THESIS

LEK ATTENDANCE OF MALE SAGE GROUSE IN NORTH PARK, COLORADO

Submitted by

Steven R. Emmons

Fishery and Wildlife Biology

In partial fulfillment of the requirements

for the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Summer, 1980

COLORADO STATE UNIVERSITY

Summer, 1980

WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY STEVEN R. EMMONS ENTITLED LEK ATTENDANCE OF MALE SAGE GROUSE IN NORTH PARK, COLORADO BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

Clait E. Braun

Dale Heinz

Phyllis N. Glenn

Ronald A. Ryder
Adviser

Ronald A. Ryder
Head of Department

ABSTRACT OF THESIS

LEK ATTENDANCE OF MALE SAGE GROUSE IN NORTH PARK, COLORADO

Daily lek attendance patterns, breeding season movements, and habitat selection of male sage grouse (Centrocercus urophasianus) were investigated in North Park, Colorado from late March through mid-June 1978-79. Thirty-seven males (20 adults and 17 juveniles) were equipped with radio transmitters and studied on 5 leks.

Peak male attendance occurred 25-37 days after peak female attendance on the 3 largest leks investigated. Lek attendance of radio-marked juveniles increased to 91-95% in mid-May and decreased thereafter. Adult male attendance increased to 98-100% in mid-May and then decreased. A non-lek attending segment of the male population was not observed.

Juvenile males visited 2-4 leks, remaining on each for an average of 4.3 days. One juvenile visited 2 leks (4.5 km apart) in 1 morning. Most adult males (72.7%) visited only 1 lek but 2 visited 1-2 additional leks for 1 day and 1 moved to an alternate lek after 15 May. Juveniles and adults moved at least 23.9 and 10.0 km, respectively, during the breeding season. Four juvenile males moved from the study area, including a move of over 25 km in 5 days. Three adults moved to leks 12-21 km from the study area.

Off-lek locations were within 0.5 and 1.0 km of a lek for 39.9 and 62.6% of 160 locations, respectively. Males typically dispersed over 1 km in non-random directions from leks to feeding and loafing sites. Subsequent mid-day moves over 150-300 m resulted from disturbance. Over 60% of the juveniles (60.4) and adults (69.8) returned to leks in the evening to roost.

Sagebrush (Artemisia spp.) canopy coverage and height at 160 feeding-loafing sites averaged 28.1% and 43.5 cm, respectively. Approximately 90% (89.7) of the roosting locations occurred in sagebrush with a canopy coverage of less than 20% (avg. 8.7) and height less than 40 cm (avg. 18.7).

Recommended procedures for counting leks are given.

Steven R. Emmons
Department of Fishery and
Wildlife Biology
Colorado State University
Fort Collins, Colorado 80523
Summer, 1980

ACKNOWLEDGMENTS

This study was supported by the Colorado Division of Wildlife through Federal Aid to Wildlife Restoration Project W-37-R. This support is gratefully acknowledged.

Dr. R. A. Ryder, Department of Fishery and Wildlife Biology, served as my advisor and critically reviewed this thesis. His encouragement and assistance are sincerely appreciated. Other members of my graduate committee, Dr. D. Hein, Department of Fishery and Wildlife Biology, and Dr. P. N. Lehner, Department of Zoology and Entomology reviewed the thesis and were available for consultation throughout.

Dr. C. E. Braun, Wildlife Researcher, Colorado Division of Wildlife, served on my graduate committee and critically reviewed the thesis. In addition to field assistance, he provided valuable administrative support. Dr. Braun was a constant stimulus for my research efforts and his interest in my progress as a student and development as a biologist is sincerely appreciated.

The U.S. Fish and Wildlife Service, Denver Research Center, provided the radio transmitters used. The expertise of J. Bourassa and L. Kolz is acknowledged.

Others assisting in various aspects of this study included H. D. Funk, Colorado Division of Wildlife, administrative support and thesis review; S. Porter and J. Wagner, Colorado Division of Wildlife, field assistance; and B. Petersen, K. Giesen, T. Schoenberg, J. Dingman and S. McElderry, field assistance and companionship during 2 long, snowy, North Park springs. The assistance and suggestions of these people are sincerely appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

INTRODUCTION

Sage grouse are widely distributed in western North America, inhabiting rangelands dominated by sagebrush and subdominant grasses and forbs with interspersed native and cultivated hay meadows. Sage grouse dependence on sagebrush for food and cover in all seasons has been documented by Patterson (1952), Dalke et al. (1963), Klebenow (1969), Peterson (1970), Eng and Schladweiler (1972), and Wallestad et al. (1975).

In most states with sage grouse populations, state wildlife agencies routinely collect population data and regulate hunter opportunity and harvest. Sage grouse management has primarily been based on counts of males on leks (strutting grounds) in April and estimates of nesting success and brood size obtained in July and August. Although peak counts of male and female sage grouse on leks have been used to estimate trends in breeding population size, little is known concerning daily attendance patterns of individual males to a particular lek. Recent studies of other lekking grouse, i. e. black grouse (Lyrurus tetrix) (Robel 1969) and sharp-tailed grouse (Pedioecetes phasianellus) (Rippin and Boag 1974), suggest that less than 50% of the male population is present on a lek at any given time. Data presented in this report are from March through

July 1978 and 1979, and include information on lek attendance, breeding season movements, and habitat selection of male sage grouse in North Park, Colorado.

The primary objective of this study was to increase knowledge concerning daily activity patterns of male sage grouse during the breeding season. Samples stratified by age (juvenile and adult) and location (trapped on and off leks) were used to document daily lek attendance of males. Hypotheses tested were: (1) juvenile (< 1 year of age) males attend leks less than 3 days/7-day period; (2) adult males attend leks daily during the breeding season; (3) males (both adults and juveniles) trapped off leks rarely go to leks during the breeding season of initial capture; (4) juvenile males display on more than 1 lek; and (5) adult males display on only 1 lek. In addition, breeding season movements and habitat selection were examined.

DESCRIPTION OF THE STUDY AREA

The investigation was conducted in North Park, Jackson County, Colorado. The study area was near Lake John in northwest North Park, approximately 16.0 km northwest of Walden (Fig. 1). The area was within 40° 30' and 41° 00' north latitude and 106° 10' and 106° 30' west longitude. Gill (1965) presented a detailed description of the study area's location.

The area was bounded on the north by Independence Mountain, west by Boettcher Ridge and Sheep Mountain, south by the North Fork of the North Platte River, and east by the North Platte River (Fig. 2). Total area was approximately 219.5 km^2, although exact boundaries were flexible depending on bird movements.

Elevations were from 2400 m along the North Platte River near the northeast boundary to 2964 m on Independence Mountain. Elevation of most of the sagebrush habitat was between 2400 and 2585 m (Beck 1975). The area was relatively flat with low undulating benches and ridges separated by drainages. Major drainages included Lake Creek which drains from north to south into Lake John, the North Fork of the North Platte River draining from north to south then turning eastward until joining the North Platte which drains all of the Park from south to north. Lakes in the study area included

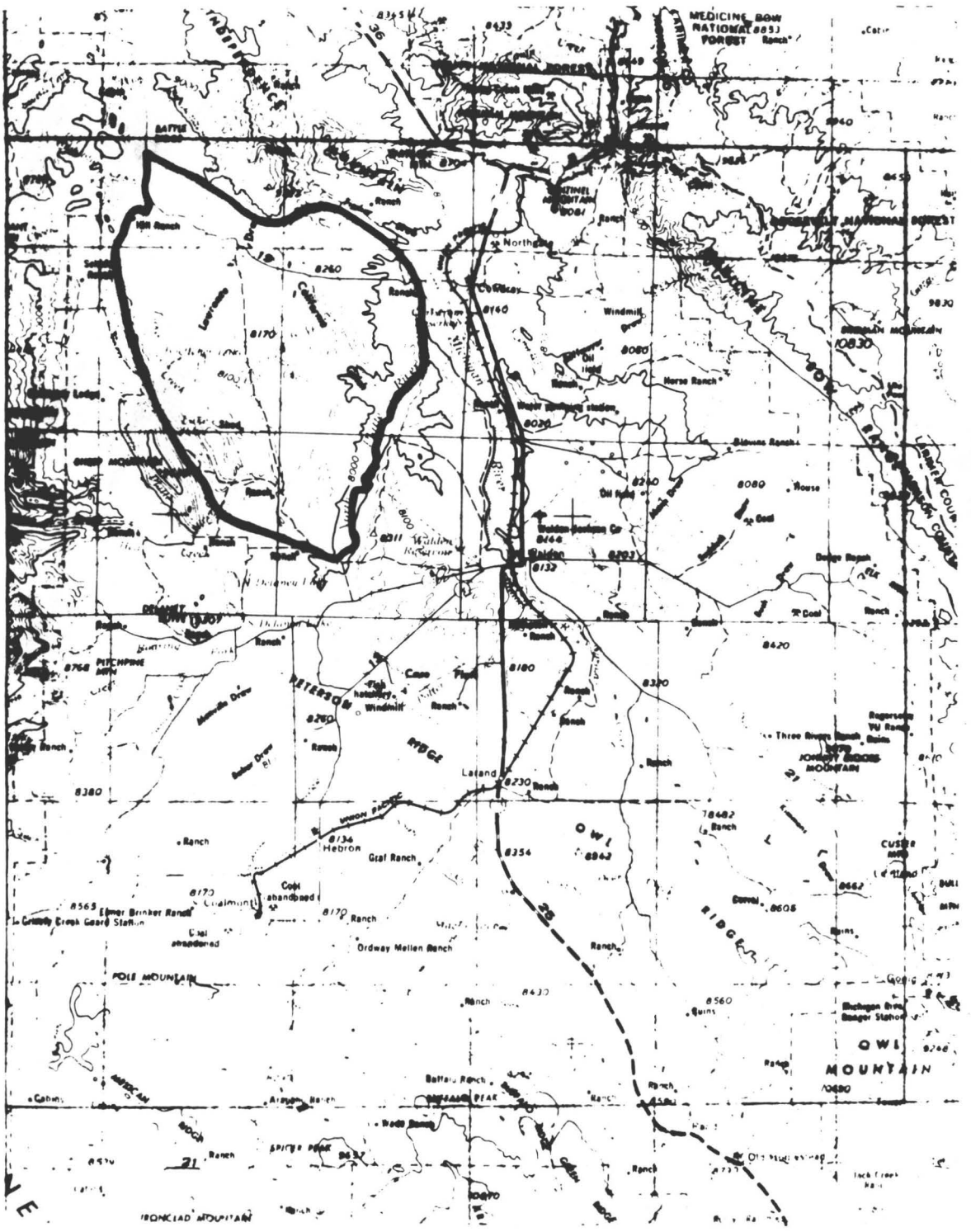

Fig. 1. Lake John study area, North Park, Colorado.

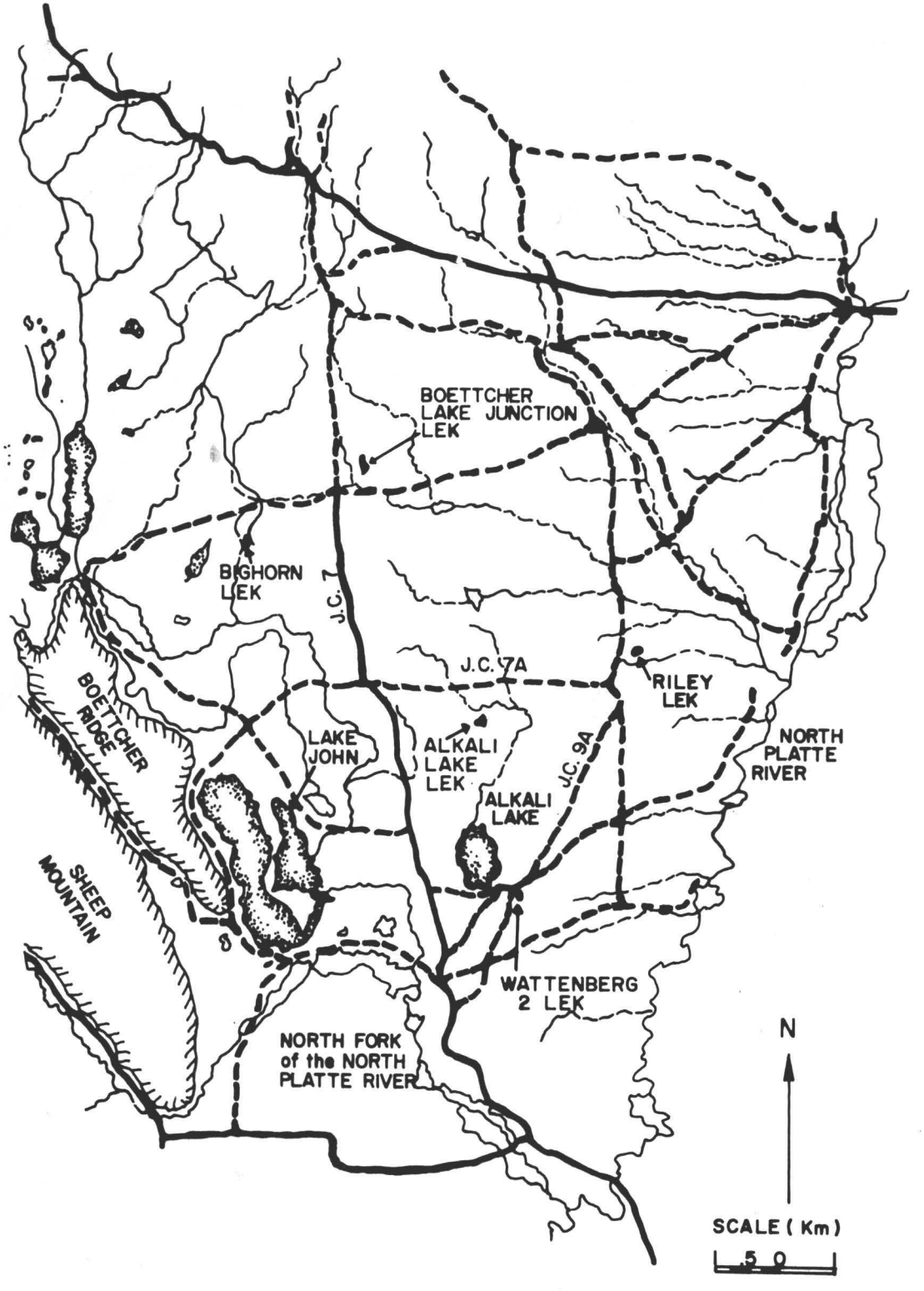

Fig. 2. Location of active leks in the Lake John area, North Park, Colorado.

Lake John, Alkali Lake, Boettcher Lake and numerous smaller ephemeral unnamed lakes scattered throughout. The northern half of the study area was more rolling than the southern half. Geology of the area has been described by Beekly (1915), Finch (1957), and Hail (1965).

The vegetation of the area was dominated by sagebrush-bunchgrass with scattered hay meadows. Big sagebrush (Artemisia tridentata vaseyana) comprised approximately 90% of the sagebrush type in North Park. Alkali (A. longiloba), silver (A. cana viscidula), coaltown (A. argilosa) and black sagebrush (A. nova) occupied limited areas where soil conditions were favorable (Beetle 1960, Smith 1966, Terwilliger and Smith 1978). Other important shrubs in the study area were greasewood (Sarcobatus vermiculatis), rabbitbrush (Chrysothamnus spp.), snakeweed (Gutierrezia sarothrae), willows (Salix spp.), and bitterbrush (Purshia tridentata). Herbaceous vegetation consisted primarily of low-growing perennial forbs and perennial bunch grasses with few annual forbs (Beck 1975).

The climate of North Park is cold and dry. Although no wind measurements are available, prevailing winds are from the southwest with frequent high velocities, particularly in winter and spring. Precipitation in spring normally accounts for 23.3% of the annual moisture in the study area (U.S. Department of Commerce 1973). Precipitation normally increases throughout the spring (Table 1).

Table 1. Spring precipitation and temperature, Walden, Colorado, 1978-79.

Year	Precipitation (cm)					Mean daily temperature (C)			
	Mar	Apr	May	Jun	Totals	Mar	Apr	May	Jun
1978[a]	2.01	2.16	8.03	1.57	13.77	-1.3	3.1	5.6	11.9
1979[b]	3.58	1.24	3.46	3.15	11.42	-3.8	1.6	6.3	11.2
30-year avg.[c]	1.27	1.83	2.59	2.82	8.51	-4.6	1.8	7.1	11.6

[a]U.S. Department of Commerce (1978).

[b]U.S. Department of Commerce (1979).

[c]U.S. Department of Commerce (1973).

Most of the study area is usually snow-free by mid-March except following snowstorms during March, April and May. Mean annual temperature is 2.5C, varying during the study period from -4.6 in March to 11.6C in June. The average frost-free season in Walden is 46 days from mid-June to early August.

Spring precipitation was 61.8% above the 30-year average in 1978 and 34.2% above in 1979. Late snowstorms occurred frequently delaying access both years. Permanent access to Boettcher Lake Junction lek occurred on 22 March 1978 and 15 April 1979, and to Alkali Lake lek on 30 March 1978 and 30 April 1979. Spring temperatures were approximately 2.0C higher in 1978 than 1979.

METHODS AND MATERIALS

Sage grouse were captured at night while roosting on leks and along roads. Most birds were located using a spotlight with a back-pack or hand-held power source and captured with long-handled nets (Pyrah 1959, Braun and Beck 1976). A vehicle-mounted cannon net (Lacher and Lacher 1964) was used on 1 occasion. Sage grouse banded and released were marked with aluminum serially numbered leg bands (size 16, National Band and Tag Co., Newport, Kentucky) and plastic, colored bandettes coded to the individual (1978) or year (1979). Weights and primary molt were determined for all captured birds. Age and sex classification of captured birds followed Eng (1955).

Selected males were equipped with 14-15 g, 164 MHz radio transmitters (U.S. Fish and Wildlife Service, Denver Research Center) in 1978. Some transmitters were reused in 1979 in addition to 14-15 g and 21-25 g transmitters obtained from AVM Company (Champaign, Illinois), and Wildlife Materials, Inc. (Carbondale, Illinois), respectively. Transmitter packages represented 0.4-0.9% of the birds' body weights (range 2440-3460 g). Transmitters were attached to the central rectrices using a bolt and clamp device similar to the tail clip described by Bray and Corner (1972).

Counts of male and female sage grouse on leks were made daily supplemented with periodic counts by Colorado Division of Wildlife personnel following prescribed procedures (Braun and Beck 1976). Counts were made from 23 March through 30 May 1978 and 26 March through 4 June 1979 between 0430 and 0730 MST.

Radio-marked males were located concurrently with lek counts each morning using a portable receiver (Wildlife Materials, Inc., Carbondale, Illinois) and hand-held 3-element yagi antenna (U.S. Fish and Wildlife Service, Denver Research Center). Their locations with respect to a lek were classified by triangulation of radio signals. If radio-marked males were determined to be on a lek, visual location was attempted. Birds located more than 0.1 km from the periphery of a lek were recorded as being off-lek. Radio-marked males not on leks were located after completion of counts. Selected males were located periodically at 1-2 hour intervals throughout chosen days to ascertain daily activity patterns. Slope, aspect, total vegetative coverage, sagebrush canopy coverage and height, and snow coverage were recorded on a standardized form at the time of location. Locations in 1979 were marked with 1.2 m surveyor's lath and colored plastic surveyor's tape to facilitate relocation for vegetation analysis. Locations were plotted on 7.5 minute (scale = 1:24,000) U.S. Geological Survey topographic maps with movements measured to the nearest 0.1 km.

Vegetative cover measurements for radio locations were made using Canfield's (1941) line intercept technique. At each location examined, a 1.5 m steel rod was driven into the ground at a randomly located site. A steel (1978) or plastic (1979) measuring tape was stretched between the central rod and a 2nd rod located by compass directions. Each transect was 15.2 m in 1978 and 15.0 m in 1979. Three to 4 transects were examined at each location except on leks. Lek vegetation was analyzed using 3-4 transects originating from 1-3 central points depending upon size of the lek. All vegetation was measured to the nearest 0.5 cm along transects according to species except for grasses which were recorded as 1 group. Vegetative height was recorded to the nearest 0.5 cm for big and silver sagebrush, black greasewood, and rabbitbrush.

The data were analyzed with the Student's t test except that chi-square analysis was used to test for differences in lek attendance, roosting locations, and direction of movements. The level of significance was $P = 0.05$.

RESULTS

Trapping and Transmitter Life

Male sage grouse were captured and equipped with radio transmitters from 25 February through 1 May 1978 and 21 March through 4 May 1979 (Tables 2 and 3). Late capture dates both years were related to poor access resulting from late winter storms.

Capture efforts were concentrated along Jackson County (J. C.) roads 7 and 7A and on Alkali Lake, Bighorn and Boettcher Lake Junction leks in 1978. Access difficulties on the Bighorn Ranch (Bighorn lek), resulted in shifting capture efforts in April 1978 to include Wattenberg 2 lek and along J. C. 9A (Fig. 2). Heavy snow accumulation and the decision to intensively monitor birds on fewer leks resulted in trapping efforts being reduced to Boettcher Lake Junction lek and along J. C. 7 in 1979.

Thirty-seven male sage grouse (17 in 1978, 20 in 1979) were equipped with 35 radio transmitters (16 in 1978, 19 in 1979). Age class and capture site stratification were: 14 adults and 13 juveniles caught on leks and 6 adults and 4 juveniles caught off leks (Tables 2 and 3). Few males were located roosting off leks during the breeding season. This resulted in low representation of that capture site class in the sample.

Table 2. Capture data and transmitter life for male sage grouse, North Park, Colorado, 1978.

Band number	Capture date	Capture location	Date last located	Transmitter life (days)	Remarks
Juveniles					
7035	25 Feb	J.C. 7	31 Mar	76	Experimental bird
7036	22 Mar	J.C. 7	14 Apr	27	Moved from study area
7043	3 Apr	Alkali	13 Apr	19	Moved from study area
7044	3 Apr	Alkali	21 Apr	24	Moved from study area
7051	5 Apr	Boettcher	27 May	53	Shot 9 Sep 1978
7101	11 Apr	J.C. 9A	24 Apr	20	Shot 9 Sep 1978
7147	22 Apr	Boettcher	8 Jul	89	Shot 9 Sep 1978
7183	29 Apr	Alkali	8 Jul	129[a]	
Adults					
2543	4 Apr	Wattenberg	8 Apr	4	Transmitter failure
6759	29 Mar	Boettcher	3 May	67	Intermittent transmitter
6907	14 Apr	Boettcher	9 Jun	66	
6943	31 Mar	Alkali	22 May	52	
7037	28 Mar	J.C. 7	12 Jun	81	Moved from study area; killed by eagle
7039	29 Mar	Boettcher	25 Apr	33	Killed (coyote?)
7040	31 Mar	Alkali	27 Apr	a	
7042	31 Mar	Bighorn	8 Jul	99	
7190	1 May	Boettcher	5 Aug	96	

[a]Transmitter lost by 7040 and reused on 7183.

Table 3. Capture data and transmitter life for male sage grouse, North Park, Colorado, 1979.

Band number	Capture date	Capture location	Date last located	Transmitter life (days)	Remarks
Juveniles					
7297	10 Apr	J.C. 7	16 Apr	8	Transmitter failure
7303	17 Apr	Boettcher	29 May	48	Intermittent transmitter
7310	20 Apr	Boettcher	9 Aug	111	
7325	24 Apr	Boettcher	17 Jun	54	
7391	24 Apr	Boettcher	13 Jul	80	
7402	1 May	Boettcher	9 Aug	90	
7407	4 May	Boettcher	17 Jun	44	Shot 8 Sep 1979
7408	4 May	Boettcher	17 Jun	44	
7410	4 May	Boettcher	13 Jul	70	
Adults					
6338	7 Apr	J.C. 7	10 Apr	a	Killed by eagle
6929	17 Apr	Boettcher	9 Aug	114	
7053	10 Apr	J.C. 7	25 May	47	
7294	9 Apr	J.C. 7	13 Jul	94	Moved from study area; shot 15 Sep 1979
7296	10 Apr	J.C. 7	14 Apr	11[a]	Transmitter failure
7298	11 Apr	J.C. 7	20 Jun	73	Moved from study area; shot 20 Jun 1979
7304	17 Apr	Boettcher	13 Jul	87	
7305	17 Apr	Boettcher	9 Aug	114	
7308	18 Apr	Boettcher	31 May	43	
7409	4 May	Boettcher	9 Aug	87	
7411	4 May	Boettcher	17 Jun	44	

[a]Transmitter used on 6338 and 7296.

Transmitters functioned an average of 64.3 days, ranging from 4 to over 129 days (Tables 2 and 3). Fourteen transmitters were operational beyond termination of the intensive research periods (9 June 1978, 17 June 1979). These birds were periodically located from mid-June through August.

Breeding Activities

Lek Attendance

Counts of male and female sage grouse present on leks in the Lake John study area were initiated on 23 March and continued through 30 May 1978. During this interval 204 counts were made on 4 active leks. In 1979, 107 counts were made on 3 leks from 7 April through 4 June. Peak female attendance occurred from 3 to 7 April 1978 and about 20 April 1979 (Table 4). Female attendance declined rapidly thereafter in both years (Figs. 3 and 4). Lower peaks occurred 4 to 5 weeks later, a situation previously reported by Dalke et al. (1960, 1963), Eng (1963), and Gill (1965). Late female attendance in 1979 was related to extensive snow cover. Peak male attendance occurred 25 to 37 days after the female peak on the 3 largest leks studied (Table 4). The rapid increase in male attendance observed both years (Figs. 3 and 4) was similar to the late spring situation described by Jenni and Hartzler (1978).

Table 4. Peak counts of sage grouse on 4 leks, North Park, Colorado, 1978-79.

Lek	Males				Females			
	1978		1979		1978		1979	
	No.	Date(s)	No.	Date(s)	No.	Date(s)	No.	Date(s)
Alkali Lake	56	10 May	72	27 May	20	3 Apr	a	
Bighorn	44	29 Apr	31	8 May	19	4 Apr	a	
Boettcher Lake Junction	84	1, 3 May	107	19 May	84	4 Apr	120	20 Apr
Wattenberg 2	21	26 May	b		7	7 Apr	b	

[a]No access prior to 30 April 1979.

[b]Intensive counts discontinued after 1978.

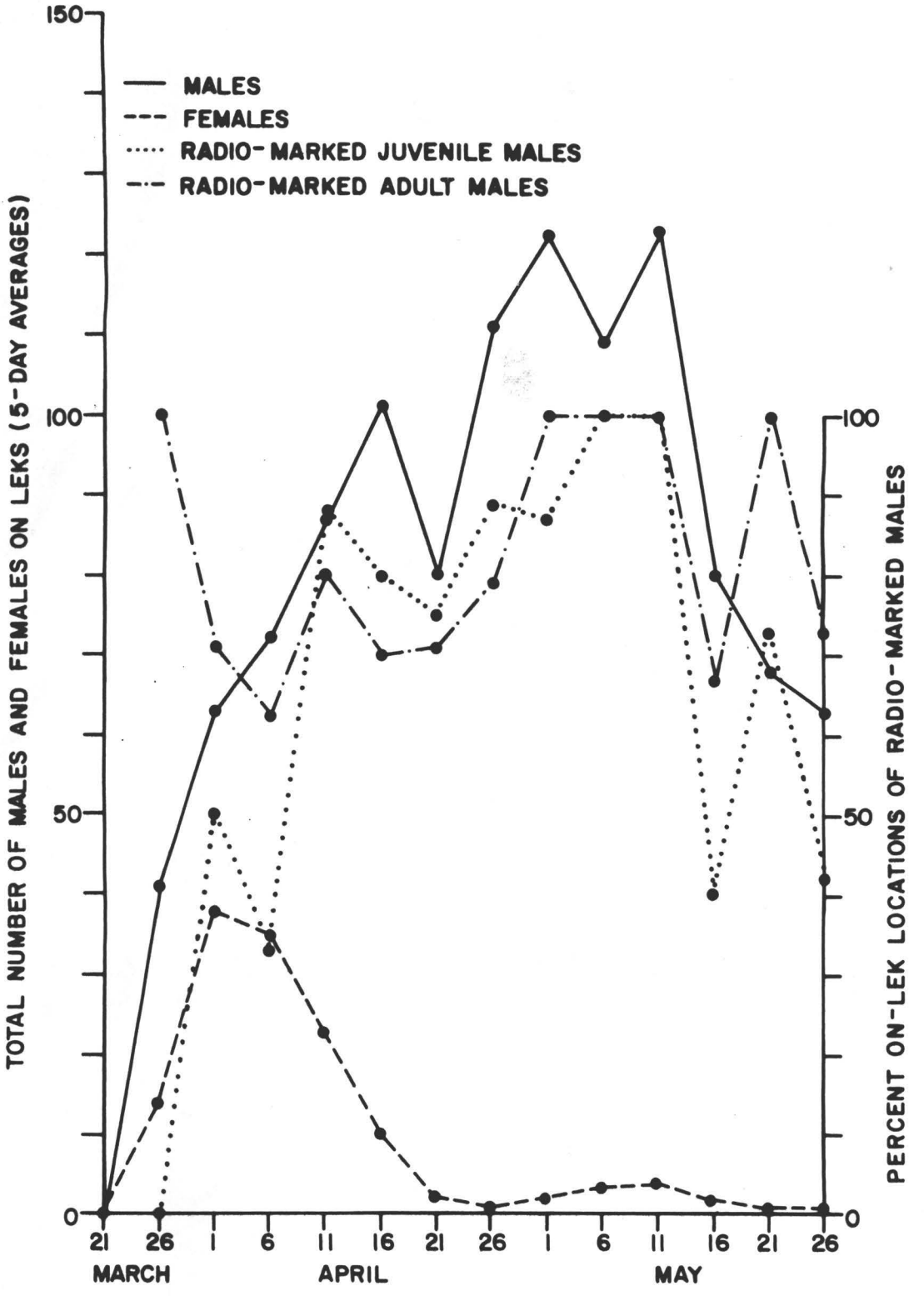

Fig. 3. Sage grouse attendance on 2 leks, North Park, Colorado, 1978.

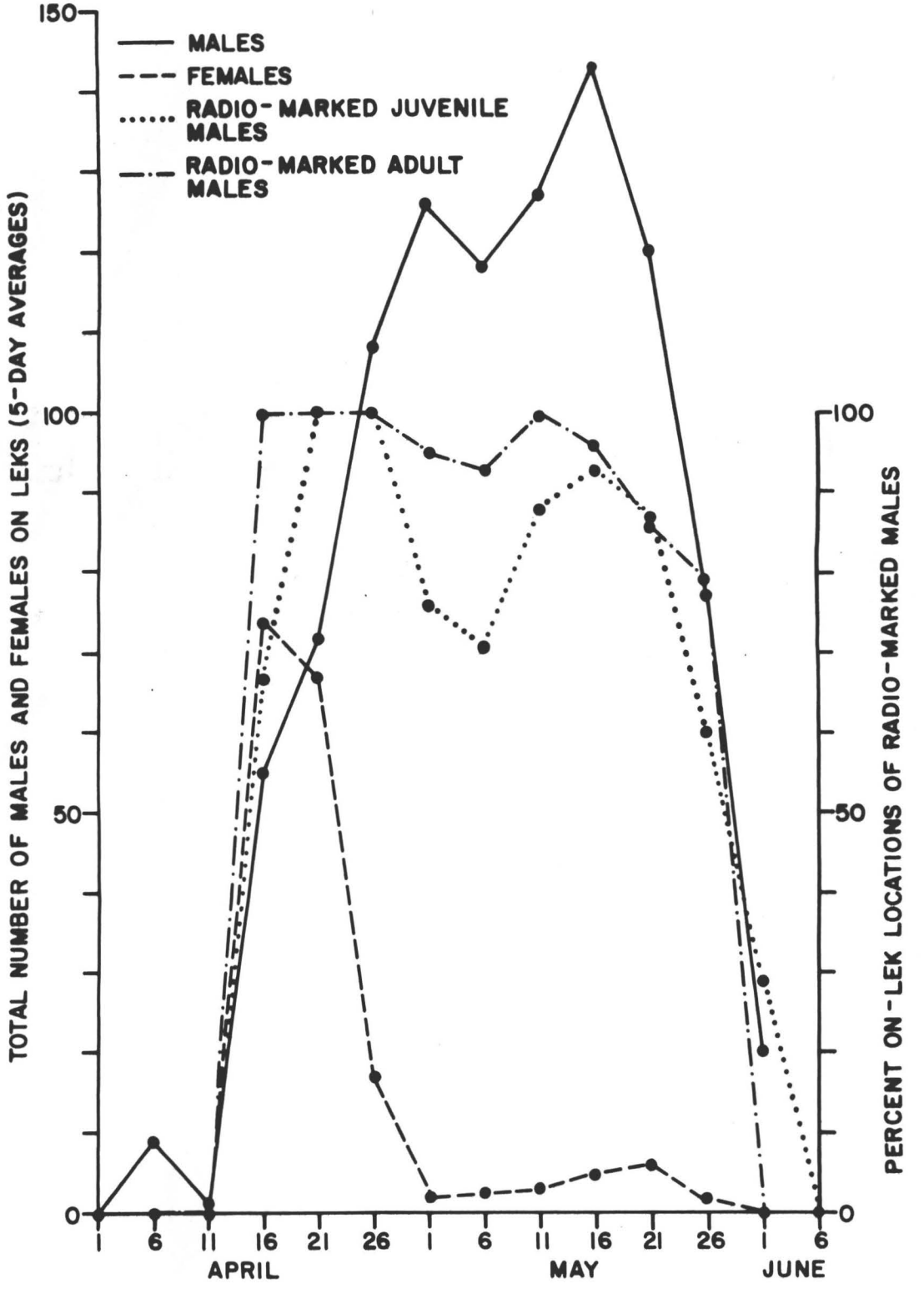

Fig. 4. Sage grouse attendance on 2 leks, North Park, Colorado, 1979.

Data from 33 birds (16 juveniles and 17 adults) were used to evaluate daily attendance patterns. Data from 4 birds were eliminated from analysis because of injury and subsequent depredation (7039), premature transmitter failure after 4 days (2543), and movement from the study area after 1 to 4 days (7037, 7043) (Table 2). Data were also eliminated if off-lek locations were attributed to late observer arrival or disturbance on the lek prior to my arrival.

Few data were available for analysis of lek attendance in March because of late capture dates both years. Two juveniles captured off leks were monitored from 22-31 March 1978. Only 2 of 16 (12.5%) early morning locations were possibly on leks; exact locations were not determined because of access difficulties. Neither bird was known to visit a lek prior to 30 March. Two adults visited a lek for 4 locations from 26 to 31 March 1978 (Fig. 5). Lek attendance of 6 juvenile males increased from 41.7 to 83.3%, from 1-10 to 11-20 April 1978 (Fig. 5). This increase ($\underline{P} < 0.05$) supports other observations that numbers of juvenile males attending leks increase following peak female attendance (Patterson 1952:153-154, Dalke et al. 1963, Eng 1963, Gill 1965, Jenni and Hartzler 1978). Lek attendance was 81.0% for 21-30 April 1978. Thirty-seven of 50 (74.0%) locations were on leks during 29 days of observations.

Attendance of juveniles increased ($\underline{P} > 0.05$) to 95.1% from 1-15 May and decreased ($\underline{P} < 0.05$) to 53.6% in late May 1978

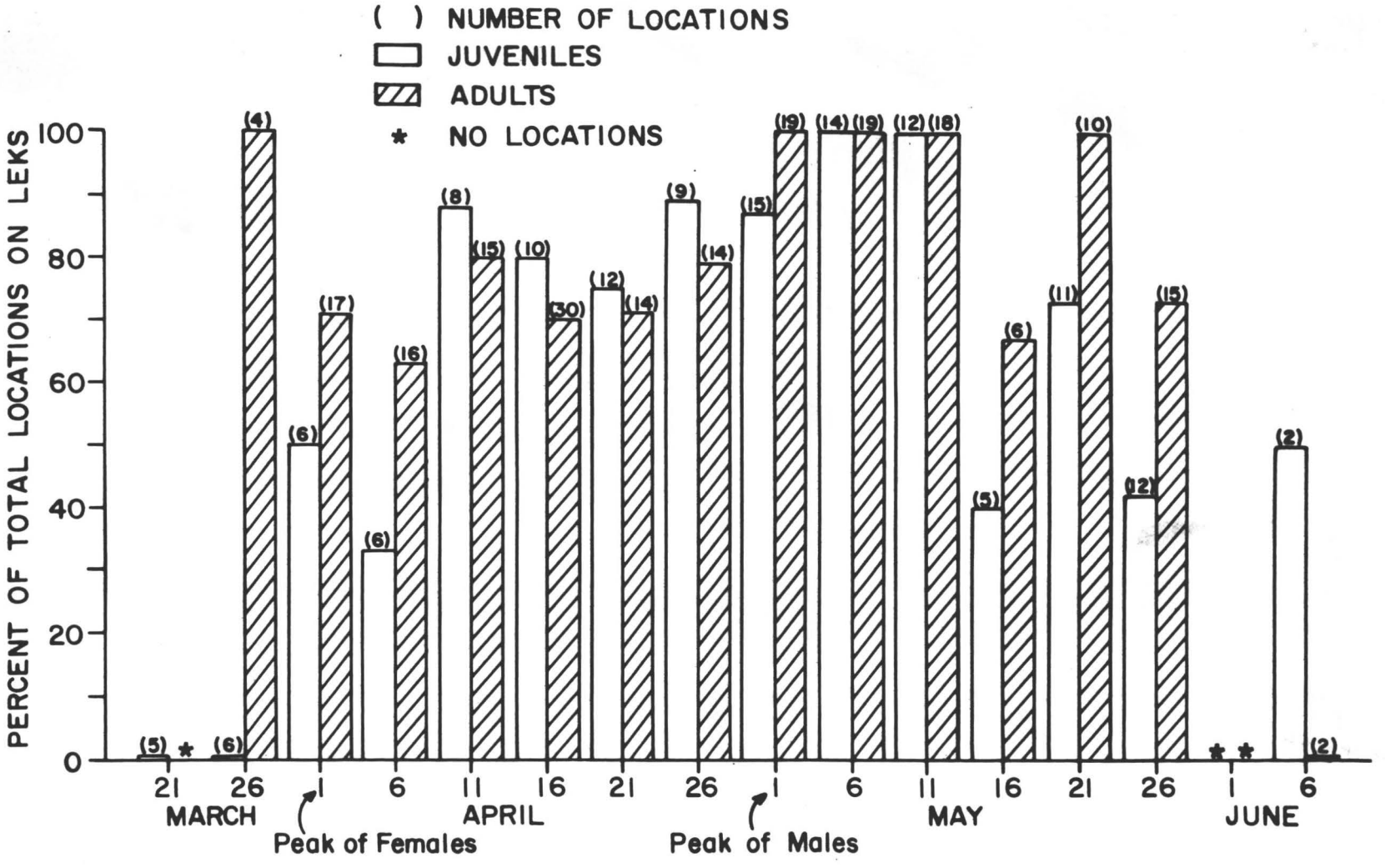

Fig. 5. Lek attendance of radio-marked male sage grouse, North Park, Colorado, 1978.

(Fig. 5). However, during 16-31 May I was absent from the study area for 4 days and a late snowstorm prohibited access to 1 lek for 2 additional days (Fig. 3). These factors may have influenced the magnitude of the decrease. Average attendance for May 1978 was 78.3% of 69 locations for 3 radio-marked juveniles. Juvenile lek attendance decreased ($P > 0.05$) during 1-10 June. Only 1 of 2 (50.0%) locations was on a lek.

Lek attendance of 6 radio-marked adults was 71.9% of 96 locations in April 1978. Attendance per 5-day interval ranged from 62.5 (6-10 April) to 80.0% (11-15 April) ($P > 0.05$) (Fig. 5). Adult attendance increased ($P < 0.05$) to 100.0% in 1-15 May, and decreased ($P < 0.05$) to 80.6% thereafter (Fig. 5). Eighty-one of 87 (93.1%) locations of 5 birds were on leks during 27 days of observation. Lek attendance decreased rapidly ($P < 0.05$) for adults in early June. None (0 of 2) was present on a lek during 1-10 June.

During the 5-day period which included peak female counts in 1978 (1-5 April), 50.0 and 70.6% of radio-marked juvenile and adult males, respectively, were on leks (Figs. 3 and 5). Ninety-two and 94.2% of the juveniles and adults, respectively, were present on leks during the 15-day period which included peak male counts (26 April-10 May) (Table 4).

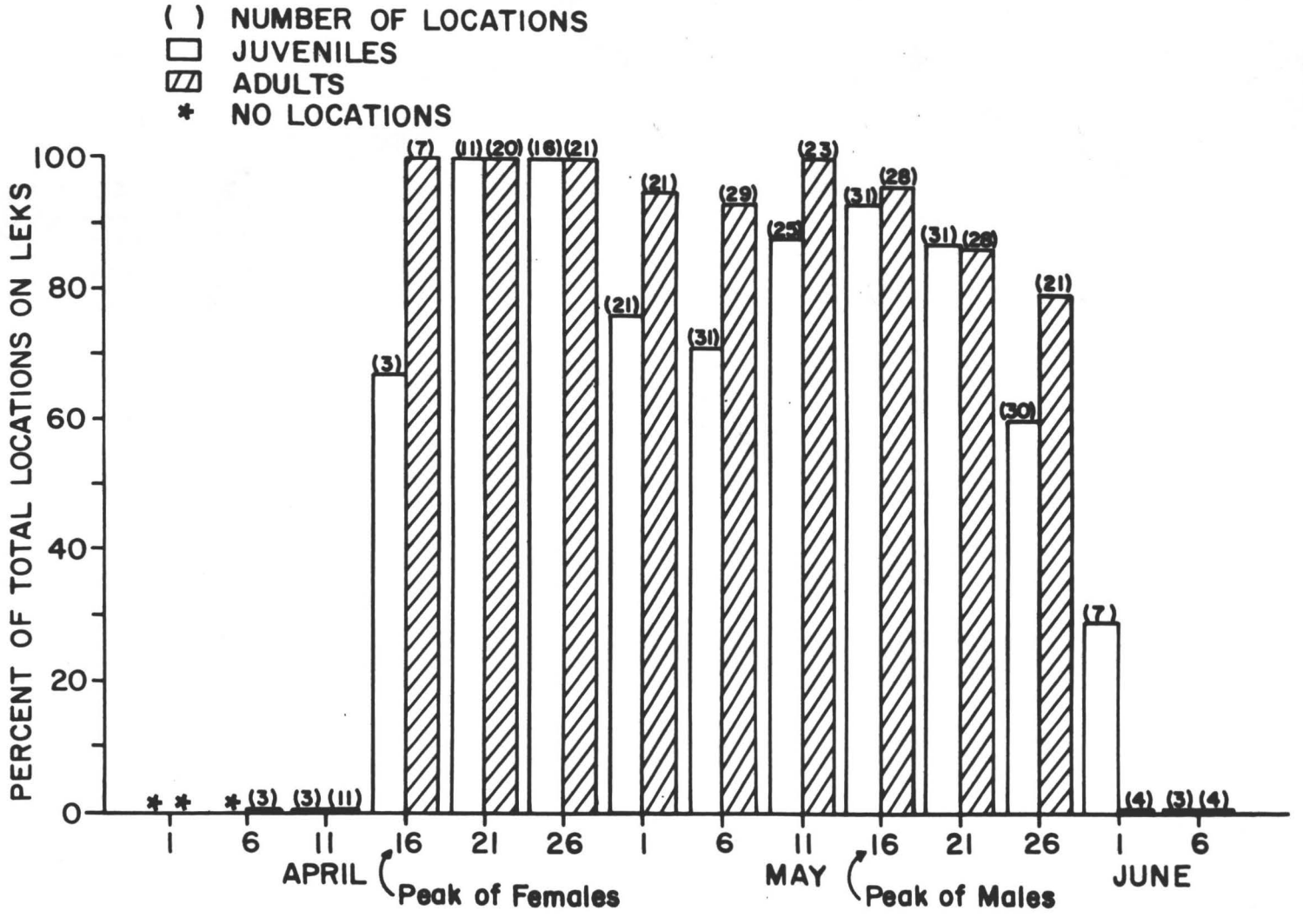

Fig. 6. Lek attendance of radio-marked male sage grouse, North Park, Colorado, 1979.

Juvenile and adult male sage grouse were not equipped with radio transmitters and monitored until 10 and 7 April 1979, respectively. Lek attendance of 5 radio-marked juveniles increased ($P < 0.05$) from 33.3 (11-20 April) to 100.0% (21-30 April) following the peak of female attendance in 1979 (Figs. 4 and 6). Lek attendance averaged 87.9% of 33 locations during 16 days of observations. Attendance of 8 juveniles decreased ($P < 0.05$) to 73.1% from 1-10 May and increased ($P < 0.05$) to 91.1% during 11-20 May (Fig. 6). Lek attendance was 78.8% ($P < 0.05$) for 21-31 May. Average attendance for May 1979 was 79.3% of 169 locations obtained on 28 days.

Nine adult males were monitored on 17 days in April 1979. Lek attendance increased ($P < 0.05$) from 0.0 (1-15 April) to 100.0% (16-30 April) (Fig. 6). Attendance averaged 77.4% of 62 locations throughout April. Lek attendance of 7 radio-marked adults decreased ($P > 0.05$) to 94.0% from 1-10 May, increased ($P > 0.05$) to 98.0% in 11-20 May, and decreased ($P < 0.05$) to 82.7% from 21-31 May (Fig. 6). Average attendance for 153 locations was 91.5% during May 1979. Lek attendance decreased rapidly ($P < 0.05$) for both age classes in early June. Two of 10 (20.0%) locations recorded for 7 juveniles were on leks. None of 8 locations of 4 adults was on leks during 1-10 June (Fig. 6).

Juvenile and adult males were present on leks for 66.7 and 100.0% of the locations, respectively, during the peak of female

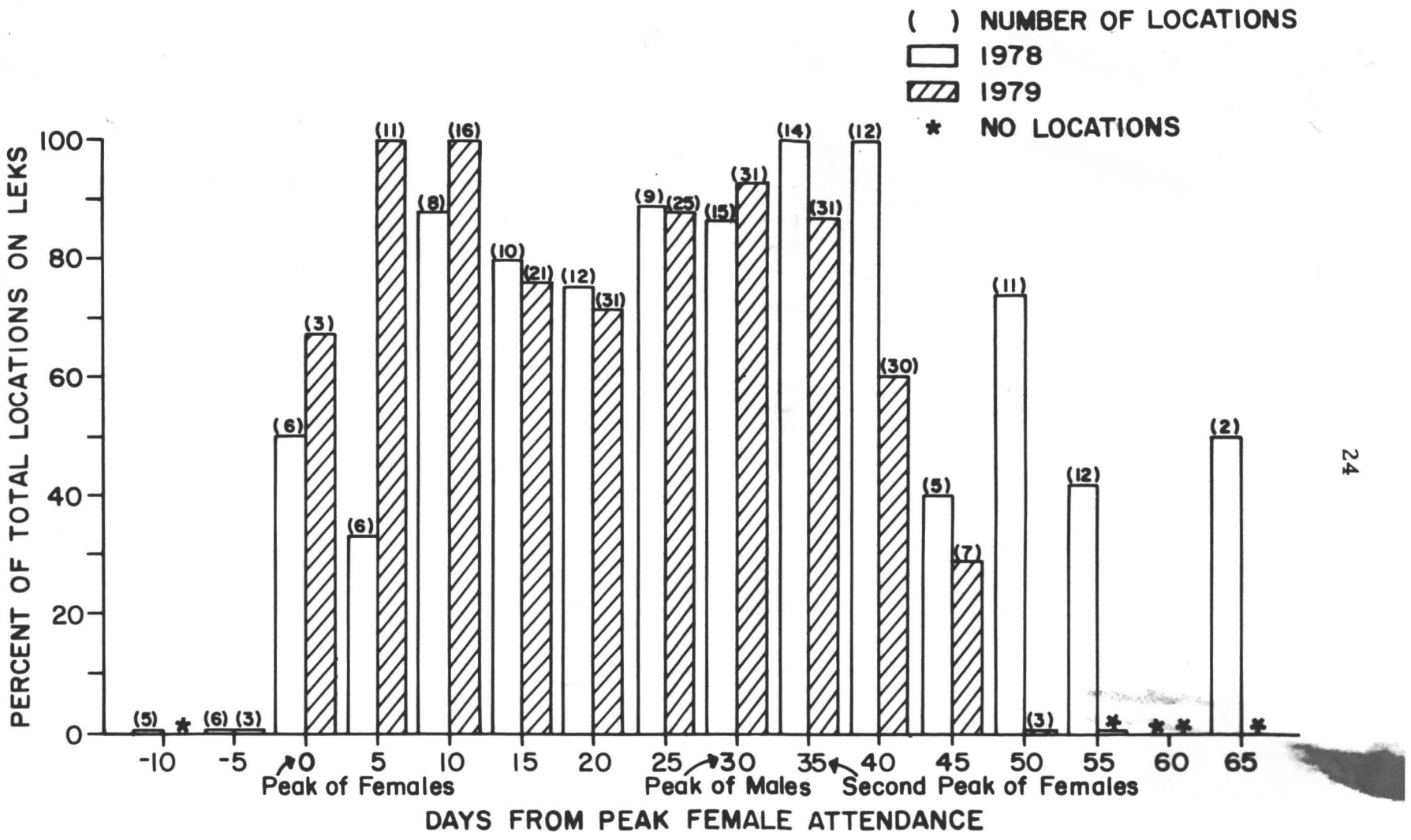

Fig. 7. Lek attendance of radio-marked juvenile male sage grouse, North Park, Colorado, 1978-79.

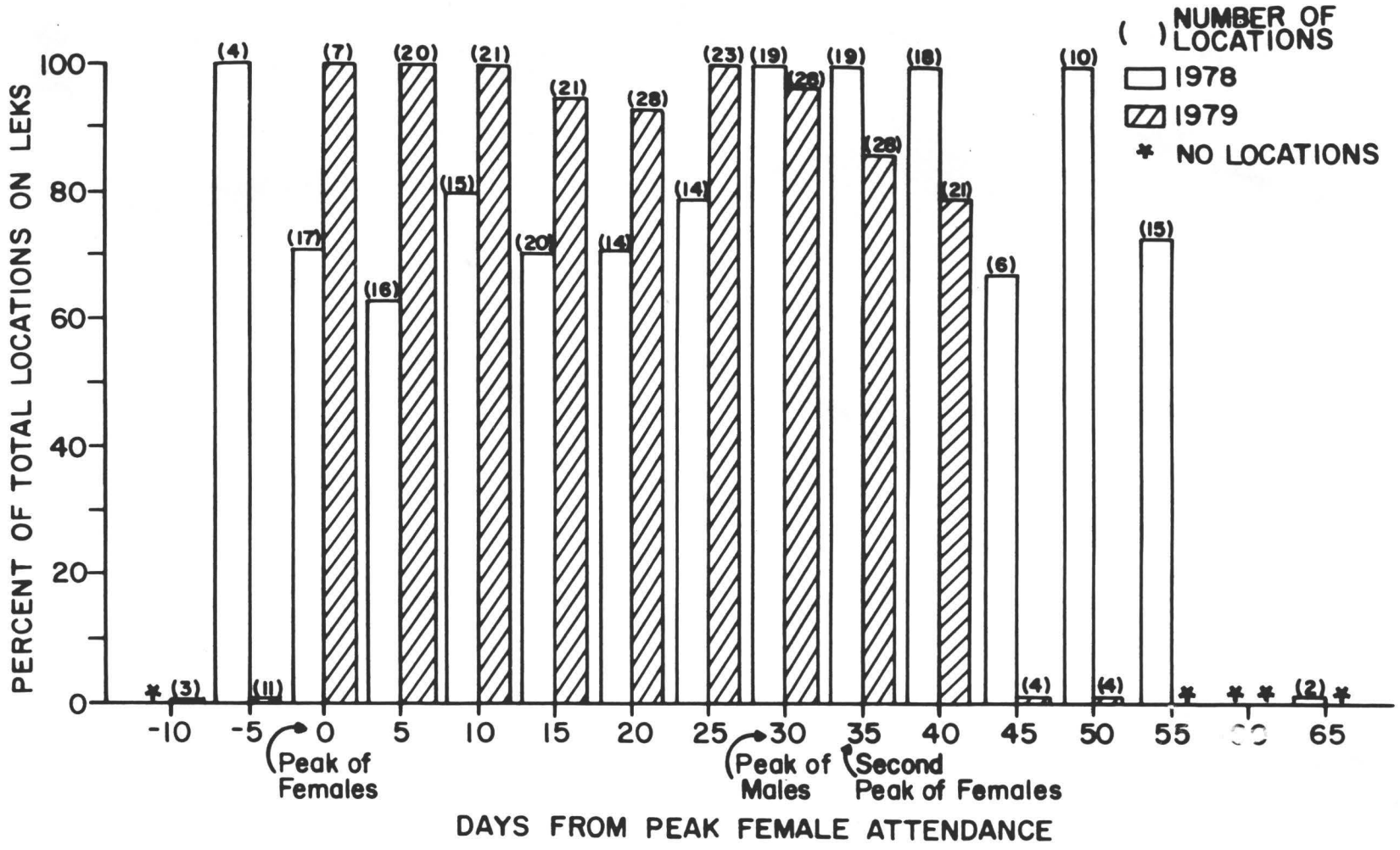

Fig. 8. Lek attendance of radio-marked adult male sage grouse, North Park, Colorado, 1978-79.

attendance (16-20 April 1979) (Table 4). During the 15-day period which included peak male counts (11-25 May), 89.7 and 93.7% of the juveniles and adults, respectively, attended leks (Figs. 4 and 6).

The 2 years were compared by superimposing the 5-day periods which include the peak of female attendance (1-5 April 1978, 16-20 April 1979) (Figs. 7 and 8). During the period of peak female attendance, 55.6 and 79.2% of the radio-marked juvenile and adult males, respectively, were on leks. Over 90% of the juveniles (90.4%) and adults (93.9%) attended leks during the 15-day period (25-40 days after the female peak) which included peak male counts (26 April-10 May 1978, 11-25 May 1979).

Sage grouse males captured while roosting off leks regularly attended leks during the breeding season. Four juveniles were captured off leks and radio-equipped. One transmitter (7297) failed prematurely prior to the beginning of lek attendance, 1 bird (7035) moved from the study area after 2 days and may have visited a lek thereafter, and 2 birds (7036, 7101) visited 2 leks for 9 of 20 (45.0%) locations. Six adult males were captured along roads. One bird (6338) was killed by a raptor while moving towards the lek where originally banded in 1975, 1 transmitter (7296) failed prematurely, and 4 birds (7037, 7053, 7294, 7298) visited leks for 19 of 30 (63.3%) locations. Three of these males moved to leks not in the study area.

Movements

Movements between leks within the study area by juvenile males were common (3.9 each) but were infrequent for adults (0.6 each). No differences ($P > 0.05$ occurred between years although juveniles had up to 13 movements (avg. 4.4) in 1978 and no more than 6 in 1979 (avg. 3.6). This does not include moves to leks outside the study area and possible moves on 5 days in 1978 when data were not collected.

Interchange between leks by juveniles increased ($P < 0.05$) as the breeding season progressed (Fig. 9). This may have been more the result of number of birds equipped with radios (8 in April, 11 in May) than large changes in movement patterns. Number of leks visited increased ($P < 0.05$) from April (1-2) to May (2-4). Each juvenile visited from 2 to 4 leks (avg. 2.8) during the breeding season.

Distances between leks in the study area ranged from 2.4-8.1 and averaged 5.0 km (Table 5). The average distance per juvenile interlek move was 4.0 km. Moves commonly occurred between Alkali Lake and Boettcher Lake Junction leks (49.0% of all interlek movements), Alkali Lake and Wattenberg 2 (17.6%), and Boettcher Lake Junction and Bighorn (15.7%). The number of interlek movements between Alkali Lake and Boettcher Lake Junction was unexpected because shorter distances and topography should have increased

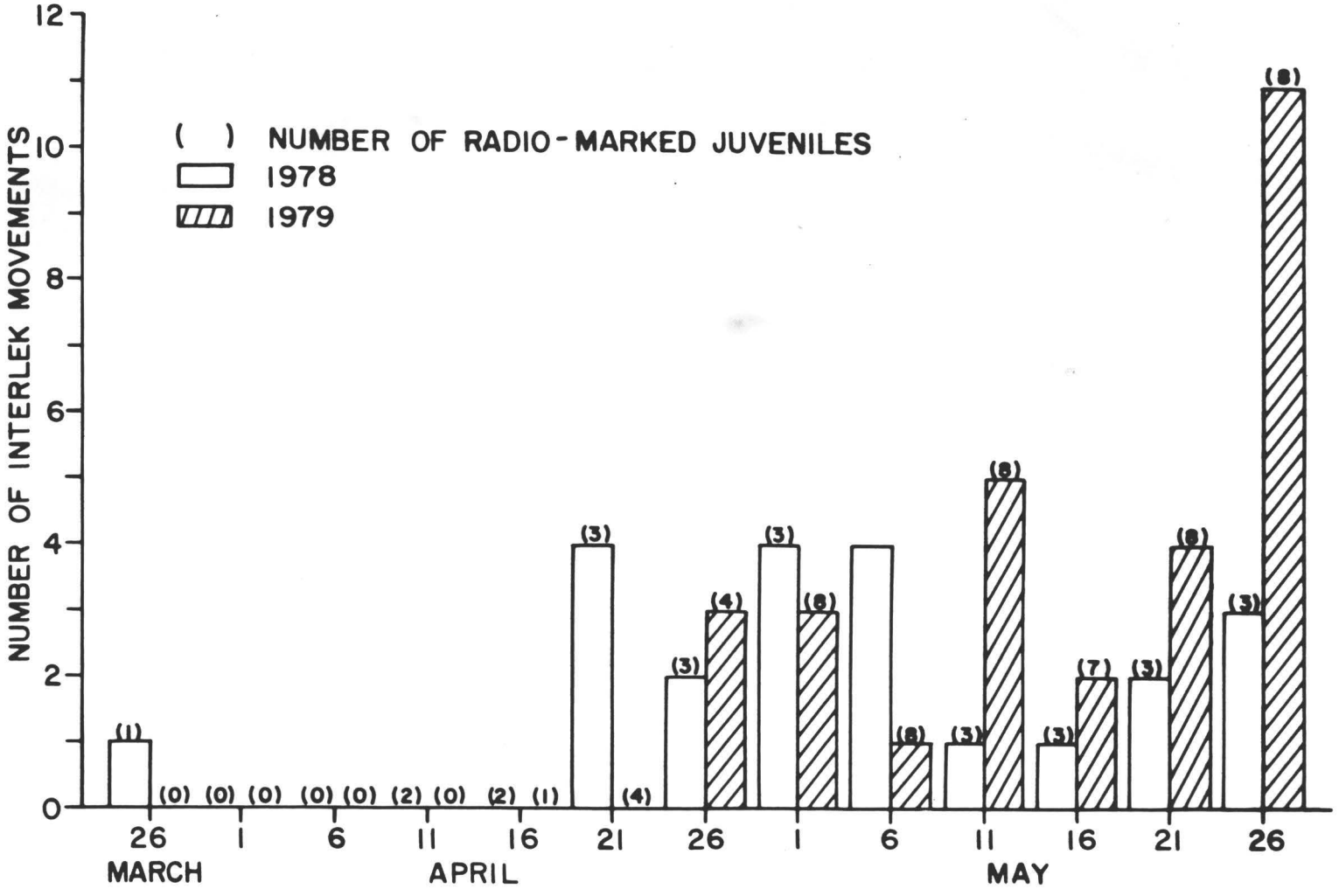

Fig. 9. Time distribution of interlek movements by juvenile male sage grouse, North Park, Colorado, 1978-79.

Table 5. Interlek distances (km) and sage grouse movements, Lake John area, North Park, Colorado, 1978-79.

	Alkali Lake			Bighorn			Boettcher Lake Junction			Riley		
	Distance between	No. of movements Juv.	Ad.	Distance between	No. of movements Juv.	Ad.	Distance between	No. of movements Juv.	Ad.	Distance between	No. of movements Juv.	Ad.
Bighorn	5.1	2	0	--	--	--	--	--	--	--	--	--
Boettcher Lake Junction	4.5	25	0	2.4	8	1	--	--	--	--	--	--
Riley	2.7	4	2	6.9	0	0	5.5	1	0	--	--	--
Watten-berg 2	3.2	9	2	8.1	1	0	7.6	1	2	4.2	0	0

movements between Alkali Lake-Wattenberg 2, Alkali Lake-Riley, and Boettcher Lake Junction-Bighorn. The reason for this interchange is unknown but may be related to lek size (Table 4). Juveniles averaged at least 15.6 km (range 2.4-58.7) in interlek movements during the breeding season. Juvenile males moved at least 23.9 km (range 5.1-60.8) throughout the breeding season for both years (Table 6). Mean distance per move was 1.9 km. No difference ($P > 0.05$) existed between years.

Juveniles attended a lek an average of 4.3 days, ranging from 1-36 non-consecutive days where visits to that lek were intermixed with off-lek days. The average number of consecutive days per visit was 2.8, with a maximum of 15 days. Because of my absence from the study area, 3 birds may have visited a lek for over 20 consecutive days (range 22-37).

Interlek movements of individual juveniles varied. Three birds were extremely sedentary and remained on or near the lek of capture throughout most of the breeding season, finally moving to a 2nd lek in late May. One bird moved 13 times between 4 leks and remained on each lek for 3 days or less. Other individuals were intermediate between these extremes including 1 bird which visited 2 leks (Boettcher Lake Junction and Alkali Lake) in 1 morning moving 4.5 km between 0510 and 0610 MDT on 22 May 1979.

Table 6. Distances (km) traveled by male sage grouse during the breeding season, North Park, Colorado, 1978-79.

	No. birds	No. moves[a]	Total distance	Mean distance per bird	Mean distance per move
Juveniles					
1978	7	87	187.8	26.8	2.2
1979	9	111	195.0	21.7	1.8
Subtotals	16	198	382.8	23.9[b]	1.9
Adults					
1978	6	84	99.7	16.6	1.2
1979	10	78	60.4	6.0	0.8
Subtotals	16	162	160.1	10.0[c]	1.0[c]
Totals	32	360	542.9	17.0[d]	1.5[d]

[a]Includes interlek movements.

[b]No difference between years ($P > 0.05$).

[c]Difference between years ($P < 0.05$).

[d]Difference between age classes ($P < 0.05$).

Only 3 of 11 (27.3%) adult males visited more than 1 lek during the breeding season. Two adults (6943, 7190) visited 1-2 additional leks for only 1 day. One of these visits followed 12 days of non-attendance to a lek. One other adult male (6929) displayed on the lek where marked (Boettcher Lake Junction) through 15 May 1979 and then attended Bighorn lek.

Adult males moved an average of 10.0 km (range 0.6-31.3) during the breeding season (Table 6). Differences ($\underline{P} < 0.05$) existed between 1978 (16.6 km) and 1979 (6.0 km). Differences ($\underline{P} < 0.05$) also existed between years for mean distance per move (1.2 km in 1978, 0.8 km in 1979). Average distance per adult movement (1.0 km) was considerably less ($\underline{P} < 0.05$) than that of juveniles. This was attributed to the large number (58 of 198) of relatively long (> 1.5 km) interlek movements by juveniles.

Twenty-two percent of all off-lek locations were beyond 1.5 km (Table 7). Off-lek distances beyond 2.0 km comprised 11.1 and 8.8% of all off-lek locations for juveniles and adults, respectively. Over 50% (55.3) of 313 off-lek locations were between 0.26 and 1.00 km from a lek. Only 7.3% of the locations were within 0.25 km of a lek.

Long distance movements from the study area were recorded for 4 juvenile and 3 adult male sage grouse. Juvenile 7036 moved a minimum of 25.7 km in 5 days to the Spring Creek area southeast

Table 7. Distances from leks to feeding-loafing sites of male sage grouse, North Park, Colorado, March-May, 1978-79.

Distance (km)	Juveniles[a]		Adults[b]		Totals	
	No.	%	No.	%	No.	%
0.01-0.25	9	5.9	14	8.8	23	7.3
0.26-0.50	44	28.7	58	36.1	102	32.6
0.51-0.75	9	5.9	18	11.2	27	8.6
0.76-1.00	21	13.7	23	14.4	44	14.1
1.01-1.25	14	9.2	11	6.9	25	8.0
1.26-1.50	13	8.5	11	6.9	24	7.7
1.51-1.75	9	5.9	6	3.8	15	4.8
1.76-2.00	17	11.1	5	3.1	22	7.0
2.0+	17	11.1	14	8.8	31	9.9
Totals	153	100.0	160	100.0	313	100.0

[a]Distances measured from nearest lek.

[b]Distances measured from normal lek attended.

of Walden. Two juveniles left the study area 5 days after instrumentation. Juvenile 7043 moved 2.5 km north of Walden Reservoir about 6.0 km east of the study area, while 7044 moved approximately 6 km south of Wattenberg 2 lek. This bird then moved north 1st to Alkali Lake lek and then to near Bighorn lek before signals were lost. Juvenile 7035 moved a minimum of 80 km between 25 February and 31 March 1978.

Three of 6 adults captured off leks moved to leks outside of the study area. Bird 7037 was captured on 28 March 1978 along J.C. 7 (Table 2). From 31 March to 9 May this bird was near Aspen lek west of Delaney Butte, 12 km southwest of the study area. Bird 7294 moved to Cheyenne lek, 13 km south-southwest, after 15 April, while 7298 moved to Migan lek, 21 km south, by 6 May. Both birds were captured along J.C. 7 in early April 1979 (Table 3).

Daily Activity Patterns

Selected transmittered birds were monitored at 2-3 hour intervals throughout chosen days to document daily activity patterns during the breeding season. Three to 7 locations were ascertained for 2-4 males between 0500 and 2120 MDT on 21 and 24 May 1978, and on 13, 21, 25, 27 and 30 May 1979. Activity patterns were also available for juvenile and adult males when 2-3 daily locations were obtained from 23 March to 9 June 1978 and 8 to 21 May 1979.

Juveniles present on a lek in early morning were relocated later in the day on 13 occasions. Distances from the lek ranged from 0.4 to 3.2 km (avg. 1.2). Midday moves over 0.5 km were uncommon as only 6 of 22 (27.3%) were beyond 0.5 km. The average move during midday was 0.3 km (range < 0.1-1.4).

Juveniles travelled as far as 3.2 km when leaving a lek. Undisturbed birds subsequently moved only 150-300 m. Midday moves over 1.0 km usually resulted from disturbance. Juveniles may be more mobile during the day early in the breeding season. This was observed with 1 juvenile averaged 2.1 km (range 0.8-3.7) ($\underline{P} < 0.1$) between morning and afternoon locations from 23 to 31 March. Juveniles remained in a particular flock until disturbed or intermixing occurred at a lek with subsequent dispersal changing flock composition.

Adult males were relocated after leaving a lek on 18 occasions. Dispersal from the lek averaged 1.1 km (range < 0.1-2.9). No difference ($\underline{P} > 0.05$) existed between adult and juvenile dispersal. Subsequent midday moves averaged 0.2 km (range < 0.1-1.0) for adults. Adult male sage grouse had activity patterns similar to that of juveniles, i.e., relatively long distance dispersal from a lek with subsequent short moves. Disturbance usually resulted in moves over 1.0 km.

Daily dispersal from a lek was non-random in direction ($P < 0.05$). Forty-one percent (24 of 58) of the radio-marked adult males dispersed southwest to south-southeast from Boettcher Lake Junction lek while 39.7% dispersed northeast to southeast (Fig. 10). Thirty-one percent (8 of 26) of the radio-marked juveniles dispersed south from Boettcher Lake Junction, 23.1% east to southeast, and 23.1% west to southwest. Individual adult males appeared to disperse in the same direction daily. Bird 6907 moved 0.4-0.5 km south of the lek prior to moving 0.1-0.6 km west of J. C. 7 (Fig. 2) for 4 days between 14 and 21 May 1978. Adult 7409 was located 0.1-0.5 km east to northeast on 6 of 7 days located after 0900 MDT (8-17 May 1979). Reasons for the directions of dispersal are unknown but may be related to topography, other leks in the area (Fig. 2), association with other males, and location of sprayed areas.

Non-random dispersal was also observed from Alkali Lake lek as 85.7 and 72.7% of the radio-marked adult and juvenile males, respectively, dispersed to the south (Fig. 11). Few data were available for dispersal from other leks in the study area.

Roosting

Roosting data were obtained from capture sites and evening locations (after 1700 MST). Capture sites were biased towards lek-roosting birds because trapping was most successful on leks throughout the field season.

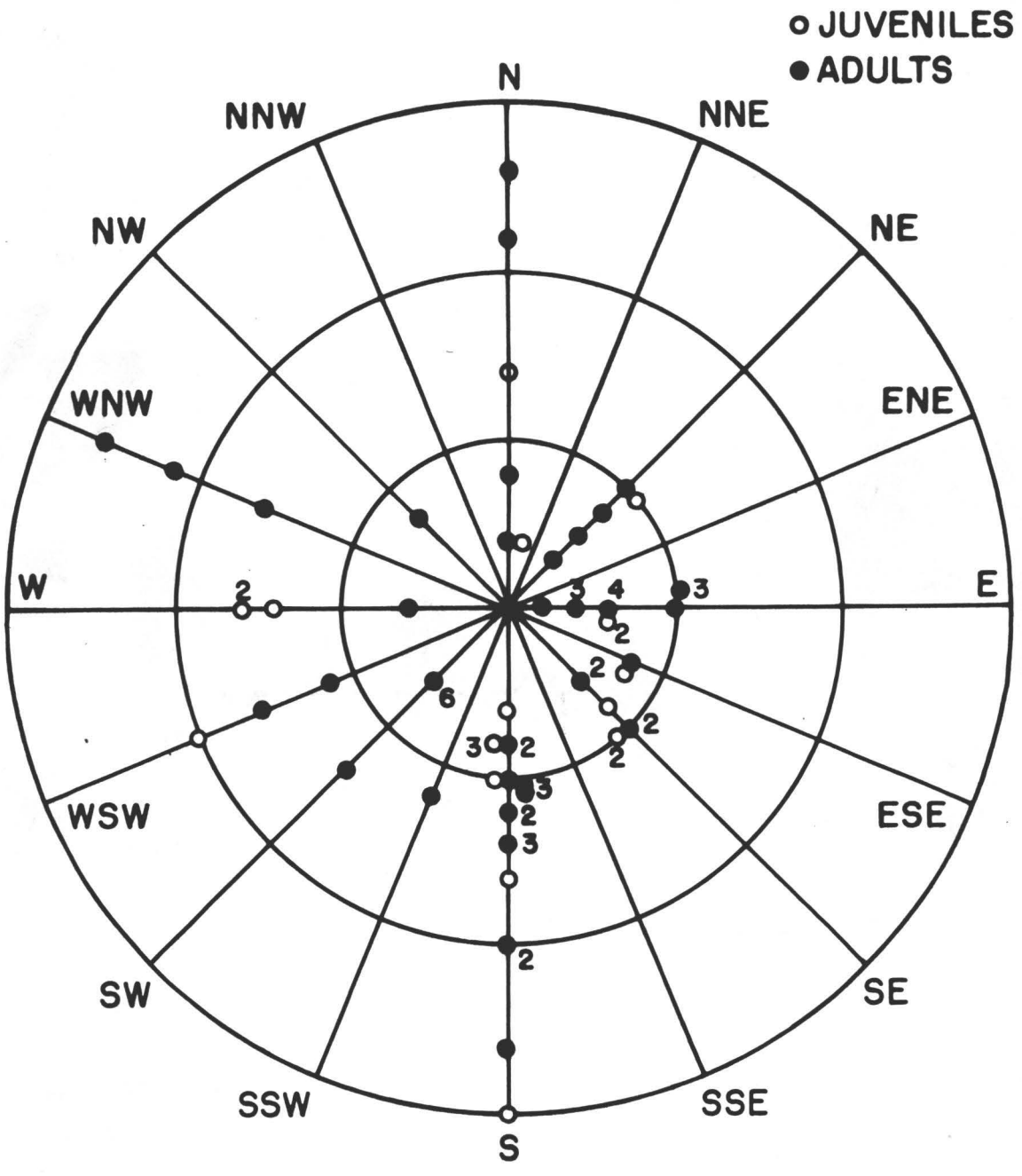

Fig. 10. Dispersal of male sage grouse from Boettcher Lake Junction lek, North Park, Colorado, 1978-79. Each concentric circle represents 0.5 km. Number of locations at each site is indicated (no number indicates only 1 location). Locations (N = 12) beyond 1.5 km are not shown.

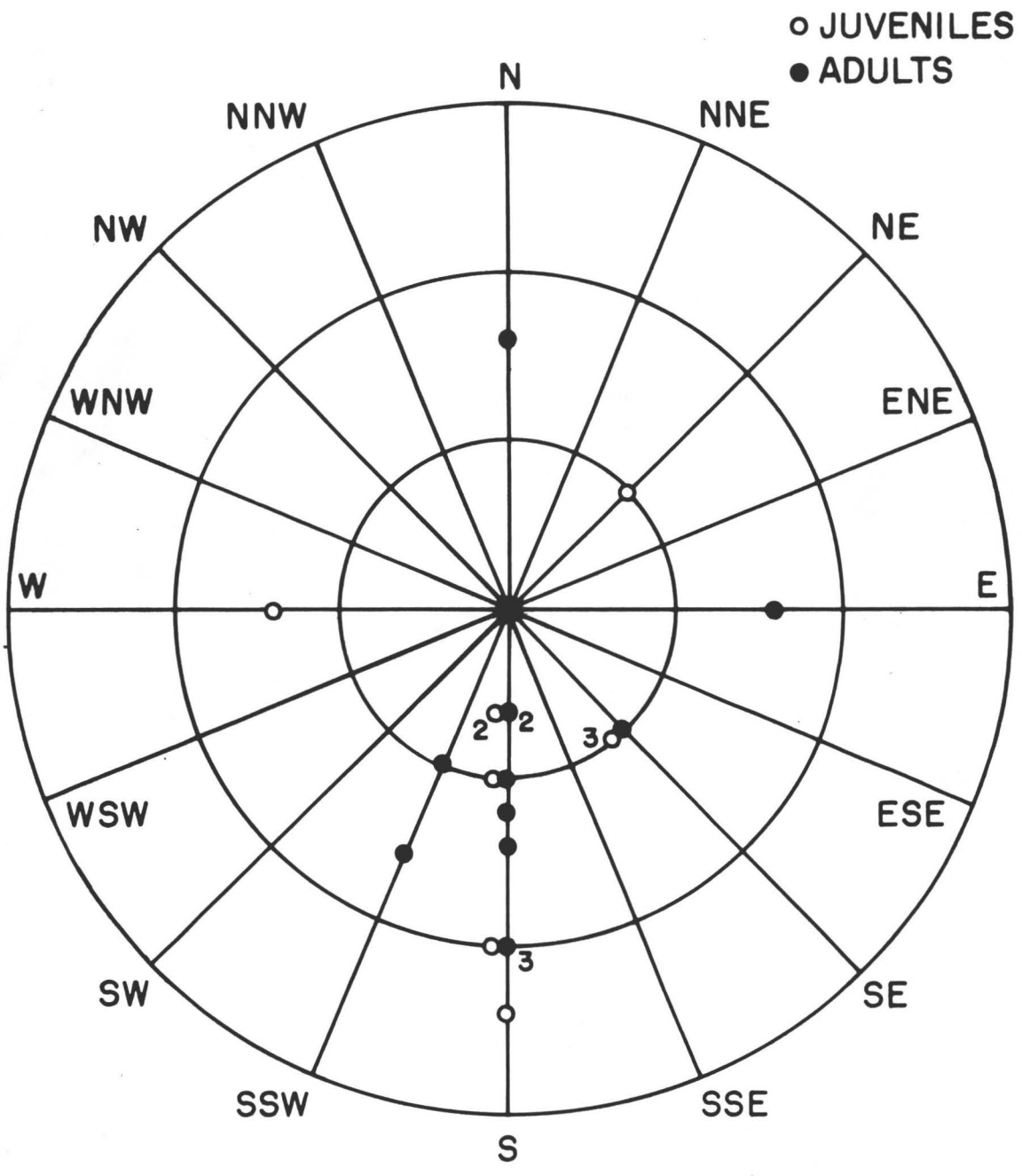

Fig. 11. Dispersal of male sage grouse from Alkali Lake lek, North Park, Colorado, 1978-79. Each concentric circle represents 0.5 km. Number of locations at each site is indicated (no number indicates only 1 location). Locations ($\underline{N}$ = 2) beyond 1.5 km are not shown.

Twenty-nine of 48 (60.4%) roosting locations for juvenile males were on leks (Table 8). Highest on-lek roosting occurred in April (84.6%), with 60.7% of the roost sites in May being on leks. Adult males roosted on leks 69.8% of the total locations obtained with 55.0 and 78.1% of the roost sites on leks in April and May, respectively. No difference ($P > 0.05$) existed between the 2 age classes except during March ($P < 0.05$) when 16.7 and 87.5% of the roost sites of juveniles and adults, respectively, were on leks.

Table 8. Roosting sites of radio-marked male sage grouse, North Park, Colorado, 1978-79.

Month	Juveniles			Adults		
	On-lek	Off-lek	Totals	On-lek	Off-lek	Totals
Feb	0	1	1	--	--	--
Mar	1	5	6	7	1	8
Apr	11	2	13	12	10	22
May	17	11	28	25	7	32
Totals	29	19	48	44	19	63

Vegetation Analysis

Sagebrush height and canopy coverage measurements were obtained at 160 daytime feeding and loafing sites, and 88 roosting

sites. Measurements of forb and grass coverage were obtained for all locations, including the 5 leks.

Approximately 56% (56.3) of all feeding and loafing sites occurred in sagebrush with a canopy coverage of 20-50% (Table 9). Sagebrush canopy coverage averaged 28.1% (range 2.9-68.8) for 160 sites.

Table 9. Frequency distribution of male sage grouse feeding-loafing and roosting sites by sagebrush canopy coverage class, North Park, Colorado, 1978-79.

Canopy coverage class[a]	Feeding-loafing sites		Roosting sites[b]	
	Number of locations	%	Number of locations	%
0.1-10.0	25	15.6	75	85.2
10.1-20.0	30	18.7	4	4.5
20.1-30.0	31	19.4	1	1.2
30.1-40.0	42	26.3	6	6.8
40.1-50.0	17	10.6	2	2.3
50.1+	15	9.4	0	0.0
Totals	160	100.0	88	100.0

[a]Expressed as percent of fully closed canopy.

[b]Includes 71 on-lek roosting sites.

Eighty percent of the daytime feeding and loafing locations were in sagebrush with a height of 20-70 cm (Table 10). The average maximum height for the 160 locations was 43.5 cm (range

9-88). This may reflect actual height distribution of sagebrush in the area instead of selection by the birds (Wallestad and Schladweiler 1974).

Table 10. Frequency distribution of male sage grouse feeding-loafing and roosting sites by sagebrush height class, North Park, Colorado, 1978-79.

Sagebrush height class (cm)[a]	Feeding-loafing sites		Roosting sites[b]	
	Number of locations	%	Number of locations	%
0.1-10.0	1	0.6	8	9.1
10.1-20.0	19	11.9	68	77.3
20.1-30.0	22	13.8	2	2.3
30.1-40.0	30	18.8	1	1.1
40.1-50.0	19	11.9	0	0.0
50.1-60.0	32	20.0	7	7.9
60.1-70.0	25	15.6	2	2.3
70.1-80.0	9	5.6	0	0.0
80.1-90.0	3	1.8	0	0.0
Totals	160	100.0	88	100.0

[a]Measurement of height of tallest living plant.

[b]Includes 71 on-lek roosting sites.

Approximately 90% (89.7) of the roosting locations including 71 on leks occurred in sagebrush with a canopy coverage of less than 20% (Table 9). The average canopy coverage for the 88 locations was 8.7 and ranged from 0.4 (Alkali Lake lek, Table 11) to

Table 11. Vegetative cover (%) of 5 leks, North Park, Colorado, 1978-79.

Plant species	Lek					
	Alkali Lake	Bighorn	Boettcher Lake Junction[a]	Riley	Wattenberg 2	Averages
Big sagebrush (Artemisia tridentata)	0.37	7.31	5.45	0.96	16.62	6.14
Fringed sagebrush (A. frigida)	5.28	1.43	1.82	2.73	4.82	3.22
Snakeweed (Gutierrezia sarothrae)	0.00	2.72	0.56	5.64	2.36	2.25
Winterfat (Eurotia lanata)	12.32	0.10	0.66	0.36	0.59	2.69
Moss phlox (Phlox bryoides)	0.50	2.58	1.22	0.31	3.84	1.69
Bluebell (Mertensia bakeri)	0.00	0.29	0.02	0.00	0.07	0.08
Low Daisy (Erigeron pumilus)	0.00	0.11	0.09	0.00	0.25	0.09
Grasses	5.57	6.01	6.28	11.98	7.90	7.55
Totals[b]	24.08	20.57	18.00	23.23	36.14	24.40

[a]Two separate areas of the lek were combined to form composite values.

[b]Includes additional species not found on all leks.

49.3%. Eight of 17 (47.1%) off-lek roosting sites were in sagebrush with < 20% canopy coverage. The average canopy coverage for the off-lek locations was 22.4%. The large number of on-lek roosting sites resulted in differences ($P < 0.05$) between feeding-loafing and roosting sites.

Seventy-six (86.4%) roosting locations occurred in sagebrush less than 20 cm in height (Table 10). Average sagebrush height was 18.7 cm (range 9-68) compared with 38.7 cm for the 17 off-lek roosts ($P < 0.05$).

Sagebrush canopy coverage averaged 6.1% (range 0.4-16.6) on leks. Grasses (Agropyron smithii, Koeleria cristata, Bouteloua gracilis, Calamagrostis montanensis, Poa secunda, and Stipa lettermani), fringed sage (Artemisia frigida), winterfat (Eurotia lanata), phlox (Phlox bryoides), and snakeweed each contributed an average of 1.0% or more coverage. Total vegetative cover averaged 24.4% (range 18.0-36.1) for the 5 leks (Table 11). Sagebrush height averaged 15.3 cm (range 9-27).

Band Recoveries

Nine radio-marked male sage grouse were recovered between 25 April 1978 and 15 September 1979. Three adults (Tables 2 and 3) were depredated during spring, 2 by golden eagles (Aquila chrysaetos), and 1 possibly by a coyote (Canis latrans).

Three transmittered juvenile males (Table 2) were harvested in the Lake John area on 9 September 1978 during the sage grouse hunting season. In 1979, 1 juvenile and 1 adult were harvested during the hunting season. One juvenile was shot in the Lake John area on 8 September while the adult was harvested 20 km south of the study area on 15 September (Table 3). One additional adult was collected for parasite analysis near Migan lek, 21 km south of the study area on 6 June 1979.

DISCUSSION

Transmitter Life

Transmitter life averaged 64. 3 days, ranging from 4-129 days. Five of 35 (14. 3%) transmitters experienced operational problems due to premature transmitter failure (3) and cold temperature-induced intermittency (2).

Three additional transmitters slipped off the tail when preened. Tail clip-mounted transmitters (Bray and Corner 1972) were used to eliminate problems associated with back-pack harnesses such as restricted movement of displaying males (Emmons and Petersen 1979) and excessive mortality (Rothenmaier 1979). Tail-mounted transmitters did not appear to adversely affect male strutting behavior and flight, or result in high mortality (only 3 of 37 males were killed by predators).

Breeding Activities

Seasonal lek attendance patterns of sage grouse have been previously reported (Patterson 1952:153-154, Dalke et al. 1963, Eng 1963, Gill 1965). Patterson (1952:93-94) recommended census techniques based on the pattern he observed and the assumption that all males in a population regularly visit leks. Jenni and Hartzler

(1978) confirmed the validity of the Patterson technique without testing the assumption that all males regularly attend leks. Dalke et al. (1963) reported that relative proportions of adult and juvenile males and all females varied daily throughout the breeding season. Daily counts indicated that the male population was actually 19% higher than counts obtained by the Patterson technique because some males did not attend leks daily. Although no consistent trends were observed, banded males were ordinarily absent from leks for 1-3 days at a time. Less dominant males were irregular in their lek visitation, whereas, "dominant males were present almost daily under all conditions ..." (Dalke et al. 1963:820).

Braun and Beck (1976) reported annual fluctuations in the maximum numbers of male sage grouse on leks and noted problems influencing the precision and accuracy of counts. Variation in male counts during the 9-day period when attendance was considered most stable was 24.3%. These investigators questioned the validity of using lek counts to indicate changes in sage grouse populations because of the high variation in daily attendance and the possibility that not all males attend leks. Rothenmaier's (1979) findings were similar to those of Braun and Beck (1976) as he observed a disparity between actual census and Lincoln-Peterson estimates of the male population in northeastern Wyoming. Non-displaying males have been documented for other lekking grouse with only 50% of the males

present on leks when peak male counts were obtained (Robel 1969, Rippin and Boag 1974). According to Braun (1979:20), "it is quite obvious that the basic assumption concerning percent of the male population present during periods of peak lek counts is critical."

Seasonal lek attendance patterns observed in 1978-79 (Figs. 3 and 4) were similar to patterns reported by Gill (1965), Braun and Beck (1976), Jenni and Hartzler (1978), and Rothenmaier (1979). However, I observed the peak of male attendance 25-37 days after the female peak, not during the 3 weeks following the female peak recommended for census (Patterson 1952:92-93). A difference ($\underline{P} < 0.05$) existed in lek attendance of radio-marked adult males between 1978 (74.6%) and 1979 (96.7%) during the 3-week period following the peak of female attendance (11-31 April 1978, 26 April-15 May 1979) (Fig. 8). No difference ($\underline{P} > 0.05$) existed for juvenile lek attendance during this period in 1978 (82.1%) and 1979 (82.3%) (Fig. 7).

No difference ($\underline{P} > 0.05$) in attendance existed between years for either age class during the period 2-5 weeks after the peak of female attendance (21 April-10 May 1978, 6-25 May 1979) which included the male peaks (Figs. 3 and 4). Lek attendance for the 2 years was 88.0 and 83.3% (avg. 84.8), respectively, for juvenile males (Fig. 7), and 89.4 and 93.5% (avg. 92.0), respectively, for adult males (Fig. 8). During this period, only 1 of 11 (9.1%) juvenile

males was present on leks for less than 5 days/7-day period; it was present on 8 of 17 days (3.3 days/7 days). Therefore, hypothesis 1 (juveniles attend leks less than 3 days/7-day period) is rejected. Four of 10 (40.0%) adult males visited leks daily while 6 adults visited for 5.6-6.2 days/7-day period. This indicates that the 2nd hypothesis (adults attend leks daily) cannot be rejected completely and may be true.

Although based on small samples, male sage grouse captured off leks regularly attended leks. Lek attendance was 9 of 20 (45.0%) locations for 2 juveniles, and 19 of 30 (63.3%) locations for 4 adults captured while roosting off leks. Therefore, the 3rd hypothesis (males captured off leks rarely go to leks during the breeding season of initial capture) is rejected.

I was unable to identify males which did not attend leks throughout the breeding season. One adult male provided data possibly indicating the temporary existence of groups of non-breeding birds. Bird 6943 (Table 2) was absent from a lek between 6-17 April 1978 while displaying on Riley lek on 18 April and on Alkali Lake lek the remainder of the period from 1 April to 22 May 1978. This period of non-attendance followed peak female attendance (3 April) and was a period when average female attendance remained relatively high (avg. 4.4 females/day). Only 1 other male (age undetermined) accompanied 6943 for 1 day during this 12-day period

in contrast to the flocks of non-breeding black grouse reported by Robel (1969). Other radio-marked male sage grouse (juveniles and adults) did not attend leks for periods of 1-7 days and may represent a temporary non-breeding male population.

Interlek movements by male sage grouse have been reported in various portions of their range. In Idaho, Dalke et al. (1960) reported more juveniles than adults were involved in interlek movements between years. Dalke et al. (1963) reported distances involved in interlek movements within the banding year and between years. Fluctuations in numbers of males on leks appeared to correspond with interlek movements in at least 1 year. Interlek movements by males were reported to be uncommon in central Montana, with only 1 of 13 (7.7%) radio-marked birds visiting more than 1 lek (Wallestad and Schladweiler 1974). Within the Lake John area of North Park, Colorado, Gill (1965) reported interlek movements of juvenile male sage grouse during the banding year. Carr (1967) and May (1970) also noted interlek movements of males within and between years. Interlek movements of males in North Park were summarized by Braun and Beck (1976) who found that 51.9 and 14.6% of the banded juveniles ($\underline{N}$ = 27) and adults ($\underline{N}$ = 48), respectively, were involved in interlek movements.

Interlek movements by juvenile and adult males were found to be more common than reported by Braun and Beck (1976). All

13 juveniles remaining in the study area visited 2 or more leks during the breeding season averaging 3.9 (range 1-13) moves per bird. Therefore, the 4th hypothesis (juveniles display on more than 1 lek) is accepted. Three of 11 (27.3%) adult males displayed on more than 1 lek during the breeding season for an average of 0.6 (range 0-4) moves per bird. The 5th hypothesis (adults display on only 1 lek) is rejected although interlek movements by adults were unusual. Interlek movements documented in this study emphasize the importance of counting all leks in a complex on the same day. Decreased attendance on 1 lek may be a result of movements to other leks.

Patterson (1952:92-93) recommended censusing populations of male sage grouse in spring by taking the maximum of 3 lek counts performed on 3 different days during the 3-week period immediately following the female peak. Counts are to be obtained between $\frac{1}{2}$ hour before and $\frac{1}{2}$ hour after sunrise. Jenni and Hartzler (1978) presented data showing that in central Montana, lek counts could be performed from $\frac{1}{2}$ hour before until $1\frac{1}{2}$ hours after sunrise without sacrificing accuracy, thereby extending the daily count period to 2 hours. Rothenmaier (1979) observed that during the 3-week period following the peak of mating, at least 50.0% of the males on 4 of 9 days had departed by $1\frac{1}{2}$ hours after sunrise and on 1 occasion all birds had departed by that time. This was attributed

to raptor predation and Rothenmaier (1979) recommended using the Patterson (1952:92-93) method in areas where raptors are common.

Regressions of daily lek departure times were calculated against sunrise, and $\frac{1}{2}$ and $1\frac{1}{2}$ hours after sunrise for the North Park data (Figs. 12 and 13). In 1978, 42 of 44 (95.5%) occasions when less than 50% of the males were present occurred within $1\frac{1}{2}$ hours after sunrise and 16 of 44 (36.4%) occurred within $\frac{1}{2}$ hour after sunrise. The 1979 data were similar as all of the 18 occasions when less than 50% of the males were present occurred within $1\frac{1}{2}$ hours, and 7 of 18 (38.9%) occurred within $\frac{1}{2}$ hour after sunrise. These results support Rothenmaier's (1979:51-54) conclusions that in areas of high raptor populations (i.e. North Park) counts should be obtained within $\frac{1}{2}$ hour after sunrise.

Braun and Beck (1976) recommended counting leks 4 times during a 30-day period with 2 counts during 11-20 April, 1 count during 21-30 April, and 1 count during 1-10 May. Jenni and Hartzler (1978) also reported that increased number of counts provided more reliable estimates.

Acceptable counts would have been obtained during 1978 but not in 1979 using the technique of Braun and Beck (1976). The highest count for the 4 leks investigated in 1978 was 182 males on 8 May. Assuming a count above 150 males would be acceptable as

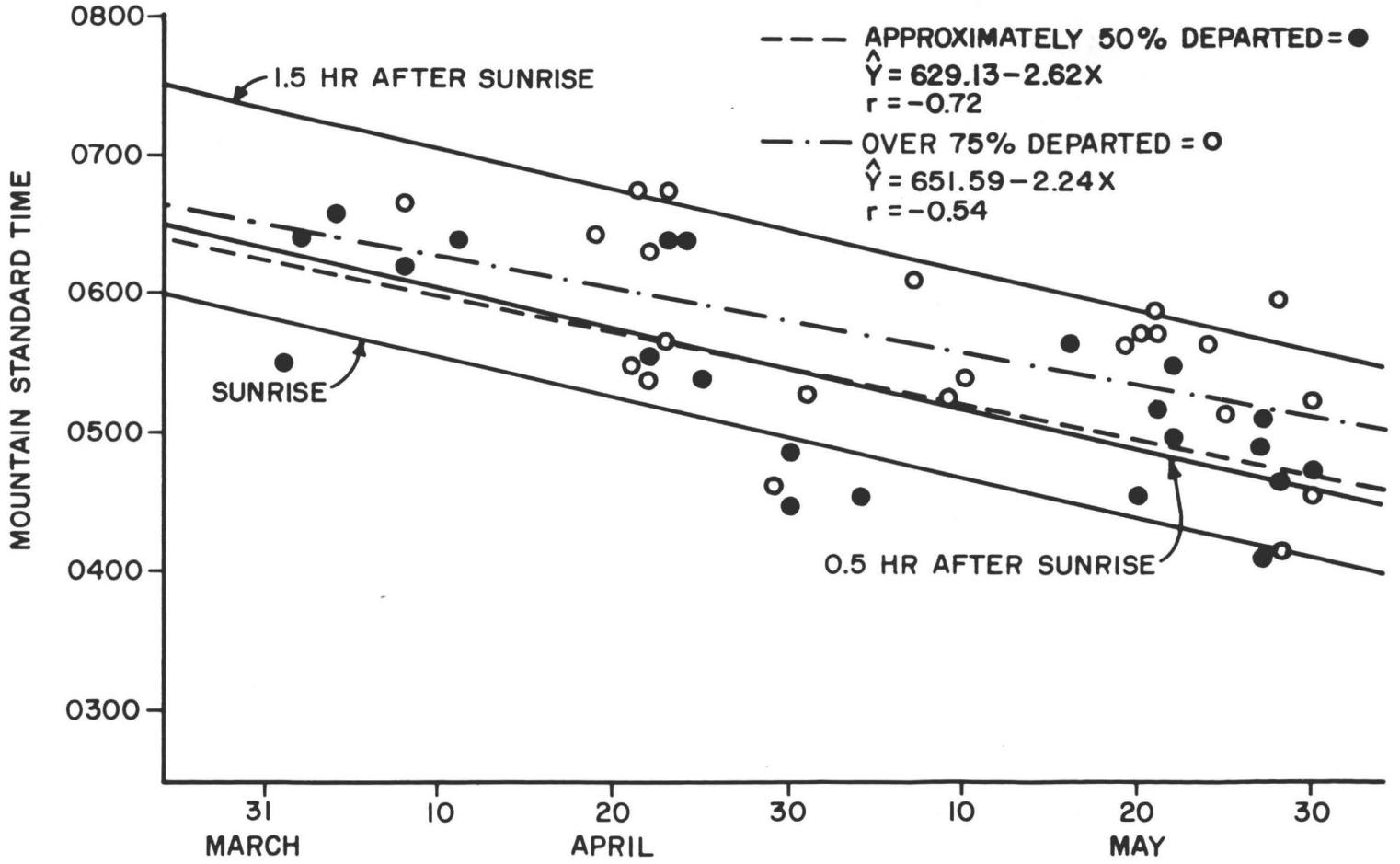

Fig. 12. Regression of sunrise and daily departure times of male sage grouse from 4 leks, North Park, Colorado, 1978.

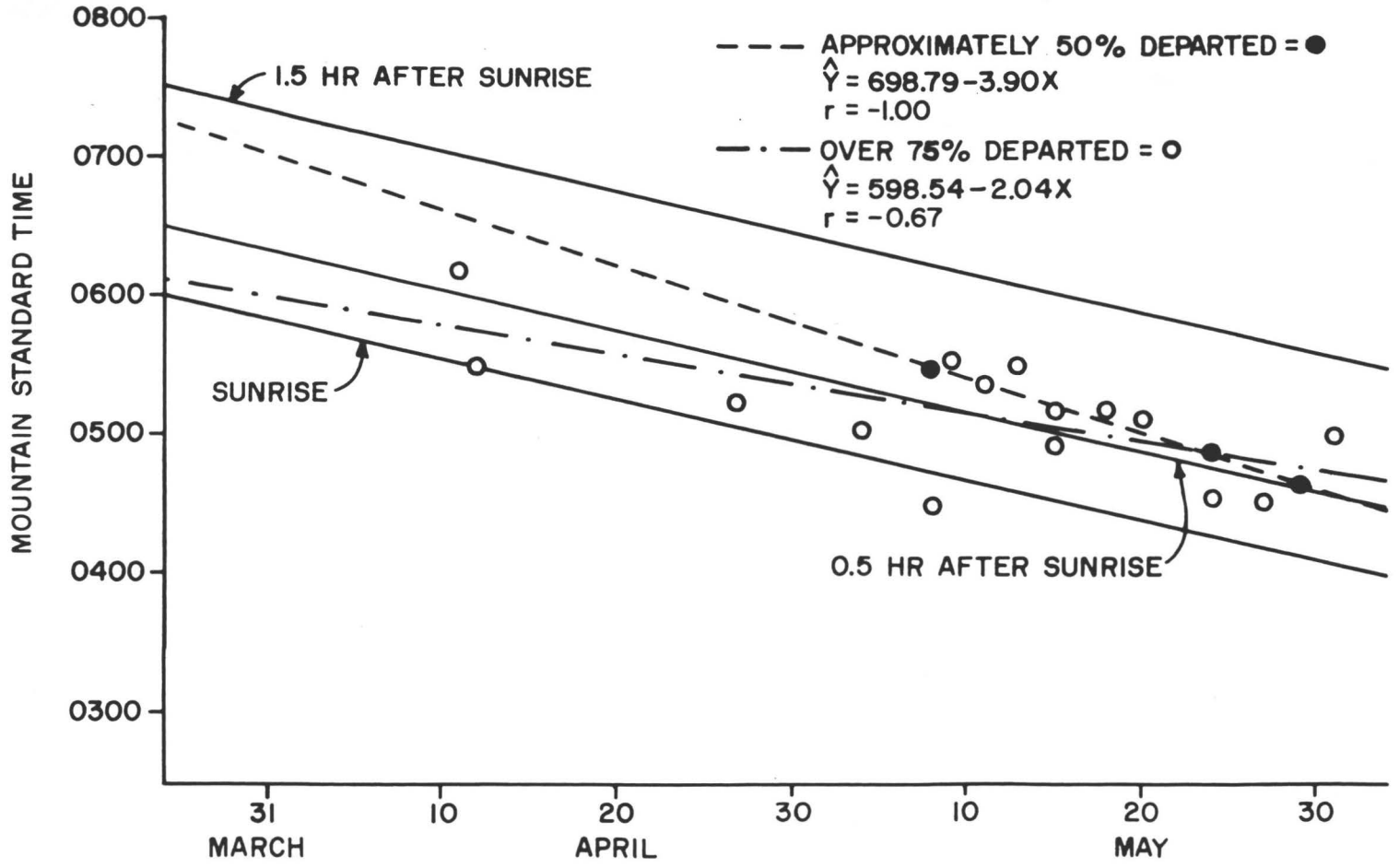

Fig. 13. Regression of sunrise and daily departure times of male sage grouse from 3 leks, North Park, Colorado, 1979.

the high count, 20.0, 30.0 and 70.0% of the daily counts obtained during 11-20 April, 21-30 April and 1-10 May 1978, respectively, were in the acceptable range (Table 12). The probability of obtaining acceptable counts would have increased by counting once during 16-25 April, twice during 26 April-5 May, and once during 6-15 May when 20.0, 70.0 and 70.0% of the counts, respectively, were above 150 males. Higher counts increased in occurrence during the last 20 days of the count periods from 3 (15.0% during 21 April-10 May) to 7 (35.0% during 26 April-15 May) days/20-day period.

Table 12. Number of counts with acceptable numbers of male sage grouse using 2 techniques in North Park, Colorado, 1978.

References	Dates	No. of males			
		151-160	161-170	171-180	181-190
Braun and Beck (1976)	11-20 Apr	1	1	0	0
	21-30 Apr	1	1	1	0
	1-10 May	4	1	1	1
This study	16-25 Apr	1	1	0	0
	26 Apr-5 May	4	1	2	0
	6-16 May	1	1	4	1

In 1979, the highest count for 3 leks was 175 males on 16 May. The acceptable range was established at 141-175 males and 0.0, 10.0 and 30.0% of the counts during 11-20 April, 21-30 April and 1-10 May, respectively, were above 140 males (Table 13). This improved to 20.0, 30.0 and 70.0% if counts were made during 26 April-5 May, 6-15 May and 16-25 May (6-35 days after the female peak). Higher counts (161-175 males) increased from 2 (11 April-10 May) to 8 (26 April-25 May) days/20-day period in the latter part of the period.

Table 13. Number of counts with acceptable numbers of male sage grouse using 2 techniques in North Park, Colorado, 1979.

References	Dates	No. of males			
		141-150	151-160	161-170	171-180
Braun and Beck (1976)	11-20 Apr	0	0	0	0
	21-30 Apr	0	0	1	0
	1-10 May	2	0	1	0
This study	26 Apr-5 May	1	0	1	0
	6-15 May	1	0	2	0
	16-25 May	1	1	2	3

The 1978-79 data indicate that lek counts in North Park should be conducted later in the breeding season than previously recommended (Patterson 1952:92-93, Braun and Beck 1976, Jenni and Hartzler 1978, Autenreith et al. 1979). During an early spring (i.e. 1978) when snow melt occurs early and females peak from 1-10 April, lek counts should be conducted from 16 April-15 May with 1 count during 16-25 April, 2 counts during 26 April-5 May and 1 count during 6-15 May. During a late spring (i.e. 1979) when females do not peak until 15 April or later, lek counts should be conducted 5-35 days following the female peak with 1 count during the 1st 10 days, 2 counts during the 2nd 10 days and 1 count during the last 10 days.

Neither of the 2 years investigated can be considered normal because the peak of male attendance occurred more than 3 weeks following the female peak. Therefore, my recommended count periods may be too late during normal years. During an early spring the optimum schedule to count leks should be 1 count during 11-20 April, 2 counts during 21-30 April and 1 count during 1-10 May. Radio-marked juvenile and adult males visited leks on 86.8 (range 75.0-100.0/5-days) and 84.2% (range 70.0-100.0/5-days), respectively, of the locations obtained during this 30-day period in 1978.

During a late spring, 4 lek counts should be conducted during the 30 days following the female peak with 2 counts during the 2nd

10 days and 1 count each during the 1st and last 10 days. Lek attendance of radio-marked juveniles and adults was 85.9 (range 71.0-100.0/5 days) and 97.2% (range 93.1-100.0/5-days), respectively, during 21 April-20 May 1979. Telemetry data indicate that at least 85% of the juvenile and adult males were present on leks during the peak of male attendance. Lek attendance may exceed 90% during this time as 90.4 and 93.9% of the juveniles and adults, respectively, were present.

Six percent of 313 off-lek locations were beyond 2.5 km. These distances exceeded maximum distances previously reported (Carr 1967, Wallestad and Schladweiler 1974, Rothenmaier 1979). Gill (1965) reported that the daily cruising radii from leks increased from 0.4-1.6 km during the breeding season in North Park, Colorado. Carr (1967) found maximum cruising radii of 1.4-1.8 km throughout the breeding season in the same area. Daytime movements to 1.3 km from a lek were common in central Montana with a maximum distance of 1.8 km (Wallestad and Schladweiler 1974). Rothenmaier (1979) reported off-lek distances to 2.5 km with 64% within 1.0 km in northeast Wyoming. This was similar to the 62.6% of the off-lek locations within 1.0 km of a lek in North Park, Colorado during 1978-79 (Table 7).

Vegetation Analysis

Over 55% (56.3) of 101 feeding and loafing sites occurred in sagebrush with a canopy coverage of 20-50% (Table 9). This contrasts with the 80% use in these coverage classes reported by Wallestad and Schladweiler (1974). Sagebrush use in North Park in the 0.1-20.0% class was 2.5 times greater than reported in Montana (Wallestad and Schladweiler 1974). Reasons for this difference are unknown but may be related to differences in vegetation types. Sagebrush canopy coverage averaged 28.1% (range 2.9-68.8), similar to the 28 and 32% for winter and spring cover, respectively, in central Montana (Eng and Schladweiler 1972, Wallestad and Schladweiler 1974).

The average canopy coverage for 88 roosting locations was 8.7% (range 0.4-49.3) and 89.7% of the locations occurred in sagebrush with a canopy coverage of less than 20% (Table 9). The large number (71 of 88) of on-lek roosting sites resulted in differences ($\underline{P} < 0.05$) between feeding-loafing and roosting sites. This contrasts with similar vegetative parameters of winter cover in North Park reported by Beck (1975). Apparently, lek position is stimulus enough to overcome normal selection to roost in heavier cover.

Average sagebrush height for roosting sites on leks was 18.7 cm (range 9-68) compared with 38.7 cm for the 17 off-lek

roosts (Table 10). This difference ($\underline{P} < 0.05$) reflected the apparent desire to roost on leks.

RECOMMENDATIONS

1. Systematic searches for new or relocated leks should be made annually throughout North Park and other sage grouse ranges in Colorado. Aerial (preferably from helicopter) and ground searches should be conducted in April and early May.
2. Leks with 40 or more males should be counted 1-2 times early in the breeding season (20 March-20 April) to identify the peak of female attendance. These counts would be in addition to the regular 4 counts of males on leks.
3. All active leks should be counted between $\frac{1}{2}$ hour before and $\frac{1}{2}$ hour after sunrise. In areas where raptor predation and harassment are not considered a problem, the daily count period can be extended to $1\frac{1}{2}$ hours after sunrise (Jenni and Hartzler 1978).
4. All active leks should be counted 4 times each spring during a 30-day period. One count should be made during the 1st 10 days, 2 counts during the 2nd 10 days and 1 count during the last 10 days.
5. During years when the female peak occurs between 20 March and 10 April, the 30-day count period should begin on 11 April and continue through 10 May. At lower elevations than North

Park (below 1500 m) it may be necessary to begin the count period 5 to 10 days earlier because of earlier peak attendance of females.

6. During years with delayed snow melt and late female arrival (peak after 11 April), the 30-day count period should begin immediately following the peak of females.

7. All leks in a particular area which are closely associated and which could involve interlek movements should be counted as a complex on the same day (i.e. Boettcher Lake Junction, Bighorn, Alkali, Wattenberg 2 and Riley should be considered a complex). Over 85% of the males within the area of a complex should be present on the leks during the period of peak male attendance.

SUMMARY

Investigations of male sage grouse were conducted in Colorado from late March through mid-June 1978-79. Investigations were conducted in the Lake John area of North Park, Jackson County, Colorado. Objectives were to determine male lek attendance patterns, breeding season movements, and habitat selection.

Thirty-seven male sage grouse were equipped with radio transmitters and studied on 5 leks. Transmitters functioned for 4-129 days (avg. 64.3). Five of 35 (14.3%) transmitters experienced operational problems due to premature transmitter failure (3) and cold temperature-induced intermittency (2). Three transmitters slipped off the tail when preened.

Peak female attendance on leks occurred between 3-7 April 1978 and about 20 April 1979. Male attendance peaked 25-37 days after the female peak on the 3 largest leks. In 1978, lek attendance of juvenile and adult males increased ($P < 0.05$) to 95.1 and 100.0%, respectively, during 1-15 May, and decreased ($P < 0.05$) thereafter. During the 5-day period which included most high female counts (1-5 April), 50.0 and 70.6% of the radio-marked juvenile and adult males, respectively, were on leks. Over 90% of the

juveniles (92.1) and adults (94.2) visited leks during the period of peak male attendance (26 April-10 May).

Lek attendance of males increased ($P < 0.05$) to 100.0% in late April 1979. Juvenile attendance decreased ($P < 0.05$) to 73.1% on 1-10 May, increased ($P < 0.05$) to 91.1% on 11-20 May, and decreased ($P < 0.05$) to 78.8% from 21-31 May. Attendance of adults remained high (94.0-98.0%) ($P > 0.05$) through mid-May and decreased ($P < 0.05$) thereafter. Attendance was 66.7 and 100.0% for juveniles and adults, respectively, during the peak of female attendance (16-20 April) and 89.7 and 93.7%, respectively, during the male peak (11-25 May) in 1979. Over 90% of the juveniles (90.4) and adults (93.9) attended leks during the period of high male counts for the 2 years combined.

Juvenile and adult males caught while roosting off leks visited leks for 45.0 and 63.3%, respectively, of the locations obtained. I was not able to identify a segment of the male sage grouse population which did not attend leks.

All radio-marked juvenile males visited more than 1 lek (range 2-4) during the breeding season. Interlek movements averaged 3.9 (range 1-13) per juvenile and were common between Alkali Lake-Boettcher Lake Junction, Alkali Lake-Wattenberg 2, and Boettcher Lake Junction-Bighorn leks. One juvenile moved from Boettcher Lake Junction to Alkali Lake lek (4.5 km distance)

between 0510 and 0610 MDT (22 May 1979). Juveniles remained on a lek an average of 4.3 days (range 1-36). Interlek movements were infrequent for adult males (avg. 0.6 each). Only 3 of 11 (27.3%) adults visited alternate leks with 2 visiting 1-2 additional leks for 1 day and 1 attending the alternate lek the remainder of the breeding season after 15 May 1979.

Radio-marked juvenile and adult male sage grouse averaged 23.9 and 10.0 km, respectively, in movements during the breeding season. Four juveniles moved from the study area with 1 moving over 25 km in 5 days, 1 moving over 80 km between 25 February and 31 March 1978, and 2 moving 6 km away. Three of 6 adults captured off leks moved 12-21 km to leks not in the study area.

Six percent of the off-lek locations were beyond the maximum distance (2.5 km) previously reported. Most locations (62.6%) were within 1.0 km of a lek with 39.9% within 0.5 km and 55.3% within 0.26 and 1.00 km. Dispersal distances averaged 1.2 and 1.1 km for juveniles and adults, respectively. Males travelled considerable distances ($\geq$ 3.2 km) in a non-random direction when leaving a lek. Undisturbed birds subsequently moved only 150-300 m. Midday moves over 1.0 km usually resulted from disturbance. Over 60% of the juveniles (60.4) and adults (69.8) returned to leks in the evening to roost.

Approximately 56% (56.3) of 160 feeding-loafing sites occurred in sagebrush with a canopy coverage of 20-50%. Sagebrush canopy coverage and height at feeding-loafing sites averaged 28.1% and 43.5 cm, respectively. Eighty percent of the daytime feeding and loafing sites were in sagebrush with a height of 20-70 cm. Approximately 90% (89.7) of the roosting sites (including 71 on leks) analyzed occurred in sagebrush with a canopy coverage of less than 20% and less than 40 cm high. Average canopy coverage and height for all 88 roosting locations were 8.7% and 18.7 cm, respectively, compared with 22.4% and 38.7 cm for the 17 off-lek roosts ($\underline{P} < 0.05$).

Nine of 37 (24.3%) radio-marked male sage grouse were recovered. Three adult males were killed by predators in spring 1978. Three juveniles were harvested during the 1978 hunting season and 3 males (2 adults and 1 juvenile) were shot in 1979.

Recommended procedures for conducting spring lek counts are: counts should be conducted between $\frac{1}{2}$ hour before and $\frac{1}{2}$ hour after sunrise to minimize the effects of raptor harassment; 4 counts should be made in a 30-day period (twice during 2nd 10 days) beginning on 11 April (or 5-10 days earlier at lower elevations such as 1200-1500 m) during a year when peak female attendance occurs before 10 April, or immediately after the female peak in a late year; all leks in a closely-associated complex should be counted on the same

day to minimize effects of interlek movements; and searches should be continued for new leks in the count area.

LITERATURE CITED

Autenrieth, R., W. Molini, and C. E. Braun. 1979. Recommended sage grouse management practices. 2nd Draft. Western States Sage Grouse Committee, Twin Falls, Idaho. 41pp.

Beck, T. D. I. 1975. Attributes of a wintering population of sage grouse, North Park, Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 49pp.

Beekly, A. L. 1915. Geology and coal resources of North Park, Colorado. U.S. Geol. Surv. Bull. 596. 121pp.

Beetle, A. A. 1960. A study of sagebrush, the section Tridentatae of Artemisia. Bull. Univ. Wyoming Exp. Sta. 368. 83pp.

Braun, C. E. 1979. Evaluation of the effects of changes in hunting regulations on sage grouse populations. Colorado Div. Wildl. Job Progress Rep., Fed. Aid Proj. W-37-R-32, Work Plan 3, Job 9a. pp. 11-35.

_____, and T. D. I. Beck. 1976. Effects of sagebrush control on distribution and abundance of sage grouse. Colorado Div. Wildl. Final Rep., Fed. Aid Proj. W-37-R, Work Plan 3, Job 8a. pp. 21-84.

Bray, O. E., and G. W. Corner. 1972. A tail clip for attaching transmitters to birds. J. Wildl. Manage. 36:640-642.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. For. 39:388-394.

Carr, H. D. 1967. Effects of sagebrush spraying on abundance, distribution, and movements of sage grouse. M.S. Thesis. Colorado State Univ., Fort Collins. 106pp.

Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. Schlatterer. 1960. Seasonal movements and breeding behavior of sage grouse in Idaho. Trans. North Am. Wildl. and Nat. Res. Conf. 25:396-407.

Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. Schlatterer. 1963. Ecology, productivity, and management of sage grouse in Idaho. J. Wildl. Manage. 27:810-841.

Emmons, S. R., and B. E. Petersen. 1979. Telemetry investigations of sage grouse in North Park, Colorado. Int. Conf. Wildl. Biotelem. 2:215-218.

Eng, R. L. 1955. A method for obtaining sage grouse age and sex ratios from wings. J. Wildl. Manage. 19:267-272.

_____. 1963. Observations on the breeding biology of male sage grouse. J. Wildl. Manage. 27:841-846.

_____, and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. J. Wildl. Manage. 36:141-146.

Finch, W. C., ed. 1957. Guidebook to the geology of North and Middle Parks Basin, Colorado. Rocky Mtn. Assoc. Geol., Denver. 157pp.

Gill, R. B. 1965. Distribution and abundance of a population of sage grouse in North Park, Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 185pp.

Hail, W. J. 1965. Geology of northwest North Park, Colorado. U.S. Geol. Surv. Bull. 1188. 133pp.

Jenni, D. A., and J. E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring censuses. J. Wildl. Manage. 42:46-52.

Klebenow, D. A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-661.

Lacher, J. R., and D. D. Lacher. 1964. A mobile cannon net trap. J. Wildl. Manage. 28:595-597.

May, T. A. 1970. Effects of sagebrush control on distribution and abundance of sage grouse. Colorado Game, Fish and Parks Div., Job Compl. Rep., Fed. Aid Proj. W-37-R-23, Work Plan 3, Job 8a. 23pp.

Patterson, R. L. 1952. The sage grouse in Wyoming. Sage Books, Inc., Denver. 341pp.

Peterson, J. G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.

Pyrah, D. B. 1959. Sage grouse population trend and trapping study. Wyoming Game and Fish Comm., Job Compl. Rep., Fed. Aid Proj. W-50-R-8. 27pp.

Rippin, A. B., and D. A. Boag. 1974. Recruitment to populations of male sharp-tailed grouse. J. Wildl. Manage. 38:616-621.

Robel, R. J. 1969. Movements and flock stratification within a population of blackcocks in Scotland. J. Anim. Ecol. 38:755-763.

Rothenmaier, D. 1979. Sage grouse reproductive ecology: breeding season movements, strutting ground attendance and site characteristics, and nesting. M.S. Thesis. Univ. of Wyoming, Laramie. 97pp.

Smith, E. L. 1966. Soil vegetation relationships of some Artemisia types in North Park, Colorado. Ph. D. Diss. Colorado State Univ., Fort Collins. 203pp.

Terwilliger, C., and E. L. Smith. 1978. Range resource types in North Park, Colorado. Colorado State Univ., Range Sci. Ser. 32. 48pp.

U.S. Department of Commerce. 1973. Monthly normals of temperature, precipitation, and heating and cooling degree days, 1941-70. Climatography of the U.S. 81(5). 12pp.

_____. 1978. Climatological data: annual summary, Colorado. National Oceanic and Atmospheric Admin. 83(13). 14pp.

_____. 1979. Climatological data: annual summary, Colorado. National Oceanic and Atmospheric Admin. 84(13). 14pp.

Wallestad, R. O., and P. Schladweiler. 1974. Breeding season movements and habitat selection of male sage grouse. J. Wildl. Manage. 38:634-637.

_____, J. G. Peterson, and R. L. Eng. 1975. Foods of adult sage grouse in central Montana. J. Wildl. Manage. 39:628-630.