Ecology of the Badger in Southwestern Idaho
Author(s): John P. Messick and Maurice G. Hornocker
Source: *Wildlife Monographs*, No. 76, Ecology of the Badger in Southwestern Idaho (Jan., 1981), pp. 3-53
Published by: Allen Press
Stable URL: http://www.jstor.org/stable/3830719
Accessed: 25/08/2010 14:32

WILDLIFE MONOGRAPHS

A Publication of The Wildlife Society
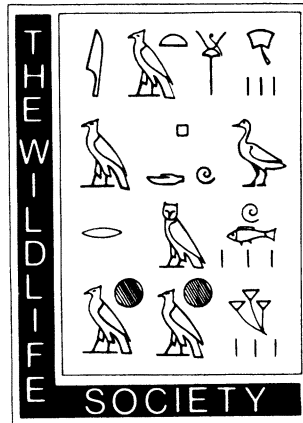
ECOLOGY OF THE BADGER
IN SOUTHWESTERN IDAHO

by

JOHN P. MESSICK AND MAURICE G. HORNOCKER

FRONTISPIECE.   A female North American badger at the age of 5 months. Over 30 percent of young-of-year females bred when they were 4 or 5 months old. (Photograph by J. P. Messick.)

ECOLOGY OF THE BADGER IN SOUTHWESTERN IDAHO

John P. Messick[1] and Maurice G. Hornocker

Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho 83843

CONTENTS

[1] Present address: Department of Biology, Missouri Southern State College, Joplin, Missouri 64801.

INTRODUCTION

The North American badger *Taxidea taxus* is a mustelid with remarkable morphological adaptations for feeding on burrowing prey. A compact body, loose skin, and stout forelimbs armed with long curved claws are combined into a unique solution to the problem of underground feeding. But structural features are only one of the many interlocking ways that organisms adapt to a continuously changing environment. Behavior, physiology, and even population dynamics may also relate to the manner in which carnivores exploit food resources (Ewer 1973, Wilson 1975).

Speculation on the ultimate factors that produce adaptation requires, first, an understanding of the life history of the organism. That is, the immediate factors that influence reproduction, mortality, and behavior must be well documented. In this study, we assembled information on the population variables, movement, activity, and food habits of a badger population in southwestern Idaho, compared those data with other badger studies, and tried to identify adaptations related to fossorial predation.

Another reason for this study concerns the management of extraordinary ecosystems. The Snake River Birds of Prey Natural Area, administered by the federal Bureau of Land Management, was established in 1971 to protect the habitat of perhaps the densest breeding population of raptors in the world. Portions of the natural area and adjacent areas are also exceptional because of high concentrations of Townsend ground squirrels *Spermophilus townsendi* and North American badgers. Recognizing that enlightened management of the natural area demanded better understanding of habitat needs of the raptors, composition and population biology of the prey, and assessment of the role of mammalian predators, the Bureau, in 1975, began the Snake River Birds of Prey Research Project. Our study, conducted from 1975 to late summer 1977, is the badger segment of that project.

Following were the objectives of the study:

(1) To determine density, sex, and age structure and other characteristics of the badger population;
(2) To investigate movements, activity, and social organization of badgers; and
(3) To gather data on food habits as an aid to assessing the role of the badger as a predator.

ACKNOWLEDGMENTS

FIG. 1.   Location of the badger study area within the Snake River Birds of Prey Natural Area and Snake River Birds of Prey Study Area, Idaho.

FIG. 2.   The badger study area, Snake River Birds of Prey Study Area, Idaho.

FIG. 3. Badger and Townsend ground squirrel burrows on the Snake River Birds of Prey Natural Area, Idaho.

STUDY AREA

The Snake River Birds of Prey Study Area (SRBPSA) is a 1,933-km² area between Walters Ferry and Indian Cove, Idaho, and encloses the smaller Snake River Birds of Prey Natural Area (Fig. 1). Badger mark–release and radiotracking studies were conducted primarily within a 50-km² area (hereafter referred to as the badger study area) near Swan Falls (Figs. 1, 2). We collected badgers on surrounding lands with habitat similar to that of the Swan Falls area.

The Snake River Canyon is the major geographical feature of the region (Malde 1965, Walker 1963). Flats that extend outward from the canyon rim are dissected by side canyons and dotted with buttes. Vegetation of the Snake River Plain can be characterized as shrub–steppe (Daubenmire 1970). In the badger study area, a mosaic of big sagebrush *Artemisia tridentata* Nutt. and winterfat *Eurotia lanata* (Pursh) Moq. dominates most of the overstory; Sandberg's bluegrass *Poa sandbergii* Vasey and cheatgrass *Bromus*

tectorum L. dominate the understory. Cheatgrass and Russian thistle *Salsola kali* L. dominate in highly disturbed sites such as traditional sheep camps and recently burned areas. Badger and Townsend ground squirrel burrows are a conspicuous feature of the landscape (Fig. 3). Annual precipitation, rain and occasional snow, is about 20 cm at Swan Falls Dam (U.S. Dept. of Commerce 1975–1977). Strong winds are common in spring. Annual temperature extremes during the study ranged from about −20 to 43°C.

Cattle and sheep range through the study area in winter. Irrigated agriculture, potatoes, sugar beets, alfalfa, corn, small grains, and vegetable seed crops, is the predominant land use near Melba and Kuna. Approximately 10 percent of the badger study area is in irrigated agriculture (Fig. 2).

Coyotes *Canis latrans* are the other common carnivore; bobcats *Lynx rufus* are reported infrequently (Hornocker et al. 1977). The Townsend ground squirrel is among the most important prey

species. In the badger study area, Town-send ground squirrel densities are from 4 to over 10 residents (adults and year-lings) per ha. Elsewhere in the Birds of Prey Study area densities vary from 5/ha in big sagebrush–winterfat habitats to less than 1/ha in crested wheatgrass *Agropyron cristatum* L. and shadscale *Atriplex confertifolia* (Torr. and Frem.) Wats. There are no squirrels in grease-wood *Sarcobatus vermiculatus* (Hook) Torr. or south of the Snake River except in scattered colonies near Fossil Butte (Johnson and Smith 1978). Deer mice *Peromyscus maniculatus* and Ord's kan-garoo rat *Dipodomys ordi* are the most common smaller rodents (Montan 1977, unpublished master's thesis, Utah State University, Logan, Utah). Black-tailed jackrabbits *Lepus californicus* are the major lagomorph. Nuttall's cottontail *Syl-vilagus nuttalli* are found mainly near rocky buttes and along the canyon rim (Wolf et al. 1977). Montan (unpublished thesis) and Wolf et al. (1977) described the composition of the entire small mam-mal and bird fauna on the study area. Western rattlesnakes *Crotalus viridis,* gopher snakes *Pituophis melanoleucus,* western whiptail lizards *Cnemidophorus tigris,* and side-blotched lizards *Uta stansburiana* are the most common snake and lizard species on the study area (Johnson et al. 1977a).

METHODS

Mark–Release, Collections, Radiotracking

Badgers were trapped for mark–release at burrows with No. 2 coil spring traps (Victor Animal Trap Co., Oneida, N.Y.). Other capture techniques included spot-lighting and netting while the animals were above ground, often with the aid of a dog. Known maternal dens were trapped repeatedly in efforts to capture entire family groups (female with young).

We collected individuals by shooting or trapping in similar habitats outside the badger study area to obtain supplemental data on food habits, age, and reproduc-tion. Fur trappers provided additional carcasses, and road kills were salvaged where possible.

We immobilized live-trapped badgers with ketamine hydrochloride (Vetalar, 100 mg/ml, Parke-Davis, Detroit, Mich.) at an estimated dose of 10 mg/kg of body weight. The drug was given intramuscu-larly with a 10-cc syringe fitted with an 18 gauge, 2.5-cm needle and attached to the end of a broom handle. Such a dose usually kept a badger tractable for 30 min to 1 hour. Ketamine hydrochloride has a wide margin of safety in badgers, and we sometimes gave repeated doses during prolonged handling. Side effects of the drug, including excessive salivation, can be controlled with acepromazine maleate (Ramsden et al. 1976), but we had no need to use it.

Standard body measurements were re-corded. The second lower incisor and sometimes the first lower premolar were pulled for age determination. We tat-tooed an ear for permanent identification and fitted animals with numbered, ad-dressed, Standard Rototags (Nasco, Inc., Modesto, Cal.); they were retained better than aluminum cattle tags used the first few weeks.

Selected individuals were equipped with radio transmitters. The badger's fun-nel-shaped head and neck, loose skin, and fossorial habits made attachment of transmitters difficult, and the original prefabricated collars (LM or D collars with SB2 transmitters, AVM Instrument Co., Champaign, Ill.) proved unsuitable. T. Dunstan developed a smaller package with a round neck strap that was a marked improvement, and with further modification we produced an expandable collar for use on growing young (Fig. 4). Retention of collars was a continuing problem throughout the study, and har-nesses modified from the design of Lind-zey (1978) were not successful.

All collars incorporated the AVM SB2 transmitter and usually lithium 2.7-V bat-teries. Instrumented badgers were mon-

itored 1 or more times daily using AVM LA12 receivers and yagi antennas that were hand held or mounted to a truck or an airplane.

Capture or radio locations were recorded as grid coordinates. The grid system was based on the township and range lines of United States Geological Survey topographic maps. Burrows used by badgers were marked with wooden labels. Twigs placed at burrow entrances showed badger departures (Lindzey 1978).

Food samples came from 3 sources: digestive tracts (stomachs and colons) from badger carcasses, scats from captured badgers, and scats picked up in the field. Captured badgers were confined in holding cages for 24 or more hours to obtain fecal specimens, then released. Except for 14 individuals, badgers were released at the original capture location. Six escaped from holding cages, and 8 were relocated because they had damaged irrigation structures. Those displaced badgers provided the basis for a homing experiment.

Sample Preparation and Identification

Stomach samples were preserved in 10 percent formalin. Scats or colon contents were air dried in heavy paper bags and weighed to the nearest gram. We used established procedures (Korschgen 1969) to analyze food samples and separated the components into broad categories (bones, fur, etc.). Mammalian remains usually were identified from comparisons with a reference collection. If hard parts were absent or insufficient for identification, hair samples were used (Hardy and Plitt 1940, Moore et al. 1974). Reptiles, arthropods, and avians were identified from comparisons with a reference collection. Names of all food organisms are given in Appendix H.

Skulls and bacula were cleaned by boiling. Bacula were also boiled in weak NaOH (Petrides 1950) and degreased in acetone (Harris 1978) before oven drying and weighing to the nearest milligram.
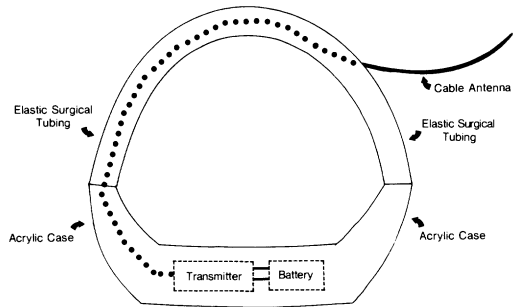
FIG. 4. Radiotracking collar used on the badger study, Snake River Birds of Prey Study Area, Idaho, 1975–1977.

Vernier calipers were used for tip-to-base bacular length (Long and Frank 1968) and standard skull measurements (Long 1972, Thomas 1905).

Female reproductive tracts were fixed in alcohol, formaldehyde acetic acid (AFA), or Bouin's fluid afer placental scars had been counted. Tracts were washed in 35 percent alcohol, then placed in 50 and finally 70 percent alcohol (Wright 1966). Ovaries were dissected free of the oviduct and individually weighed after draining for 1 min on paper toweling (Mead 1968). They were then serially sectioned at 8 μ and stained with hematoxylin and eosin or Mallory's. Corpora lutea and other structures were measured by ocular micrometer. Uteri were cleared in methyl salicylate, benzyl benzoate, or xylene and examined under indirect or oblique lighting for placental scars (Martin et al. 1976, Wright 1966), after which counts were compared with those on fresh samples.

Testes were fixed in AFA or Bouin's fluid and transferred to 70 percent alcohol. Epididymides were freed from testes, and connective tissue removed (Wright 1969). Paired testes and epididymides were weighed after draining as described for ovaries.

Age Determination

Ages of badgers were determined by several methods from which we could

judge their relative validity. For cementum age determination, we used the incisors and/or premolars pulled from mark–release animals and usually 1 each of incisor, canine, and premolar from collected animals. Teeth from a total of 435 badgers were processed by Matson's Microtechnique, Inc., Milltown, Mont. Analysis was based on 1 or more teeth per animal (Table 1).

Counts of cementum annuli produced the most detailed age structure and were used for age determination in 354 (81%) of the 435. For the American badger, as for many other species, that technique presents several problems of interpretation (Fig. 5), the most important of which involve split or merged annuli, timing of annulus deposit, and visibility. Variation in annular counts may exist among different kinds of teeth in an individual. We minimized those problems by having 2 people read tooth sections independently. To resolve disagreements we resorted to additional criteria: skull measurements (Appendix A), degree of suture closure (Appendix B), development of saggital crest and postorbital process (Appendix C), tooth wear (Appendix D), bacular length and weight (Appendix E), and pulp cavity size and cementum thickness. For the most part, those subjective criteria were useful only in segregating young of year from yearlings or confirming adult status in the absence of tooth sections. Known age animals (usually those captured at a very young age and again later in life), and those sampled in different years, helped correlate annuli with age. Badgers less than 1 year old are called young of year. Yearlings are those 1 year old, and adults include all badgers 2 years or older.

Crowe and Strickland (1975) believed that badgers do not lay down the first annulus until their second summer (about 15–17 months old). Our data indicate that the initial dark staining annulus may be formed in a badger's first winter, but may only become visible after several more months, during which lighter staining cementum is deposited outside the annulus. Similar conclusions were reached by Johnston and Beauregard (1969) and Harris (1978) for the red fox *Vulpes vulpes,* although Grue and Jensen (1973) cited evidence that formation of the dark annulus in the red fox may not be restricted to a specific time of year. Klevezal and Kleinenberg (1967) stated that in mammals it generally forms in winter. The deposition of newly formed, lighter cementum can be easily stripped away when teeth are extracted, thus confounding interpretation.

Recording and Analyzing

We recorded data both on form cards and in field notes and used an IBM 37-/168 or a DEC PDP-11/40 computer to help analyze them. MIDAS (Michigan Interactive Data Analysis System, Statistical Research Laboratory, University of Michigan, Ann Arbor, Mich.) largely provided the programs. Graphs and figures of animal movement were traced from originals produced on a Calcomp plotter.

Comparison of means was by a *t*-test or analysis of variance. Treatment means in the analysis of variance were compared a posteri using Scheffe's method or Duncan's New Multiple Range Test. Chi-square was used to test goodness of fit. Alpha has been reported as the probability of the calculated value occurring by chance. Standard deviations (SD) have usually been reported in lieu of standard errors.

POPULATION CHARACTERISTICS

Sources of Data

Age structure, fecundity, mortality, and density were estimated from 4 sources: the mark–release sample of 215 badgers captured 366 times on the badger study area, a collection of 128 carcasses taken outside the badger study area, 51 known mortalities of marked and unmarked badgers that occurred during the study, a collection of 32 skulls found on the badger study area.

TABLE 1.—AGE CRITERIA FOR 435 BADGERS CAPTURED OR COLLECTED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Criteria	All years		1975		1976		1977	
	No.	%	No.	%	No.	%	No.	%
Incisor only	121	27.8	58	52.7	33	20.5	30	18.3
Canine only	9	2.1	5	4.6	2	1.2	2	1.2
Premolar only	10	2.3	0	0.0	8	5.0	2	1.2
All three	161	37.0	21	19.1	55	34.2	85	51.8
Combination of 2 teeth[1]	53	12.2	11	10.0	28	17.4	14	8.5
Known age from tooth replacement	53	12.2	5	4.6	25	15.5	23	14.0
Estimated age from size and appearance	19	4.3	7	6.3	9	5.6	3	1.8
Technique failure or not aged	9	2.1	3	2.7	1	0.6	5	3.0
Totals	435	100.0	110	25.3	161	37.0	164	37.7

[1] Different kinds of teeth. Replicates of same kind not included in count.

We assumed that the same population was represented in the mark–release and collected samples. Vegetation, food supplies, patterns of land use, and amount of human activity were similar in both areas sampled.

Age Structure

Ages of 354 badgers were obtained by cementum analysis (Appendix F), and 81 badgers that could not be aged by cementum analysis were assigned to 1 of 3 age groups based on subjective judgment (Appendix G).

Multitooth samples from 214 badgers (Table 1) agreed in annular counts 78 percent of the time (Table 2), and compared favorably with other studies that used more than 1 tooth per animal (Knudsen 1976, unpublished master's thesis, Utah State University, Logan, Utah; Harris 1978, Roberts 1978). Agreement of counts was boosted by the high proportion of young (without an annulus) in the sample. If more older animals had been present in the collection, the agreement among different teeth presumably would have been lower.

In the collected samples, the most accurate ages were obtained from canines, premolars, and incisors, in that order. When checked against skull size and appearance, tooth replacement, and other criteria (Appendixes A–E), incisors underestimated age more often than canines and premolars. In the 204 badgers aged by incisors plus canines or premolars or both, 24 (12%) had 1 fewer incisor annulus. Only 1 animal displayed a 2-annulus disparity. Eleven (5%) might have been underaged if premolars alone had been used (Table 2).

This implies that 12 to 17 percent of ages determined solely by incisors or premolars would be 1 and sometimes 2 years less than ages determined by canines. The actual error was not that great because of checking against other criteria.

For mark–release animals, incisors were the chief age criterion (although young of year could usually be separated from older badgers by body size and tooth replacement well into the summer). Average age in the mark–release sample is therefore less than in the collected sample.

Sample sizes are 215 and 128 in the mark–release and collected samples, respectively (Table 3), and are large enough to show the population's standing age structure when sampling biases are identified. Chi-square tests indicated that age structure within each of the samples did not change significantly during
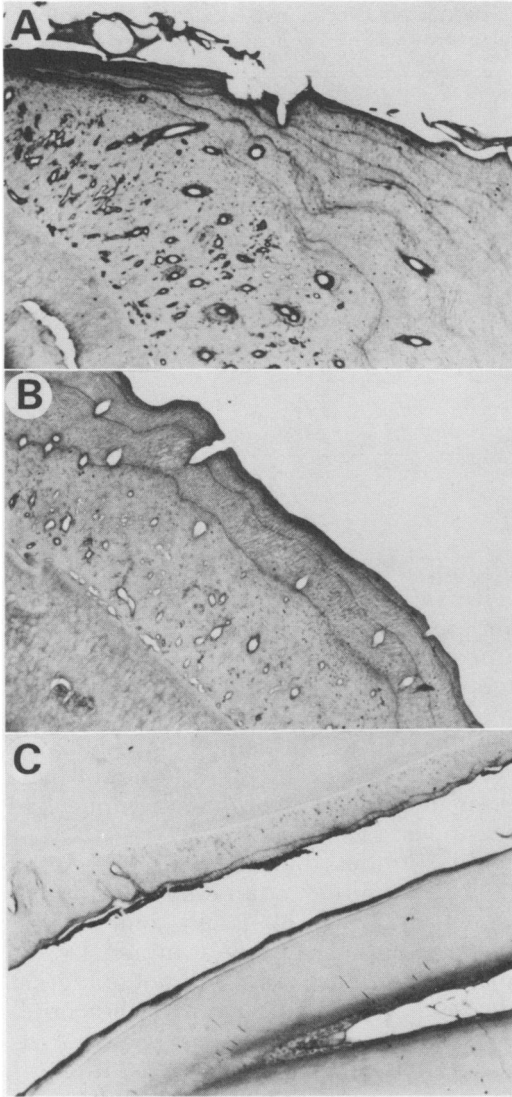
FIG. 5.　Photomicrographs of longitudinal sections of badger teeth. The approximately 6 annuli split and fade in A compared with the greater clarity in B with 3 annuli. Both A and B are canines. The canine (top) in C has 1 distinct annulus that is not easily discernible in the incisor (bottom) from the same animal. All 30×.

TABLE 2.—COMPARISON OF ANNULAR COUNTS IN 214 BADGERS AGED BY MORE THAN 1 KIND OF TOOTH, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Category[1]	All teeth agree No.	All teeth agree %[2]	One annulus disparity No.	One annulus disparity %[2]	Two annulus disparity No.	Two annulus disparity %[2]
I = C = P	119	74.4				
I < C = P			18	11.3		
I > C = P			5	3.1		
I = C < P			2	1.3	1	0.6
I = C > P			5	3.1	1	0.6
I = P < C			4	2.5		
I = P > C			2	1.3	1	0.6
I < C < P					1	0.6
I < P < C					1	0.6
I = C	10	90.9				
I < C			1	9.1		
C = P	10	100.0				
I = P	27	81.8				
I < P			5	15.2	1	3.0
Totals	166	77.6	42	19.6	6	2.8

[1] I = incisor, C = canine, P = premolar.
[2] Percentages (except for totals) calculated on basis of number of animals in each category: I + C + P = 160, I + C = 11, C + P = 10, I + P = 33.

ulation, and that the difference is caused by sampling technique. Much of the deviation is in the young-of-year group. In the mark–release sample, 52 percent were young of year compared with 27 percent in the collected sample (Table 3). The higher proportion of young in the mark–release sample resulted from our efforts to mark as many young badgers as possible during the 3 months a family was together. The probability of capturing young of year was increased because several traps were set at burrows known to be used by family groups. On the other hand, we curtailed collections during that period. Collections made after family breakup provided no opportunity for such multiple captures of young. In addition, young of year became more wary with increasing age, and carcasses salvaged from fur trappers during the winter should be less biased toward young. With the probable sources of bias identified, we merged the data from the mark–release and collected samples to produce 1 age distribution (Fig. 6). The standing age structure, together with other vari-

the study, but the mark–release sample was different from the collected sample ($\chi^2 = 24.2$, df = 4, $P < 0.001$). That difference would be expected if the samples came from different populations, but we believe that they represent the same pop-

TABLE 3.—AGE STRUCTURE OF THE BADGER POPULATION CAPTURED, COLLECTED, AND FOUND ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

| Age in years | Year | Source of data | | | | | | | |
| | | Mark–release | | Collected | | Known mortality | | Skulls found | |
		No.	%	No.	%	No.	%	No.	%
<1	1975	40	53.3	8	33.3	3	50.0		
	1976	39	49.4	11	23.4	11	61.1	4	44.4
	1977	32	52.5	15	26.3	11	40.7	1	6.7
	All	111	51.6	34	26.6	25	49.0	5	15.6
1	1975	21	28.0	2	8.3	2	33.3	4	50.0
	1976	20	25.3	12	25.5	5	27.8	1	11.1
	1977	16	26.2	13	22.8	9	33.3	7	46.7
	All	57	26.5	27	21.1	16	31.4	12	37.5
2	1975	4	5.3	4	16.7			1	12.5
	1976	10	12.7	6	12.8			1	11.1
	1977	3	4.9	10	17.5	2	7.4	2	13.3
	All	17	7.9	20	15.6	2	3.9	4	12.5
3	1975	2	2.7	5	20.8	1	16.7	1	12.5
	1976	4	5.1	7	14.9	2	11.1	2	22.2
	1977	5	8.2	6	10.5	3	11.1	1	6.7
	All	11	5.1	18	14.1	6	11.8	4	12.5
4	1975			2	8.3				
	1976	1	1.3						
	1977			5	8.8	1	3.7	2	13.3
	All	1	0.5	7	5.5	1	2.0	2	6.3
5	1975	1	1.3					1	12.5
	1976	1	1.3	4	8.5				
	1977	3	4.9	4	7.0	1	3.7	1	6.7
	All	5	2.3	8	6.3	1	2.0	2	6.3
6	1975	1	1.3	1	4.2			1	12.5
	1976			2	4.3				
	1977			4	7.0				
	All	1	0.5	7	5.5			1	3.1
7	1975	1	1.3						
	1976								
	1977	1	1.6					1	6.7
	All	2	0.9					1	3.1
12, 14[1]	1975								
	1976	1	1.3	1	2.1				
	1977								
	All	1	0.5	1	0.8				
Adults not aged to year	1975	5	6.7	2	8.3				
	1976	3	3.8	4	8.5			1	11.1
	1977	1	1.6						
	All	9	4.2	6	4.5			1	3.1

[1] No samples in 8–11, 13 year age groups.
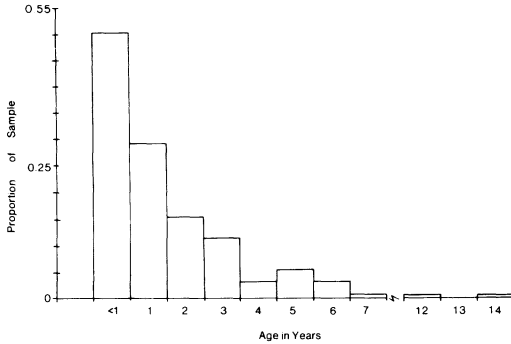
FIG. 6. Standing age structure of the badger population on the Snake River Birds of Prey Study Area, Idaho 1975–1977 (combined data from the mark–release and collected samples).

TABLE 4.—WEIGHTS (G) OF PAIRED TESTES AND EPIDIDYMIDES FROM YOUNG-OF-YEAR AND OLDER BADGERS, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age	Number of badgers	Paired testes		Paired epididymides	
		Mean	SD	Mean	SD
<1	9	1.32	0.37	1.23	0.19
>1	42	20.52	10.78	11.36	3.99

ables, is used later to draw conclusions about the dynamics of the badger population.

Fecundity

Young-of-year male badgers do not breed, but some young-of-year females do. The latter's sexual maturity at so young an age may be unique among American mustelids (Wright 1963, 1966; Wright and Coulter 1967). We estimated age specific reproduction for both the mark–release and collected samples. Because the morphology and histology of both male and female reproductive tracts were identical with Wright's (1966, 1969) descriptions, they will not be described here.

Size of testes in yearlings and adults in the mark–release sample increased in mean length between May and July from 4.9 to 5.5 cm. Weights of paired testes and epididymides in the collected samples are given in Table 4. Data from yearlings and adults are presented together because there was no significant difference in those age groups. Those data agree with a study (Wright 1969) that shows full spermatogenesis in yearlings and adults from late May through August. Testes and epididymides of young of year, as expected, were small and undeveloped.

Histological examination of ovaries showed that conception occurred in late July and August (although copulation was observed, in 1 instance, on 22 June 1976). With the exception of 1 sample collected on 28 July 1977, no corpora lutea were found until August. Those on the verge of ovulation had follicles that measured over 1 mm and often bulged from the ovarian wall. An exception was a 16-month-old badger collected 1 July 1977 whose left ovary had a ripe 2-mm follicle.

There were no significant differences in the weights of left or right ovaries, or between young-of-year and older age groups. The mean weight of young-of-year ovaries was 191 mg (N = 31, SD = 88). For badgers 1 year or older, the mean weight was 213 mg (N = 53, SD = 75). Because we observed no monthly pattern in weight, ovarian weight alone was not a good indication of reproductive status. Potential fecundity was estimated from counts of corpora lutea and embryos. Counts of placental scars indicated the number actually born (realized fecundity).

Corpora lutea develop from ruptured follicles and persist to birth if fertilization occurs. In delayed implantation, blastocysts remain unattached to the ovarian wall until late January or early February (Hamlett 1932; Wright 1963, 1966). We found no unimplanted blastocysts (they may have been obliterated by postmortem changes or lost in processing), but we did find 5 embryos between 1.0 and 2.8 cm long in collections made on 28 February 1976, 25 February 1977, and 9 March 1977. Maximum variation in embryo length within a female was 0.8 to 1.0

TABLE 5.—FECUNDITY OF 89 FEMALE BADGERS COLLECTED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age in years	Year	Total females collected	Sample size (potential)[2]	Sample size (realized)[2]	Productive females		Births	
					No.	%	No.	Female births/female[3]
≤1	1975	6	1	5	2	33.3	4	0.333
	1976	17	7	10	8	47.1	20	0.589
	1977	19	10	9	9	47.4	23	0.605
	1978		3		1	33.3	2	0.333
1–2	1975	2		2	1	50.0	1	0.250
	1976	3		3	1	33.3	3	0.750
	1977	14	8	6	8	57.1	29	1.036
	1978		3		2	66.7	5	0.833
2–3	1975	3		3	2	66.7	7	1.167
	1976	5	1	4	4	80.0	7	0.700
	1977	5	2	3	3	60.0	8	0.800
	1978		4		3	75.0	12	1.500
>3	1975	2		2	1	50.0	3	0.750
	1976	4	2	2	4	100.0	15	1.875
	1977	9	4	5	8	88.9	24	1.333
	1978		2		1	50.0	4	1.000
All	All	89	47	54	58	57.4	167	0.827

Potential and realized fecundity for same birth season[1]

[1] Potential fecundity determined from counts of corpora lutea and/or embryos. Corpora lutea visible August (1 sample 25 July) to March. Embryos present in February and early March. Those were pregnant badgers or those in which pregnancy was very likely. Realized fecundity determined from appearance of mammary tissue and counts of corpora albicantia and/or placental scars. Corpora albicantia disappeared in June or before. Retention of placental scars were highly variable. If scars were recorded as a range (i.e., the exact number uncertain), the mean was used.

[2] Sample sizes reflect the number of females collected during the season when the criteria could be evaluated.

[3] Sex ratio is 1:1. Only female births tallied.

cm. Numbers of embryos and corpora lutea agreed in each female. In many species, old corpora lutea persist for years as scars (corpora albicantia), but the American badger does not appear to be in that group. Our findings agree with those of Wright (1966), who thought that corpora albicantia disappeared by June.

Persistence of placental scars was extremely variable. In a few specimens, scars were visible for nearly a year; in others, none showed after midsummer. If counts of placental scars made in fresh reproductive tracts did not agree with counts made after clearing (i.e., recorded as a range), we used the mean.

Because counts of unimplanted blastocysts were not made, we had nothing to compare with numbers of corpora lutea. If intrauterine mortality took place, potential fecundity (based on corpora lutea numbers) is overestimated. On the other hand, fading of placental scars probably led to a conservative estimate of realized fecundity.

We sorted samples by age and collection date so that both potential and realized fecundity (Table 5) pertained to the same season of births. Potential fecundity of females collected in August and September 1977 was projected to the 1978 birth season, after fieldwork had ended. Females with evidence of potential or realized fecundity were classified as productive. Because sex ratios did not significantly deviate from 1:1 in the population as tested by chi-square, only female births per female (m_x) are shown. We grouped data for females 4 years and older because of small sample sizes.

Reproductive rates in the mark–release sample (Table 6) were calculated from pregnant animals captured in the latter half of February and early March (when pregnancy could be determined from external examination) and from lactating or

TABLE 6.—FECUNDITY OF FEMALE BADGERS IN THE MARK–RELEASE SAMPLE CAPTURED ON AND NEAR
THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age in years	Year	Total females captured[1]	Sample size (pregnant)[2]	Sample size (lactating or post-lactating)[2]	Productive females		Young[3]		
					No.	%	Number births	Number litters	Female births/female
≤1	1975	20	2						
	1976	18	3						
	1977	17							
1–2	1975	9	2	7	1	11.1			
	1976	13	2	8	2	20.0	1	1	0.500
	1977	7		5					
2–3	1975	3		3	1	33.3			
	1976	7	2	5	4	57.1	5	2	1.250
	1977	6	1	5	5	83.3	6	2	1.500
>3	1975	3	1	2	3	100.0			
	1976	11		7	7	100.0	8	4	1.000
	1977	12		11	7	63.6	8	3	1.333

[1] The reproductive status of some females captured could not be determined and were not included in the analysis.

[2] Pregnancy determined by visual appearance in late February and early March. Lactating or postlactating females were those captured in March to approximately June, with or without litters. Sample sizes reflect the number captured when these criteria could be evaluated.

[3] Litter sizes corrected for known but uncaptured young. Female births per female are calculated on the basis of 1:1 sex ratio and do not refer to actual number of female young captured.

postlactating animals captured with or without litters. Such animals could be recognized until June or longer from appearance of the teats and mud clinging to the hair around the nipples. Females that were pregnant (and presumably gave birth) and those lactating or postlactating were classified as productive.

Fecundity of the badger population apparently increased during the study period based on our estimates derived from both the mark–release and collected samples (Figs. 7, 8). The proportion of productive females was 0.33, 0.54, 0.58 for 1975–1977, respectively. Female births per female in the same sequence were 0.3, 0.6, 0.7. The 1975 data probably are underestimates because we lacked experience in recognizing productive females, but even if 1975 data are excluded, fecundity was higher in 1977 than in 1976. The 1978 projections in Table 5 indicate that fecundity would have continued to rise. The proportion of females breeding for 1978 was 0.58 and potential female births per female was 0.96. The data also show rising fecundity with age. Because sampling and aging techniques were biased toward young of year, esti-

mated potential fecundity of that age group was too high.

Mortality, Survivorship, and Density

The mortality pattern for the badger population could be described from any of 4 sources of data (Table 3). Age distributions in both mark–release and collected samples measure survivorship (l_x); mortalities of known cause and the 32 skulls measure mortality (d_x), (see Caughley 1966), but in different ways. Known mortalities reflected factors operating during the 3 years of the study (Table 7). It is unlikely that those factors were equally represented: road kills, for example, were more easily discovered than losses to farm machinery and predators. Skulls, on the other hand, were often weathered and far from roads, and could not be associated with a specific date or mortality factor. We believe that most of those badgers were victims of shooting or coyote poisons in years past, although Koford (1958) reported that badgers are relatively immune to Compound 1080.

We calculated density estimates from

FIG. 7. Estimated proportion of productive female badgers on the Snake River Birds of Prey Study Area, Idaho, 1975–1977.
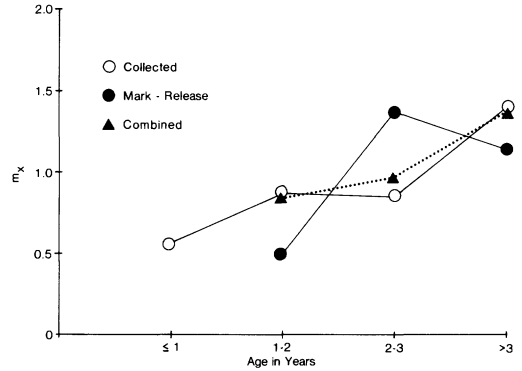
FIG. 8. Estimated m_x (female births per female) for badgers on the Snake River Birds of Prey Study Area, Idaho, 1975–1977.

the mark–release sample using capture–recapture and other techniques. Eberhardt (1978) stated that methods that normally yield absolute density estimates may be conservatively treated as measures functionally related to density (indexes) in order to minimize the effects of potential bias. Because the badger population was open and not equally catchable, we used several absolute estimators as indexes to compare the relative abundance of badgers in each year of the study.

We tried to identify the biases in our mark–release data and predict their effect on the density estimates. Within the badger study area (Fig. 2), trapping effort was approximately equal over the 3 years. For that reason, although an outside area near Bruneau (Fig. 1) was trapped in 1977, only capture–recapture data from the 50-km² badger study area were used.

Unequal catchability of badgers resulted from learning (trap shyness) and nonrandom distribution of traps (Eberhardt 1969a). Capture at a trap site improved the chances for subsequent catches of both new and recently marked animals. At certain maternal dens, some members of the family group were trapped 2 or more times in attempts to mark the adult and her entire litter. However, instrumented badgers, whose locations were known exactly, were sometimes very skill-

ful at avoiding traps. Our impression was that trap shyness varied greatly among individuals and declined considerably with time after capture. Meanwhile, netting and captures by hand accounted for 22 percent (81 of 366) of the captures. Those captures were opportunistic and selected for badgers close to our routes of travel.

We fitted the badger data to the negative binomial, geometric, and poisson frequency-of-capture models using Caughley's (1977) methods. Geometric and poisson results are in Table 8. Negative binomial fit was poor, and chi-squares were several times larger than for the geometric and poisson. The reasonably good fit of the latter 2 models implies that trap shyness and trap proneness tended to balance each other. Those distributions result from equal and constant catchabilities (Eberhardt 1969a).

We calculated Peterson and Jolly-Seber population estimates (Table 9). In all methods, including frequency-of-capture models, each year was treated as a fresh beginning, and animals marked 1 or 2 years earlier were considered unmarked at the start of the year.

The point-to-animal distance index (Southwood 1966, Caughley 1977) and our subjective estimate also appear in Table 9. The subjective estimate was cal-

TABLE 7.—CAUSES OF 51 BADGER MORTALITIES ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Cause	Year	Age				
		<1	1	2	>2	All ages
Road killed	1975	2	2		1	5
	1976	9	3		2	14
	1977	3	4	1	3	11
	All	14	9	1	6	30
Shot	1975	1				1
	1976		1			1
	1977		2	1		3
	All	1	3	1		5
Farmer destroying problem	1975					
animal or mortality caused	1976	1				1
by farm machinery	1977	3	2		1	6
	All	4	2		1	7
Fur trapper[1]	1975					
	1976		1			1
	1977		1		1	2
	All		2		1	3
Other	1975					
	1976	1[2]				1
	1977	5[2]				5
	All	6				6
Total	1975	3	2		1	6
	1976	11	5		2	28
	1977	11	9	2	5	27
	All	25	16	2	8	51[3]

[1] Many badgers taken by trappers but only marked animals included here.
[2] Collection No. 456 (1976) and tattoo 185 (1977) killed by eagles. Tattoo 199 (1977) killed by coyote, dog, or possibly another badger. Tattoo 200 and collection No. 1145 (1977) appeared to have starved. Uncollected badger of unknown sex (1977) possibly killed by ravens.
[3] Chi-square showed no significant sex differences ($\chi^2 = 1.7$; df = 1; $P > 0.10$). 29 males, 20 females, 2 sex unknown.

culated by recording the number of individual badgers (minus known mortalities) captured each year within a 5-km² part of the badger study area and extrapolating that value to the 50-km² badger study area. A very high proportion of the population on the 5-km² area was marked because of near saturation trapping and capture effort. Radiotracking and recapture information indicated that adults and most yearlings were resident during the study. The proportion of unmarked badgers in the catch decreased sharply in the second and third years, further indicating that a high proportion of the resident population was marked. This indicates that we achieved nearly a total count of the adult and yearling population in the 5-km² area.

All indexes show a decrease in num-

bers of badgers between 1975 and 1977. The observed rate of increase, $\bar{r}$ (Caughley and Birch 1971) suggests the magnitude of the population decline for each index (Table 9). Fig. 9 displays $\bar{r}$ for the 3 most conservative indexes: our subjective estimate and the 2 frequency-of-capture models.

We believe that numbers of badgers declined on the study area between 1975 and 1977, but probably no more so than the minimal calculated observed rate of increase ($\bar{r} = -0.252$). The declines suggested by the capture–recapture indexes and point-to-animal distance probably are exaggerated. Standard errors of the capture–recapture estimates are very large (Table 9). Also, several factors in the conservative indexes suggest a lesser decline: our efforts to mark family groups

TABLE 8.—POPULATION SIZE OF BADGERS CALCULATED FROM FREQUENCY OF CAPTURE MODELS, 50-KM^2 AREA, IDAHO, 1975–1977

Number of times captured	Observed (O) and expected (E) capture frequencies from geometric (G) and poisson (P) distributions											
	1975			1976			1977			All		
	O	EG	EP	O	EG	EP	O	EG	EP	O	EG	EP
1	47	50.45	48.91	52	49.15	46.79	30	31.45	28.28	61	64.32	55.01
2	19	13.56	15.98	12	15.60	18.91	16	13.13	16.68	33	29.84	38.50
3	3	3.65	3.48	3	4.95	5.10	3	5.48	6.56	12	13.85	17.96
4		0.98	0.57	1	1.57	1.03	4	2.29	1.93	12	6.42	6.28
5		0.26	0.07		0.50	0.17	1	0.96	0.46	1	2.98	1.76
6		0.07	0.01		0.16	˙0.02		0.40	0.09	0	1.38	0.41
7		0.02			0.05			0.17	0.02	1	0.64	0.08
8		0.01			0.02			0.07			0.30	0.01
9					0.01			0.03			0.14	
10								0.02			0.06	
>10								0.01			0.05	
Estimated population size (50 km^2)		256.7	143.9		226.9	129.90		129.32	77.99		258.6	159.4
q (geometric)		0.27			0.32			0.42			0.46	
X̄ (poisson)^2			0.65			0.81			1.18			1.40
χ^2		6.21	3.96		4.21	11.67		4.11	6.7		8.87	8.89
d.f.		1	1		3	2		2	2		3	2

[1] Probability that a given individual will be captured at least once.
[2] Estimated mean number of captures per head of all individuals in the population.

were more intensive in 1976–1977 than in 1975, resulting in more recaptures and fewer first time captures. In 1975, we did not fully realize the potential of continued trapping at successful sites, which may also have increased the frequency of recaptures in the last 2 years. Any bias that increases the proportion of marked animals will produce a lower population estimate when using the capture–recapture methods. For all those reasons we favor the subjective estimate. The observed rate of increase for that estimate (−0.252) can be divided by 3 to give the

TABLE 9.—THE OBSERVED EXPONENTIAL RATE OF INCREASE (r̄) CALCULATED FROM DIFFERENT METHODS OF ESTIMATING RELATIVE POPULATION SIZE OF BADGERS ON THE 50-KM^2 BADGER STUDY AREA, IDAHO, 1975–1977

Method	Population size or index			r̄[1]	P[2]
	1975	1976	1977		
Subjective estimate	266	180	160	−0.252	0.192
Frequency of capture					
Geometric	257	227	129	−0.343	0.225
Poisson	144	130	78	−0.306	0.234
Capture–recapture[3]					
Peterson	285 ± 92	214 ± 43	108 ± 16	−0.486	0.148
Jolly-Seber	2,061 ± 2,074	1,941 ± 932	136 ± 48	−1.359	0.321
Point-to-animal distance index	6.35	3.44	2.28	−0.513	0.071

[1] $\bar{r} = \dfrac{\Sigma Nt - (\Sigma N)(\Sigma t)/n}{\Sigma t^2 - (\Sigma t)^2/n}$

(for 3-year period; r̄/3 = yearly r̄)

[2] Probability of slope of r̄ being 0.
[3] Estimates with ± standard error.

where N = log$_e$ population size or index;
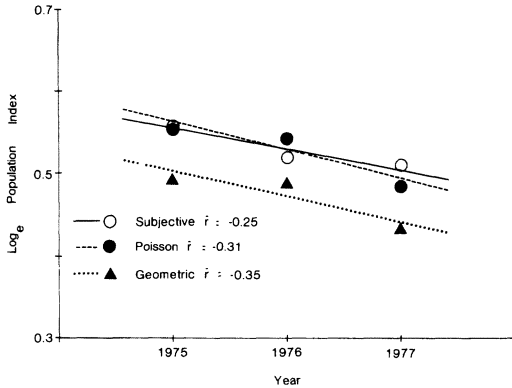t = time units in years: 1, 2, 3;
n = number of estimates = 3.

FIG. 9. The observed rate of increase, r̄, calculated from the 3 most conservative estimates of relative badger density on the 50-km² badger study area, Snake River Birds of Prey Study Area, Idaho, in 1975, 1976, and 1977.

yearly r̄ of −0.08. When this is converted to a finite rate ($e^r = e^{-0.08} = 0.92$), an average yearly loss of 8 percent of the population is observed.

Circumstantial evidence also supports the hypothesis of a badger population decrease between 1975 and 1977. Known cause mortality increased during the last 2 years of the study (Table 8). Higher fur prices in recent years and renewed interest in trapping produced a dramatic rise in Idaho's actual and projected badger harvest (Table 10). A scarcity of Townsend ground squirrels in 1977 might have affected the badger population directly through starvation (Table 7) or indirectly by increasing vulnerability to other mortality factors, although a switch to other foods (discussed later) indicates that fewer ground squirrels did not greatly affect the population. One possible cause for the badger decline, lowered fecundity, had to be ruled out; despite small sample sizes and other uncertainties, reproductive data suggest that fecundity did not decline and may have actually increased between 1975 and 1977 (Tables 5, 6; Figs. 7, 8).

With substantial evidence for a decrease in density and a stable age distribution, we produced a life table for badgers on the Birds of Prey Study Area

(Table 11), using Caughley's (1977) method 6 and incorporating the correction factor for r̄ = −0.08. The frequency of the 0 age group was calculated by combining the fecundity estimates from the mark–release and collected samples (Fig. 8; Tables 5, 6) and multiplying those female births per female values by half the frequency (1:1 sex ratio) of each class. The sum doubled gives the estimated number in the 0 age group at the current age and fecundity schedules.

As shown in Table 11, apparent sampling error resulted in 15 samples in the 5-to-6-year age compared with only 9 in the younger group. Age frequencies had to be smoothed with the log polynomial regression taken to the quadratic term (Caughley 1977).

The badger survivorship curve is shown in Figure 10. The youngest age group has only 5–10 percent more mortality than animals up to age 4. The mortality rate in older groups is irregular.

We also calculated survival estimates using the Chapman-Robson method (Chapman and Robson 1960, Robson and Chapman 1961, Eberhardt 1969b, Seber 1973) and found that survivorship based on those estimates did not change during the study. That atypical finding was probably because the Chapman-Robson method is based solely on age structure, that can fail to correlate with methods based on age, density, and harvest (Eberhardt 1960, 1969b). Caughley (1974) showed that a sudden change in mortality rate that affected all age groups equally did not change the age ratio. We believe that the decline in badger density, as shown by our data and by the less restrictive calculation methods, was real, and that it was caused by increased mortality.

Despite the decline, the study area may support a higher density of badgers than other areas. Our subjective estimate indicates a density of up to 5 residents (adults and yearlings) per km². Lindzey (1971, unpublished master's thesis, Utah State University, Logan, Utah) estimated a minimum density of 1 badger per 2.6 km² in Curlew Valley, Utah, but no other comparisons are available.

TABLE 10.—TREND IN BADGER FUR HARVEST IN IDAHO SINCE 1972[1]

	Season					
	1972–1973	1973–1974	1974–1975	1975–1976	1976–1977	1977–1978
Number caught	182	326	380	396	952	1,297
Number trapping licenses sold				1,291	1,840	2,393
Number trappers reporting trapping for badgers				145	267	379

[1] From 1977–1978 Idaho Fur Harvest Report. Idaho Fish and Game Department, Boise, Idaho.

MOVEMENTS AND ACTIVITY

Kinds of Data and Presentation

Data on movement and activity of badgers were obtained by radiotracking supplemented by recapture information, tracking on snow, and visual observations. Among several methods for presenting those data (see reviews by Mohr and Stumpf 1966, Sanderson 1966; papers by Van Winkle 1975, Cooper 1978), we chose home range, distance between successive locations, and patterns of burrow use because they provided realistic descriptions and are comparable to methods used in other badger studies (Sar-

geant and Warner 1972, Kruuk 1978a, Lindzey 1978).

Home range is defined here in the traditional way: the area traversed by an animal in its daily activities (Burt 1943). We included areas used by young of year for comparison only, since few individuals in that age group confined movements to 1 locale.

To calculate home range, radio and capture locations were plotted to scale and the outlying points connected. That area was measured with a polar compensating planimeter and considered the home range. Distances between successive locations were calculated from the formula: $D = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2}$

TABLE 11.—LIFE TABLE FOR BADGERS ON THE SNAKE RIVER BIRDS OF PREY STUDY AREA WITH ASSUMED STABLE AGE DISTRIBUTION AND OBSERVED RATE OF INCREASE OF $\bar{r} = -0.08$[1]

x	m_x	f_x	F_x	$e^{\bar{r}x}$	$F_x e^{\bar{r}x}$	l_x	d_x	q_x
0		293[3]	293	1.00	293	1,000	546	0.546
≤1	0.560	145	145	0.92	133	454	212	0.467
1–2	0.850	84	83	0.85	71	242	119	0.492
2–3	0.971	44	45	0.79	36	123	62	0.504
3–4	1.381[2]	33	25	0.73	18	61	27	0.443
4–5		9	15	0.67	10	34	13	0.382
5–6		15	9	0.62	6	21	11	0.524
6–7		9	6	0.57	3	10	3	0.300
7–8		2	4	0.53	2	7	0	0.0
8–9			3	0.49	2	7	4	0.571
9–10			2	0.45	1	3	0	0.0
10–11			2	0.42	1	3	3	1.000
11–12			1	0.38		0		
12–13		1	1	0.35				
13–14			1	0.33				
14–15		1	1	0.30				
15–16								

[1] Notation as follows: x = age in years; m_x = female births per female; f_x = sample age frequency; F_x = f_x smoothed with log-polynomial regression, log f_x = 2.526 − 0.323x + 0.010x^2; $e^{\bar{r}x}$ = correction factor for $\bar{r}$ = −0.08; $F_x e^{\bar{r}x}$ = corrected F_x; l_x = survival; d_x = mortality; q_x = mortality rate.
[2] Pooled m_x for age groups ≥ 3.
[3] Estimated from fecundity: $f_o = \Sigma(m_x f_x/2)(2) = (0.560)(73) + (0.850)(42) + (0.971)(22) + (1.381)(35) = (146.27)(2) = 293$.
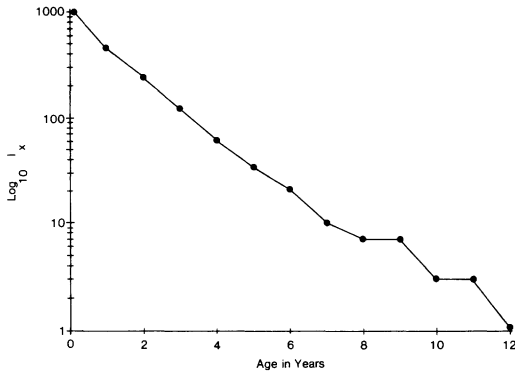
FIG. 10.   Survivorship (l_x) curve for badgers on the Snake River Birds of Prey Study Area, Idaho, 1975–1977.

where X_1, Y_1 are the horizontal and vertical coordinates of the first location and X_2, Y_2 the coordinates for the successive location. Body movements caused a change in transmitter signal strength and beats per minute, but varied greatly among radios and was reliable only as a very crude index of activity.

Of the 48 badgers (25 adults and yearlings, 23 young of year) instrumented in this study, 28 provided data on movement and activity (Tables 12, 13). Although several of those were monitored for comparatively brief periods, we believe their movement and activity were typical and valid for inclusion in Tables 12 and 13. Badgers were radiotracked in

every month, but nearly 75 percent of the data (Tables 12, 13) was collected in March through July. Distances between capture locations for the 83 badgers captured 2 to 7 times (Table 14) were not used in home range calculations unless they were instrumented.

Residents

Adult and yearling movement and activity on the study area were characterized by:

(1) Restriction to home ranges of less than 4 km², with males using larger areas than females;
(2) Return to previously used burrows;
(3) Solitary existence despite overlap of home ranges with other sex and age groups;
(4) Reduced activity and home range size in winter; and
(5) Underground stays without emergence for usually less than 24 hours but increasing to several days or weeks for certain individuals in winter.

Since most badgers were tracked in spring and summer, it is possible that adults could have shifted home ranges in different years or seasons. However, recapture locations in different years gave no hint of relocated seasonal or yearly ranges in most instances. Instrumented badgers Nos. 7, 8, 19, and 20 used the

TABLE 12.—SIZE OF HOME RANGE FOR 28 BADGERS RADIOTRACKED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Sex and yearly age group	Number of animals	Potential days of monitoring			No. of locations including captures			Home range size[1] (km²)		
		Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Males < 1	6	42	26	15–80	32	17	18–85	12.1[3]	15.0	0.9–34.3
Females < 1	6	22	24	1–66[2]	20	23	3–63	7.7[3]	4.4	3.4–14.9
Males 1	2	15	14	5–25	13	8	7–18	0.6	0.2	0.5–0.8
Females 1	4	59	57	7–109	68	63	9–127	0.8	0.4	0.2–1.2
Males > 1	3	91	46	48–139	71	42	13–101	2.4	1.4	0.8–3.4
Females > 1	7	67	47	9–128	58	43	12–114	1.6	1.2	0.4–3.8

[1] Young of year had not established home ranges. Areas used by young calculated for comparison with other badgers.
[2] Female No. 138 included because of her 52.1 km movement (Table 13) determined from recapture. Radio monitoring ended after 1 day.
[3] Greater than older badgers ($P < 0.05$). Analysis of variance of $\log_{10}$ transformed data and comparison of group means with Duncan's New Multiple Range Test.

TABLE 13.—DISTANCE BETWEEN SUCCESSIVE LOCATIONS AND PATTERNS OF BURROW USE FOR 28 BADGERS RADIOTRACKED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977 (SEE TABLE 6 FOR SAMPLE SIZES, NO. OF LOCATIONS, ETC.)

Sex and yearly age group	Distances between locations (km)			Percentage of locations in burrows			Maximum number times a burrow used as a percentage of number of locations			Maximum number days in burrow without emergence		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Males < 1	0.6[1,2]	1.4	0–16.4	73.2	11.2	60.0–92.6	15.1	7.6	7.4–27.8	1.5	0.8	1–3
Females < 1	1.1[1]	5.0	0–52.1	60.6	23.0	33.3–92.6	25.0	13.5	7.7–42.9	3.2	4.4	1–12
Males 1	0.4[2]	0.4	0–1.6	63.1	28.6	42.9–83.3	22.6	8.4	16.7–28.6	1.5	0.7	1–2
Females 1	0.3	0.4	0–2.1	73.1	34.1	22.2–94.4	15.0	8.3	5.1–22.2	1.3	0.6	1–2
Males > 1	0.4[2]	0.6	0–3.3	85.7	3.9	82.6–90.1	18.4	7.4	11.2–26.1	4.0	4.2	1–7
Females > 1	0.2	0.7	0–12.2	85.6	11.0	66.7–96.2	37.4	22.0	16.7–82.8	7.7	13.4	2–38

[1] Greater than older badgers (*P* < 0.05). Analysis of variance of $\log_{10}$ transformed data and comparison of group means with Duncan's New Multiple Range Test.
[2] Grouped males greater than females (*P* < 0.05) (*t*-test).

same areas in each of the 3 years they were monitored (Fig. 11). Strong attachment to a home range is further indicated by the return of displaced residents to their initial capture area (Table 15). Though not conclusive, the data suggest that adults and yearlings Nos. 5, 31, and 145 made such an effort. Since the second capture was a chance event, other displaced badgers that were not recaptured may have returned to their home area.

Adult females usually had smaller home ranges than adult males, although the opposite was true for yearlings (Table 12). However, sex or year differences in home range or percentage of locations in burrows was not significant (Tables 12–13). Distances between locations were larger in males than in females (*P* < 0.05) when all ages were considered together. (The case of 1 yearling female, No. 153, who moved 13 km between 1976 and 1977 was atypical and may represent dispersal.) Difference in distance between locations was not present in the recapture data (Table 14), perhaps because parous females were not included, as they were in Table 13. There, the maximum burrow use column shows strong female attachment to the maternal den.

We were not often able to monitor neighboring badgers simultaneously and thus obtain extensive data on social in-

teractions. However, we did monitor adults No. 5 (male) and No. 8 (female) at the same time and found that they had a range overlap of about 20 percent between mid-March and early June 1975. So far as is known, those 2 were never in the overlap area simultaneously. Also, between mid-July and September 1977, we monitored 2 adults (male No. 202, female No. 203) intermittently near Bruneau (Figs. 1, 11), where densities of badgers appeared to be lower than those near

TABLE 14.—DISTANCES BETWEEN SUCCESSIVE CAPTURE LOCATIONS FOR 83 BADGERS CAPTURED 2 TO 7 TIMES ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977[1]

Category	No. of locations	Mean (km)	SD
All animals	142	2.14	5.68
Sex			
Males	76	2.17	4.60
Females	66	2.12	6.75
Age (years)			
<1	71	3.05[2]	7.64
>1	71	1.24	2.24
Years			
1975	39	1.53	2.74
1976	57	3.10	8.19
1977	46	1.48	2.99

[1] Badgers released at locations different from capture site omitted.
[2] Greater than older badgers (*P* < 0.05) analysis of variance of $\log_{10}$ transformed data.
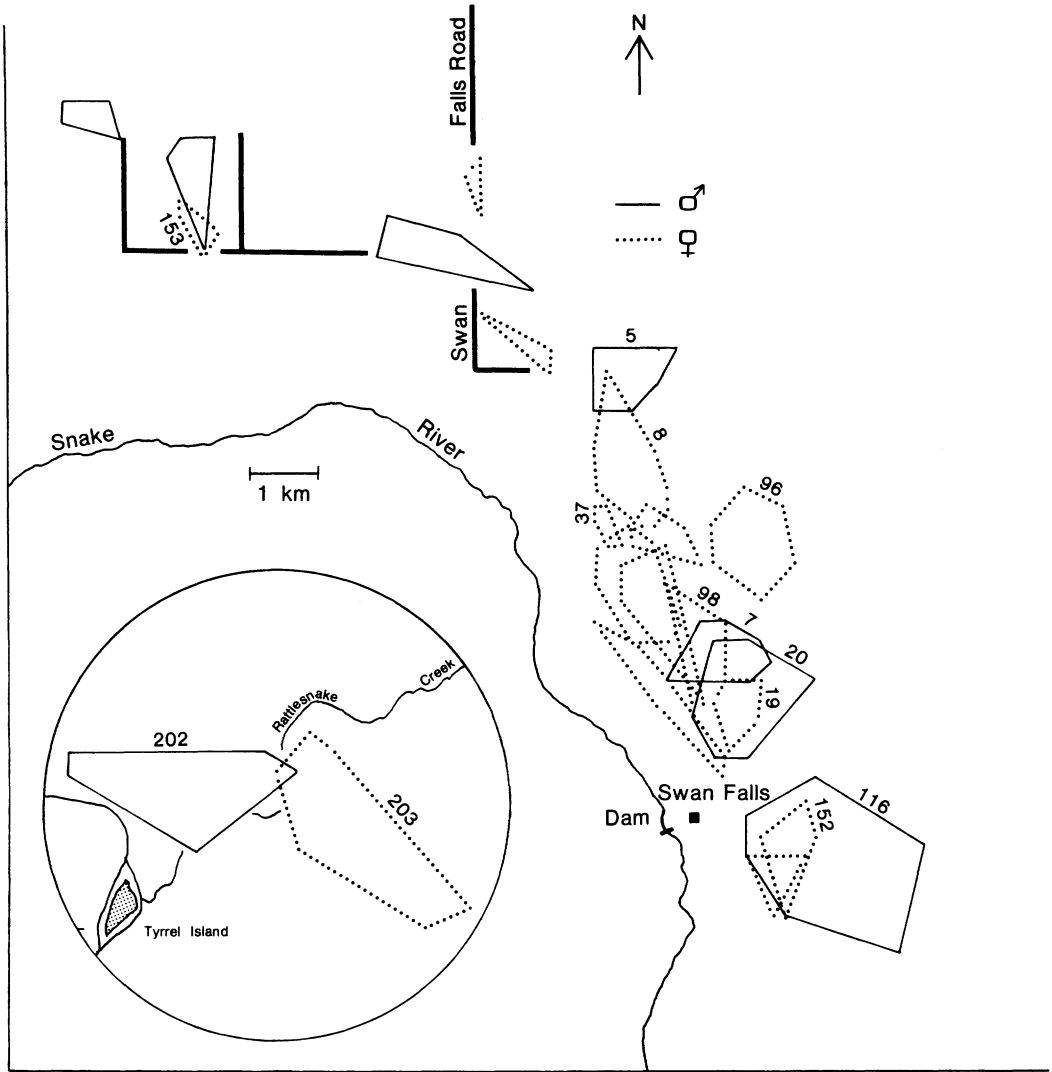
FIG. 11. Home ranges of resident badgers on the badger study area, Snake River Birds of Prey Study Area, Idaho, 1975–1977, determined by radiotracking. Numbered badgers are those discussed in text. Inset displays 2 adults monitored in 1977 near Bruneau.

Swan Falls. Home ranges of those 2 overlapped and were larger than the average for most other adults (Table 12, Fig. 11). The male's home range was nearly 3 km²; the female's 2.7 km². Again, the 2 were not found together, even though badgers breed in July and August.

That badgers used common ground was shown by other instrumented adults and yearlings (Fig. 11). Overlap of home ranges was also evident from the density of captures (Fig. 12) and from our visual observations. For example, adults of both sexes were often trapped at the same set within hours of each other, and it was not uncommon to capture 1 or more uninstrumented badgers within home ranges of instrumented animals. Spotlighting also showed close spacing of badgers, even with allowances for young and family

TABLE 15.—DISTANCES MOVED BY BADGERS WHEN RELEASED AT LOCATIONS DIFFERENT FROM ORIGINAL CAPTURE, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Animal no.	Sex	Age in years	Distance between release and original capture (km)	Distance between second and original capture (km)	Days between release and second capture
5	Male	Adult	6.8	1.4	8
31	Female	1	3.3	1.8	6
144	Male	<1	11.4	12.4	406
145	Male	3	11.4	0.2	216
187	Male	2	4.3	5.1	11
155	Female	6	7.3	7.3	143
216	Male	<1	4.3	0.0	5

FIG. 12. Capture locations for badgers (residents, family groups, and young) on the badger study area, Snake River Birds of Prey Study Area, Idaho, 1975–1977.

groups. Paradoxically, badgers seemed to be asocial. Aside from family groups, the apparently transient mating bond, and 2 isolated incidents where a yearling or young of year occupied a den with an unrelated adult, badgers maintained a largely solitary existence on the study area.

Certain badgers restricted movement and activity during winter, as substantiated by radiotracking, decreased capture success, lack of visual observation, and fewer fresh burrows (Table 16). The data in Table 16 actually reflect hunting attempts for Townsend ground squirrels, but may also serve as a general index of badger activity. The movement pattern of No. 116, a 3-year-old male monitored between 20 June and 5 November 1976 (the maximum uninterrupted period for radiotracking an individual), was typical of adults. He was never underground without emergence for more than 24 hours until October and November, when his stays lasted up to 7 days.

The maximum number of days without emergence for adult females was nearly twice that for males (Table 13), undoubtedly caused in part by the long inactivity of No. 152. On 13 February 1977, that female finally emerged from the burrow she had occupied continuously since 3 December 1976. During those 72 days, she emerged only once (at 38 days). Monitoring continued until 20 February, when she lost her collar. Before her long stay underground, No. 152 (instrumented 16 October) had used 23 burrows with a maximum stay underground of 3 days. Much of December 1976 and January 1977 was extremely cold, with temperatures between −15 and −20°C or lower for days at a time. No badgers radiotracked in warmer months displayed such long inactive periods. However, fresh burrows were observed occasionally in even the most frigid weather, indicating that winter inactivity on the badger study area is highly variable and possibly individualistic.

TABLE 16.—FRESH BADGER BURROWS COUNTED ON 5 1-HA GRIDS ON THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO IN 1976[1]

Period	No. of fresh burrows
Jan–Feb	2
Mar–Apr	18
May–Jun	46
Jul–Aug	338
Sep–Oct	186
Nov–Dec	31

[1] Tabulated from Johnson et al. (1977b). Only 1976 data used since counts were not taken every month in 1975 or 1977.

TABLE 17.—FAMILY GROUPS OF BADGERS CAPTURED ON THE SNAKE RIVER BIRDS ON PREY STUDY AREA, IDAHO, 1975–1977 (MEAN OF CORRECTED LITTER SIZE = 2.33; SD = 0.99; N = 12 LITTERS)

Adult no.	Age in years	Year sampled	Litter size (captured)		Correction for uncaptured young (total known litter size)[1]	Comments
			Males	Females		
19	4	1976	1		2	
37	3	1976	1			No. 37 lactating when captured in 1975
37	4	1977	4			Two of young possibly another's litter
43	3	1977	2	1		No. 43 also productive in 1975
92	3	1977	2	1		
96	2	1977	1	2		No. 96 also productive in 1976
98	2	1976	3			
101	2	1976	1	1		
104	1	1976		1		No. 104 also productive in 1977
155	6	1977	1	1	3	
Not captured		1976	1	1		Probably complete litter count
160	3	1977		1		

[1] Represents a minimum known litter size. Undetected young may have been present.

Foraging activity was observed throughout the year. The amount of digging in all seasons was variable and highly localized, presumably depending on predatory intentions. Lampe (1976, unpublished doctoral dissertation, University of Minnesota, Minneapolis, Minn.) related that clumped pattern to badger tactics in capturing pocket gophers *Geomys bursarius*. Search for prey appeared to be based on scent in particular holes. If a badger's initial attempts to find prey were unsuccessful, the digs became more widely spaced as it expanded its area of search. We also saw plugged burrows as described by Knopf and Balph (1969), but not the passive technique where badgers seem to wait in ambush rather than pursue prey actively (Balph 1961).

Some diggings were very small, in the form of mounds containing only 1–2 kg of soil or shallow trenches 1–2 m long. The small mounds rarely contained scats, and we could never detect scent. Such mounds and ruts were found most often in late summer and fall. Perhaps badgers were foraging for arthropods or small rodents. Our total impression from tracks on snow, distribution of fresh digs, and other visual observation is that badger foraging was highly exploratory. Old burrows were investigated consistently.

Family Groups and Young

We radiotracked productive female Nos. 19, 37, 96, and 98 and supplemented data with visual observation and captures of 7 other families (Table 17). Movement and activity of those females differed from that of other resident badgers primarily in attachment to the maternal den and in a pattern of shifting the den after birth of young. As noted, 23 young of year were radiotracked. Recaptures and carcass or tag recoveries provided additional data on dispersal. Movement and activity of young badgers after family breakup were characterized by:

(1) Dispersal of most but not all young from their natal area;
(2) Erratic and greater movements than residents;
(3) Movement into or through farmland or other unsuitable habitats and more daytime activity than residents; and
(4) Weight loss during dispersal (adult females usually lost weight during lactation). Case histories of 2 radiotracked productive females and their offspring are illustrative.

No. 96 was pregnant when instrumented on 7 March 1977 (Fig. 13). She began using 1 den on 11 March and emerged
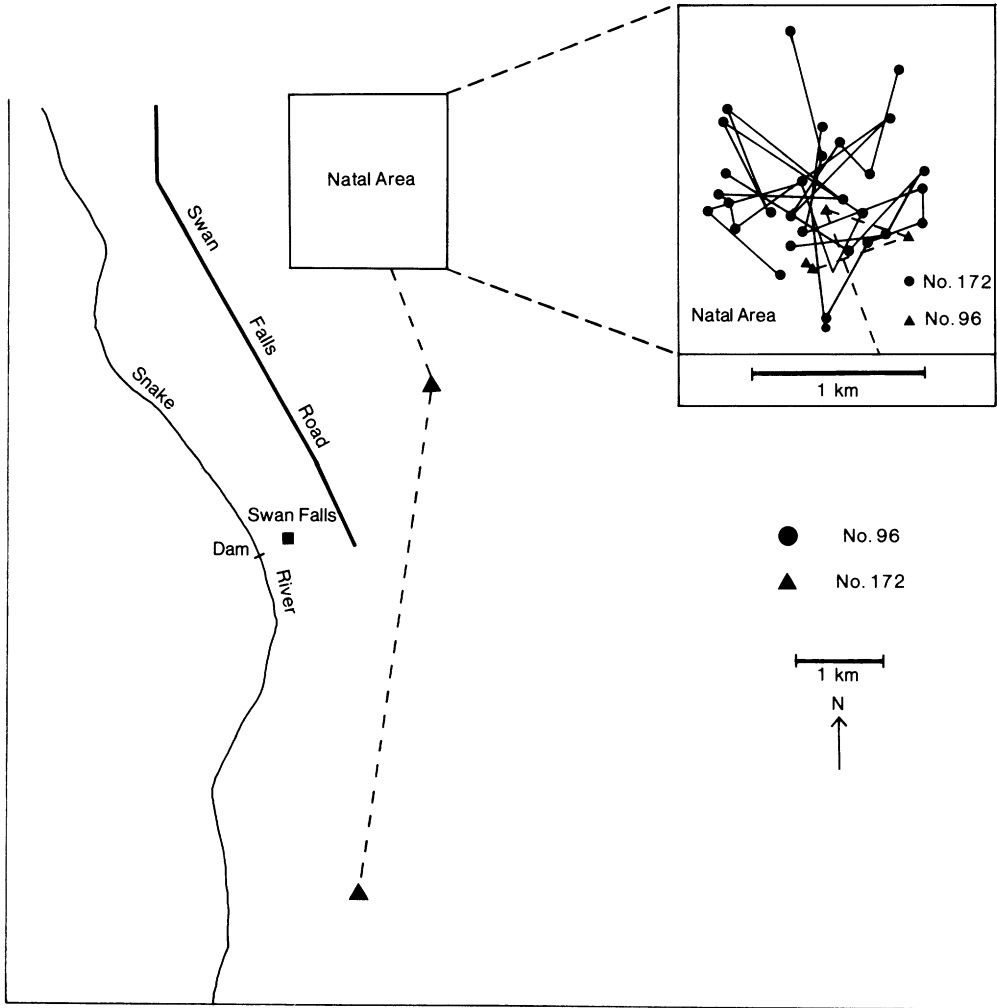
FIG. 13.　Movement of adult Female No. 96 between 7 March and 20 June 1977 and of her male offspring, No. 172, between 17 May and 17 June 1977, badger study area, Snake River Birds of Prey Study Area, Idaho.

from it almost every day. On 5 April she abruptly shifted to another den 0.4 km to the northeast, and shortly thereafter we heard litter noises from the new den. Young probably were born after 11 March, but before 5 April. She stayed within a few hundred meters of the den for the next several weeks, but her time away from it increased in late April. It was last occupied on 3 May. The first of the litter (female No. 165) was captured and released on 10 May; the other 2 young (female No. 171, male No. 172) on 16 and 17 May, all within 0.4 km of the natal den. We were uncertain of the litter's movements between 5 April and 10 May, but they probably accompanied the mother to some extent during the latter part of the period. No. 96 was reinstrumented on 31 May and monitored until she lost her collar on 20 June. Between 7 March and 31 May No. 96's weight de-

FIG. 14. Movement of young Male No. 87 between 29 April and 1 September 1976, badger study area, Snake River Birds of Prey Study Area, Idaho.

creased from 8.4 to 6.7 kg. No. 172 was fitted with an expandable collar on 28 May (Fig. 13). They 2 stayed separate, though within a few hundred meters of each other, for more than a week. Whether the separation was caused by trapping or marked the beginning of family break-up is unknown. Fearing the former, we left food for the juvenile, and after hand capture on 8 June released him at his mother's location. Two days later, No. 96 moved 0.7 km to the northeast, while No. 172 remained stationary until he made a large southerly movement (2.1 km) on 12 June. Contact with him was lost, and he was relocated by airplane even farther south on 16 June. His collar was found on the surface the next day, and predation was considered a possibility. The fate of the littermates is unknown.

No. 19 was captured each year of the study, but apparently raised a litter only in 1976. Her denning activity was similar to that of No. 96, and like other females, she lost weight during lactation (from 8.2 kg on 5 March to 7.3 kg on 17 May). No. 19 used 1 den between 14 March and 8 April, and emerged, presumably to hunt, at least every other day. Young were born during that period. From late April until 9 May, when monitoring ceased, No. 19 and her litter used 9 other dens. One of at least 2 young (No. 105, male) was in the same den as his mother when he was captured on 17 May. When trapped exactly a year later, he had moved only 1.4 km from his natal area. No. 105 was one of the few badgers in this study that had not dispersed by the age of 1 year, or had dispersed only a short distance.

The case history of a young male (No. 87) is another example of dispersal and weight loss during dispersal. No. 87 was captured and released after his natal den was flooded on 29 April 1976. (No other family members were captured.) He was f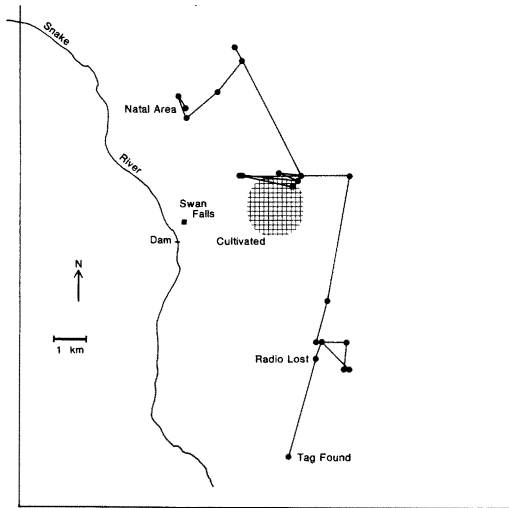itted with an expandable collar on 22 June, after being trapped 0.4 km from the initial site (Fig. 14). Weight had increased from 3.2 kg to 8.3 kg. Dispersal began soon after, and he was monitored irregularly until his collar fell off on 1 September. Much of his late July and early August activity was near or inside a 2.6-km^2 center pivot irrigation project (cultivated circle in Fig. 2). His weight decreased during dispersal to 6.3 kg on 3 August. Late August activity apparently was confined to a recently burned area, a barren landscape with dried cheatgrass, the only vegetation. No. 87's eartag was found 3 km south of the radio recovery site on 12 March 1978.

Dispersal movements of 8 other young-of-year badgers from their natal areas are shown in Fig. 15. Those were recaptures or recoveries of carcasses and tags with known causes of mortality. Female No. 138 and Male No. 198 made the largest dispersal movements. The female was captured on 14 July 1976, presumably near her birthplace. Radio contact was lost after only 1 location, but when taken by a trapper on 11 November 1977 she was 52 km from the original capture site, a move that required crossing the Snake River. Male No. 198 was captured on 24 June 1977 and taken by a trapper in Oregon on 16 November 1977. That 110 km movement also required crossing the Snake River and other major drainages. Swimming by badgers has been reported
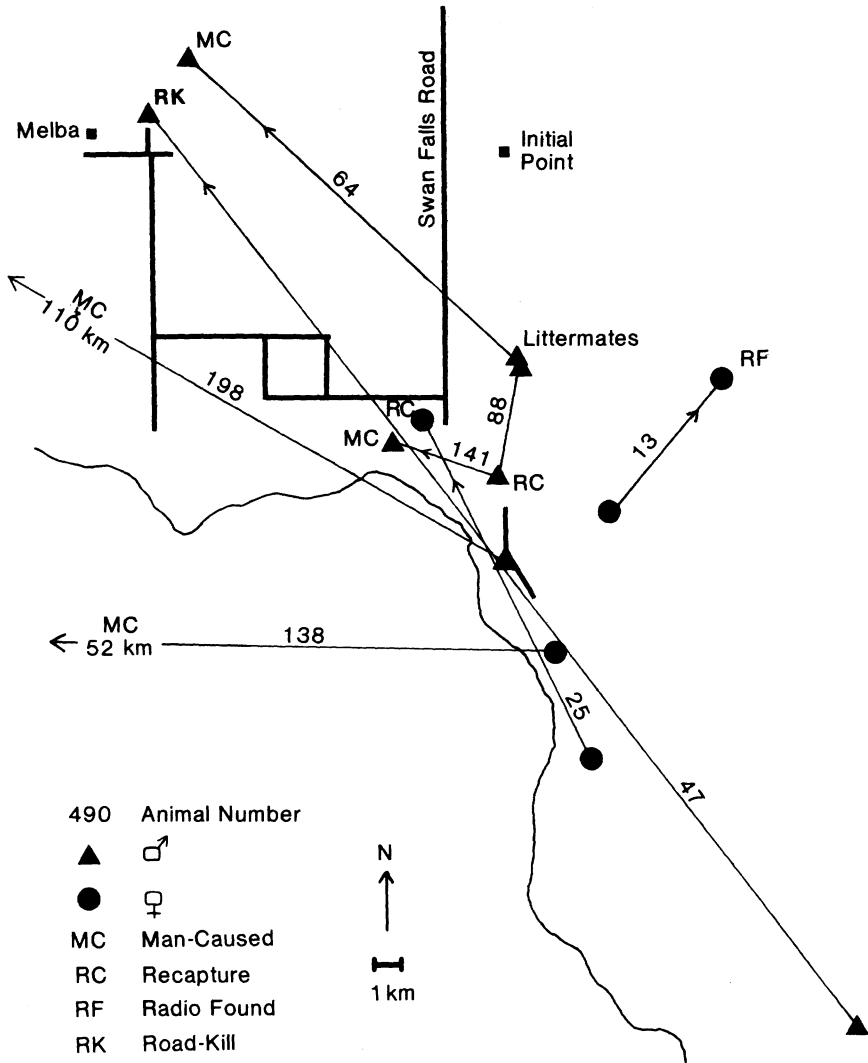
FIG. 15. Recaptures, tag recoveries, or carcass recoveries for 8 young-of-year badgers with known birth area, in or near Snake River Birds of Prey Study Area, Idaho, 1975–1977.

by Wood (1921), Hall (1946), and Duebert (1967), and badgers also wander onto bridges (P. Olmstead, pers. comm.). Distances moved by other young were small in comparison to that of Nos. 138 and 198, but whether their movements were extraordinary is unknown. We believe that most of the recorded dispersal distances were substantially below the eventual value, because nearly all young were sampled during only a part of the dispersal period.

We estimated time of birth and first appearance above ground from field data. A mid-March birth seems most likely, but individuals probably vary by several weeks. The earliest capture of young, on 4 April, was clearly abnormal: the juvenile weighed only 456 g, was only 24 cm long, and had unopened eyes. Our at-

TABLE 18.—SOURCES OF MATERIAL FOR BADGER FOOD HABITS STUDIES, SNAKE RIVER BIRDS OF PREY
STUDY AREA, IDAHO, 1975–1977

	Kinds of samples with sample sizes and percentage													
	All sources[1]		Stomach		Colons		Regurgitation		Scats (captured badgers)		Scats (found)		Stomachs + colons	
Year	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1975	73	15.8	2	2.7	18	24.7	1	1.4	34	46.6	9	12.3	9	12.3
1976	214	46.3	5	2.8	36	16.8			40	18.7	119	55.6	13	6.1
1977	175	37.9	13	7.4	28	16.0	1	0.6	83	47.4	5	2.9	45	25.7
All years	462		21	4.5	82	17.7	2	0.4	157	34.0	133	28.8	67	14.5

[1] Samples containing food = 427. An additional 33 scats or colons contained only soil and/or vegetation. One scat and 1 colon contained nothing but gastric secretions.

tempts to capture a female at that den may have separated the pair, causing the hungry young to surface. A young female was captured on 27 April under similar circumstances. Our observations indicate that litters normally do not venture from the den until early May.

Adults may carry food to the den even before lactation ceases. Dead Townsend ground squirrels were found at 2 natal dens, and a family group was seen playing with a dead ground squirrel. Aside from providing solid food, exposure of young to prey may be important in developing predatory skills.

One female was seen carrying her young by the scruff of the neck, even though the juvenile, a male, weighed 2.3 kg and was capable of moving on his own. One would expect young to be moved in that way while small, perhaps less than 2.0 kg, but eventually to follow the mother as the season progressed.

Family breakup takes place in late May or June, and most young disperse. What proportion do not leave or delay leaving their natal area is uncertain, but the number probably is small, as indicated by the recapture and radiotracking data. Only 7 of 33 badgers first captured as young of year did not emigrate. However, the birthplace of 4 was unknown, and they may have immigrated from a natal area some distance away. We had no reason to suspect a priori that dispersal out of the study area was greater than into it.

Use of farmland or other disturbed habitats by dispersing young was extensive.

For example, of the 23 radiotracked juveniles, 9 foraged into farmland and another 3 spent considerable time near the margins of cultivated areas. In contrast, none of the 25 instrumented adults and yearlings was known to have made more than an isolated foray into farmland, although 2 were located at the edges of cultivated fields 6 percent of the time. Young were often active in daylight, and seemed less wary than adults, as indicated by an increase in our opportunistic hand captures. Many young captured in June, July, and August had superficial wounds, possibly made by other badgers.

FOOD HABITS

Data Analysis

Percentage frequency of occurrence (the number of samples in which a given food item appear divided by the sample size) is used to describe food habits based on 462 samples from different sources (Table 18). The collection method did not substantially affect occurrence of food items in a sample. Because the number of individuals of a species eaten in a feeding period does not always correlate with the number that can be counted after digestion (Scott 1941, Lockie 1959, Floyd et al. 1978), especially where prey vary in size as on the study area, the number of prey type per sample was not used in the data analysis.

A chi-square test between stomach and colon analyses was not significant, hence
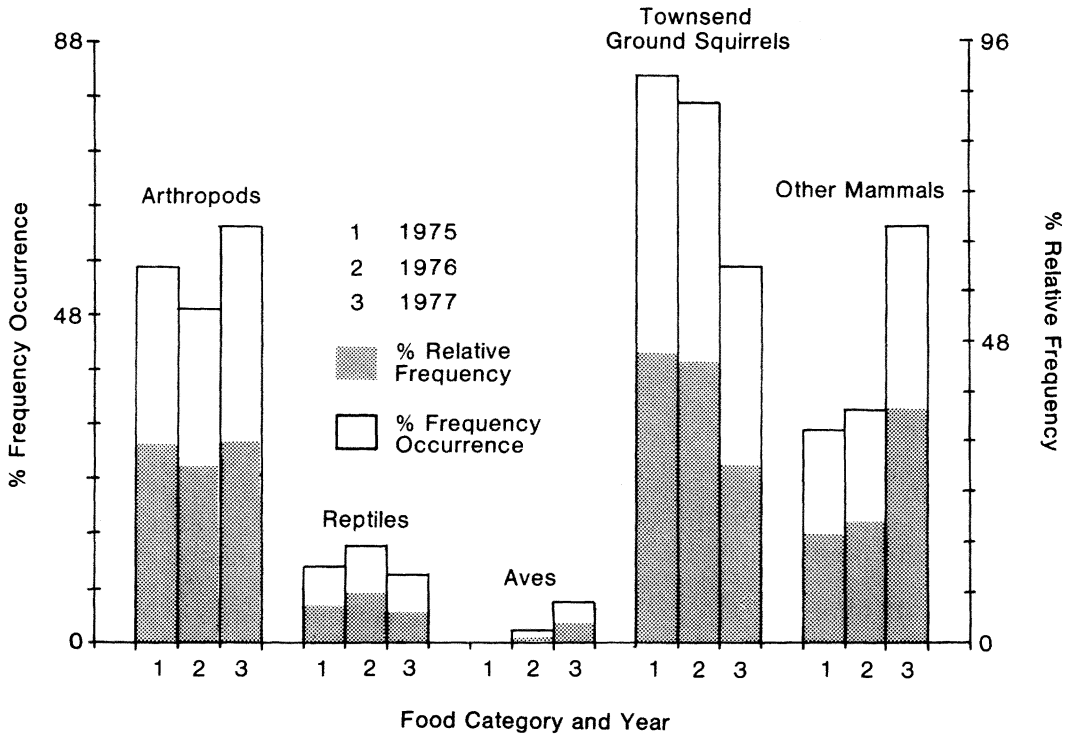
FIG. 16.   Percentage frequency of occurrence and relative percentage frequency of occurrence of 5 food categories in 427 badger stomachs, colons, and scats collected on and near the Snake River Birds of Prey Study Area, Idaho, 1975–1977. The frequency of occurrence is different between 1975–1976 and 1977 in Aves ($P < 0.02$), Townsend ground squirrels ($P < 0.01$), and other mammals ($P < 0.001$). No significant yearly differences exist in arthropods or reptiles, or in any food category between 1975 and 1976.

those data from individual badgers were combined. Prey found in both stomach and colon was counted only once. A chi-square test between the composition of scats found and those obtained from caged badgers during the same time period was also not significant, indicating badger origin of field collected scats.

Feeding Patterns

A complete list of prey in the 427 food containing samples collected between February 1975 and September 1977 is in Appendix H. Badger food habits on the study area are characterized by:

(1) Townsend ground squirrels as most important prey species,
(2) Increase in variety of prey species

eaten after decrease in ground squirrel density,
(3) Strong seasonal and yearly changes in diet corresponding to shifts in prey availability, and
(4) Differences in diet between young-of-year and older badgers.

Food habits displayed as percentage frequency of occurrence and as a percentage of all occurrences (relative percentage frequency) are similar (Fig. 16). Although the latter gives values that will total 100 percent for each year, we will hereafter refer to the more familiar percentage frequency of occurrence. Relative percentages may be calculated from the data in Appendix H and other tables.

Townsend ground squirrels were the major item in badger food samples in

TABLE 19.—THE VARIETY (NUMBER OF DIFFERENT ITEMS EATEN) IN BADGER DIETS IN DIFFERENT YEARS, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Year	Number of samples	Number of different items per sample	
		Mean	SD
1975	65	2.17	1.09
1976	197	2.27	1.11
1977	165	2.87[1]	1.32

[1] Greater than 1975 or 1976. Scheffe's test for analysis of variance treatment means $P < 0.001$ (1975 and 1976 not significantly different).

FIG. 17. Seasonal changes of badger food habits in 1975 and 1976 compared with 1977, Snake River Birds of Prey Study Area, Idaho.

1975 and 1976, but not in 1977 ($\chi^2 = 9.6$, df = 2, $P < 0.01$) (Fig. 16). Badgers responded to a decrease in squirrel abundance (Johnson et al. 1977b), primarily by increasing predation on lagomorphs, deer mice, kangaroo rats, and other rodents ($\chi^2 = 18.0$, df = 2, $P < 0.001$) (Fig. 16). Decreased density of Townsend ground squirrels in 1977 was because of breeding failure and the fact that squirrels estivated several weeks earlier. Those changes may have been caused by the severe drought of 1976 and 1977, which eliminated the normal greenup of annual grasses, an important food for ground squirrels. No clear-cut effects of the drought were observed in other mammalian prey.

Despite the 1977 reproductive failure, Townsend ground squirrels remained a substantial part of the badger diet (Fig. 16). In 1976, 159 adult and yearling and 313 juvenile squirrels were trapped on 6 1-ha sites in the badger study area. In 1977, almost the same number of adults and yearlings (N = 165) was caught, but no juveniles (Johnson et al. 1977b). Although the total number of trapped ground squirrels decreased by 65 percent, the proportional decrease of this species in the badger food samples was much less, from 79 percent in 1976 to 55 percent in 1977 (Appendix H).

Response of badgers to the decline in ground squirrels was evident not only in the shift to alternate prey but also in the variety of diet items (Table 19), which was significantly greater in 1977. We

wondered if the pooling of stomachs and colons could have increased the 1977 mean; but when the data were reanalyzed without the stomach samples, the significant differences remained.

Frequency of birds and bird eggs in annual samples was significantly greater in 1977 ($\chi^2 = 8.4$, df = 3, $P < 0.02$), but no annual differences were observed in reptiles and arthropods. No significant differences were found in the frequency of any food category between 1975 and 1976.

The percentage frequency occurrence (Fig. 16) artificially inflates the importance of arthropods, whose overall caloric contribution was small. Over 50 percent of the stomachs contained 1 or 2 insects or scorpions, but only 4 of 67 stomachs contained large masses of scorpions, grasshoppers, beetles, or unidentified larvae.

Seasonal patterns in badger food habits reflect the opportunistic manner in which most predators exploit prey (Fig. 17). Results of 1975 and 1976 were combined because of their similarity. The high frequency of arthropods in the badger's diet in the autumns of those years could have resulted from the mild weather that persisted into October and November, especially in 1976. The high frequency of Townsend ground squirrels for January–March 1977 may have been related to squirrel phenology. In 1975 and
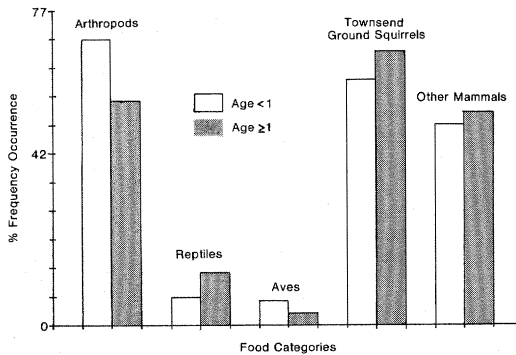
FIG. 18. Comparison of annual diet in young-of-year versus older badgers, Snake River Birds of Prey Study Area, 1975–1977.

TABLE 20.—THE VARIETY (NUMBER OF DIFFERENT ITEMS) IN BADGER FOOD SAMPLES AS RELATED TO AGE GROUP AND YEAR, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Year	Age group in years	Number of samples	Number of different food items per sample	
			Mean	SD
1975	<1	28	2.25	1.04
	>1	27	2.22	1.09
1976	<1	27	2.59	1.08
	>1	57	2.49	1.17
1977	<1	46	3.20[1]	1.57
	>1	115	2.78	1.19

[1] Greater than <1 and >1 1975 and >1 1976. Duncan's New Multiple Range Test for analysis of variance treatment means $P < 0.05$.

1976, male squirrels emerged from hibernation in January and early February, females in mid-February, and yearlings by early March, but in 1977 the squirrels did not emerge until the third week of February, and there was little spread in the appearance of males, females, and yearlings (Johnson and Melquist 1975; Johnson et al. 1976, 1977b). Thus, in 1977, badgers were exposed to all of the population in a shorter time. The end of March coincides with the normal parturition period for Townsend ground squirrels on the study area. The effects of no reproduction by ground squirrels were therefore most evident in the succeeding months.

Year-round diets of young-of-year and older badgers are compared in Fig. 18. Young of year ate more arthropods, but the difference only approached significance in 1977 ($\chi^2 = 3.76$, df = 1, $P < 0.10$). Although differences were not significant, samples from young of year contained proportionally fewer reptiles, Townsend ground squirrels, and other mammals. When the data were viewed separately for each year, the difference in percentage frequency of occurrence of squirrels between age groups was slightly greater in 1977 than in 1975 or 1976, suggesting that young of year were more sensitive to decreased numbers of squirrels than were yearlings and adults. The greater use of Aves and arthropods by

young of year may be related to dispersal and undeveloped predatory skills. As discussed earlier, young badgers typically moved into or through agricultural lands, which probably supported larger insect populations than native habitats. Also, dead birds and abandoned ground nests were often found following hay cutting; in 1977 we saw a young of year feeding on a pheasant *Phasianus colchicus* shortly after an alfalfa *Medicago sativa* L. harvest.

Young badgers had more variety in their diet than did adults (Table 20). That difference was significantly larger in 1977 ($P < 0.05$), again suggesting that young of year were more affected than adults by lack of squirrels.

The extent to which badgers ate carrion or cached food is largely unknown. One stomach contained maggot infested lagomorph remains, and isolated findings of muskrat *Ondatra zibethicus* and marmot *Marmota flaviventris* (Appendix H) could well have represented carrion feeding; trappers regularly dumped their skinned muskrat and other carcasses along Swan Falls road. However, our attempts to bait badgers with dead ground squirrels were unsuccessful, nor did we observe badgers scavenging on the seasonally abundant road killed jackrabbits. It appears that badgers on our study area feed on carrion, primarily larger species, only occasionally. We did not find badger food caches on the study area, but Snead
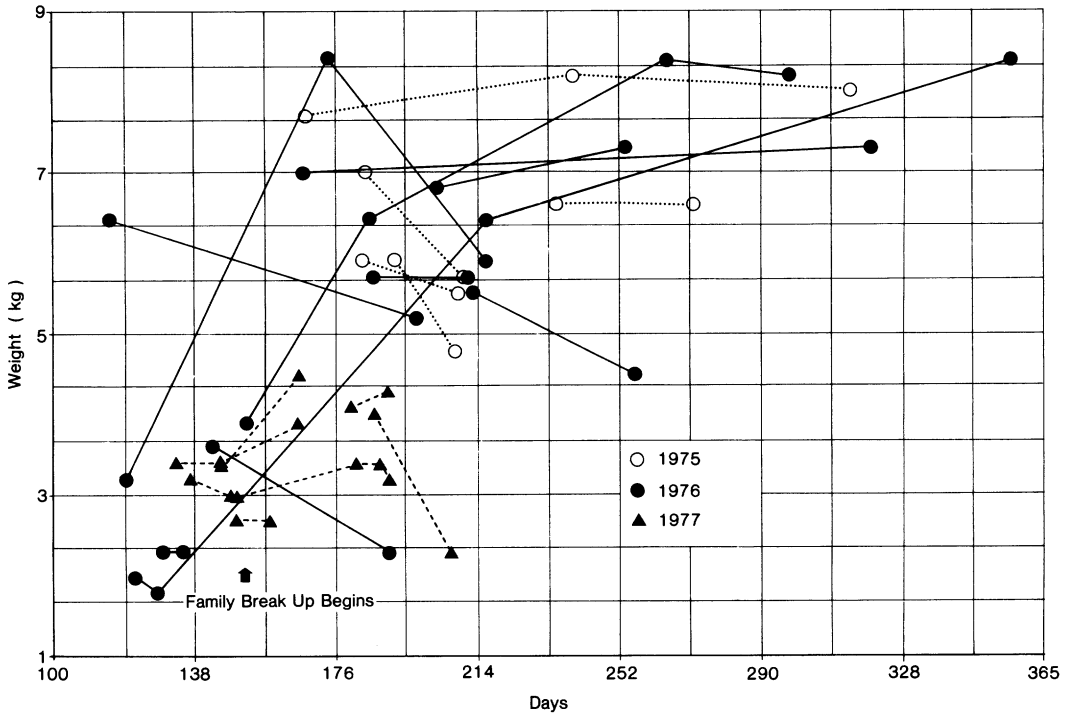
FIG. 19. Changes in body weight in 22 young-of-year badgers captured 2 or more times in a given year, Snake River Birds of Prey Study Area, Idaho, 1975–1977.

and Hendrickson (1942) and Lindzey (unpublished thesis) found caches of rabbit and other prey.

Our data do not reveal a conclusive relationship between the seasonal and yearly feeding patterns and body size in badgers. Weights of growing young were highly variable not only in size among animals of the same age but also in sporadic individual changes, especially after family breakup (Fig. 19). Although many young lost weight during dispersal, yearlings were equal in size or only slightly smaller than adults (Appendix I). With maturity, badgers become sexually dimorphic in standard body measurements (Appendix J). Adult and yearling males increased in body weight from spring through fall, but many females lost weight during the first half of the year because of the rigors of raising a litter (Appendix K). Females quickly regained weight after lactation ceased, and weights of adults of both sexes were nearly the same when recorded at yearly intervals.

DISCUSSION

Population Dynamics

Mortality

Mortality may be the single most important factor in the dynamics of the badger population on the Birds of Prey Study Area, and, as noted, it seems responsible for the decline between 1975–1977. Furthermore, most mortality, or at least the most visible mortality, was caused by man (Table 7). We did not partition mortality by season, but road kills and losses to farmers and farming operations peaked between June and August, undoubtedly because of badger breeding and dispersal activities. Case (1978) observed that badger road kills more than doubled be-

tween May and June, increased more slowly through August, then dropped off sharply in September. Fur trappers took most animals between November and March, although badgers are unprotected in Idaho and can be killed at any time.

If the decline of Townsend ground squirrels resulted in mortality, its only direct effects could have been on young of year. Two young of year apparently starved (Table 7), and the lighter weights and appearance of several others indicated malnutrition. Adults, on the other hand, were larger in 1977, and weights of those captured at yearly intervals were virtually constant.

The indirect effects of food availability and starvation are more difficult to assess. Badgers are reported to wander long distances when excessively disturbed or if food supplies collapse (Hall 1946, Thomas 1954, Schwartz and Schwartz 1959, Jackson 1961). Our recapture and radio-tracking data gave no indication that adult and yearling badgers on the study area vacated their home ranges. However, egress of marked adults could have occurred without detection. Vagrant animals could have been exposed to more man caused mortality as they crossed roads and roamed through cultivated areas. The number of known mortalities in badgers over 2 years old was 7 in 1977, compared with 2 in 1976 and 1 in 1975 (Table 7). Sample sizes were small and possible confounding variables such as traffic volume were not measured. Farmers did, however, complain about the abnormally large number of badgers in their fields, and the Boise city police were busier removing problem animals in 1977 than in previous years. Although most wandering badgers probably were dispersing young, there is enough circumstantial evidence to suggest that a few adults may have died as they moved in search of other food sources.

Natural mortality from a host of other possible causes would have been hard to detect. Badgers on the study area harbored ticks, but very few other external parasites, and only 6 badgers had visible internal parasites. Badgers probably are resistant to plague *Yersinia pestis* (Messick unpublished data), and we know of no recent cases of other diseases in Idaho badgers. An unknown number of young die before emergence and others succumb to eagles and coyotes before maturity, but adults have few enemies except man. Although 2 young of year were killed by eagles, and another possibly by a coyote (Table 7), the significance of natural mortality on the badger population in the Birds of Prey Study Area remains unclear.

Reproduction

Polygyny is a possibility in the population, assuming all adults come into estrus, because the sex ratio is balanced, some juvenile females breed, and male ranges are larger and may overlap several female ranges. The usually abundant food resources available to parous females and the total absence of male involvement in rearing young meet the criteria for the evolution of polygyny (see review by Wiley 1974). Also, male badgers are the larger sex, the predicted condition when males complete for and mate with several females (Orians 1969, Trivers 1972). If badgers are induced ovulators, as suggested for other mustelids (Wright 1963), then frequent copulation over an extended period might ensure a high conception rate and breeding by only the most vigorous males, as suggested for felids (Eaton 1976).

Dispersal is very stressful for young badgers, and at first it seems surprising that any juvenile females should mate. The factor that determines which of them are physiologically capable of breeding is unknown but could well be nutrition. Actually, those females could find it beneficial to breed: the burden of pregnancy is largely offset by delayed implantation, which would not demand much extra energy during dispersal, and if the most robust young females are the ones to mate, they should also be the ones most likely to survive and leave their offspring whenever dispersal ends.

The output of male genes is limited because young-of-year males do not breed, but other factors compensate. Young-of-year males have not established home ranges and would have to compete with resident males for mates, which would decrease a young badger's chances of survival. A better strategy is to delay reproduction until established on a home range (Wiley 1974, Wilson 1975).

Reproductive performance in carnivores may vary in response to population density, food supply, or other environmental conditions. Perhaps the apparent rise in fecundity in the badger population of the Birds of Prey Study Area was compensation for declining density. However, if the altered food situation of 1977 caused hardship, then badgers should have slackened reproduction, if not in 1977 then certainly in 1978. We propose the following explanations. In 1977, badgers were well into their reproductive period before effects of the squirrel decline were manifest. Delayed implantation allows a species faced with an unpredictable food resource to conceive, but to postpone the bearing of young until the season of abundant food (Ewer 1973), but we could not test this since no fieldwork was conducted in 1978. Even if badgers were not stressed by the lack of ground squirrels, delayed implantation makes good evolutionary sense. For a fossorial predator that must limit winter activity because of hibernating prey and frozen ground, delayed implantation conserves energy for the important rearing period.

Behavior

Movement, Activity, Home Range

Movement and activity patterns of badgers on the Birds of Prey Study Area are similar to other studies, although our badgers had smaller home ranges than have been reported in other areas. Lindzey (unpublished thesis, 1978) monitored movements of 7 badgers in Curlew Valley, Utah, an area with vegetation similar to that of the study area. There, 2 males radiotracked in fall and winter had a mean home range of 583 ha and 5 females had ranges that averaged 237 ha, values 2.5 and 1.5 larger than average resident male and female home ranges on the study area (Table 12). Lindzey monitored his badgers for an average 4 to 5 months, which was twice our time and could have contributed to the larger home range findings.

Lindzey observed that 85 percent of occupied dens had been dug before the day of use, and that dens on the home range boundaries received more use than those in the interior. Male and female ranges overlapped but appeared to be exclusive, at least for the instrumented animals. Curlew Valley badgers extended their stays underground and used a smaller part of their ranges in winter.

Sargeant and Warner (1972) monitored a female for over 6 months in east-central Minnesota. Her summer range occupied 752 ha, and she reused only 2 of her 46 known dens. Activity became more restricted in fall and winter and was characterized by return to previously used dens and extended stays underground. She used only 1 den between 2 December and 9 January, and left it on only 4 days.

Harlow (1979) observed a 92 percent reduction of above ground activity between November and February for badgers kept in outside enclosures in Wyoming.

The data reported here on maternal activities are comparable to those on a productive female in Minnesota (R. Lampe pers. comm.). In that study, spring movements radiated from maternal dens. In mid to late May, the adult stayed away from the young for periods of 30–32 hours, perhaps because of depleted proximal food resources. The young apparently remained in the same area as the adult for the first half of June. The young were not captured, and if or when they dispersed is unknown. The adult became more sedentary in the fall. Her total

home range size was about 1,700 ha, twice that reported for another female in the same locality (Sargeant and Warner 1972). Lampe suggested that the female's larger area was needed to provide the extra food demanded by reproduction.

The shifting sequence of maternal dens was also documented by Lindzey (1978); one of his females used 3 dens between 27 March and 8 June. Maternal dens excavated by Lindzey (1976) contained large numbers of scats, and he thought that accumulation of feces as well as exploitation of new food resources might prompt movement to a new den.

The picture that emerges for badgers on the Birds of Prey Study Area is one of a solitary and mainly nocturnal existence. (Daytime movement increases in June, July, and early August, mostly because of dispersing young and perhaps adults and yearlings trying to find mates.) Resident badgers show very strong attachment to a home area; how solitude can be maintained despite overlapping ranges is hard to deduce from our field data.

It may be that total home range size is sufficient to meet food demands in all but the worst famines. The general statement that familiarity with an area should allow the occupant to find food and shelter with a minimum expenditure of energy (Vaughan 1972) may be especially important to badgers. Extensive reuse of dens saves energy required for digging and offers the bonus of chance encounters with prey that occupy old dens. Overlap of home ranges increases the density of available dens and hunting sites. Since fossorial prey are not highly mobile, several badgers operating in the same area would not cause egress of prey as they otherwise might.

Bailey (1974) hypothesized that the kind of social organization displayed by bobcats should depend on the characteristics of major prey. Uniformly distributed and sedentary prey should select for exclusive areas, but clumped or mobile prey should favor common use of areas because bobcats would have to follow

prey, and exclusive areas would have little survival value. On the badger study area, the Townsend ground squirrel is sedentary, and while not uniform in distribution, is found in most habitats. If Bailey's model is appropriate for badgers, exclusive home ranges might be expected. Perhaps the advantages of previously prepared denning and hunting sites, that resulted in part from overlapping ranges, outweighs those of an exclusive area.

Data are not yet sufficient to show the extent that social characteristics of badgers are molded by density, food supplies, and other environmental conditions. A comparison of Curlew Valley data (Lindzey unpublished thesis, 1978) and ours shows an inverse relationship between density and home range size: densities in our study are greater, but home range sizes smaller. However, comparisons with other data also show many common patterns in the way badgers use their habitat. Winter inactivity, seasonal variation in range size, and reuse of dens have been identified in most studies. Those patterns suggest a very flexible system to ensure maximum energy efficiency as weather and prey characteristics interact to influence fossorial predation.

Social Organization

Badgers might maintain their solitary existence by mutual avoidance, as described in house cats (Leyhausen 1965) and mountain lions *Felis concolor* (Hornocker 1969, Seidensticker et al. 1973), or by a combination of overt aggression and avoidance. The relative importance of each might vary depending on population density and food supply, as is the case in stoats *Mustela erminea* and weasels *Mustela nivalis* (Lockie 1966).

Proximity might also influence reactions to conspecifics. Barash (1974) observed that conspecific pairs of male raccoons *Procyon lotor* and red foxes trapped close to each other displayed fewer aggressive interactions than did

animals trapped at widely separated points. If a similar mechanism operates in badgers, then neighbors might be tolerated while invaders would be attacked. This could explain the wounding of dispersing young.

In our study, fighting was observed only once between what were evidently fullgrown badgers, but adults often had facial scars that might have been acquired in fighting. We did not find evidence of scent marking as is known in the European badger *Meles meles* (Kruuk 1978b), although abdominal glands in males and anal glands in both sexes were conspicuous in summer, and secreted a waxy, bluish-white substance with a strong, but not foul, odor. However, the senior author's hand-reared female badger has exhibited marking behavior since maturity that is remarkably similar to what Kruuk described. Lampe (unpublished dissertation) mentioned both agonistic and marking behavior in *Taxidea* but gave no details. Despite meager field evidence, scent marking and agonistic behavior probably play a role in *Taxidea* social organization similar to that in *Meles* and perhaps most mustelids (Lockie 1966), but how or when exhibited is not known. The term territory, by any definition (see Noble 1939, Burt 1943, Etkin 1964, Kaufman 1971, Wilson 1971), seems inappropriate until more data are collected.

Dispersal

Dispersal of young from their natal area is true of many species, but the mechanisms that cause its onset and the adaptive value of the trait are still poorly understood. Dispersal has been said to prevent inbreeding, promote colonization, and limit density. Wilson (1975) reviewed those ideas, and emphasized the disagreement over whether dispersal is selected for at the group or individual level. Even if most young perish, the chance that some will survive and reproduce elsewhere may make emigration of young advantageous to the adult (Bertram 1976).

Among carnivores, a direct correlation between dispersal of juveniles and parental aggression is hard to demonstrate. Sargeant (1972) and Storm et al. (1976) found that red foxes avoided social contacts before dispersal began, and dispersers moved farther the first night than would be expected if they were avoiding aggressive residents. Verts (1967) found no indication that family breakup of striped skunks *Mephitis mephitis* was precipitated by aggression. The period after weaning in *Meles* is characterized by gradual independence (Neal and Harrison 1958).

Evidently, a blend of physiological and behavioral factors influences the onset of dispersal. The process is not necessarily maladaptive, however, because it may permit fortunate individuals to encounter new patches of prey. In the drought of 1976–1977, the only Townsend ground squirrels that reproduced were in alfalfa fields (Johnson et al. 1977b). Certain dispersers may have benefited through chance encounters with these isolated prey patches.

Food Habits

The small decrease in Townsend ground squirrels in badger food samples between 1976 and 1977, relative to the large decrease in squirrels, may indicate that because badgers are skillful fossorial predators they take prey in higher proportion than would be expected if density were the only criterion. Koford (1958) believed that badgers were the most effective natural enemy of prairie dogs *Cynomys* sp., and could take fairly constant numbers even when density was low. Hall (1946) stated that badgers are capable of thoroughly cleaning out rodents in an area. Silver (1928) observed that badgers prevented reestablishment of prairie dogs following control operations. Our badgers did not display such dramatic efficiency, perhaps because alternate prey was available on the Birds of Prey Study Area and badgers used it, while retaining interest in ground squirrels.

The importance of fossorial prey is il-

lustrated by the parallel between the geographical distribution of badgers and such prey (Bailey 1931, Davis 1939, Rust 1946). The presence of badgers in Ohio may be related to range extensions of the 13-lined ground squirrel (Mosely 1934, Leedy 1947). Although we did not study badger densities as specifically related to squirrel distribution, Johnson et al. (1977b) found strong positive correlation ($P < 0.05$) between transect counts of badger burrows and Townsend ground squirrel holes throughout the Birds of Prey Study Area.

Despite that close link to fossorial prey, badgers are surprisingly general in selecting food types and sizes. Apart from typical opportunistic foraging, there could be 2 reasons for this. (1) The importance of old burrows. Snead and Hendrickson (1942) believed that both ground squirrels and nonfossorial rabbits used old badger burrows extensively, and that badgers exploited those prey concentrations by reworking the burrows. Lindzey (unpublished thesis) observed that foraging badgers thoroughly investigated old dens, which served as cover or homesites for rabbits, birds, and lizards. Hetlet (1968, unpublished master's thesis, Colorado State University, Fort Collins, Colorado) made similar observations. Our data show intensive reuse of old burrows on the study area, which numbered as high as 39 per ha in winterfat and harbored an array of insects, reptiles, small and large rodents, and jackrabbits. (2) The second possible reason for badger's generalism in food selection relates to coexistence of competing species. Rosenzweig (1966) showed that sympatric carnivores with similar hunting strategies partitioned the food supply by size, larger species taking larger prey, and so forth. The North American badger does not compete with any other strictly fossorial predator and is not partial to any given food size.

Whether badger predation is age selective is uncertain. Because stomachs usually were not obtained in spring, we have little data on the proportion of very young ground squirrels in the kill compared to the population at large. Ground squirrels can be aged from cementum annuli (Adams and Watkins 1967), but sample sizes of the appropriate teeth were too small for definitive results. In 1975, on 1 of the 1-ha grids, badgers eliminated 2 litters of Townsend ground squirrels before they emerged and 2 following emergence, plus several members of the 2 remaining litters (Johnson and Melquist 1975), but were less successful on the 4 other live trapping grids. Slade and Balph (1974) found that badger predation on Uinta ground squirrels *Spermophilus armatus* was minimal during the active period (loosely April–August), and may have accounted for less than half of the inactive season losses. Sheppard and Swanson (1976) found no indication of age selective predation by badgers, red foxes, or long-tailed weasels *Mustela frenata* on Richardson's ground squirrels *Spermophilus richardsonii*.

Plague was isolated from only a few dead Townsend ground squirrels between 1975 and 1977, but the high frequency of badgers possessing serum antibodies to plague (Messick unpublished data) might indicate that badgers were selecting for afflicted individuals.

Badgers in this study preyed on hibernating ground squirrels, but the seasonal pattern in food habits (Fig. 17) indicates that squirrel activity aids in detection and capture. We saw sign of above ground predation on ground squirrels during only 1 period of snow cover in 1976. Sawyer (1925) saw badgers taking ground squirrels above ground, but the extent that above ground predation occurs on our study area is unknown. We believe that even when squirrels are active, badgers probably make almost all captures underground.

Seasonal trends in badger diets are well documented. Snead and Hendrickson (1942) found that Iowa badgers consumed most 13-lined ground squirrels *Spermophilus tridecemlineatus* (=*Citellus tridecemlineatus*) in summer, when fewest mice were taken, and that many more bumblebees, beetles, and other insects were eaten at that time. Jense (1968,

unpublished master's thesis, South Dakota State University, Vermillion, S.D.) observed a similar inverse relationship between mice and ground squirrels, but in contrast to the present study he found that consumption of rabbits peaked in spring and summer, when road kills were most plentiful. Our data show that lagomorphs (22% of badger food samples) were taken mostly in January, February, and March. Also, Townsend ground squirrels estivated several months earlier than sciurids in Snead and Hendrickson's and Jense's studies.

Lampe (unpublished dissertation) found significant frequency of occurrence differences in 9 of 11 mammal species from bimonthly May–October badger samples. Consumed biomass increased in each 2-month period, but the number of species in the diet declined. Decreased prey diversity on Lampe's study area matched the change in badger diets, although pocket gophers were the most important food in all periods. A similar relationship between the number of prey species in the diet and availability of key species was reported for bobcats (Beason and Moore 1977).

In comparisons of young and adult carnivore diets, Errington (1937) suggested that badger scats that contained mostly insects were from juveniles. Scott (1943) found more warm-blooded vertebrates in red fox scats collected at dens, i.e., from young dependent on adults for food, than in those found on trails (adult in origin). In contrast, our age comparison in badgers (Table 20, Fig. 18) was based primarily on samples from independent young versus adults.

Studies of badger predation are difficult because the species is largely nocturnal and secretive, and ordinarily consumes the entire victim (if it is small) at 1 feeding. Lampe (unpublished dissertation), in his work on the energetics of fossorial predation, overcame some of those problems by using large enclosures, where he telemetered the heart rate of badgers hunting gophers. He was able to measure the time required for detection, pursuit, and consumption, and also estimate the energy required for each phase of the predatory process. It would be interesting to extend Lampe's experiments using sciurids for prey and introducing some alternate, less fossorial prey. Also, further study of *Taxidea* predation would lead to more precise comparisons with *Meles*, and apparently less fossorial, more social, and somewhat omnivorous species (Kruuk 1978a, 1978b).

Adaptations for Fossorial Predation

The morphohogical features of the North American badger represent evolution toward a highly specialized method of predation perhaps unequaled among carnivores. Specialization is not, however, without its disadvantages (Leopold 1966), and natural selection on other aspects of badger biology has perhaps been less directional.

Throughout the badger's range, their prey consists primarily of fossorial rodents in the families Sciuridae and Geomyidae, supplemented by a wide array of smaller rodents, arthropods, and reptiles. Lampe (unpublished dissertation) reviewed all studies of badger food habits and found that 17 of 34 mammalian prey species were inhabitants of burrows and 8 others often used burrows or crevices. Many sciurids hibernate or estivate. Prairie dogs and many ground squirrels are colonial, have disjunct distributions related to soil type and other factors, and frequently invade disturbed and overgrazed habitats. Fossorial sciurids in the western United States undergo periodic die-offs from plague, after which numbers remain greatly reduced for months or years (see review by Olsen 1970). Thus, the key species the badger is so perfectly built to harvest are seasonally less available, patchy in distribution, and sometimes unpredictable. Badger acceptance of the wide variety of supplemental prey is a utilitarian adaptation.

Evolution of the badger's physiology and behavior has also been toward a flexible system related to food gathering ef-

ficiency. Winter inactivity is an adaptation to cold and food stress shared by certain members of the Ursidae, Procyonidae, and Mustelidae (Ewer 1973). The correlation between that trait and an omnivorous diet with marked seasonal variation in the vegetable component is fairly good but does not apply to *Taxidea*, which is strictly carnivorous. Unlike vegetation, which may completely disappear in winter, fossorial prey only become more energetically expensive to secure. This may explain why badgers on our study area (and perhaps in other regions) were so individually variable in their winter denning. Badgers may behaviorally thermoregulate by limiting above ground activity during cold period, thereby minimizing energy expenditures (Harlow 1979).

Solitary foraging may be related to prey size and possibly other prey characteristics. All are much smaller than the badger, and no hunting cooperation is necessary. It is interesting that European badgers, though social in denning habits, forage as individuals (Kruuk 1978a). Their foraging strategy appears to be closely related to catching earthworms, an important item in the diet (Kruuk 1978b, Kruuk and Parish 1977).

In conclusion, although the evolution of its morphology has been toward a very specialized method of food getting, we suggest that the badger has remained a widely distributed, adaptable species because many other aspects of its life history are flexible, having been molded by a variety of selection pressures.

These features of badger ecology may be useful considerations in the management of the species on the Snake River Birds of Prey Natural Area and elsewhere. The Bureau of Land Management is understandably interested in maintaining raptor populations on the Natural Area as its primary goal. The obvious overlap of diet between badgers and certain raptors led to questions about the impact of the former on the latter, and that was one of the reasons this study was proposed.

We learned that when confronted with a reduced ground squirrel population, badgers in this study responded by altering food habits, as did, for example, the prairie falcon *Falco mexicanus* (Peterson et al. 1977). Badgers and raptors have coexisted a very long time and probably can do so in the future. The Bureau should recognize the badger for its contribution to the Birds of Prey Natural Area. Despite the indicated decline, badger density may be higher there than anywhere else. The badger is little understood by the public, and because it appears to be particularly sensitive to man caused mortality, perhaps the species should receive more attention from management agencies.

SUMMARY

The ecology of the badger population on the Snake River Birds of Prey Study Area was investigated between spring 1975 and late summer 1977. Density, sex and age structure, fecundity, and mortality were assessed through mark–release, carcass, and skull collections. Radiotracking was used to monitor movement and activity, with additional data from recaptures, tracking on snow, and visual observations. Food habits data came from analysis of colons, stomachs, and fecal samples.

Major findings were:

1. The population was composed of almost equal numbers of males and females. Approximately 50 percent were young of year. The oldest badger captured was 14 years of age.
2. Fecundity increased with age, and during the 3 years of the study. Approximately 30 percent of young-of-year females bred, but males became sexually mature as yearlings.
3. Mortality was slightly higher in young of year than in yearlings and adults.
4. Fur trapping, road kills, and other man caused mortality were the most visible agents that affected badger numbers and were apparently responsible for a decline in badger density during the study.

5. Home ranges averaged 2.4 and 1.6 km² for adult males and females, respectively. Adults and most yearlings were resident, but most young of year dispersed during the first summer. Maximum dispersal was 110 km.

6. Home ranges overlapped, but individuals were solitary except for the transient mating bond and the 3 months that females were with their litters.

7. Badgers returned to previously used dens, but rarely stayed underground for more than 24 hours except in winter. One female emerged from her winter den only once during a 72-day period.

8. Activities of females with young (between March and May) centered on a sequence of maternal dens.

9. Townsend ground squirrels were the major prey and occurred in 70 percent of 427 food samples. All other mammals combined occurred in 44 percent of the samples. Scorpions, insects, snakes, lizards, and birds were among other items in the diet.

10. Food habits varied seasonally and yearly, with an inverse relationship between Townsend ground squirrels and other items, especially other mammals. Predation on ground squirrels was highest in spring and early summer. A dramatic drop in squirrel density in 1977 was accompanied by decrease of that species and increase of other mammals, arthropods, and avians in the badger diet.

11. Variety in food samples was greater in 1977 than in 1975 and 1976, apparently in response to the ground squirrel decline.

12. Young-of-year badgers took more arthropods and birds but fewer reptiles and mammals than did adults.

13. Ecologically, the badger appears to be a highly adaptable species despite its extreme morphological specialization.

LITERATURE CITED

ADAMS, L., AND S. G. WATKINS. 1967. Annuli in tooth cementum indicate age in California ground squirrels. J. Wildl. Manage. 31(4):836–839.

BAILEY, T. N. 1974. Social organization in a bobcat population. J. Wildl. Manage. 38(3):435–446.

BAILEY, V. 1931. Mammals of New Mexico. N. Amer. Fauna 53.

BALPH, D. F. 1961. Underground concealment as a method of predation. J. Mammal. 42(3):423–424.

BARASH, D. P. 1974. Neighbor recognition in two "solitary" carnivores: the raccoon (*Procyon lotor*) and the red fox (*Vulpes fulva*). Science 185:794–796.

BEASOM, S. L., AND R. A. MOORE. 1977. Bobcat food habit response to a change in prey abundance. Southwest. Nat. 21(4):451–457.

BERTRAM, B. C. R. 1976. Kin selection in lions and in evolution. Pp. 281–301. *In* P. P. G. Bateson and R. A. Hinde (Eds.). Growing points in ethology. Cambridge Univ. Press, London, Eng.

BURT, W. H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24(3):346–352.

CASE, R. M. 1978. Interstate highway road-killed animals: a data source for biologists. Wildl. Soc. Bull. 6(1):8–13.

CAUGHLEY, G. 1966. Mortality patterns in mammals. Ecology 47(6):906–918.

———. 1974. Interpretation of age ratios. J. Wildl. Manage. 38(3):557–562.

———. 1977. Analysis of vertebrate populations. John Wiley & Sons, Inc., New York, N.Y.

———, AND L. C. BIRCH. 1971. Rate of increase. J. Wildl. Manage. 35(4):658–663.

CHAPMAN, D. G., AND D. S. ROBSON. 1960. The analysis of catch curve. Biometrics 16(3):354–368.

COOPER, W. E. 1978. Home range criteria based on temporal stability of areal occupation. J. Theor. Biol. 73:687–695.

CROWE, D. M., AND M. D. STRICKLAND. 1975. Dental annulation in the American badger. J. Mammal. 56(1):269–272.

DAUBENMIRE, R. F. 1970. Steppe vegetation of Washington. Wash. Agric. Exp. Sta. Tech. Bull. 62.

DAVIS, W. B. 1939. The recent mammals of Idaho. Caxton Printers, Caldwell, Idaho.

DUEBBERT, H. F. 1967. Swimming by a badger. J. Mammal. 48:323.

EATON, R. L. 1976. Why some felids copulate so much. The World's Cats 3(2):73–88.

EBERHARDT, L. L. 1960. Estimation of vital characteristics of Michigan deer herds (Report 2282), Game Div., Michigan Dept. Cons., Lansing, Mich. XIV.

———. 1969a. Population estimates from recapture frequencies. J. Wildl. Manage. 33(1):28–39.

———. 1969b. Population analysis. Pp. 457–495. *In* R. L. Giles (Ed.). Wildlife management techniques. The Wildlife Society, Washington, D.C.

———. 1978. Appraising variability in population studies. J. Wildl. Manage. 42(2):207–238.

ERRINGTON, P. L. 1937. Summer food habits of the badger in northwestern Iowa. J. Mammal. 18(2):213–216.

ETKIN, W. 1964. Cooperation and competition in social behavior. Pp. 1–64. *In* W. Etkin (Ed.). Social behavior and organization among vertebrates. Univ. Chicago Press, Chicago, Ill.

EWER, R. F. 1973. The carnivores. Cornell Univ. Press, Ithaca, N.Y.

FLOYD, T. J., L. D. MECH, AND P. A. JORDAN. 1978. Relating wolf scat content to prey consumed. J. Wildl. Manage. 42(3):528–532.

GRUE, H., AND B. JENSEN. 1973. Annular structures in canine tooth cementum in red foxes (*Vulpes vulpes* L.) of known age. Danish Rev. of Game Biol. 8(7):1–12.

HALL, E. R. 1946. Mammals of Nevada. Univ. Calif. Press, Berkeley, Cal.

HAMLETT, G. W. D. 1932. Observations on the embryology of the badger. Anat. Rec. 53:283–301.

HARDY, J. I., AND T. M. PLITT. 1940. An improved method for revealing the surface structure of fur fibers. U.S. Fish Wildl. Serv. Wildl. Circ. No. 7.

HARLOW, H. J. 1979. A photocell monitor to measure winter activity of confined badgers. J. Wildl. Manage. 43(4):997–1001.

HARRIS, S. 1978. Age determination in the red fox (*Vulpes vulpes*)—an evaluation of technique efficiency as applied to a sample of suburban foxes. J. Zool., Lond. 184:91–117.

HORNOCKER, M. G. 1969. Winter territoriality in mountain lions. J. Wildl. Manage. 33(3):457–464.

———, S. CHERRY, J. P. MESSICK, AND J. S. WHITMAN. 1977. Dynamics of predation upon a raptor prey base in the Snake River Birds of Prey Natural Area, Idaho (coyote segment). Pp. 130–140. *In* Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

JACKSON, H. H. T. 1961. Mammals of Wisconsin. Univ. Wisconsin Press, Madison, Wis.

JOHNSON, D. R., L. DILLER, AND T. DAEHNKE. 1977a. Ecology of reptiles on the Snake River Birds of Prey Natural Area. Pp. 102–121. *In* Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

JOHNSON, D. R., AND W. E. MELQUIST. 1975. Population ecology and habitat requirements of Townsend ground squirrels. Pp. 156–176. *In* Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

———, AND G. W. SMITH. 1978. Ecology of Townsend ground squirrels in the Birds of Prey Study Area. Snake River Birds of Prey Research Proj. Contract 52500-CT5-1002 Final Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

———, G. W. SMITH, AND R. M. OLSON. 1976. Population ecology and habitat requirements of Townsend ground squirrels. Pp. 202–225. *In*

Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

———, ———, E. M. COBB, AND C. E. WOODLEY. 1977b. Population ecology and habitat requirements of Townsend ground squirrels, Pp. 143–163. *In* Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

JOHNSTON, D. H., AND M. BEAUREGARD. 1969. Rabies epidemiology in Ontario. Bull. Wildl. Dis. Ass. 5:357–370.

KAUFMAN, J. H. 1971. Is territoriality definable? Pp. 36–40. *In* A. H. Esser (Ed.). Behavior and environment. The Use of Space by Animals and Men. Plenum Press, New York, N.Y.

KLEVEZAL, G. A., AND S. E. KLEINENBERG. 1967. Age determination of mammals from annual layers in teeth and bones. Translated from Russian: Israel Prog. Scient. Translat. 1969, Cat. 5433.

KNOPF, F. L., AND D. F. BALPH. 1969. Badgers plug burrows to confine prey. J. Mammal. 50(3):635–636.

KOFORD, C. B. 1958. Prairie dogs, whitefaces, and blue grama. Wildl. Monogr. No. 3:1–78.

KORSCHGEN, L. J. 1969. Procedures for food-habits analyses. Pp. 233–250. *In* R. H. Giles (Ed.). Wildlife management techniques. The Wildlife Society, Washington, D.C.

KRUUK, H. 1978a. Spatial organization and territorial behaviour of the European badger *Meles meles*. J. Zool., Lond. 184:1–19.

———. 1978b. Foraging and spatial organization of the European badger, *Meles meles* L. Behav. Ecol. Sociobiol. 4:75–89.

———, AND T. PARISH. 1977. Behaviour of badgers. Inst. Terrestrial Ecol., Cambridge, Eng.

LEEDY, D. L. 1947. Spermophiles and badgers move eastward in Ohio. J. Mammal. 28(3):290–292.

LEOPOLD, A. S. 1966. Adaptability of animals to habitat change, Pp. 66–75. *In* F. F. Darling and J. P. Milton (Eds.). Future environments of North America. Natural History Press, Garden City, N.Y.

LEYHAUSEN, P., VON. 1965. The communal organization of solitary mammals. Symp. Zool. Soc. London 14:249–263.

LINDZEY, F. G. 1976. Characteristics of the natal den of the badger. Northwest Sci. 50(3):178–180.

———. 1978. Movement patterns of badgers in northwestern Utah. J. Wildl. Manage. 42(2):418–422.

LOCKIE, J. D. 1959. The estimation of the food of foxes. J. Wildl. Manage. 23:224–227.

———. 1966. Territory in small carnivores. Symp. Zool. Soc. London 18:167–177.

LONG, C. A. 1972. Taxonomic revision of the American badger, *Taxidea taxus*. J. Mammal. 53(4):725–759.

———, AND T. FRANK. 1968. Morphometric vari-

ation and function in the baculum, with comments on correlation of parts. J. Mammal. 49(1):32–43.

MALDE, H. E. 1965. Snake River Plain, Pp. 255–263. In H. E. Wright, Jr. and D. G. Frey (Eds.). The Quaternary of the United States. Princeton Univ. Press, Princeton, N.J.

MARTIN, K. H., R. A. STEHN, AND M. E. RICHMOND. 1976. Reliability of placental scar counts in the prairie vole. J. Wildl. Manage. 40(2):264–271.

MEAD, R. A. 1968. Reproduction in eastern forms of the spotted skunk (genus *Spilogale*). J. Zool., Lond. 156:119–136.

MOHR, C. O., AND W. A. STUMPF. 1966. Comparison of methods for calculating areas of animal activity. J. Wildl. Manage. 30(2):293–304.

MOORE, T. D., L. E. SPENCE, AND C. E. DUGNOLLE. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Dept. Bull. No. 14.

MOSELEY, E. L. 1934. Increase of badger in northwestern Ohio. J. Mammal. 15:156–158.

NEAL, E. G., AND R. J. HARRISON. 1958. Reproduction in the European badger (*Meles meles* L.). Trans. Zool. Soc. Lond. 29(2):67–130.

NOBLE, G. K. 1939. The role of dominance in the social life of birds. Auk 56:263–273.

OLSEN, P. F. 1970. Sylvatic (wild rodent) plague, Pp. 200–213. In J. W. Davis, L. H. Karstad, and D. O. Trainer (Eds.). Infectious diseases of wild mammals. Iowa St. Univ. Press, Ames, Ia.

ORIANS, G. H. 1969. On the evolution of mating systems in birds and mammals. Amer. Nat. 103(934):589–603.

PETERSON, S. R., G. M. SITTER, AND B. W. JAMES. 1977. Feeding activity and behavior of prairie falcons, Pp. 165–176. In Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage., Boise, Idaho.

PETRIDES, G. A. 1950. The determination of sex and age ratios in fur animals. Amer. Midl. Nat. 43(2):355–382.

RAMSDEN, R. O., P. F. COPPIN, AND D. H. JOHNSTON. 1976. Clinical observations on the use of ketamine hydrochloride in wild carnivores. J. Wildl. Dis. 12:221–225.

ROBERTS, J. D. 1978. Variation in coyote age determination from annuli in different teeth. J. Wildl. Manage. 42(2):454–456.

ROBSON, D. S., AND D. G. CHAPMAN. 1961. Catch curves and mortality rates. Trans. Amer. Fish. Soc. 90(2):181–189.

ROSENZWEIG, M. L. 1966. Community structure in sympatric carnivora. J. Mammal. 47(4):602–612.

RUST, H. J. 1946. Mammals of northern Idaho. J. Mammal. 74(4):729–731.

SANDERSON, G. C. 1966. The study of mammal movements—a review. J. Wildl. Manage. 30(1):215–235.

SARGEANT, A. B. 1972. Red fox spatial characteristics in relation to waterfowl predation. J. Wildl. Manage. 36(2):225–236.

———, AND D. W. WARNER. 1972. Movement and

denning habits of a badger. J. Mammal. 53(1):207–210.

SAWYER, E. J. 1925. Badger runs down ground squirrels. J. Mammal. 6(2):125–126.

SCHWARTZ, C. W., AND E. L. SCHWARTZ. 1959. The wild mammals of Missouri. Univ. Missouri Press, Columbia, Mo.

SCOTT, T. G. 1941. Methods and computation in fecal analysis with reference to the red fox. Iowa State College J. Sci. 15(3):279–285.

———. 1943. Some food coactions of the Northern Plains red fox. Ecol. Monogr. 13:429–479.

SEBER, G. A. F. 1973. The estimation of animal abundance and related parameters. Griffin, London, Eng.

SEIDENSTICKER, J. C., IV, M. G. HORNOCKER, W. V. WILES, AND J. P. MESSICK. 1973. Mountain lion social organization in the Idaho Primitive Area. Wildl. Monogr. No. 35:1–60.

SHEPPARD, D. H., AND S. M. SWANSON. 1976. Natural mortality in Richardson's ground squirrel. Can. Field-Nat. 90:170–172.

SILVER, J. 1928. Badger activities in prairie dog control. J. Mammal. 9(1):63.

SLADE, N. A., AND D. F. BALPH. 1974. Population ecology of Uinta ground squirrels. Ecology 55(5):989–1003.

SNEAD, I. E., AND G. O. HENDRICKSON. 1942. Food habits of the badger in Iowa. J. Mammal. 23(4):380–391.

SOUTHWOOD, T. R. E. 1966. Ecological methods. Chapman and Hall, Ltd. London, Eng.

STORM, G. L., R. D. ANDREWS, R. L. PHILLIPS, R. A. BISHOP, D. B. SINIFF, AND J. R. TESTER. 1976. Morphology, reproduction, dispersal, and mortality of midwestern red fox populations. Wildl. Monogr. No. 49:1–82.

THOMAS, E. M. 1954. Wyoming fur-bearers. Their life histories and importance. Bull. No. 7, Wyoming Game Fish Dept., Cheyenne, Wyo.

THOMAS, O. 1905. Suggestions for the nomenclature of the cranial length measurements and of the check-teeth of mammals. Proc. Biol. Soc. Wash. 18:191–196.

TRIVERS, R. L. 1972. Parental investment and sexual selection, Pp. 136–177. In B. Campbell (Ed.). Sexual selection and the descent of man. Aldine Publ. Co., Chicago, Ill.

U.S. DEPT. OF COMMERCE, N.O.A.A. 1975–1977. Climatological Data, Annual Summaries Idaho. Vol. 78–80.

VAN WINKLE, W. 1975. Comparison of several probabilistic home-range models. J. Wildl. Manage. 39(1):118–123.

VAUGHAN, T. A. 1972. Mammalogy. W. B. Saunders Co., Philadelphia, Pa.

VERTS, B. J. 1967. The biology of the striped skunk. Univ. Illinois Press, Urbana, Ill.

WALKER, E. H. 1963. A geologic history of the Snake River country of Idaho. Idaho Historical Series No. 8. Idaho Historical Society, Boise, Idaho.

WILEY, R. H. 1974. Evolution of social organiza-

tion and life-history patterns among grouse. Quart. Rev. Biol. 49:201–227.

WILSON, E. O. 1971. Competitive and aggressive behavior, Pp. 181–271. *In* J. F. Eisenburg and W. S. Dillon (Eds.). Man and Beast: Comparative Social Behavior. Smithson. Inst. Press, Washington, D.C.

———. 1975. Sociobiology, the new synthesis. Belknap Press, Cambridge, Mass.

WOLFE, M., L. O. OFTEDAHL, P. OLMSTEAD, J. JOHANSEN, AND A. GARCIA. 1977. Density and species composition of small mammals and birds on the Snake River Birds of Prey Natural Area, Idaho, Pp. 54–81. *In* Snake River Birds of Prey Research Proj. Annu. Rept. U.S. Dept. Int., Bur. Land Manage. Boise, Idaho.

WOOD, N. A. 1921. Badger as a swimmer. J. Mammal. 2(3):170.

WRIGHT, P. L. 1963. Variations in reproductive cycles in North American mustelids. Pp. 77–97. *In* A. C. Enders (Ed.). Delayed implantation. Univ. Chicago Press, Chicago, Ill.

———. 1966. Observations on the reproductive cycle of the American badger (*Taxidea taxus*). Symp. Zool. Soc. Lond. 15:27–45.

———. 1969. The reproductive cycle of the male American badger, *Taxidea taxus*. J. Reprod. Fert., Suppl. 6:435–445.

———, AND M. W. COULTER. 1967. Reproduction and growth in Maine fishers. J. Wildl. Manage. 31(1):70–86.

APPENDIXES

APPENDIX A.—MEASUREMENTS (MM) OF BADGER SKULLS IN AGE GROUPS ASSIGNED BY CEMENTUM, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age in years	Males				Females				Sex unknown			
	No.	Mean	SD	Range	No.	Mean	SD	Range	No.	Mean	SD	Range
Greatest length												
<1	5	131.6[1]	5.6	126.0–140.0	8	117.6[2]	5.1	108.9–124.8				
1	9	129.2	5.6	118.0–138.5	6	127.3	3.3	121.0–130.0	4	126.0	4.9	120.5–131.0
2	5	135.1	6.4	123.9–140.0	1	120.0			1	132.5		
3–14	3	134.6[1]	4.5	132.5–114.0	8	124.6	3.3	117.3–128.0	8	128.3	5.3	121.7–138.2
Basal length												
<1	5	119.3[1]	4.0	115.0–125.6	8	107.7[2]	6.3	98.4–117.8				
1	9	117.1	4.1	110.0–123.3	6	116.3	2.3	113.3–118.9	3	115.6	3.9	112.7–120.0
2	5	122.3	4.7	114.0–125.0	1	110.3			1	120.8		
3–14	3	123.4[1]	2.6	120.9–126.0	8	112.7	6.1	98.0–117.3	8	119.2	5.0	113.4–128.5
Palatal length												
<1	9	67.9[1]	2.8	64.6–73.4	16	63.3[2]	2.9	56.6–66.8				
1	12	68.6	2.6	63.9–71.9	10	66.7	2.4	63.0–70.9	5	66.9	3.7	62.4–71.0
2	5	71.3	2.5	67.3–73.6	1	62.9			1	66.3		
3–14	8	70.4[1]	2.3	68.0–85.0	11	65.6	1.9	62.9–68.5	7	68.6	3.8	64.6–75.0
Maxillary tooth row length												
<1	11	42.9[1]	1.7	40.0–45.0	17	40.1	3.2	31.9–44.0				
1	10	42.2	1.7	38.8–44.1	9	41.9	1.8	39.0–45.0	4	42.0	1.4	41.0–44.0
2	5	44.0	1.5	42.0–45.3	2	41.0	1.6	39.8–42.1	1	44.3		
3–14	9	44.9[1]	0.7	44.0–46.0	11	41.6	1.5	39.6–44.4	4	44.7	1.3	42.9–46.0
Carnassial length												
<1	10	11.4[1]	0.8	10.3–12.2	14	10.8	0.7	9.3–11.7				
1	11	11.2	0.7	10.0–12.1	9	11.1	0.5	10.6–12.5	4	11.0	0.6	10.6–11.8
2	5	11.5	0.5	10.9–12.0	2	10.9		10.9–10.9	1	11.6		
3–14	7	11.2	0.6	10.0–11.6	12	10.9	0.5	10.0–11.6	4	11.2	0.9	10.0–12.0
Zygomatic breadth												
<1	5	76.6	3.1	73.1–80.7	12	73.0[2]	3.8	67.8–78.7	1	78.0		
1	10	81.5	2.6	77.4–85.0	8	76.9	2.9	74.5–83.0	4	80.0	1.4	78.0–81.4
2	5	86.1[1]	6.1	76.0–91.2	2	76.0	2.9	73.9–78.0	2	85.3	0.5	84.9–85.6
3–14	5	85.3	3.0	80.8–87.8	9	77.8	2.2	75.0–81.1	7	83.0	5.3	77.0–90.9
Postorbital breadth												
<1	10	36.2[1]	2.0	32.8–39.0	19	33.1[2]	2.3	27.9–37.5	1	37.0		
1	12	36.5	2.2	32.5–40.7	11	35.0	1.3	32.8–37.0	6	35.0	2.5	31.9–38.4
2	5	38.6	2.5	35.0–41.0	1	34.7			3	35.7	3.5	32.0–39.0
3–15	6	39.5[1]	1.7	36.8–41.4	12	36.3	2.1	33.9–41.7	8	36.6	2.5	33.7–41.0
Cranial depth												
<1	5	44.7[1]	1.7	42.3–46.7	10	41.4	3.0	35.0–46.7	1	43.7		
1	8	45.5	1.7	41.9–47.1	6	43.3	2.0	40.5–45.0	4	44.4	1.5	43.0–46.3
2	5	46.8[1]	3.4	41.4–50.4	1	43.2			2	46.1	3.6	43.5–48.6
3–15	2	41.8	2.8	39.8–43.7	8	44.4	2.2	41.9–49.2	7	46.3	2.4	44.0–50.0

[1] Different from females of same age (P < 0.05), Duncan's New Multiple Range Test.
[2] Different from next higher age group of same sex (P < 0.05), Duncan's New Multiple Range Test.

APPENDIX B.—ASSOCIATION BETWEEN AGES OF BADGERS AS DETERMINED BY CEMENTUM AND DEGREE OF SUTURE CLOSURE, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

	Age in years							
	<1		1		2		3–14	
Degree of suture closure	No.	%	No.	%	No.	%	No.	%
Nasal sutures								
Open	20	87.0	2	8.7			1	4.3
Partial fusion	10	43.5	12	52.2	1	4.3		
Nearly complete fusion	7	21.9	12	37.5	4	12.5	9	28.1
Fused			5	15.6	5	18.8	21	65.6
Zygomatic–maxillary, basioccipital–basisphenoid, maxillary–palatine sutures								
Open	15	75.0	4	20.0			1	5.0
Partial fusion	9	69.2	4	30.8				
Nearly complete fusion	6	26.1	13	56.5	2	8.7	2	8.7
Fused			5	14.7	8	23.5	21	68.8

APPENDIX C.—ASSOCIATION BETWEEN AGES OF BADGERS AS DETERMINED BY CEMENTUM AND DEVELOPMENT OF SAGITTAL CREST AND POSTORBITAL PROCESS, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

	Age in years							
	<1		1		2		3–14	
Degree of crest development	No.	%	No.	%	No.	%	No.	%
Sagittal crest								
Absent	14	82.4	2	11.8			1	5.9
Slight development	4	21.1	7	36.8	3	15.8	5	26.3
Moderate development	1	5.9	8	47.1	2	11.8	6	35.3
Very prominent	1	5.9	3	17.6	4	23.5	9	52.9
Postorbital process								
Absent	9	100.0						
Slight development	19	48.7	15	38.5	2	5.1	3	7.7
Moderate development	7	16.3	14	32.6	3	7.0	19	44.2
Very prominent					4	36.4	7	63.6

APPENDIX D.—ASSOCIATION BETWEEN TOOTH WEAR AND AGES OF BADGERS AS DETERMINED BY CEMENTUM, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

	Age in years							
	<1		1		2		>2	
Degree of tooth wear and condition	No.	%	No.	%	No.	%	No.	%
Deciduous present, recently replaced	30	90.9	3	9.1				
Replacement teeth sharp, little wear	17	38.6	19	43.2	1	2.3	7	15.9
Evidence of wear; canines not sharpened by age	5	6.3	28	35.0	16	20.0	31	38.8
Teeth very worn, perhaps decayed, canines show sharpening by age					1	12.5	7	87.5

APPENDIX E.—BADGER BACULAR WEIGHT (G) AND LENGTH (MM) BY ASSIGNED AGE GROUP, SNAKE RIVER BIRDS OF PREY STUDY AREA, 1975–1977

Age in years	No.	Length			Weight		
		Mean	SD	Range	Mean	SD	Range
<1	18	81.2[1]	9.1	60.0–93.0	1.320[1]	0.564	0.500–2.304
1	19	99.6[1]	3.6	89.5–105.0	3.542[1]	0.713	2.030–5.254
2	11	105.0	4.4	98.0–114.0	5.239	0.549	4.257–6.097
3–14	23	105.8	4.5	98.5–114.0	5.354	0.774	3.605–6.849

[1] Significantly different from next higher age group ($P < 0.05$), Duncan's New Multiple Range Test.

APPENDIX F.—AGES OF 354 BADGERS AS DETERMINED BY CEMENTUM ANALYSIS, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age in years[1]	1975		1976		1977		All years	
	No.	%	No.	%	No.	%	No.	%
<1	42	44.2	36	28.6	32	24.1	110	31.1
1	26	27.4	43	34.1	44	33.1	113	31.9
2	11	11.6	19	15.1	17	12.8	47	13.3
3	9	9.5	15	11.9	19	14.3	43	12.1
4	2	2.1	3	2.4	7	5.3	12	3.4
5	2	2.1	5	4.0	9	6.8	16	4.5
6	2	2.1	2	1.6	4	3.0	8	2.3
7	1	1.0	1	0.8	1	0.8	3	0.8
12			1	0.8			1	0.3
14			1	0.8			1	0.3
Totals	95	26.8	126	35.6	133	37.6	354	

[1] Disagreement in multiple tooth samples was resolved by accepting canine, premolar, and incisor annular counts, respectively. All ages were checked against other age criteria. This is not the age structure of the population.

APPENDIX G.—AGE GROUPS OF 81 BADGERS ESTIMATED BY TECHNIQUES OTHER THAN CEMENTUM ANALYSIS, SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Age group	No.	Technique	Accuracy
Young of year	53	Tooth replacement, morphology	Excellent
Young of year	1	Appearance	Fair
Yearling	2	Morphology, appearance	Good
Adult	16	Morphology, appearance	Good (possibly a few were yearlings)
Unknown	9		
Total	81		

APPENDIX H.—FREQUENCY OF OCCURRENCE OF FOOD FOUND IN 427 BADGER STOMACHS, COLONS, AND SCATS COLLECTED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977. (PERCENTAGE SHOWN IS PERCENTAGE FREQUENCY)[1]

Item	1975		1976		1977		All years	
	No.	%	No.	%	No.	%	No.	%
Arthropods								
Scorpion	20	30.8	50	24.4	28	17.0	98	23.0
Black widow spider *Lactrodectus mactans*			1	0.5			1	0.2
Centipede					1	0.6	1	0.2
Grasshopper	7	10.8	12	6.1	38	23.0	57	13.3
Beetle	7	10.8	33	16.8	19	11.5	59	13.8
Fly					1	1.2	2	0.5
Cicadas			1	0.5			1	0.2
Bee					2	1.2	2	0.5
Immature arthropods					5	3.0	5	1.2
Unknown arthropods	2	3.1			5	3.0	7	1.6
Reptiles								
Western whiptail lizard *Cnemidophorus tigris*	1	1.5	3	1.5	3	1.8	7	1.6
Collared lizard *Crotophytus collaris*	1	1.5	3	1.5	1	0.6	5	1.2
Side-blotched lizard *Uta stansburiana*			1	0.5	2	1.2	3	0.7
Unknown lizard	1	1.5	1	0.5	1	0.6	3	0.7
Gopher snake *Pituophis melanoleucus*	1	1.5	7	3.6	1	0.6	9	2.1
Unknown snake	1	1.5	4[2]	2.0	7	4.2	12	2.8
Unknown reptiles			3	1.5	2	1.2	5	1.2
Reptile eggs	2	3.1	6[3]	3.1			8	1.9
Aves								
Starling *Sturnus vulgaris*					1	0.6	1	0.2
Unknown passerine			1	0.5			1	0.2
Unknown aves			1	0.5	7	4.2	8	1.9
Avian eggs			1	0.5	2	1.2	3	0.7
Mammals								
Nuttall's cottontail *Sylvilagus nuttalli*			1	0.5	5	3.0	6	1.4
Black-tailed jackrabbit *Lepus californicus*	5	7.7	6	3.1	7[4]	4.2	18[4]	4.2
Least chipmunk *Eutamias minimus*			1	0.5			1	0.2
Yellow-bellied marmot *Marmota flaviventris*					1	0.6	1	0.2
White-tailed antelope squirrel *Ammospermophilus leucurus*					1	0.6	1	0.2
Townsend ground squirrel *Spermophilus townsendi*	54	83.1	156	79.2	90	54.6	300	70.3
Townsend pocket gopher *Thomomys townsendi*			3	1.5			3	0.7
Great Basin pocket mouse *Perognathus parvus*					5	3.0	5	1.2
Kangaroo rat *Dipodomys* spp.[5]	2	3.1	12	6.1	13	7.9	27	6.3
Western harvest mouse *Reithrodontomys megalotis*	1	1.5			8	4.9	9	2.1
Deer mouse *Peromyscus maniculatus*	6	9.2	18	9.1	22	13.3	46	10.8
Grasshopper mouse *Onychoms leucogaster*			2	1.0	2	1.2	4	0.9
Woodrat *Neotoma* spp.[6]			1	0.5			1	0.2
Montane meadow vole *Microtus montanus*			4	2.0	14	8.5	18	4.2
Muskrat *Ondatra zibethicus*[7]					1	6.1	1	0.2
House mouse *Mus musculus*					1	0.6	1	0.2
Spotted skunk *Spilogale putorius*					1	0.6	1	0.2

APPENDIX H.—CONTINUED.

Item	1975		1976		1977		All years	
	No.	%	No.	%	No.	%	No.	%
Coyote *Canis latrans*[8]			1	0.5	1	0.6	2	0.5
Unknown lagomorphs	1	1.5	2	1.0	3	1.8	6	1.4
Unknown mammals	5	6.7	16	8.2	18	11.5	29	6.8
Total (food-containing samples)	65		197		165		427	

[1] An additional 35 samples were collected, but contained only soil, vegetation, or other nonfood items.
[2] One sample is possible striped whipsnake *Masticophis taeniatus*.
[3] One sample is possibly avian egg.
[4] Maggots in one sample indicate carrion.
[5] *Dipodomys ordii* and *D. microps* both occur in area; *D. ordii* is more common.
[6] *Neotoma cinerea* and *N. lepida* both occur in study area.
[7] Possibly carrion.
[8] Hair only.

APPENDIX I.—WEIGHTS AND MEASUREMENTS OF BADGERS BY AGE GROUP CAPTURED AND COLLECTED ON THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Measurement	Year[1]	Age								
		<1			1			>1		
		No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Total length (cm)	1975	50	70.4	4.7	23	75.8	5.0	27	76.4	6.7
	1976	61	67.4	11.5	38	77.0	5.5	41	76.6	5.4
	1977	34	61.3	9.8	22	78.0	3.3	19	79.3	3.4
Body length (cm)	1975	46	56.7	7.1	23	61.4	5.0	27	62.4	6.6
	1976	55	55.0	9.2	30	61.3	9.5	36	63.0	4.4
	1977	32	50.3	7.4	21	63.4	4.5	18	64.9	3.6
Hind foot (cm)	1975	44	10.9	0.8	22	10.6	0.7	27	10.7	0.7
	1976	55	10.1	1.5	30	10.8	0.7	36	10.8	1.0
	1977	30	9.6	1.0	21	10.7	0.7	16	10.7	0.6
Weight (kg)[2]	1975	55	6.1	1.3	29	7.9	1.9	30	8.1	1.9
	1976	71	5.4	2.1	41	7.6	1.5	51	8.0	1.7
	1977	65	4.6	1.7	49	8.0	1.3	73	8.7	1.9

[1] Differences between years may be caused by date of measurement, not actual year effects. That is especially true for growing young.
[2] Pelted carcasses corrected by: weight without hide ×1.2 = estimated weight before skinning.

APPENDIX J.—WEIGHTS AND MEASUREMENTS OF BADGERS BY SEX CAPTURED AND COLLECTED ON AND NEAR THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Measurement	Males			Females			t-test difference[2]
	No.	Mean	SD	No.	Mean	SD	
Total length (cm)	164	73.9	10.1	151	70.8	7.8	$P < 0.05$
Body length (cm)	150	59.9	9.5	138	57.8	6.7	$P > 0.1 \quad < 0.2$
Hind foot (cm)	146	10.7	1.1	135	10.3	0.9	$P < 0.05$
Body weight (kg)[1]	233	7.6	2.6	231	6.3	1.6	$P < 0.05$

[1] Pelted carcasses corrected by weight without hide ×1.2 = estimated weight before skinning.
[2] Data transformed $\log_{10}$ to equalize variances.

APPENDIX K.—SEASONAL CHANGES IN BODY WEIGHTS OF ADULT AND YEARLING BADGERS, CAPTURED AND COLLECTED ON THE SNAKE RIVER BIRDS OF PREY STUDY AREA, IDAHO, 1975–1977

Quarterly divisions of years, 1975–1977 combined	Males			Females		
	No.	Mean[1]	SD	No.	Mean[1]	SD
Jan–Mar	10	7.6	1.48	20	6.9	0.89
Apr–Jun	61	8.8	1.50	60	6.7	0.79
Jul–Sep	64	9.8	1.54	47	7.2	0.93
Oct–Dec	1	10.9		9	7.8	0.88

[1] Means different $P < 0.001$ for males and females analyzed separately. Pelted carcasses corrected by: weight without hide $\times 1.2$ = estimated weight before skinning.