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Ecology of Badgers in Curlew Valley, Utah and Idaho With Emphasis on Movement and Activity Patterns

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ECOLOGY OF BADGERS IN CURLEW VALLEY, UTAH AND IDAHO WITH EMPHASIS ON MOVEMENT AND ACTIVITY PATTERNS

by

Frederick G. Lindzey

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Frederick G. Lindzey

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ABSTRACT

Ecology of Badgers in Curlew Valley, Utah and Idaho

with Emphasis on Movement and Activity Patterns

by

Frederick G. Lindzey, Master of Science

Utah State University, 1971

Major Professor: Dr. Frederic H. Wagner
Department: Wildlife Resources

Between March, 1969 and July, 1970, 16 badgers *(Taxidea taxus)* were caught and fitted with radio transmitters in the southern part of Curlew Valley. The animals were followed telemetrically; seven animals contributed sufficient data from which home-range, movement and activity patterns could be discerned. The average annual home-range size of five females was 664 acres (± s.d. 99.5 acres). Female home-range sizes were approximately the same within crested wheat-grass *(Agropyron cristatum)* and sagebrush *(Artemisia tridentata)* vegetation types, with greater distances traveled each night by females in the crested wheat-grass. Both home-range size and total movement were less during winter in the one badger observed during more than one season. The average home range of two males followed between September and mid-December was 1,440 acreas, twice the average female home-range size.

The necropsy of badgers in the study collection and a scat collection yielded information on the food habits and breeding biology of badgers in Curlew Valley. Many prey species were used, but mice were the most frequently eaten food item. Badgers bred between mid-July and the

end of August. Delayed implantation persisted until approximately January 26. Pregnant females gave birth to an average of 2.2 young about April 1.

(57 pages)

INTRODUCTION

Although badgers *(Taxidea taxus)* are common predators in much of the United States, relatively little is known about their ecology. Errington (1937) and Snead and Hendrickson (1942) have published information on badger food habits in Iowa. Wright (1966, 1969) has presented a comprehensive view of the breeding biology of the animal. Only one study (Sargeant and Warner, 1964), and this based on a single badger, has provided information on home-range, movement and activity trends.

This study was carried out both to obtain data which will add to the general ecological knowledge of the badger and to arrive at some parameters useful in measuring its role within the Curlew Valley ecosystem.

To accomplish these goals the objectives of the study were to collect information on: (1) home-range characteristics, (2) seasonal and diel movement and activity patterns, (3) food habits and predatory techniques, and (4) the reproductive biology of the population in this locale.

METHODS AND MATERIALS

Study Area

Curlew Valley, the general area in which the study was carried out, is approximately 1,300 square miles in size, and located in south-eastern Idaho and north-western Utah. Gross (1967) provides a general discription of the valley. The telemetry area in which badgers were tracked was located in the southern portion of Curlew Valley (Figure 1), approximately 10 miles west and 6 miles south of Snowville, Utah between Cedar Hill and the Wildcat Hills. With the exception of a centrally located crested wheat-grass *(Agropyron cristatum)* seeding planted by the U. S. Bureau of Land Management, sagebrush *(Artemisia tridentata)* represented the dominant vegetation of the area. The seeding was transected in numerous places by belts of sagebrush. Elevation of the telemetry area ranged from 4,350 to 4,700 feet with the two receiving antennas used for tracking badgers located on the most easterly bench of the Wildcat Hills.

Home-Range and Activity Patterns

The badger's home-range and activity patterns were determined with a transmitter modified from the one used by Nelson (1970)(Figure 2). Pulse-rates varied from 12-26 pulses per minute. The transmitter components and antenna were sealed in dental acrylic, and attached to the badgers with a teflon harness (Figure 3). Weight of transmitter units (packs) averaged 210 grams, and each was custom fitted to the animal.

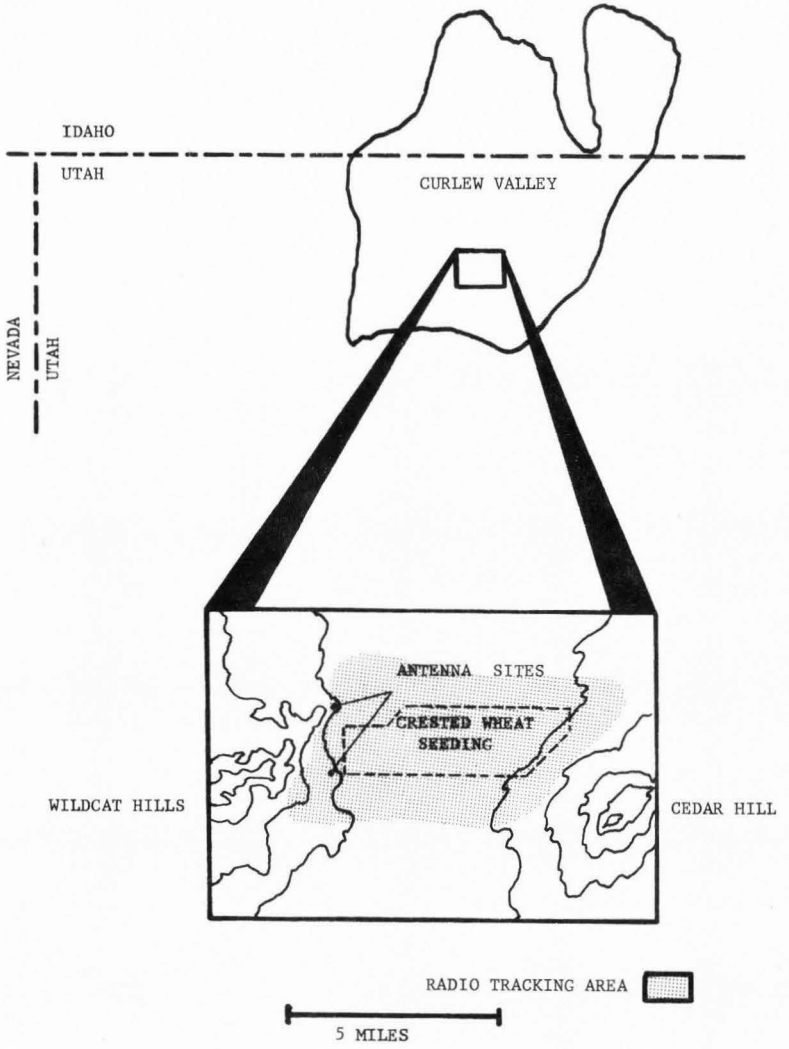

Figure 1. Location of study area.

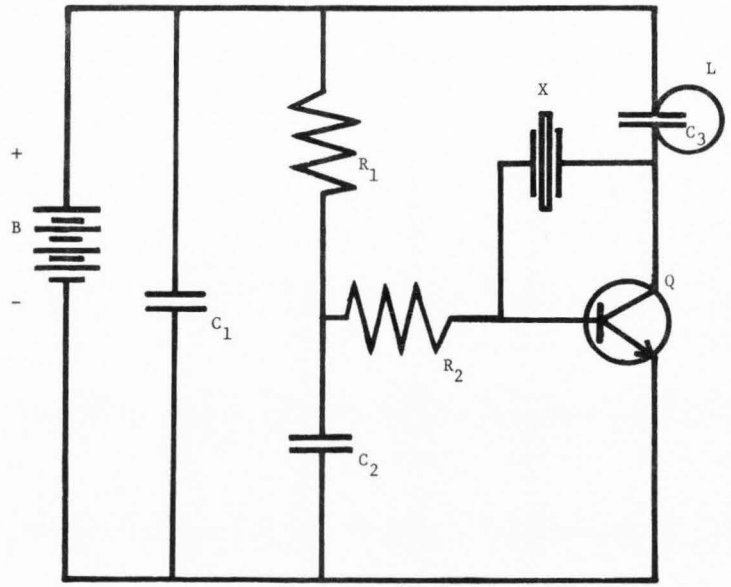

Figure 2. Schematic diagram of modified Nelson (1970) transmitter. (B) four Eveready E-3 batteries; (C_1) .005 mf. ceramic capacitor; (C_2) 10 mf. tantalum capacitor; (C_3) 39-56 mmf. silvered mica capacitor; (R_1) 1/4 watt carbon resistor, .5-1.5 megohms; (R_2) 1500 ohm carbon resistor, 1/4 watt; (X) International crystal 5 mhz; (Q) Motorola 2N834 transistor; (L) transmitting loop.

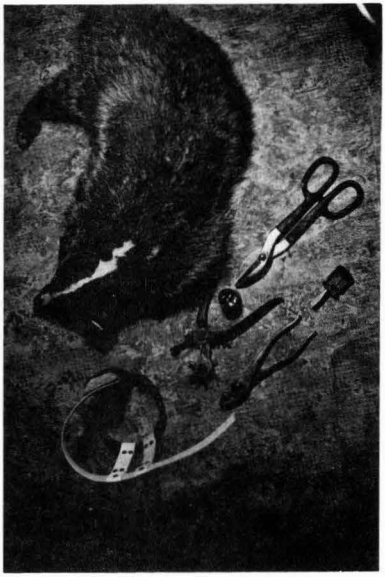

Figure 3. Teflon harness and equipment used in attaching transmitters to badgers.

Packs were mounted slightly to one side of the badger's back to prevent abrasions. Each instrumented badger was identifiable by the transmitting frequency of the unit it carried.

Badgers were captured in No. 3 steel traps which had offset padded jaws to minimize injury. Traps were selectively set in areas where badgers were to be studied.

Once captured a badger was removed from the trap with a specially designed choker, and immobilized with either Sucostrin (succinylcholine chloride) or Sernylan (phencyclidine hydrochloride), both injected intramuscularly. Sucostrin was administered at the level of .25 mg. per pound body weight. Data from anesthetized animals indicated that for best results the animal's weight should be judged to within a pound. A 1.5 mg. overdose proved fatal, and a 1 mg. underdose failed to immobilize. The dosage level found to be most effective for Sernylan was twice that of Sucostrin (0.5 mg. per pound body weight). A 3.5 mg. underdose failed to completely immobilize a badger, and overdoses up to 65 percent did not prove fatal. Duration of immobilization was not directly related to dosage levels, and probably was affected by the individual's condition.

The use of Sernylan provided a greater margin for dosage error. However, the time from injection to immobilization was greater (5 minutes-range = 3-7 minutes) than for Sucostrin (1 minute 11 seconds). The average recovery time was greater for Sernylan (1 hour plus) than for Sucostrin (37 minutes).

Body measurements and weights were taken, and each animal was then fitted with a pack. The animal's ears were notched for identification, and it was released at the capture site.

Radio-tracking was accomplished with two permanent receiving stations, and a portable receiver. One permanent station consisted of a 12-foot, Hy-Gain double yagi antenna mounted on a 70-foot tower, antenna rotor, Hammerlund Hq-145-A receiver, and a 2.5 KW Kohler gasoline generator. The other station had a 8-foot yagi antenna mounted on a 42-foot tower with rotor, receiver, and power supply identical to the first. The portable receiver was a 50 MC crystal-tuned unit which yielded an audible 1 KC signal. A hand-held directional loop antenna was used with the portable receiver.

In this region, badgers move about at night and spend each day in old or freshly dug dens which are scattered about the animals' home range. Movement and home-range patterns in this study were observed by locating the instrumented badgers daily, generally at a den site.

A badger's approximate field location was determined using the permanent tracking stations. It was then located at its den site using the portable receiver and directional loop antenna. Each den location was flagged, and data noted on den usage, vegetation type in which it was found, and location. A small twig was placed across the den entrance to permit detection of an animal's departure. Points of location were recorded in degrees by triangulation with an engineer's transit from two of the bench marks in the area. Point location by this method yielded accuracy within .20 degrees. The badgers' locations were later transcribed on graph paper. Snow tracking was used to complement telemetry data.

Annual home-range and natal-range (the area in which the young are born and raised prior to the time they begin hunting with the adult) boundaries were delineated by the minimum-area range determination method

(Dalke, 1942). Home range is used in this paper to mean that area in which a badger obtains food, breeds and raises its young. All location points were included in home range determinations when ten or fewer location points were obtained for an animal. Locations were excluded when found to be distant from all other points, and tracking history revealed a lack of previous or subsequent use of the concerned area. Home-range areas were determined using both a planimeter and calibrated dot grid. It was necessary for accurate comparison to adjust a single home range (Female 510-3) to compensate for the area contained in numerous gullies. Measurements were taken of the gullies, and the acreage added. Activity patterns were determined by analysis of distances between consecutively used dens and intensity of den use over time. During the study 16 badgers were caught and instrumented. Of the 16 only two males and five females were successfully followed.

Thirty-six transects were walked within the study area to determine the number of dens available to a badger per acre. The transects were 0.25 mile in length and 50-feet in width, and randomly located in both sagebrush and crested wheat-grass areas.

Measurements of Population Characteristics

Badger collection

Badgers were collected between Spring, 1969 and Spring, 1970 in Cassia and Oneida Counties, Idaho, and Box Elder County, Utah from: (1) road-killed animals, (2) private trappers, (3) federal trappers, (4) animals caught by Frank W. Clark during the late-summer trapping phase of his research project on coyotes, and (5) personal collecting (trapping and shooting)(Table 1). The badgers were weighed and frozen as soon as possible following their collection.

Table 1. Source, sex, and age of badgers in the study collection

SOURCE	Male		Female		TOTALS
	Juvenile	Adult	Juvenile	Adult	
Clark's Project	2	4	4	11	21
Dead on Road	3	4	0	3	10
Private Trappers Federal Trappers Personal Collecting	4	5	5	6	20
TOTALS	9	13	9	20	51

Age criteria

The baculum was removed from each male in the collection, cleaned of easily removed material, boiled in a .01 normal solution of sodium hydroxide (Petrides, 1950) and cleaned again. They were then oven dried for 48 hours at 80 C. and weighed to the nearest milligram. The bacula were separated by weight into adults and juveniles (Wright, 1969). Most males were collected during the late summer, making the separation of age classes easier.

To test the validity of the baculum as an age criterion, a centrally located longitudinal cut was made with a band saw through an upper canine of each male in the study collection. They were again separated into adults and juveniles, this time using the degree of closure of the pulp cavity (Linhart and Knowlton, 1967). Comparison of the results of the two techniques matched perfectly. The degree of pulp-cavity closure was assumed to be valid criterion for juvenile-adult separation, and the females in the collection were separated using it.

The adult segment of the collection was subdivided into yearly age classes. As a first step in determining the plausibility of using cementum layers as an age criterion, both lower canines were removed from two adult animals in the study collection. A jewler's saw and band saw were used to cut a 1/16 inch centrally located, longitudinal section from the root portion of each tooth. The specimens were then decalcified in a buffered formic acid solution (Luna, 1960), using a 50:1 volume ratio between solution and sample. The solution was changed every second day with decalcification complete in six days. The samples were sectioned with a cryostat to 25-30 μ in thickness. These sections were then mounted on a slide and stained with Fisher's papanicolaou hematoxylin stain. Under 40-power magnification, darker stained rings were observed in the cementum layer as described by Linhart and Knowlton (1967) for coyotes (Figure 4). Klevezal and Kleineberg (1967) cited studies in which cementum rings were described for the sable *(Martes zibellina)*, mink *(Mustela vison)*, and the sea otter *(Enhydra lutris)*. Ring counts for the right and left canines of each of the two individual study animals agreed.

A single canine section was then removed from each adult and two of the juveniles in the study collection. Sections from the juvenile canines exhibited no rings, extrememly large pulp cavities, and a narrow cementum band (Figure 4a). Sections from adult animals collected the same month which exhibited no rings, but had a thicker cementum band and a "closed" pulp cavity, were classified as 1-year olds (Figure 4b). Badgers older than one year were aged by adding one to the total ring count to arrive at age in years (Linhart and Knowlton, 1967)(Figures 4c and 4d).

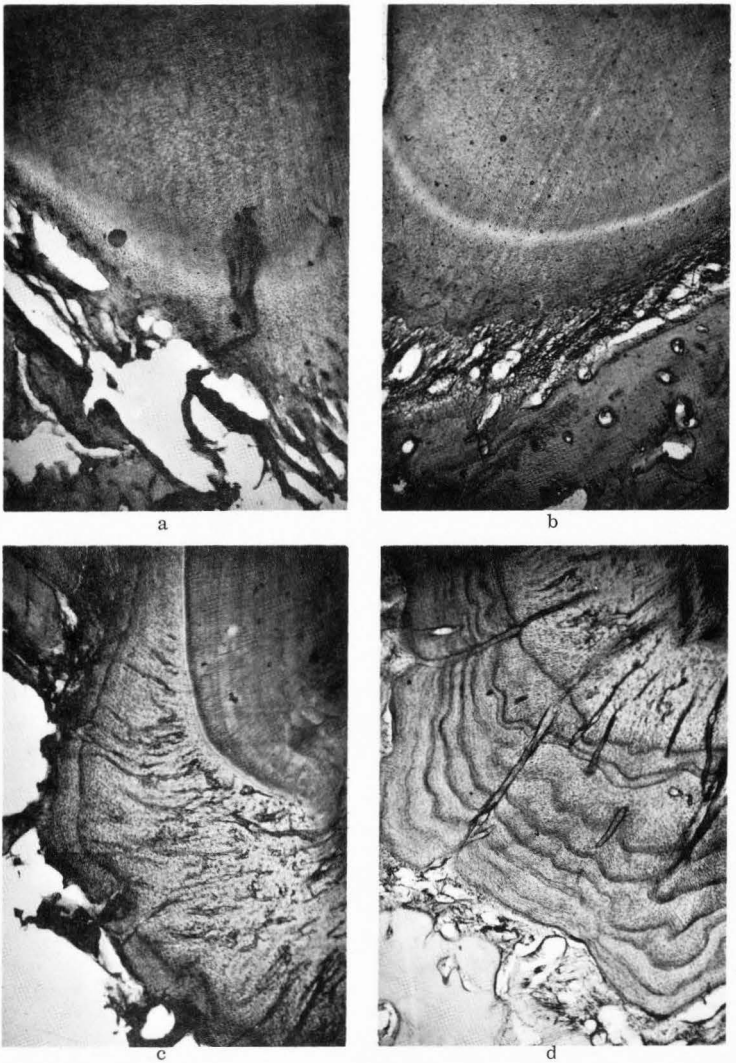

Figure 4. Photomicrographs of sectioned badger canines showing cementum layers and darker stained annual rings. a. Juvenile, b. 1-year old, c. 2-year old, d. 8-year old.

Reproduction

Reproductive tracts were dissected from each badger collected and preserved in Bouin's original fluid. Ovaries were cut free of their capsule and serially sectioned with a razor blade. Corpora lutea were visible without magnification. Counts of the corpora lutea were made in both ovaries and the results summed. Epididymides were dissected from the testes, and the paired testes were weighed wet to the nearest milligram.

Analysis of Food and Feeding Habits

The diet of Curlew Valley badgers was determined by analyses of: (1) material taken from stomachs and intestines of badgers collected, (2) feces excreted by anesthetized animals (3) scat collected around den areas, and (4) scats excavated from dens. Scat and intestinal content were analyzed separately from stomach contents. Scats used for analysis of the food habits of females with young were excavated from three natal dens (dens in which the young are raised).

The materials were either frozen or stored dry in a well-ventilated area prior to analysis. Individual specimens were soaked in warm water, manually broken apart, and throughly washed. The lighter and heavier portions were separated by flotation. Non-mannalian material was removed from the sample and identified. Material from the heavier portion of the sample (bones, teeth, claws) was identified by comparison with a prepared study collection. Two skull keys (Glass, 1965; Brown, 1952) aided in the identification of this material. Random samples taken from the hair mass of each sample were identified by comparison with prepared hair slides. All alimentary tracts were checked for parasites.

RESULTS AND DISCUSSION

Home-Range and Activity Patterns

The instrumented badgers were located daily. These daily locations when plotted provided a scattering of locations from which home ranges were determined. Additional information such as length of stay at a particular den and use of dens which had been used previously by the same animal, yielded a base from which activity and movement patterns could be inferred. The relationship of the home ranges, determined in this study, to the vegetation of the area is shown in Figure 5.

Individual case histories

Female 610-3. This adult female was followed for three days in the snow before she was captured in a den entrance on January 18, 1970. She was radio-tracked until June 8, 1970. Her location was recorded on 84 days, yielding a home range of 439 acres. After adjustment to account for the gully section, the annual home-range size was 518 acres (Figure 6). At the time of capture, the animal weighed 16 pounds and 8 ounces. For ten days prior to the first move, she occupied the den at which she was captured. Numerous gullies transected the home range from the south to the northeastern point where the home range widened into the natal area. Vegetatively, her home range consisted primarily of sagebrush, with a small amount of crested wheat in the southwestern portion and small extensions into some of the gully floors.

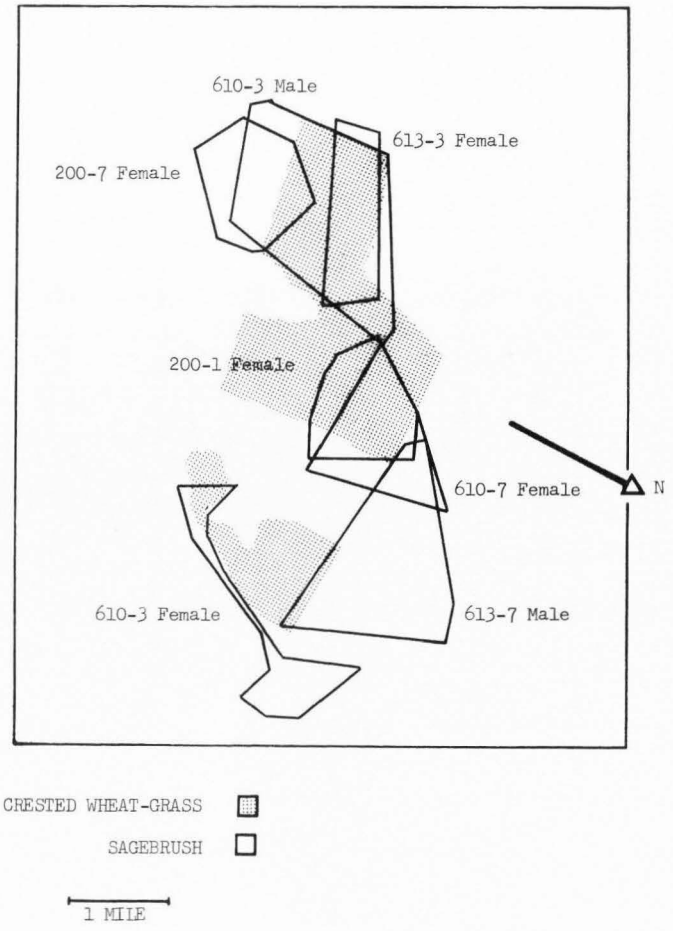

Figure 5. Composite range map showing spatial relationship of badger home range and vegetation of area.

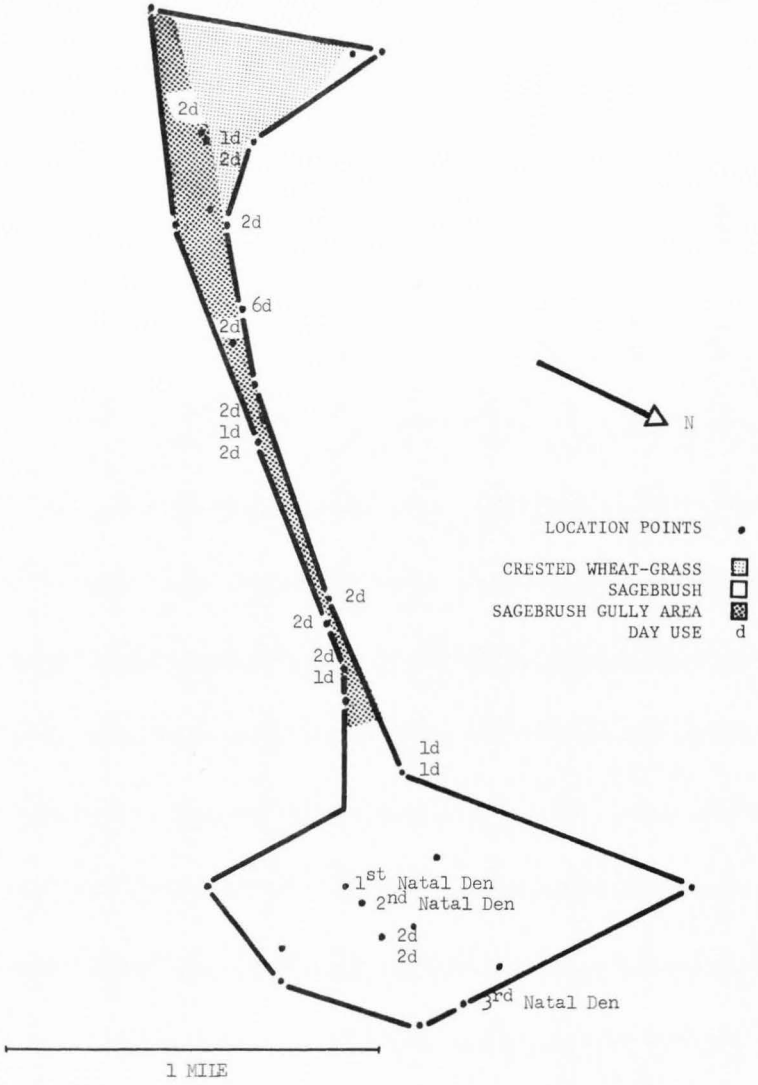

Figure 6. The 518 acre home range of Female 610-3 showing vegetative composition within home range, location points, den use, and the 282-acre natal range.

All of the 24 dens used by the badger were classified as old dens (dens which had been dug prior to the day of their use). I observed six instances, involving five dens, in which this animal returned to dens in which she had previously been located. Of 26 moves, 23 percent ended in dens which she had used before. Three of the five re-use dens were on the periphery of her home range. One extremely deep den was used on three occasions, for a total of 5 days. This den was centrally located in the animal's home range. Extended stays (habitation of a den for more than 1 day without emergence) were observed on 17 occasions. Generally, the animal remained for only 2 days, but stays of 4 to 6 days were noted. The average straight-line distance between consecutively used dens was 1,898 feet. On three occasions she had apparently left a den, but returned to it on the same night.

On March 17, I observed the first move into what later proved to be the natal range. She did not utilize the original winter range again after this date. The den in which the young were born was first inhabited by Female 610-3 on March 27, and she did not move from the den until April 2. On April 21, she moved with her young to the second of the natal dens, 330 feet north of the first. What appeared to be cub tracks were first observed on April 24. Cub tracks became increasingly obvious from this point but the young were not seen until May 23. On June 8, she moved to the third of the natal dens, 1,870 feet north of the second. Location points were recorded around the second natal den, and yielded a natal range of 282 acres (54 percent of the total home range)(Figure 6).

While I was unable to measure the extent to which the home ranges of other badgers overlapped that of Female 610-3, it is clear some

overlap occurred. A transmitter originally placed on a male was recovered within her home range. Additionally, a female, with which contact was lost, was trapped and instrumented within this home range.

Female 200-7. This female was originally caught and instrumented on November 25, 1969, at which time she weighed 15 pounds. Her transmitter was recovered November 30. She was retrapped March 15, 1970, and again instrumented. Fifty-three location points were collected for this badger until June 11, 1970.

With the exception of a single den, all of the dens known to be used by this animal (20) were old dens. There were eight occurrences of continual stays in a single den for greater than a 1-day period: six were 2 days, and the remaining two were of 3 day's duration. In addition, there were six instances when the animal moved from, but returned to, the same den within the same night. On six occasions she used dens which she had previously used. Of the re-use dens, 25 percent were on the periphery of her home range. A single den, originally used April 27, was returned to on three other occasions totaling 9 days use. The den was exceptionally deep and centrally located in her home range. During six consecutive nights of observation Female 200-7 moved over only a small portion of her home range (Figure 7).

Only the northernmost 15 percent of the home range fell within the crested wheat-grass seeding. The remainder of the 751-acre home range was in sagebrush (Figure 7). The mean straight-line distance between consecutively used dens was 1,336 feet. This female's home range overlapped 384-acres (51 percent) with that of Male 610-3. One den used by this female had previously been used by Male 610-3. Additionally, on April 28, 1970, another male was trapped and instrumented within the confines of this home range.

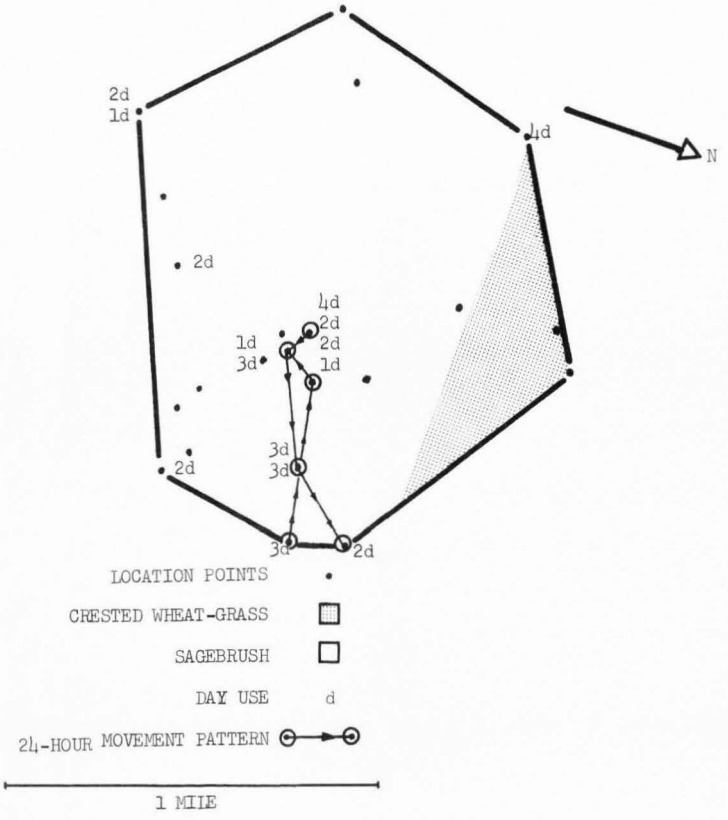

Figure 7. The 751-acre home range of Female 200-7 showing vegetative composition within the home range, location points, den use and a 6-day movement pattern.

Female 200-1. This adult female was trapped May 1, 1969, with (51) location points collected prior to her death on October 13, 1969. The 15 pound animal had been trapped and ear-tagged the previous summer by Frank W. Clark (Personal Communication) in conjunction with his coyote project. Her home range included 668 acres, 51 percent in the crested wheat seeding (Figure 8). Much activity centered in and around a dry wash which traversed the westerly portion of the home range. The wash comprised the most vegetatively heterogeneous portion of the home range. During 10 consecutive nights of observation Female 200-1 moved over a majority of her total home range (Figure 8).

Old dens represented 80 percent of the 37 dens used. The remaining 20 percent were freshly dug by the animal (new dens). Only one instance of an extended stay was noted, that of 2 days. Dens were reused on six occasions, 17 percent being located on the extreme periphery of the home range.

The average straight-line distance between consecutively used dens was 3,567 feet. There was a 6-acre overlap (1 percent) of home range with Male 610-3, a 17-acre overlap (3 percent) with Male 613-7, and a 466-acre overlap (70 percent) with Female 610-7. A total of 70 percent of this home range was overlapped by other animals. Additionally, on April 11 and April 23, 1969, two other males were caught instrumented within this home range. The animal utilized a den used on other occasions by Male 610-3 and Female 610-7, and another den inhabited once by Female 610-7.

Female 610-7. Adult Female 610-7 was originally trapped May 14, 1969. The transmitter was recovered August 6, 1969. Only three location points were collected between these dates. The badger was trapped

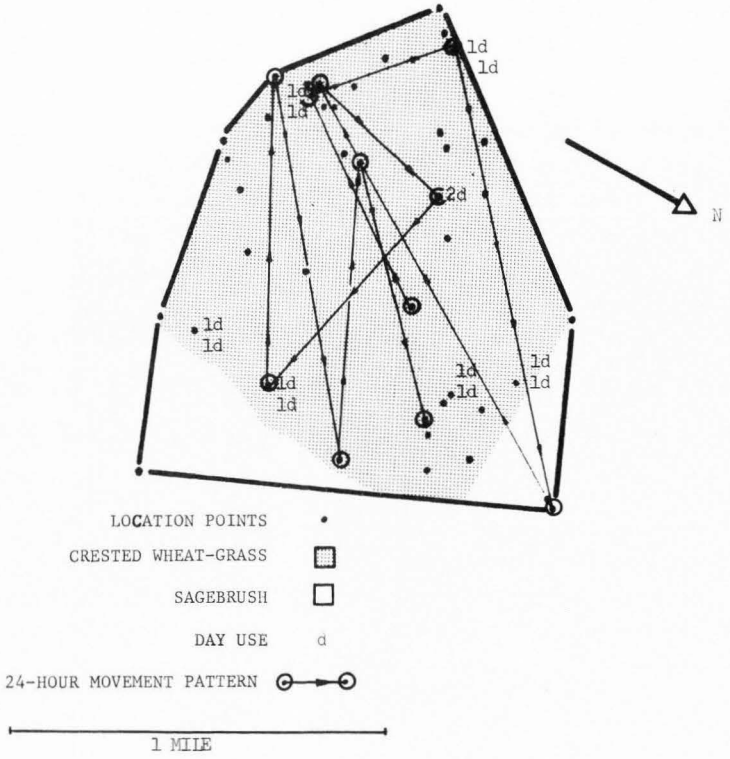

Figure 8. The 668-acre home range of Female 200-1 showing vegetative composition within the home range, location points, den use, and a 10-day travel pattern.

again September 15, 1969, and again transmittered. On September 19, she was caught again in a trap set to catch another animal active in the area. She died as a result of this trapping. The six location points available on this animal yielded a home range encompassing 760 acres, comprised of approximately 60 percent crested wheat-grass and 40 percent sagebrush (Figure 9).

The animal used a den inhabited at least once each by Male 610-3 and Female 200-1. Use of another den was also shared with Female 200-1. The home ranges of this female and Female 200-1 overlapped by 466-acres (61 percent). Additionally, the home range of Male 613-7 overlapped 166-acres (22 percent).

Female 613-3. This female was trapped September 6, 1969 on the border of the crested wheat seeding. Her weight at the time of capture was 16 pounds 6 ounces. On September 12, the detached transmitter was recovered, and all attempts to retrap the animal failed. Her home range derived from five location points, encompassed an area of 622 acres (Figure 10). Vegetatively, 83 percent of the home range was comprised of crested wheat-grass with the remaining 17 percent in sagebrush. Only one of the four dens used by this animal was classified as a new den. No data were collected on den re-use or extended stays. The home range of Male 610-3 overlapped 541-acres (87 percent) of this animal's home range.

Male 610-3. This adult male was originally trapped May 14, 1969, ear-marked, and released. He was trapped again September 19, 1969, and instrumented. Weight of the animal at the time of instrumentation was 17 pounds 10 ounces. Thirty location points were collected on this animal until December 14, 1969.

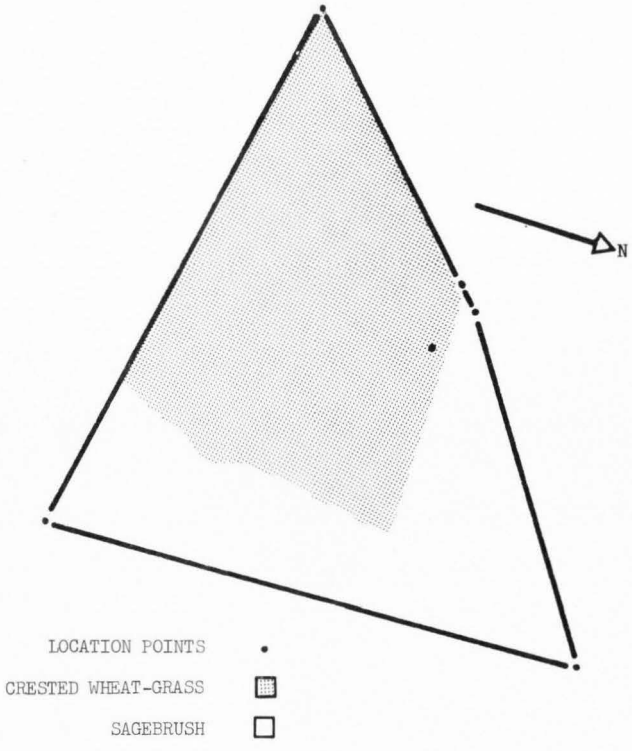

Figure 9. The 760-acre home range of Female 610-7 showing vegetative composition within the home range and location points.

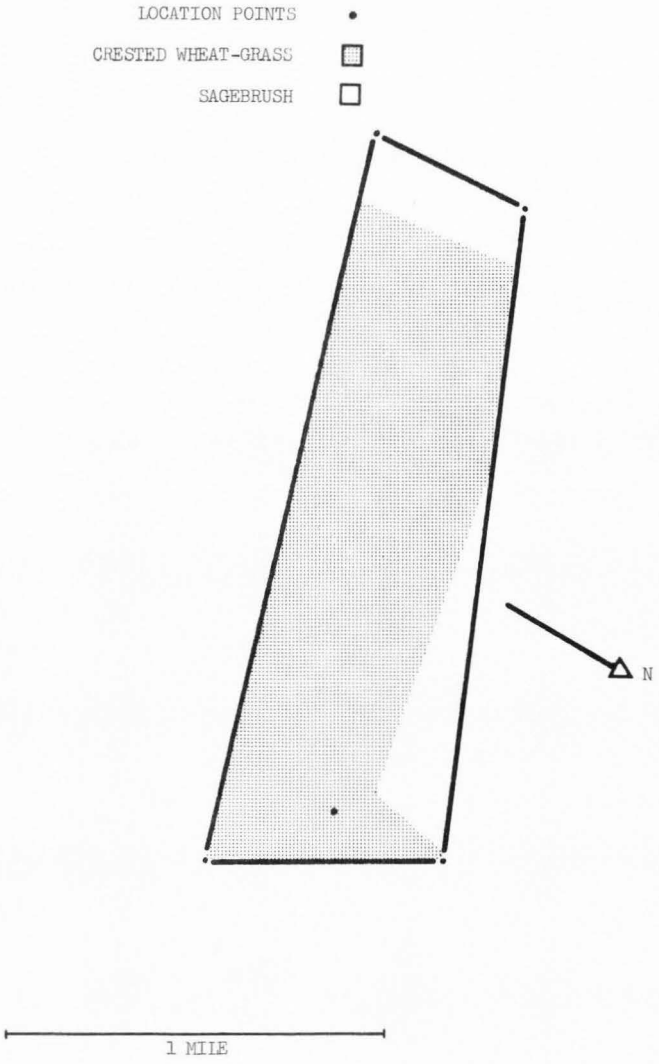

Figure 10. The 622-acre home range of Female 613-3 showing vegetative composition within the home range and location points.

The movements of this adult male were included within an area of 1,550-acres (Figure 11). Vegetatively, the home range was comprised of 45 percent sagebrush and 55 percent crested wheat-grass. On November 9, the animal moved into the northerly portion of his home range. Prior to this date he had confined himself mainly to the sagebrush portion of his home-range. This extension increased the total home range area by approximately 320-acres and included a greater portion of the crested wheat seeding. Subsequent moves were recorded between and within the two portions of the home range.

Of the 20 dens used by the animal 65 percent were classified as old dens, the remainder as new dens. There were two instances of extended stays at a den, both for 2 days. In each of three instances of the repeated use of dens by this animal, the den was located on the periphery of the home range.

The average straight-line distance between consecutively used dens was 4,160 feet. The animal used a den which was used at least once by two other animals, Female 200-1 and Female 610-7. Use of another den was shared with Female 200-7. His home range overlapped the home ranges of three females (200-1, 220-7, and 613-3). The overlaps were of 6 acres, 384 acres (25 percent) and 541 acres (35 percent). Also, a male was trapped April 28, 1970, within the confines of this male's home range.

Male 613-7. This 16 pound 1 ounce adult male was transmittered September 22, 1969, with nine location points collected until December 18. The majority of the locations on this badger were collected during the month of November. The most southerly 10 percent of the animal's home range was in the crested wheat seeding, with the remaining 90 percent in sagebrush. The home range encompassed 1,330 acres (Figure 12).

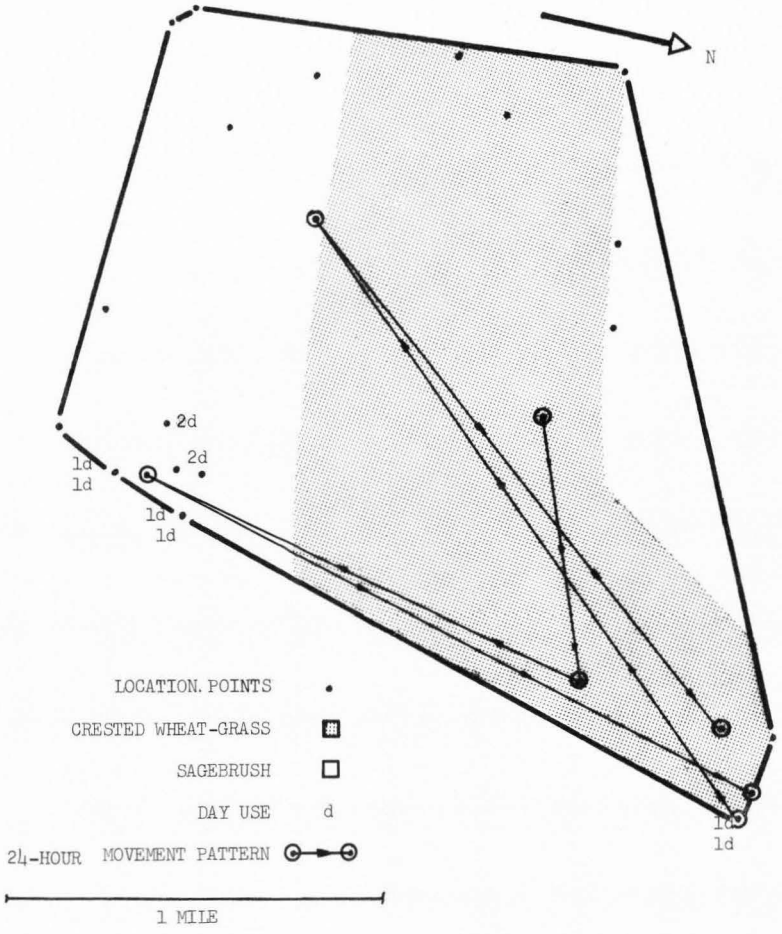

Figure 11. The 1,550-acre home range of Male 610-3 showing vegetative composition within the home range, location points, den use, and 6-day travel pattern.

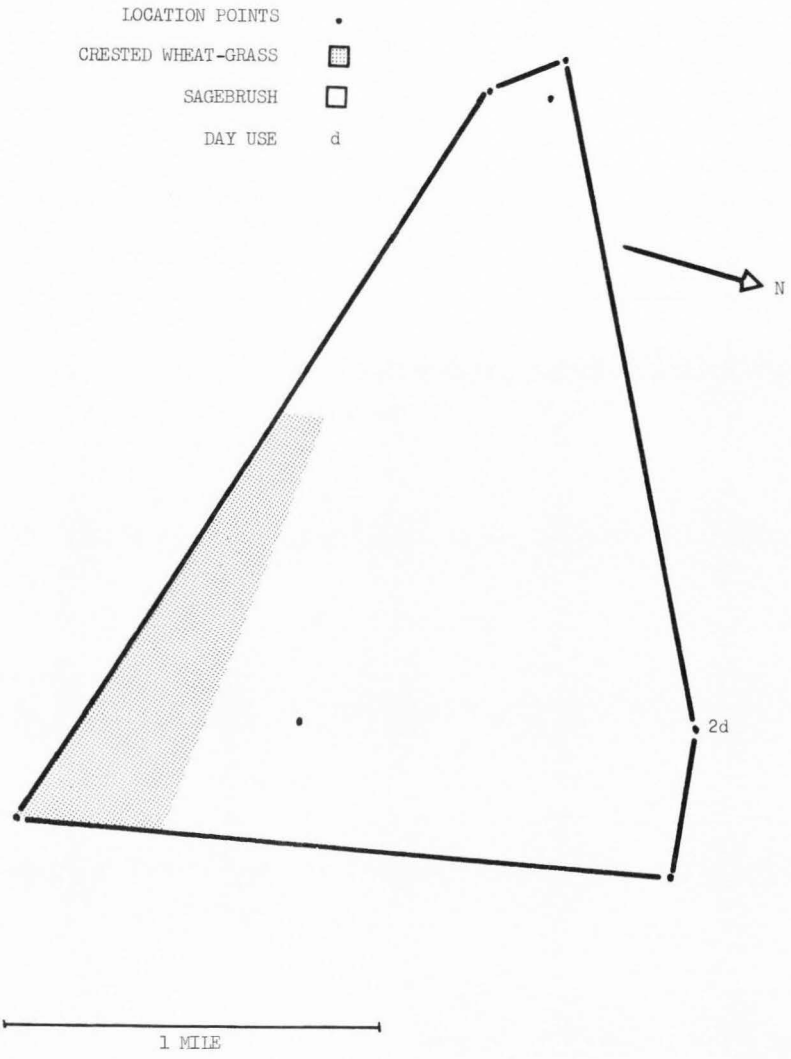

Figure 12. The 1,330-acre home range of Male 613-7 showing vegetative composition within the home range, location points, and den use.

Each den used was classified as an old den. No instances of den re-use were noted, and it remained in a single den for more than 1 day on only two occasions. The extended stays were of 2 and 3 days. The former may have been due to a mild case of poisoning. On November 12, the day preceeding the 2-day stay, the animal was observed consuming poisoned bait and chased from the station. The first contact did not prove fatal. However, the badger was found dead on December 18, 1969, in a den 40 yards north of the poisoned bait station. A search of the animal's stomach with an ultra-violet light revealed tracerite, a trace substance incorporated within the "1080" (sodium-fluoracetate) poison. Apparently, he had enough time during his second contact with the bait to consume a lethal amount. This male's home range overlapped the home ranges of Female 200-1 and Female 610-7. The overlaps represented areas of 17 acres (1 percent) and 166 acres (12 percent), respectively.

General characteristics of movement and home range

Role of dens in badger activity. Badgers, fossorial carnivores, are primarily nocturnal in the Curlew Valley locale. They occupy dens during the day-light hours, with consecutively used dens generally found several thousand feet apart. My transects disclosed an average of 406 dens per square mile, or about one den per 1.5 acres, available to badgers in the study area. Of all the dens (115) known to be used by badgers during the term of this study, 85 percent were old dens, and 15 percent were new dens dug at the time of use. The ratio of old dens used to new ones dug probably is a reflection of the availabiltiy of old dens.

Badgers generally occupied dens for only 1 day. However, I observed animals which remained in dens without emergence for periods of

2-6 days, with the mode being 2. There was a significant difference (χ^2 = .005 < P < .001) between instances of extended stays during the winter and climatically severe spring months on the one hand, and the summer and early fall months on the other. Of moves ending in a den, 48 percent resulted in extended stays during the winter-spring period, with only 5 percent resulting in extended stays during the summer-fall period. Utilization of large food items may enable a badger to remain in a den without emergence for up to 2 days. On three occasions, jackrabbit *(lepus californicus)* remains were found at den sites following the emergence of a badger after a 2-day stay.

Short-term use (2-3 days) of a den as a central point from which nightly hunting trips radiated was observed in the winter and spring months. Nine observations were made of animals moving from, and returning to, the same den apparently following the night's foraging.

The use of dens which had previously been used may indicate an active selection for certain dens. Badgers moved to and inhabited dens which they had previously used 18 percent of the time. In several instances each, four of the seven telemetered badgers traveled in excess of 0.5 miles in a single night to reach previously used dens. This suggests knowledge of den locations. Of all re-use dens, 44 percent were located on home-range peripheries suggesting fairly well defined home-range boundaries in the areas of the re-use dens.

Home-range characteristics. I have delineated the home range of each badger on the basis of locations, primarily den sites, at which it was found over observation periods of varying lengths. The home ranges of two male badgers followed from mid-September to mid-December, averaged 1,440-acres. Five females tracked during varying periods of

the year (Table 2) had an average home-range size of 664-acres (± s.d. 99.8 acres). This figure is smaller than the 2,099-acre home range reported for a single female badger in Minnesota by Sargeant and Warner (1964). Variations in badger densities and/or prey abundance between the two areas might account in part for this difference.

Table 2. Capture date, sex, and history of badgers instrumented and radio tracked

Capture Date	Sex and Number	Remarks
March 23, 1970	Male	Contact lost
April 9, 1969	Male	Transmitter recovered
April 11, 1969	Male	Transmitter recovered
April 28, 1969	Female	Transmitter recovered
April 28, 1969	Male	Contact lost
April 28, 1970	Male	Contact lost
April 29, 1969	Male	Contact lost
May 1, 1969	Female 200-1	Tracked until October 13, 1969
May 7, 1969	Female	Contact lost
May 14, 1969	Female 610-7	Tracked until September 19, 1969
September 6, 1969	Female 613-3	Tracked until September 12, 1969
September 19, 1969	Male 610-3	Tracked until December 14, 1969
September 22, 1969	Male 613-7	Tracked until March 15, 1969
November 25, 1969	Female 200-7	Tracked until June 11, 1970
December 18, 1969	Female	Died before movement
January 19, 1970	Female 610-3	Tracked until June 8, 1970

The average home-range size (655 acres) of two females (613-3 and 200-1) occupying primarily crested wheat home ranges was similar to the average 655-acre home-range size of two other females (200-7 and 610-3) ranging in sagebrush. In the course of small mammal trapping in the same

general area, Balph (1970) found small rodents slightly more than three times as abundant in the sagebrush than in the crested wheat-grass seedings. Although prey abundance is only one factor influencing the availability of prey to a predator, I would assume that a disproportionate abundance of this magnitude would be reflected in home-range size. This apparently not being the case, another factor or set of factors must be operating to limit home-range size.

The location of Female 200-1's home range appeared to be approximately permanent for 13 months. She was originally trapped in late August, 1968, during Frank Clark's (Personal Communication) coyote trapping program, tagged and released. I trapped her again May 1, 1969, less than 0.125 mile from the previous summer's capture site. Subsequent determination of her home range showed it never overlapping the point of the 1968 trapping but her home range boundary approached within 85 yards of this point. Between late August, 1968 and October 13, 1969, her home range location appeared to have been approximately permanent.

Overlap of home ranges was evidenced between sexes, with overlap of home ranges suggested for badgers of the same sex (Figure 5). The larger male home ranges overlapped portions of a number of female home ranges. Male 610-3 shared 6 acres of the home range of Female 200-1, 384 acres of the home range of Female 200-7, and 541 acres of Female 613-3's home range. These overlaps represented 1 percent, 51 percent, and 87 percent of the females' home ranges, respectively. Additionally, Male 610-3 inhabited a den used by Female 610-7 representing a single point of overlap. The second male (613-7) overlapped the home ranges of both Female 200-1 and Female 610-7. These overlaps were of 17 acres and 166 acres representing 3 percent and 22 percent, respectively of the

the females' home ranges. Both of the males overlapped the home range of Female 200-1 and the home range of Female 610-7.

In addition to the one observed case of female-female home range overlap (200-1 and 610-7)(Figure 5) two females were caught within the home-ranges of three instrumented females. Although no definitive data are available on male home range overlap, a male was trapped within the home range of Male 610-3.

Three dens were used by more than one animal during the study. One of these dens was inhabited at different times by three animals, one male and two females. A second den was utilized by two females and the third by a male and a female. In each case the dens were peripherally located in each of the concerned animals' home ranges.

The larger male home ranges overlap the home range of a number of females, and may overlap other male home ranges. Male use was noted within each of the home ranges of the five females followed. A single female home range appears to be overlapped by the home range of more than one male as well as by other females. The overlap of female home ranges by one or more males probably enhances the chance of the female being bred. The overlap of female home ranges by the male of the species has been described by Ables (1969) in the red fox *(Vulpes vulpes)*, Hornocker (1969) in the mountain lion *(Felis concolor)*, and by Saunders (1963) for the lynx *(Lynx canadensis)*.

Topography appeared to influence the configuration of only one home range. The elongated home range of Female 610-3 coincided with a bench line which was transected by numerous gullies. Dirt roads, although present in each home range, did not seem to affect home range configuration although badgers used them occasionally to travel short distances.

Home-range size may fluctuate seasonally. Female 610-3 ranged within an area of 236 acres (adjusted from 158 acres to compensate for gullies) between January 11 and March 17, 1970. This area was less than half the annual female average home range (664). Although she was pregnant during the later portion of this period (approximately January 26 to March 17) a comparison of her den-use habits with those of a non-pregnant female (200-7) did not suggest any modification in response to pregnancy. Sargeant and Warner (1964) presented data indicating a seasonal fluctuation in home-range size similar to that observed for Female 610-3.

Of the eight males transmittered, only two were successfully tracked. Of the six not radio-tracked, transmitters were recovered from two; and with the exception of three approximate points on one, all contact was lost with the other four. Attempts to locate these animals using both stationary and portable tracking equipment continued in the case of the two males instrumented in 1969 for over a year. The two males successfully tracked were both caught and instrumented in mid-September. The four with which contact was lost were instrumented in early spring (March 29 to April 29). Male 610-3 was originally trapped and released ear-tagged on May 14, 1969. I again trapped him on September 19, 1969 less than 0.1 mile from the site of the earlier trapping. After subsequent determination of his home range, it was found to encompass both of these points.

It appears unlikely that the four males with which contact was lost were occupying extremely large home ranges because no contact was ever made with them again. They may perhaps have been transient 1-year olds, accepted in the resident population during winter until they began

to develop sexually for the first time. Wright (1969) found that male badgers reach full spermatogenesis for the first time at the age of 14 months.

Although evidence presented earlier in this paper suggested reduction of home-range size in response to cold weather, Male 610-3 extended his home range in the fall (Figure 11). The extension was initiated on November 9, 1969, and it added approximately 320 acres to the home-range size. He used both the new and old parts of his home range but it appeared that only about one-third of the older portion was now being used. Thus, there probably was no expansion of total acres the animal was actually utilizing.

The home range of Female 200-1 was observed to constrict immediately prior to her death on October 13, 1969.

The natal range of Female 610-3 (Figure 6) was 282 acres in size, slightly more than one-half of the total 518 acres she occupied during the tracking period. The necessity of returing to the natal den probably restricted her movements and consequently her home-range size. During the period I observed her, she shifted her cubs to two additional natal den sites. I observed a similar pattern of natal den shifting the previous spring. Movement of this type may be a sanitation measure and/or a desire by the female to shift the focal point from which her hunting trips radiate.

On May 23, I last observed Female 610-3 when I was sure she was hunting alone. Young were seen hunting with an adult on June 10, and a juvenile female apparently separated from the adult was collected on June 11. The first data on which I observed a juvenile hunting alone was approximately July 10. It appeared that between the approximate

dates of April 1 and June 1, the parturiant female's activities are restricted to the area around her natal den(s). In the early part of June the young probably begin to hunt with the female, allowing her a greater range of movement, and continue to hunt with her until early or mid-July. Young-adult separation at this time would free the female for breeding purposes.

Sargeant and Warner (1964) found that the straight-line distances traveled between consecutively used dens (24-hour movements) were reduced as the home-range size constricted. The average straight-line distance (1,898 feet) traveled by Female 610-3 while in her winter home range, when compared to the average figure (1,336 feet) for Female 200-7 also ranging primarily in sagebrush, did not indicate a seasonal reduction of straight-line distances. The average straight-line figure for Female 610-3 was actually greater than that of Female 200-7 ($t = .25 < P < .20$).

The average straight-line distance (4,372 feet) traveled by two females (200-1 and 613-3) ranging primarily in crested wheat-grass, between consecutively used dens, was significantly larger ($t = .025 < P < .005$) than the average figure (1,786 feet) for two other females (200-7 and 610-3) utilizing primarily sagebrush home ranges. This difference may be a reflection of the unequal prey abundance between the two vegetative types, as described earlier. Crested wheat-grass had approximately one-third the prey found in the sagebrush (Balph, 1970). The distance traveled per unit time appears greatest in areas of low prey abundance.

The average straight-line distance traveled between consecutively used dens by Male 610-3, occupying a vegetatively mixed home range, was

4,160 feet. Although his home-range size (1,550 acres) was over twice the size of either of the females (200-1 and 613-3) in the crested wheat seeding, his average straight-line distance (4,160 feet) was slightly smaller than the average for the two crested wheat females (4,372 feet). Hence, the average straight-line distance traveled between consecutively used dens does not appear directly related to home-range size, but may be influenced by the density of prey within the individual's home range. Larger, or more linear home ranges would provide the potential for greater straight-line moves than would circular home ranges.

Because the distance traveled per night appears to be greater in the crested wheat, I expected a more frequent utilization of the entire crested wheat home range. A visual comparison of the charted movements of Female 200-1 (Figure 8) and Female 200-7 (Figure 7) shows this expectation to be correct. A 10-day consecutive movement pattern of Female 200-1 utilized about 80 percent of her primarily crested-wheat home range while in 6 days Female 200-7 utilized only about 10 percent of her home range.

Population Characteristics

Reproductive pattern

Reproductive phenology. The paired testis weights for adult males were greatest in May and August. Although weights were not available between these months, Wrights' (1969) data from a South Dakota collection suggests that the weights between these dates would be at least as high if not higher than the May and August weights (Figure 13). I assumed testis weights were indicative of their level of spermatogenesis; males in Curlew Valley appear to be capable of reproduction from mid-May

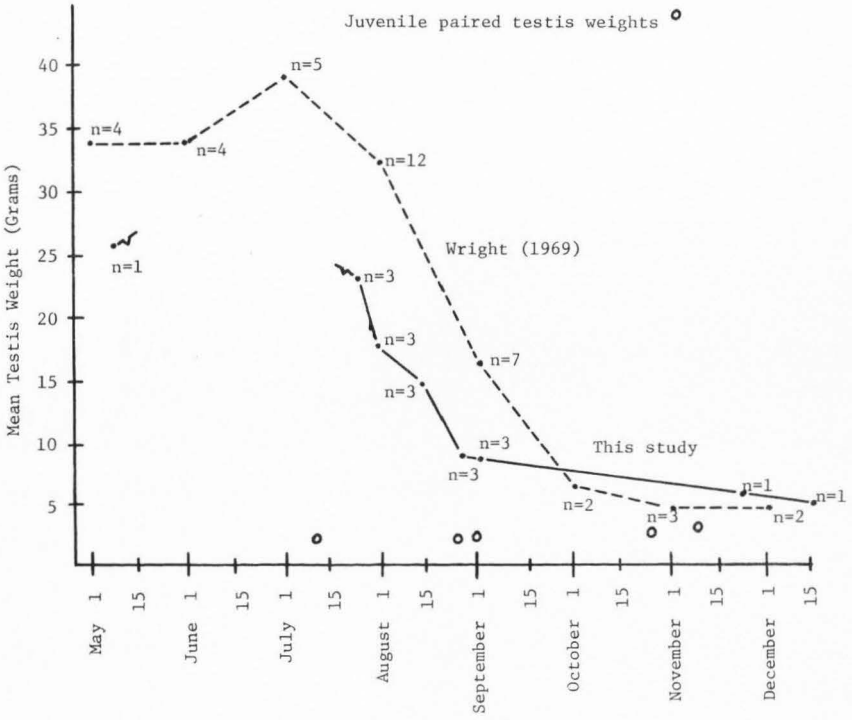

Figure 13. Comparison of paired testis weights by dates of Curlew Valley badgers (July-Sept = three points moving average) with average monthly paired testis weights from a South Dakota collection (Wright, 1969).

until the last of August. The variation in dates of testis weight decline between the two collections may be partially accounted for by the actual collection dates of the South Dakota collection (Wright, 1969) not being plotted.

I observed corpora lutea in a female collected on July 15. Unfortunately no adult females were collected during the month prior to this date, and ovulation may occur earlier. A 1-year old female collected about January 26, carried two embryos. Female 610-3 had young during a 6-day period, beginning March 27, in which she remained underground.

Wright (1966) found South Dakota and Montana badgers to breed in late July and August with implantation occuring in February. He felt that parturition occurred in March or early April. These dates compare favorably to the dates suggested above for the Curlew Valley population.

Breeding age. Although Wright (1966) presented evidence of a minority of juvenile (less than 1-year old) females breeding, no sign of ovulation was observed in the seven juvenile females (one on July 18, six between August 26 and September 8) collected in Curlew Valley (Table 2). Additionally, ovulation was not evidenced in 43 percent of the 1-year old females collected between August 14 and December 18 (n=7). Because one animal potentially may have been bred had she not been collected (August 14), the actual number of 1-year olds not breeding varied between 33-43 percent (average 38 percent). Each female (n=14) in the remaining age classes had ovulated (Table 3).

Table 3. Age class of females/corpora lutea

Age in Years	Samples (Number of individuals and corpora lutea per individual)
Juvenile	7=0
1- 2	3=0 4=2
2- 3	2=1 2=2 1=3
3- 4	---
4- 5	1=3
5- 6	1=1 1=2 1=4
6- 7	1=2
7- 8	1=3
8- 9	1=3
9-10	---
10	1=3
Totals	n=27 $\bar{x}$=2.2

The paired testis weights of the juvenile males increased slightly between June and January (Figure 13). However, at no time did they reach the weights of the inactive adult paired testes, and seemingly were incapable of sperm production. I assumed on this basis that the juvenile males did not breed during the first breeding season. Wright (1969) found that male badgers reached active spermatogenesis for the first time at the age of 14 months.

Litter size. An average of 2.2 corpora lutea was found for those animals exhibiting at least one corpus luteum. I observed six post-natal

litters, four of which had two young and the remaining two were of three and four young. The observed litter sizes did not exceed the highest corpus-luteum count for one female (4), and the average of these observation (2.5 young per litter) approximated the average corpus-luteum count of 2.2 per female.

Population change and density

Data from Frank Clark's (Personal Communication) trapping program over a 5-year period suggest a relatively stable Curlew Valley badger population. During this period (1966-1970) the number of badgers caught per 1,000 trap nights was 3.9, 5.0, 3.2, 4.1, and 2.0, respectively. The actual numbers caught each year were 12, 28, 22, 21, and 10. A chi-square test indicated that none of the years differed significantly from the mean of the 5 years.

Although no exact density estimates were available for badgers in Curlew Valley, in a 1-year period, I caught 12 badgers within the 7.5 section, centrally located portion of the study area. The capture sites were well spaced throughout this area suggesting a density in excess of one animal per square mile.

Age structure, mortality rates and recruitment

Age structure. Separation of the study collection into juvenile and adult categories by the pulp-cavity-closure criterion yielded 18 juveniles and 33 adults. Subsequent counts of the darker stained bands in the cementum layer of the adult canines yielded the numbers found in Table 4.

Table 4. Age in years of badgers in the study collection

Age in Years	Number of Animals
0- 1	18
1- 2	8
2- 3	10
3- 4	0
4- 5	4
5- 6	3
6- 7	3
7- 8	2
8- 9	2
9-10	0
10	1

Mortility rates and recruitment. Small sample sizes often precluded assignment of mortality rates to each age class. However, in a stable population, the mean annual mortality rate of a population is equal to the increment annually added to population. Thus, the percentage of juveniles in the total population is equal to the percentage of the population that died the preceeding year. This percentage is 35 (18/51).

In a hypothetical population of 100 animals, 50 males and 50 females, 35 percent of the females (18 of the 50) are non-producing juveniles. Of the remaining 32 females, 24 percent (or 8 of the 32) are 1-year olds (Table 4) of which 33-43 percent (average of 38 percent, or 3 of the 8) do not produce. Thus, only 29 of the original 50

females actually produce young. Annually then, on the basis of 2.2 young per female, 64 young are added to a population of 100. Applying the mean annual, summer-summer 35 percent mortality rate to the 164 animals, a surplus of 6 animals is added annually. To stabilize the population, a 39 percent mean annual mortality rate would be necessary.

Physical measurements

The average body weights of adult animals in the study collection were 19.5 (± s.d. 2.3) pounds for males and 15.9 (± s.d. .83) pounds for females. This was 7.6 and 12.1 percent more, males and females, respectively, than the South Dakota animals reported by Wright (1969). No association was observed between body weights and age of adult animals.

The average baculum weights were 4,629 mg for adults and 1,082 mg for juveniles. Baculum weights appeared to increase gradually between June and January of the first year's growth (Figure 14) and then increase slowly with the animal's age (Figure 15).

Foods and Feeding Habits

Year-round patterns

Originally, the content of 26 scats were analyzed separately from that of 15 stomachs. After the separate analyses the results were compared and in view of the small sizes there appeared to be little difference between the results obtained in the two. The materials were then combined and frequency of occurrence values were determined for each major food grouping (Table 5).

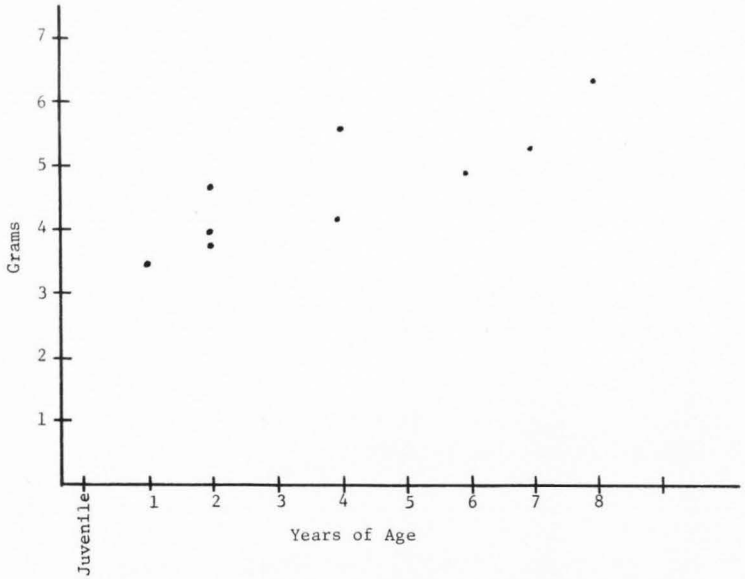

Figure 15. Individual baculum weights as a function of age.

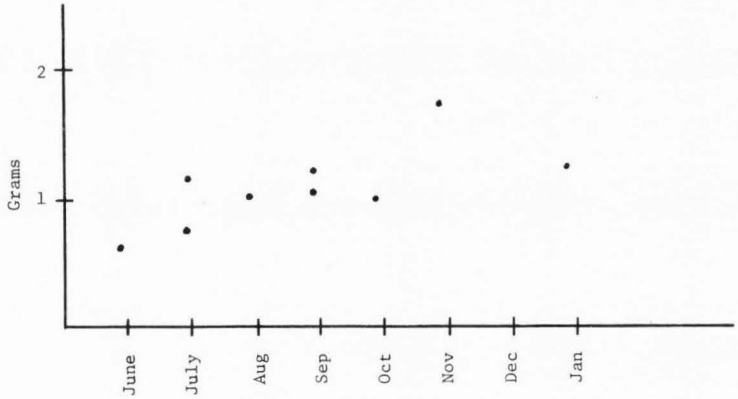

Figure 14. Monthly weights of juvenile bacula.

Table 5. Findings of food-habit analysis

Food Groupings[a]	Scat (n=26)		Stomachs (n=15)		Total (n=40)		Female With Young (Scat)	
	No.	Frequency of Occurrence	No.	Frequency of Occurrance	No.	Frequency of Occurrance	No.	Frequency of Occurrance
		%		%		%		%
Microtine	14	.54	5	.33	17[b]	.43	13	.87
Cricetine	10	.39	5	.33	13[b]	.33	12	.80
Sciurids	1	.04	1	.07	2	.05	0	0
Heteromyid	4	.15	1	.07	5	.13	1	.07
Lagomorphs	12	.46	5	.33	14[b]	.35	3	.20
Avian	2	.08	4	.26	5	.13	3	.20
Insects	10	.39	5	.33	13[b]	.33	0	0
Reptile	4	.15	0	0	4	.10	4	.27

[a] Species within each of these taxonomic food grouping are listed in Table 6.

[b] In cases where scat and stomach content came from the same animal the chance of remains in both coming from the same sources necessitated only counting them as a single occurrence when combining scat and stomachs.

Table 6. Species found within each of the major food groupings

Food Groupings	Scientific Names	Common Names
Microtines	*Microtus montanus*	mountain vole
	Lagurus curtatus	sagebrush vole
Cricetines	*Reithrodontomys megalotis*	desert harvest mouse
	Peromyscus maniculatus	deer mouse
	Neotoma sp.	woodrat
Heteromyids	*Perognathus parvus*	Great Basin pocket mouse
	Dipodomys sp.	kangaroo rats
Sciurids	*Eutamius minimus*	least chipmunk
	Citellus townsendi	Townsend ground squirrel
Lagomorphs	*Lepus californicus*	black-tailed jackrabbit
	Sylvilagus sp.	mountain cottontail and pigmy rabbit
Avian	All Species	
Insects	All Species	
Reptile	All Species	

Microtines were the most frequently found food item in the material (43 percent). Remains of cricetine rodents (77 percent of which was composed of deer mice) were observed in 33 percent of the total samples. Although microtine rodents appeared to be more frequently eaten than deer mice, Balph's (1970) trapping in Curlew Valley indicated a greater abundance of deer mice than microtines. This variation between what was eaten, and the abundance of prey species, may be explained by D. Balph's suggestion (Personal communication) that his trapping selected against microtines and/or that microtines are more available to the badger than are deer mice.

Data from the same trapping program suggested a relatively high abundance of least chipmunks in the area, but the species was

represented in only a single sample. Although abundant, they appear relatively unavailable to the badgers. Sciurids as a group, were found in only 5 percent of the samples.

Errington (1937), Snead and Hendrickson (1946), and Jense (1968) considered sciurids to be the most common food-item in the badger's diet with mice only secondary in importance. Dearborn's (1932) study in Michigan, as did this study, found mice to be the most frequently eaten food-stuff.

Lagomorph remains were found in 35 percent of the samples. Jackrabbits, with the exception of the very young, appear generally available to the badger only in the form of carrion. Cottontails and pigmy rabbits are probably taken by active means of predation as well as in the form of carrion. The frequency with which lagomorph remains were found in samples may have been influenced by the high densities of jackrabbits reported for Curlew Valley (Personal Communication, L. C. Stoddart).

Parts of birds and eggs were found in 13 percent of the samples. The frequency with which avian material appears may not be indicative of its year-round use because three samples are available for the spring months, the time at which the most active ground nests would have been available. I observed one of the transmittered animals eating a portion of a dessicated short-eared owl (*Asio flammeus*) suggesting that some avian material may be taken in the form of carrion.

Remains of insects, both larval and adult stages, were found in 33 percent of the material. Insects comprised the total bulk of the sample in two cases. Only the most chitinous portion of insects were found in scats. Easily recognizable insect remains were of the order

Orthoptera. Heteromyid rodents were represented in 13 percent of the samples, with reptilian remains found in only 10 percent.

Seasonal variations

A general trend in prey use is suggested (Figure 16) even though small sample sizes available for the spring and fall months probably preclude a confident apraisal of seasonal food usage. Mice (cricetines and microtines) appeared to be less frequently eaten during the summer months. Both Snead and Hendrickson (1946)and Jense (1968) described a similar trend, which may reflect the increasing abundance and/or availability of other prey species at this time of the year. Heteromyid rodents and reptiles are both most active during the summer months, as are insects, in Curlew Valley, and probably become more available to the badger with their increasing abundance.

Female with young

To ascertain if there were differences in the foods eaten by the female badger with young, and the non-parturient animals, only samples collected during the spring could be compared with samples from parturient females. Unfortunately, few samples (n=3) were available for the spring, and accurate comparisons could not be made. However, cricetine and microtine rodents appeared to be used as frequently or possibly more frequently by the parturient female than by non-parturient animals on the year-round basis. Insects did not appear available to the female badger with young, which was probably a function of the time of the year the natal den was occuppied (i.e., April-June). The parturient female appeared to utilize the remaining food-groupings at about the same frequency that they were used on the year-round basis.

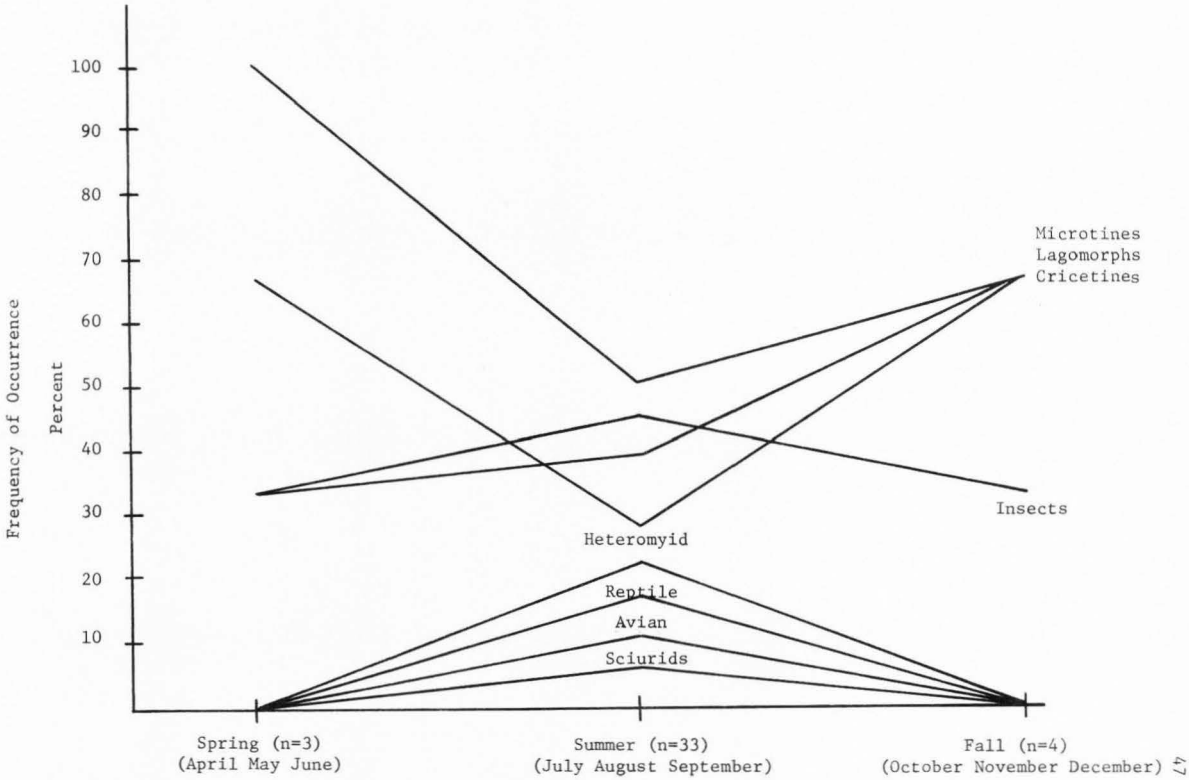

Figure 16. Seasonal frequency of occurrence percentages for food items found in badger scat.

Predation and prey use

I observed three covered caches, each of which contained jackrabbit remains. Additionally, on two occasions, I found whole jackrabbit carcasses which had been pushed into unoccupied dens.

Sign of predation on both nesting and fossorial rodents was commonly observed. A single stomach yielded 13 adult-sized deer mice, 9 immature deer mice, and 2 immature Townsend ground squirrels. Three attempts at predation on the woodrats were noted. In one case a woodrat nest which had been constructed in a badger den was destroyed.

Snow tracking revealed a den-to-den travel pattern within one night, in each animal followed, in which each den or old dig site passed was throughly investigated before the animal continued on his foraging. I often observed fresh sign at areas of previous badger use, suggesting that areas of previous use are frequented by the badgers throughout the year. Cottontail and pigmy rabbits commonly use old badger dens as home sites in the area. I saw birds and lizards in the shade of den entrances, and lizards using the den proper as escape cover. Burrowing owls *(Speotyto cunicularia)* nest in badger dens throughout the valley, and expose themselves to predation by the badgers if they are in the den.

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