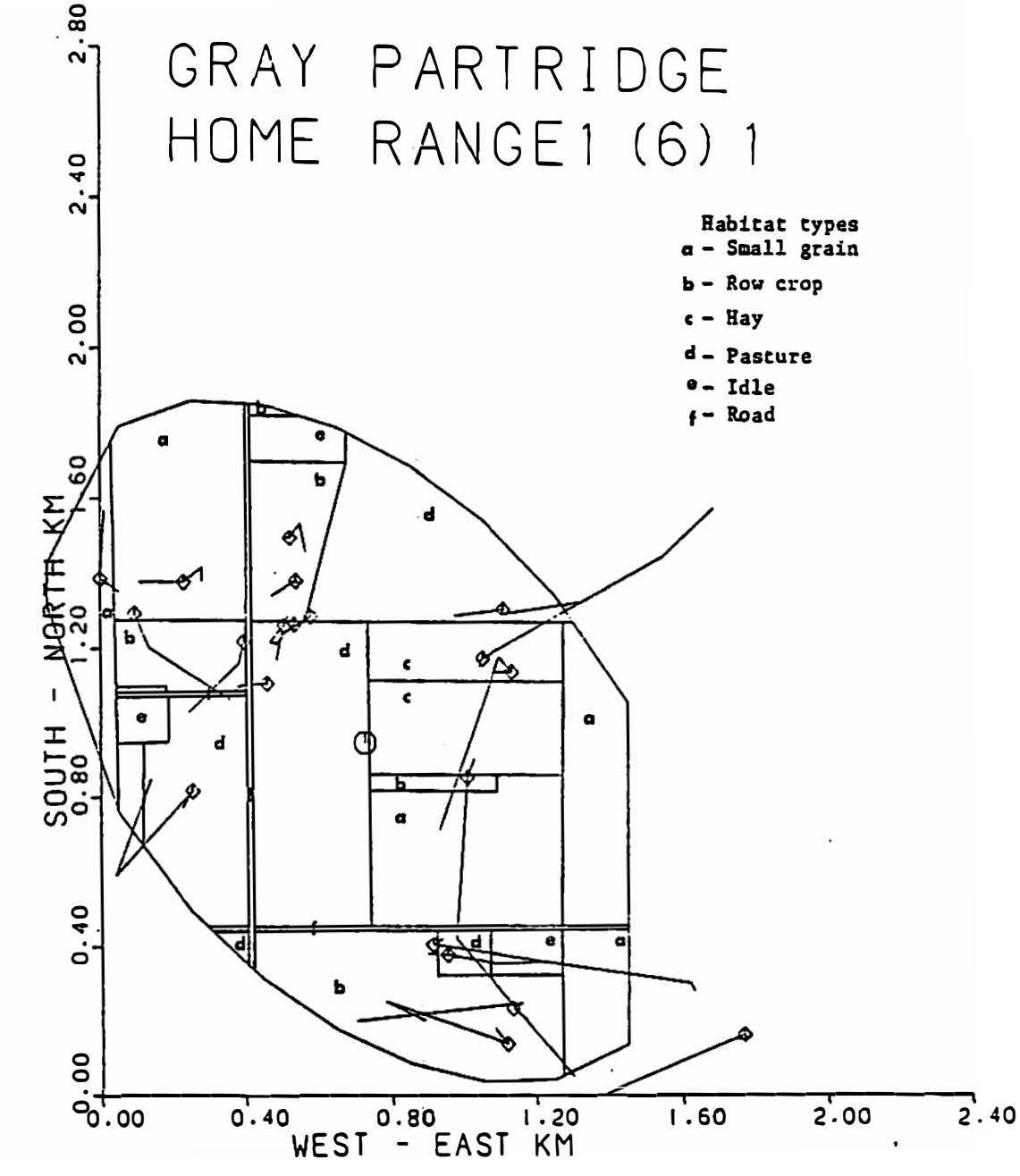

Fig. 4. Computer generated 95% confidence ellipse of home range (Dunn and Gipson 1977) for an unpaired male gray partridge on the Brookings, South Dakota study area, April 29, 1980 - May 26, 1980. ♀ -lines are movements during 1 day. The area within the ellipse is 224 ha.

Table 11. Bimonthly chi-square analysis of habitat use by gray partridge observed weekly along a 48 km roadside route in 1979 on the Brookings, South Dakota study area.

Time period	Land use combination					Chi-square value	Probability
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	89	9	19	26	26		
February 22-April 21	36	19	16	32	20		
April 22-June 21	43	15	3	10	5	36.11	P=0.0001

[a]Comb., combined non-grain associated land use combinations.

Table 12. Bimonthly chi-square analysis of habitat use by gray partridge observed weekly along a 48 km roadside route in 1980 on the Brookings, South Dakota study area.

Time period	Land use combination					Chi-square value	Probability
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	34	3	1	1	0		
February 22-April 21	41	7	10	16	12		
April 22-June 21	43	15	11	23	13	28.19	P=0.0004

[a]Comb., combined non-grain associated land use combinations.

Table 13. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use by gray partridge observed weekly along a 48 km roadside route in 1979 on the Brookings, South Dakota study area.

Time period		Land use combination					Chi-square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	OBS	89	9	19	26	26		
	EXP	65.4	23.7	15.7	25.7	26.6	18.37	P=0.0010
February 22-April 21	OBS	36	19	16	32	20		
	EXP	48.7	19.4	12.5	21.0	21.5	10.18	P=0.0375
April 22-June 21	OBS	43	15	3	10	5		
	EXP	32.1	11.1	8.4	12.3	12.1	13.14	P=0.0106

[a]Comb., Combined non-grain associated land use combinations.

Table 14. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use by gray partridge observed weekly along a 48 km roadside route in 1980 on the Brookings, South Dakota study area.

Time period		Land use combination					Chi-square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	OBS	34	3	1	1	0		
	EXP	17.3	5.5	4.5	6.8	4.8	29.72	P=0.0001
February 22-April 21	OBS	41	7	10	16	12		
	EXP	38.2	12.0	10.1	15.1	10.7	2.54	P=0.7269
April 22-June 21	OBS	43	15	11	23	13		
	EXP	46.6	14.7	12.3	18.4	13.0	1.49	P=0.8292

[a]Comb., Combined non-grain associated land use combinations.

Table 15. Bimonthly tests for significance of habitat use (Neu et al. 1974) by gray partridge observed along the roadside route from significant chi-square tests (Table 13) in 1979 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Land use combination				
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]
December 22-February 21	Proportion of total land use combinations	0.416*	0.151*	0.100	0.163	0.170
	95% confidence interval on proportion of occurrence	$0.428 \leq P_1 \leq 0.626$	$0.009 \leq P_2 \leq 0.097$	$0.050 \leq P_3 \leq 0.174$	$0.083 \leq P_4 \leq 0.225$	$0.083 \leq P_5 \leq 0.225$
Februnry 22-April 21	Proportion of total land use combinations	0.396	0.158	0.101	0.171	0.175
	95% confidence interval on proportion of occurrence	$0.187 \leq P_1 \leq 0.399$	$0.070 \leq P_2 \leq 0.238$	$0.052 \leq P_3 \leq 0.208$	$0.158 \leq P_4 \leq 0.362$	$0.077 \leq P_5 \leq 0.249$
April 22-June 21	Proportion of total land use combinations	0.422	0.146	0.111*	0.161	0.160*
	95% confidence interval on proportion of occurrence	$0.420 \leq P_1 \leq 0.712$	$0.080 \leq P_2 \leq 0.314$	$-0.018 \leq P_3 \leq 0.096$	$0.032 \leq P_4 \leq 0.232$	$-0.007 \leq P_5 \leq 0.139$

[a]Comb., Combined non-grain associated land use combinations.

Table 16. Bimonthly tests for significance of habitat use (Neu et al. 1974) by gray partridge observed along the roadside route from significant chi-square tests (Table 14) in 1980 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Land use combination				
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]
December 22-February 21	Proportion of total land use combinations	0.444*	0.077	0.117*	0.175*	0.124*
	95% confidence interval on proportion of occurrence	$0.734 \leq P_1 \leq 1.010$	$-0.330 \leq P_2 \leq 0.187$	$-0.040 \leq P_3 \leq 0.092$	$-0.040 \leq P_4 \leq 0.092$	$-0.024 \leq P_5 \leq 0.034$

[a]Comb., Combined non-grain aassociated land use combinations.

use could not be detected during early spring in 1979 (Table 15). Grain-pasture and combined non-grain associations had significantly less than expected use during late spring in 1979.

Incidental Observations

Partridge utilization of habitat combinations changed significantly among each bimonthly time period in 1979 but not in 1980 (Tables 17 and 18). Partridge did not utilize land use combinations in proportion to land use combination occurrence during winter in 1979 or 1980 (Tables 19 and 20). Grain-grain was used significantly more than expected for both years (Tables 21 and 22). Grain-hay and grain-pasture were used significantly less than expected in 1979 as were combined non-grain associations in 1980. Habitat use did not change significantly among the 3 diurnal time periods during the winter period in 1979 or 1980 (Tables 23 and 24).

Partridge utilized land use combinations in proportion to land use combination occurrence during early and late spring in 1979 and 1980 (Tables 19 and 20). Habitat use did not change significantly among the 3 diurnal time periods during early and late spring in 1979 or 1980 (Tables 23 and 24).

Coveys vs. Total Numbers of Birds

Two-way analysis of variance tests indicated utilization of habitat in 1979 changed with covey size (Table 25). There were no significant differences in covey size relative to the method in which data were collected (e.g. roadside vs. incidental)

Table 17. Bimonthly chi-square analysis of habitat use for incidental gray partridge observations in 1979 on the Brookings, South Dakota study area.

Time period	Land use combination					Chi-square value	Probability
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	179	17	20	55	64		
February 22-April 21	71	12	11	37	27		
April 22-June 21	43	15	3	10	5	27.23	P=0.0006

[a]Comb., Combined non-grain associated land use combinations.

Table 18. Bimonthly chi-square analysis of habitat use for incidental gray partridge observations in 1980 on the Brookings, South Dakota study area.

Time period	Land use combination					Chi-square value	Probability
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	27	3	11	8	5		
February 22-April 21	18	1	11	16	12		
April 22-June 21	18	1	7	5	8	10.25	P=0.2477

[a]Comb., Combined non=grain associated land use combinations.

Table 19. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use for incidental gray partridge observations in 1979 on the Brookings, South Dakota study area.

Time period		Land use combination					Chi-square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	OBS	179	17	20	55	64		
	EXP	144.1	46.0	31.3	55.0	58.6	31.36	P=0.0001
February 22-April 21	OBS	74	12	11	37	27		
	EXP	64.9	22.0	13.0	29.6	28.6	7.36	P=0.1179
April 22-June 21	OBS	37	17	9	12	13		
	EXP	37.4	15.1	6.3	14.6	14.6	2.11	P=0.7165

[a]Comb., Combined non-grain associated land use combinations.

Table 20. Bimonthly goodness of fit tests showing observed (OBS) and expected (EXP) values of habitat use for incidental gray partridge observations in 1980 on the Brookings, South Dakota study area.

Time period		Land use combination					Chi-square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-ilde	Comb.[a]		
December 22-February 21	OBS	27	3	11	8	5		
	EXP	17.5	4.5	9.5	10.5	12.0	10.56	P=0.0320
February 22-April 21	OBS	18	1	11	16	12		
	EXP	17.6	2.6	7.9	15.0	15.0	2.87	P=0.5792
April 22-June 21	OBS	18	1	7	5	8		
	EXP	17.7	2.4	5.5	5.0	8.4	1.27	P=0.8658

[a]Comb., Combined non-grain associated land use combinations.

Table 21. Bimonthly test for significance of habitat use (Neu et al. 1974) for incidental gray partridge observations from significant chi-square tests (Table 19) in 1979 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Land use combination				
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]
December 22-February 21	Proportion of total land use combinations	0.430*	0.137*	0.094*	0.164	0.175
	95% confidence interval on proportion of occurrence	$0.464 \leq P_1 \leq 0.604$	$0.027 \leq P_2 \leq 0.075$	$0.027 \leq P_3 \leq 0.093$	$0.112 \leq P_4 \leq 0.216$	$0.136 \leq P_5 \leq 0.246$

[a]Comb., Combined non-grain associated land use combinations.

Table 22. Bimonthly test for significance of habitat use (Neu et al. 1974) for incidental gray partridge observations from significant chi-square tests (Table 20) in 1980 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

Time period		Land use combination				
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]
December 22-February 21	Proportion of total land use combinations	0.323*	0.083	0.175	0.195	0.222*
	95% confidence interval on proportion of occurrence	$0.325 \leq P_1 \leq 0.675$	$-0.025 \leq P_2 \leq 0.137$	$0.063 \leq P_3 \leq 0.345$	$0.024 \leq P_4 \leq 0.272$	$-0.009 \leq P_5 \leq 0.195$

[a]Comb., Combined non-grain associated land use combinations.

Table 23. Bimonthly chi-square analysis of habitat use for incidental gray partridge observations according to day time periods in 1979 on the Brookings, South Dakota study area. The day was divided into 3 equal periods beginning 0.5 hours before sunrise and ending 0.5 hours after sunset.

Time period	Day time period	Land use combination					Chi-square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21	1	115	9	11	40	35		
	2	40	3	8	13	20		
	3	24	5	1	2	9	14.41	P=0.0718
February 22-April 21	1	42	9	8	19	11		
	2	15	1	1	3	7		
	3	14	2	2	15	9	12.47	P=0.1313
April 22-June 21	1	26	10	5	8	10		
	2	1	5	1	2	1		
	3	10	2	3	2	2	10.57	P=0.2272

[a]Comb., Combined non-grain associated land use combinations.

Table 24. Bimonthly chi-square analysis of habitat use for incidental gray partridge observations according to day time periods in 1980 on the Brookings, South Dakota study area. The day was divided into 3 equal periods beginning 0.5 hours before sunrise and ending 0.5 hours after sunset.

Time period	Day time period	Land use combination					Chi square value	Probability
		Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-Feburary 21	1	7	1	2	3	0		
	2	12	1	2	3	0		
	3	8	1	7	2	5	12.29	P=0.1386
February 22-April 21	1	4	0	2	6	2		
	2	8	1	3	7	8		
	3	6	0	6	3	2	8.52	P=0.3847
April 22-June 21	1	10	0	4	2	1		
	2	0	0	2	2	4		
	3	8	1	1	1	3	14.33	P=0.0737

[a]Comb., Combined non-grain associated land use combinations.

Table 25. Analysis of variance for differences in covey size for different land use combinations. The table presents mean gray partridge covey sizes for different land use combinations in 1979 and 1980 prior to covey break-up on the Brookings, South Dakota study area.

	Land use combination					Number of coveys	Probability
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]		
December 22-February 21 1979	9.09	8.14	10.04	7.78	10.24	444	P=0.0106
December 22-February 7 1980	10.06	11.40	7.14	7.83	14.00	54	P=0.1090

[a]Comb., combined non-grain associated land use combinations.

(P=0.6783). Tukey's w-procedure (Steel and Torrie 1960) showed significant mean covey size differences existed between combined non-grain associated land use combinations and grain-idle; and grain-pasture and grain-idle combinations (P=0.05). Combined non-grain associations and grain-pasture combinations had the largest mean covey sizes. Fifty-eight percent of the covey observations in the combined non-grain associations were from pasture-pasture combinations.

Since results showed larger coveys utilized certain habitats, chi-square tests were conducted on data from the winter of 1979 using numbers of birds rather than coveys to calculate expected values for the roadside survey and incidental observations (Tables 26 and 27). Partridge did not utilize land use combinations randomly for incidental or roadside observations. Grain-grain was used significantly more than expected for roadside and incidental observations (Tables 26 and 27). Combined non-grain associations were used significantly more than expected for incidental observations. Grain-idle and grain-hay combinations were used significantly less than expected for incidental and roadside survey observations. Grain-pasture was also used significantly less than expected for incidental observations.

One-way analysis of variance results in 1980 showed no significant differences between covey sizes and land use combinations (Table 25). Low numbers of observations prevented use of 2-way analysis of variance in 1980 to test for covey size differences

Table 26. Goodness of fit test of habitat use of weekly gray partridge observations along a 48 km roadside route and teat for significance in habitat use (Neu et al. 1974) from December 22, 1978 to February 21, 1979 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use,, indicated by *.

	Land use combination						
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]	Chi-square value	Probability
Observed	877	62	168	202	282	237.22	P=0.0001
Expected	615.3	222.9	147.6	241.5	269.9		
Proportion of total land use combinations	0.146*	0.151*	0.100	0.163*	0.170		
95% confidence interval on proportion of occurrence	$0.159 \leq P_1 \leq 0.583$	$0.027 \leq P_2 \leq 0.051$	$0.086 \leq P_3 \leq 0.126$	$0.106 \leq P_4 \leq 0.148$	$0.152 \leq P_5 \leq 0.202$		

[a]Comb., combined non-grain associated land use combinations.

Table 27. Goodness of fit test of habitat use of incidental gray partridge observations and test for significance in habitat use (Neu et al. 1974) from December 22, 1978 to February 21, 1979 on the Brookings, South Dakota study area. Proportions which are less than the lower confidence limit indicate significantly greater than expected use and values greater than the upper limit show less than expected use, indicated by *.

	Land use combination						
	Grain-grain	Grain-hay	Grain-pasture	Grain-idle	Comb.[a]	Chi-square value	Probability
Observed	1775	155	198	452	624	351.01	P=0.0001
Expected	1337.9	438.9	301.2	525.5	560.1		
Proportion of total land use combinations	0.430*	0.137*	0.094*	0.164*	0.175*		
95% confidence interval on proportion of occurrence	$0.531 \leq P_1 \leq 0.577$	$0.038 \leq P_2 \leq 0.058$	$0.051 \leq P_3 \leq 0.073$	$0.125 \leq P_4 \leq 0.157$	$0.177 \leq P_5 \leq 0.213$		

[a]Comb., combined non-grain associated land use combinations.

relative to the method in which the birds were observed (e.g. roadside vs. incidental).

Food Habits

Gray partridge diet was dominated by a few plant items. Of 25 plant items identified only 6 accounted for more than 2.0% of the volume (Table 28). Two plant items, green vegetation and corn represented 73.8% of the total volume consumed. Sunflowers and oats were also important cultivated grains in partridge food habits. Percent volume and frequency of occurrence methods indicated that green and yellow foxtail (Setaria viridis, S. lutescens) were the most important weed seeds consumed. Major insect foods were ants (Hymenoptera) and beetles (Coleoptera). Centipedes (Chilopoda) and millipedes (Diplopoda) were the dominant non-insect animal food items. Frequency of inert material, grit was 46.4%.

Percent volume and percent frequency of green vegetation was high during winter in 1979 (Table 29). Volume of green vegetation was much lower in 1980 for the same period (Table 30). Conversely, corn had a high volume in 1980 but much lower in 1979 in the winter period. Frequency and percent volume of green and yellow foxtail were relatively constant among bimonthly periods and between years. Insect foods only occurred in late spring.

Table 28. Percent volume and frequency of foods eaten by gray partridge in Brookings County, South Dakota from December 22, 1978 - June 21, 1979, and December 22, 1979 - June 21, 1980.

Food Item	Overall (N=84) V[b]	Overall (N=84) F
Green Vegetation	36.2	78.6
Tame Buckwheat	0.1	2.4
Corn	37.6	67.9
Oats	3.9	19.0
Sweet Clover	Tr[a]	1.2
Sunflower	5.1	10.7
Barley	1.3	8.3
Soybean	0.5	4.8
Proso Millet	Tr	1.2
Flax	0.2	4.8
Wheat	Tr	1.2
Setaria viridis	3.6	36.9
Setaria lutescens	4.3	35.7
Bromus spp.	0.7	3.6
Helianthus spp.	0.2	1.2
Brassica kaber	Tr	3.6
Epilobium spp.	Tr	1.2
Kochia scoparia	1.3	15.5
Salsola kali	1.6	11.9

Table 28 (cont).

Food Item	Overall (N=84) V[b]	Overall (N=84) F
Iva xanthifolia	Tr	2.4
Chenopodium album	0.3	16.7
Polygonum spp.	0.1	10.7
Ambrosia spp.	0.1	4.8
Echinochloa crusgalli	Tr	6.0
Euphrasia spp.	Tr	1.2
Non-Insect Animal	0.4	6.0
Insect	1.3	14.3
Inert	0.9	46.4

[a]Tr, Trace

[b]V, Volume; F, frequency of occurrence.

Table 29. Percent volume and frequency of foods eaten by gray partridge in Brookings County, South Dakota 1979.

Food Item	Overall (N=51)		December 22-February 21 (N=26)		February 22-April 21 (N=11)		April 22-June 21 (N=14)	
	V[b]	F	V	F	V	F	V	F
Green Vegetation	41.9	80.4	51.0	80.8	26.6	81.8	23.0	78.6
Tame Buckwheat	0.1	2.0	0.2	3.8				
Corn	37.3	72.5	29.7	73.1	61.4	72.7	33.7	71.4
Oats	4.4	29.4	5.5	26.9	1.8	27.3	3.1	35.7
Sweet Clover	Tr[a]	2.0	Tr	3.8				
Sunflower	1.8	5.9	2.7	3.8	Tr	9.1	Tr	7.1
Barley	1.5	9.8	0.6	11.5	5.3	18.2		
Soybean	0.6	7.8	0.1	7.7	2.5	18.2		
Proso Millet	Tr	2.0	Tr	3.8				
Flax	0.2	5.9	Tr	3.8	0.6	9.1	Tr	7.1
Wheat	0.1	2.0	0.1	3.8				
Setaria viridis	3.3	41.2	2.5	38.5	0.1	36.4	12.2	50.0
Setaria lutescens	3.2	33.3	Tr	26.9	0.7	27.3	22.8	50.0

Table 29 (cont).

Food Item	Overall (N=51)		December 22-February 21 (N=26)		February 22-April 21 (N=11)		April 22-June 21 (N=14)	
	V[b]	F	V	F	V	F	V	F
Bromus spp.	1.0	5.9	1.4	11.5				
Helianthus spp.	0.2	2.0	0.3	3.8				
Brassica kaber	Tr	5.9	Tr	7.7	Tr	9.1		
Epilobium spp.	Tr	2.0	Tr	3.8				
Kochia scoparia	1.1	19.6	1.7	26.9	Tr	27.3	Tr	7.1
Salsola kali	1.9	19.6	2.8	23.1	0.6	27.3		
Iva xanthifolia	Tr	3.9	Tr	7.7				
Chenopodium album	0.3	21.6	0.5	38.5	Tr	9.1		
Polygonum spp.	0.1	13.7	Tr	7.7			1.0	35.7
Ambrosia spp.	Tr	5.9	Tr	3.8	Tr	18.2		
Echinochloa crusgalli	Tr	5.9	Tr	3.8			Tr	14.3
Euphrasia spp.	Tr	2.0					Tr	7.1
Non-Insect Animal	Tr	5.9			0.1	9.1	Tr	14.3
Insect	0.2	15.7					1.9	57.1

Table 29 (cont).

Food Item	Overall (N=51)		December 22-February 21 (N=26)		February 22-April 21 (N=11)		April 22-June 21 (N=14)	
	V[b]	F	V	F	V	F	V	F
Inert	0.5	60.8	0.7	61.5	Tr	54.5	Tr	64.3

[a]Tr, Trace

[b]V, Volume; F, frequency of occurrence.

Table 30. Percent volume and frequency of foods eaten by gray partridge in Brookings County, South Dakota 1980.

	Overall (N=33)		December 22-February 21 (N=10)		February 22-April 21 (N=13)		April 22-June 21 (N=10)	
Food Item	V[b]	F	V	F	V	F	V	F
Green Vegetation	10.8	75.8	5.7	60.0	41.2	84.6	7.4	80.0
Tame Buckwheat	0.1	3.0					0.3	10.0
Corn	39.0	60.6	73.9	90.0	21.6	53.8	11.4	40.0
Oats	1.7	3.0					3.7	10.0
Sunflower	20.2	18.2	Tr	10.0			43.9	50.0
Barley	0.4	6.1					0.8	20.0
Flax	0.1	3.0					0.3	10.0
Setaria viridis	4.9	30.3	8.1	50.0	6.2	7.7	1.6	40.0
Setaria lutescens	9.0	39.4	8.1	60.0	20.6	15.4	6.9	50.0
Kochia scoparia	2.2	9.1	2.6	10.0	9.3	15.4		
Chenopodium album	Tr[a]	9.1	Tr	10.0	Tr	15.4		
Polygonum spp.	Tr	6.1			Tr	15.4		

Table 30 (cont).

Food Item	Overall (N=33)		December 22-February 21 (N=10)		February 22-April 21 (N=13)		April 22-June 21 (N=10)	
	V[b]	F	V	F	V	F	V	F
Ambrosia spp.	0.6	3.0	1.4	10.0				
Echinochloa crusgalli	Tr	6.1	Tr	20.0				
Non-Insect Animal	1.8	6.1					4.0	20.0
Insect	6.2	12.1					13.6	40.0
Inert	2.9	24.2			1.0	23.1	6.1	50.0

[a]Tr, Trace

[b]V, Volume; F, frequency of occurrence.

DISCUSSION AND CONCLUSIONS

Habitat Utilization

Habitat utilization determined from telemetry locations differed between years in the winter period. Partridge utilized pasture in 1979 and row crops in 1980. There were maximum snow depths of 56 cm in 1979 and depths of only 4 cm in 1980. McCrow (1977) noted that partridge utilized corn stubble in winter, but there was little or no snow cover during his study. McCrow (1977: 93) stated that in years of heavy snow cover, "corn-stubble fields may not be as attractive to partridges." Food habits results in winter showed a higher use of green vegetation and lower use of corn in 1979 compared to 1980 and agree with the observed differences in habitat use. Yocum (1943) also reported an increase in pasture use by partridge in winter. In severe winters pastures may be an area where partridge can locate food in the form of vegetation and seeds protruding above the snow and in active pastures from manure and areas cleared by cattle. In years with deep snow, more energy would have to be expended by partridge burrowing for corn without locating a corn kernel than searching for more ubiquitous green vegetation and weed seeds. Yeatter (1934) noted that partridge utilized small grain stubbles and corn fields in winter. There were no significant uses of small grain in either year of the study on my study area. I did not note any significant use of idle wooded areas in winter as reported by Weigand (1977b).

Telemetry results conflict with incidental and roadside survey

results during winter in 1979. Chi-square analysis for roadside and incidental observations did not show significant utilization of pasture. However, covey size observations using incidental and roadside observations showed larger coveys utilized pasture combinations. Land use combination data were difficult to interpret since each combination consisted of actually 4 land uses; the 2 habitats from the combination, the roadside, and the road. Roadside and incidental observations support significant row crop utilization in winter by radio-tagged partridge in 1980.

The difference in the numbers of observations in winter between 1979 and 1980 (Table 25) was probably not an indication of population decline but rather a difference in partridge observability due to different weather conditions between the 2 years. Furthermore, roadside observations for late spring were approximately 25% greater in 1980 than 1979.

Yeatter (1934:23) stated, "In early spring, following mating, the pairs spread out from their winter range and occupy all available types of habitat..." Roadside survey and incidental results during early spring supported Yeatter's data. Telemetry results for the same period showed a wider utilization of habitat types by radio-tagged partridge. During this period birds were engaged in dispersal, pair formation, and nesting territory selection. However, there was significant use of row crops and idle areas in 1980. Idle and row crop use for this period was not evident in 1979 and may be due to different weather conditions

between years. Snow cover persisted into late March in 1979 but was absent in March in 1980. Partridge did not utilize hay in proportion to hay occurrence. Weigand (1977a) also noted that hay was not a preferred habitat type of partridge.

Telemetry data for late spring showed significant partridge utilization of idle areas for both years. However, roadside and incidental observations for 1979-1980 did not show significant use of idle areas. The lack of significance may be due to roadsides being an intricate component of land use combinations. Futhermore, partridge observability in idle areas was probably less than the observability of partridge in habitat types such as small grain. During late spring partridge are engaged in nesting. Partridge utilized roadsides, fencerows, shelterbelts, and other idle areas for nesting in the prairie regions (Hunt 1974, Bishop et al. 1977, Hupp et al. 1980). My data similarly showed that partridge utilized idle areas during late spring.

Gray partridge did not utilize different habitat during the 3 diurnal time periods. However, I have made several observations of birds at dusk moving to a different habitat type from the type they were using during the daylight hours. K. Church (personal communication) also noted that birds may roost in different habitat types than utilized during daylight. The 3 diurnal periods may have been too broad to detect significant use of a roosting habitat.

Home Range

During early spring an unknown sex bird had an estimated home

range of 60 ha and was greater than estimates of 2.2-13.9 ha in Montana (Weigand 1977a). However, the methods I used (Dunn and Gipson 1977) are not directly comparable to previous studies. Previous partridge home range studies have connected the outermost locations with lines to form a home range polygon. This method does not allow for confidence limits to be calculated and therefore statistical comparisons are limited. Although the home range ellipse (Fig. 1) area encompassed less than 50% row crop, row crop was utilized significantly more than expected. Thus, the total area within the ellipse may not represent preferred habitat. An unpaired male partridge had a larger home range than the 2 paired birds. The home range of the 2 paired partridge each centered in idle areas (Figs. 2 and 3) while the unpaired bird utilized virtually all habitats within its home range (Fig. 4). Previous studies have noted that partridge stayed within a 0.4 km radius area (Yeatter 1934, Green and Hendrickson 1938, Yocum 1943, Bishop et al. 1977). The unpaired male partridge was the only bird which had an ellipse that was greater than a 0.4 km radius area. The male whose movements did not fit the model (Dunn and Gipson 1977) during early spring was considered to be moving in a specific direction and therefore did not have a stationary home range.

Radio-tagged partridge that are in coveys and pairs are not likely to be biased from aberrant behavior due to the influence of their cohorts. However the reader should be more cautious of the data from single birds.

Gray Partridge Mortality

Seventeen adult and subadult gray partridge depredations were recorded. Nine predators could not be identified. Avian predation accounted for 7 of 8 known depredations. Weigand (1977a) also reported that raptors were major predators on adult partridge. One red-tailed hawk (Buteo jamaicensis) and an unknown owl species were confirmed predators of 2 radio-tagged partridge on my study area. Two snowy owl (Nyctea scandiaca) depredations were witnessed. Yeatter (1934) also listed the snowy owl and red-tailed hawk as gray partridge predators. One Mustela spp. depredation was recorded in 1979. Radio-tagged birds may be more susceptible to predation than birds not carrying transmitters (Dumke and Pils 1973). Low numbers of observations and possible bias associated with radio-tagged birds prevents a statement regarding the significance of predation.

Thirty-nine gray partridge were found dead on roads in 1979 versus 3 in 1980. The severe winter in 1979 probably forced birds to roads for grit and grain while in 1980 little snow cover allowed birds to remain in fields.

Food Habits

Food habits results showed that green vegetation was an important food item in gray partridge diet and support previous studies (Kelso 1932, Yeatter 1934, Middleton and Chitty 1937, Yocum 1943, Kobriger 1977a). Westerkov (1966) hypothesized that gray partridge have adapted to severe winters in North America by consuming

grain and weed seeds rather than large amounts of green vegetation in winter as noted in Europe by Middleton and Chitty (1937). However, my results for the winter period in 1979 showed greater use of green vegetation than in 1980, a less severe winter than 1979. Furthermore, Kobriger (1977a) noted peak partridge use of green vegetation in late winter, the period of peak use in Europe (Middleton and Chitty 1937).

The importance of cultivated grains in gray partridge diet has been emphasized (Kelso 1932, Yeatter 1934, Middleton and Chitty 1937, Westerkov 1966, Hunt 1974, Kobriger 1977a). Corn had the highest frequency and volume of the cultivated grains in my food habits analysis. Yeatter (1934) and Middleton and Chitty (1937) also noted the importance of corn in partridge diet. Yeatter, however, hypothesized that corn was used mainly as an emergency food after small grains were covered with snow. My results from 1980, a winter with little snow (4 cm maximum), did not show an increase in small grain utilization over 1979 a year with deep snow (56 cm). Corn use was at a seasonal low in the winter and spring seasons in Europe (Middleton and Chitty 1937). Small grains were the most important cultivated grains utilized by partridge in North Dakota (Kobriger 1977a) and Canada (Westerkov 1966).

Weed seeds were important in gray partridge diet (Kelso 1932, Yeatter 1934, Middleton and Chitty 1937, Hunt 1974, Kobriger 1977a). My data similarly showed the importance of weed seeds especially green and yellow foxtail. Kobriger (1977a) also noted high use of foxtail seeds. The greater variety of weed seeds in 1979 than in

1980 may have been due to low sample sizes but also may have been due to differing weather conditions between years. The severe winter conditions in 1979 may have forced partridge to select food items that they normally would not have selected in a normal or mild winter.

Food habits results indicated insect use was confined to late spring and supported previous studies (Yeatter 1934, Middleton and Chitty 1937, Hunt 1974, Kobriger 1977a). Insect use was probably related to insect abundance, insects were not available in winter and early spring. My results showing use of grit may be over emphasized due to inert particles adhering to seeds and separating during the drying process. Sample sizes were low for bimonthly periods, therefore the reader interested primarily in overall gray partridge food habits rather than seasonal differences should refer to Table 28.

Management Recommendations and Research Suggestions

I recommend reducing or eliminating fall plowing of grain stubble. This would preserve a preferred gray partridge habitat in winter and increase food availability. Fall plowing also increases soil erosion which then causes silting of roadside ditches a preferred habitat in spring. Planting of shelterbelts would reduce the soil erosion. Research is needed to determine what density or interspersion of shelterbelts would most benefit partridge. Research is also needed in range management practices that would be most beneficial to partridge in years with deep snow.

Efforts to preserve small fields would benefit partridge by maintaining existing fencerow cover. Large fields with less fencerow cover needed for center pivot irrigation systems are increasing. Plowing and discing of roadside ditches should be discouraged. Any efforts discouraging the loss of idle areas would probably benefit partridge. Research is needed to determine effects of burning and grazing on roadside vegetation. There also exists need for research to determine effects of herbicide and insecticide use on the availability of partridge food items, and partridge physiology and reproduction.

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