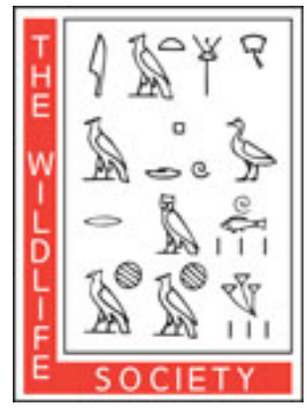

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PREY REMAINS IN GOLDEN EAGLE NESTS: TEXAS AND NEW MEXICO

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Abstract: Remains of prey in 41 golden eagle (*Aquila chrysaëtos*) nests were studied in sheep- and goat-raising areas of western Texas and New Mexico in 1968. Bones of black-tailed jack rabbits (*Lepus californicus*), cottontails (*Sylvilagus audubonii* and *S. floridanus*), rock squirrels (*Spermophilus variegatus*), and prairie dogs (*Cynomys ludovicianus* and *C. gunnisoni*) comprised nearly 90 percent of all individuals found in nests. A greater portion of individual rock squirrels and prairie dogs were eaten than of rabbits. Seventy percent of all nests contained remains of at least 66 sheep and goats, most of which were young. Of the nests containing livestock, 15 each had one sheep or goat; only 2 each had five or more. It could not be ascertained from the bony remains in nests whether prey species were brought to the nest as carrion or as fresh-kills. Sampling bias and other food habit considerations are discussed.

Golden eagles are declining in numbers in western Texas and parts of New Mexico (Spofford 1965). As a result, federal protection was given to the bird in 1962. This legislation gave a new dimension to a controversy on the role of the golden eagle as a predator on domestic sheep and goats. Ranchers contend that they have been deprived of their most effective means of predator control (unlimited hunting); conservationists suggest that control of eagle populations is unwarranted in view of the few documented instances of predation on livestock. Because of this controversy, studies of eagle–livestock relationships are useful. Previous studies of importance are Bent (1937), Arnold (1954), and Craighead and Craighead (1956), who reported on food habits based principally on items in and around nests; McGahan (1968) and Beecham (1970) mentioned species taken as prey in Montana and Idaho; Fevold and Craighead (1958), Brown and Watson (1964), and McGahan (1967) made quantitative estimates of food requirements. Our study of the contents of golden eagle nests was conducted in regions where sheep and goats are produced.

This report was supported jointly by the Bureau of Sport Fisheries and Wildlife, the National Wool Growers Association, and the National Audubon Society. We are indebted to these agencies for financial and logistical aid. The statements and conclusions reached in this paper, however, do not necessarily carry the endorsement of these agencies or of their members. We are particularly grateful to the ranchers and foremen who graciously permitted access to land in their care, and to others who provided information on nest locations. Among these were J. Hepler, R. Hubbell, M. Hughes, S. Hughes, W. Hughes, L. Kincaid, V. McElhaney, C. Miller, B. Pfingston, T. Treat, J. White, and P. White. We also thank J. Beecham, E. Bolen, Lucy Hill Porter, and J. Rollo for their field and laboratory assistance.

PROCEDURES

In the summer of 1968, prey remains were found in 41 of 53 eagle nests. Some nests were used the preceding spring, whereas others had no history of use in 12 years. An attempt was made to remove all food remains from each nest. Food materials found

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on the ground below each nest were included in the analysis for that nest. In a few cases, the food remains on the ground equaled those in the nests. Several inaccessible nests were so close together that the ground remains could not be assigned to a particular nest. Such remains were treated as if they had been obtained from one nest. The amount of material recovered ranged from a trace of unidentified bone from one nest to another containing nearly a thousand items weighing over 3,300 grams.

Contents of nests were brought to the laboratory for identification by comparison with known materials. Species composition, minimum number of animals of each species, and the number of each kind of identifiable disarticulated item (femur, cranium, feathers, and similar items) were recorded for each nest. The minimum number of animals is equal to the greatest number of identical bones per taxon (for example, within a nest containing five left jack rabbit humeri, and three right, the minimum number would be five animals). Percentage composition of prey is based on the minimum number of animals—a conservative estimate of the animals actually represented in the nest. However, this method of estimation may more accurately reflect the percentage composition of prey captured than estimates based on weight or numbers of disarticulated items per species. Neither weight nor numbers can effectively account for differences in preservation of remains or differences in prey size.

Nests studied were from five regions in western Texas, and New Mexico (Fig. 1), where ranchers had implicated the golden eagle in losses of sheep and goats. However, ranches where nests were located and studied were not necessarily ranches on which depredation of livestock was reported.

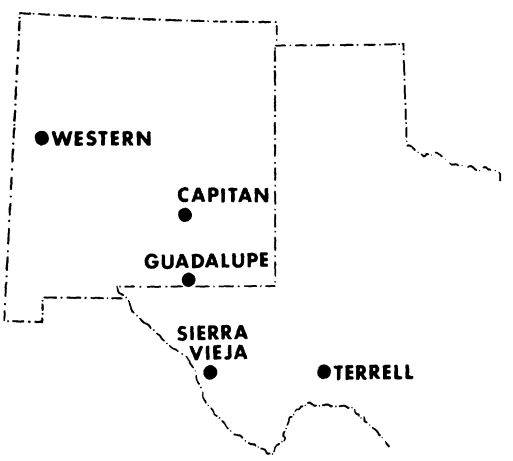

Fig. 1. Location of study areas in New Mexico and western Texas.

Terrell Area—Terrell County, Texas

All eyries examined were in two canyons on the Bill Roden Ranch near Independence Creek in the northeastern part of the county. Two eagles had been seen in and about some of the nests the preceding fall and spring. One eagle was trapped by ranch employees from a nest containing rabbits, kid goats, and a skunk (*Mephitis mephitis*). Ten of the 12 nests contained animal remains. No information prior to 1967 was available for any of the nests. Roden raised goats.

Sierra Vieja Area—Presidio County, Texas

Nests were located on the Clay Miller Ranch, about 9 miles west of Valentine. A single eagle was fledged from one of the nests checked in the spring of 1968, and another nest had young eagles the preceding year. Both nests were in the same canyon. Two additional nests were in the canyon but were not entered. Miller raised only cattle, but sheep and goats were raised in the same and nearby mountain ranges.

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Guadalupe Area—Guadalupe Mountains, Culberson County, Texas; Eddy and Otero Counties, New Mexico

Nests were abundant in this district. Twenty-six nests were entered and prey remains removed from 19; 5 other nests were not entered. Two eyries in Texas, on land operated by Laurie Kincaid, were last active in 1965 and 1966. An old photograph of one eyrie revealed the remains of 20–25 kids and one lamb. Nests in Eddy County, New Mexico, were on sheep ranches operated by Joe Hepler and the Hughes brothers. Some of these nests were within the boundary of Lincoln National Forest, largely in Devil's Den Canyon. Others were situated on the Rim, the western escarpment of the Guadalupe Mountains. Of this large series of nests, none had been active since 1966. The Brokeoff Mountains, chiefly La Paloma Canyon, in Otero County, harbored several large nests. One of these had been used in 1967. A resident there, John White, accredited significant losses to a pair of eagles nesting in a lambing pasture. This pasture yielded a 55 percent lamb crop in a year when adjacent pastures produced a 100 percent crop. In addition, Mr. White found lamb carcasses in and under the nest.

Capitan Area—Chaves and Lincoln Counties, New Mexico

In Chaves County, four nests were on the Tony Treat Ranch, about 21 miles southwest of Picacho. Prey remains were recovered from three of these on a bluff. Four of six nests on a single bluff 2 miles east of Lincoln, Lincoln County, also yielded prey remains. This land is operated by Burt Pfingston. Treat had sheep in the vicinity of the nests, Pfingston did not. Neither rancher had noted nesting eagles for several years.

Western Area

Two eyries were discovered on the Hubbell Ranch north of Quemado, Catron County, New Mexico. One nest had eaglets in 1966, but the other nest was of unknown age. An eagle claw bearing a docking ring reportedly came from this ranch. A single nest was found in the bluffs at the Narrows, in southern Valencia County.

All nests entered were on cliff faces. No nests were observed in trees.

Most nests were not destroyed but were sifted for remains. This alters, to a degree, the original structure of the nest. However, we are strongly of the opinion that our studies did not, and will not, discourage future nesting by eagles in the areas of study because most nests were only slightly altered.

RESULTS

Jack Rabbits, Cottontails, Rock Squirrels, and Prairie Dogs

These species comprised nearly 90 percent of all individuals found in the nests (Table 1). Over 50 percent of the mammals were identified as black-tailed jack rabbits. Furthermore, 38 of 41 nests had some evidence of jack rabbit remains. Cottontails were next in abundance (17.6 percent). These remains included bones of both *Sylvilagus floridanus* and S. *audubonii*. Both species are at least contiguously allopatric in all but the Capitan study area where only S. *audubonii* was found (Hall and Kelson 1959:261, 267). These two species could have been readily separated on the basis of tibiofibular length, but identification was deemed unnecessary for this report.

Rock squirrels were third in abundance and in frequency of occurrence. This species occurred in all study areas but was

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Table 1. Summary of mammal remains found in 41 golden eagle nests from five regions of New Mexico and western Texas.

Species	Western (3)[a]			Terrell (10)			Sierra Vieja (2)			Guadalupe (19)			Capitan (7)			Total (41)			
	It[b]	An[c]	Percent[d]	It	An	Percent	It	An	Percent	It	An	Percent	It	An	Percent	Fr[e]	It	An	Percent
Lepus californicus	656	80	47.3	601	70	37.4	260	43	79.6	1,756	176	52.4	1,176	118	59.0	38	4,449	487	51.6
Sylvilagus spp.	191	18	10.7	119	15	8.0	56	8	14.8	420	78	23.2	276	47	23.5	33	1,062	166	17.6
Spermophilus variegatus	89	10	5.9	334	64	34.2			–	49	16	4.8	49	11	5.5	24	518	101	10.7
Cynomys ludovicianus			–			–	3	1	1.9	68	24	7.1	32	9	4.5	15	103	34	3.6
Cynomys gunnisoni	261	54	40.0			–			–			–			–	2	261	54	5.4
Sheep and goat	8	2	1.2	221	26	13.9	1	1	1.9	166	28	8.3	40	9	4.5	29	436	66	7.0
Bassariscus astutus	3	1	0.6	31	4	2.1	2	1	1.9	30	5	1.5	11	2	1.0	10	77	13	1.4
Odocoileus spp.			–	3	2	1.1			–	1	1	0.3	3	1	0.5	4	7	4	0.4
Sciurus niger			–	13	4	2.1			–			–			–	1	13	4	0.4
Neotoma spp.			–			–			–	3	2	0.6	1	1	0.5	3	4	3	0.3
Peromyscus sp.	1	1	0.6			–			–	1	1	0.3	1	1	0.5	3	3	3	0.3
Conepatus mesoleucus			–			–			–	4	2	0.6			–	2	4	2	0.2
Eutamias spp.	30	1	0.6			–			–			–			–	1	30	1	0.1
Procyon lotor			–	4	1	0.5			–			–			–	1	4	1	0.1
Vulpes macrotis			–	3	1	0.5			–			–			–	1	3	1	0.1
Erethizon dorsatum			–			–			–	2	1	0.3			–	1	2	1	0.1
Ammospermophilus interpres			–			–			–	1	1	0.3			–	1	1	1	0.1
Cratogeomys castanops			–			–			–	1	1	0.3			–	1	1	1	0.1
Urocyon cineroargenteus	1	1	0.6			–			–			–			–	1	1	1	0.1
Mephitis mephitis			–			–			–			–	1	1	0.5	1	1	1	0.1
Taxidea taxus	1	1	0.6			–			–			–			–	1	1	1	0.1

[a] Numbers in parentheses are number of nests examined.
[b] The number of identified disarticulated items.
[c] The minimum number of animals represented.
[d] The percentage of species composition.
[e] The frequency of the number of nests in which a taxon was found.

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Table 2. A comparison of food items of 29 nests that contained sheep and goat remains, with 12 nests without sheep and goat remains.

Species	With Sheep and Goat Remains			Without Sheep and Goat Remains		
	Number of Items	Number of Animals	Percent of Animals	Number of Items	Number of Animals	Percent of Animals
Lepus californicus	3,365	355	48.1	1,084	132	63.5
Sylvilagus spp.	833	131	17.8	229	35	16.8
Spermophilus variegatus	491	96	13.0	27	5	2.4
Cynomys spp.	185	60	8.1	179	28	13.5
Sheep and goats	436	66	8.9	—	—	—
Other mammal remains	101	30	4.1	50	8	3.8

not recovered from nests in the Sierra Vieja district. Presumably, this was a result of the small sample size (two nests). Blair and Miller (1949), and our observations, suggested that rock squirrels were moderately common in the region.

Nine percent of the animals were represented by bones of one or the other of two species of prairie dog. *Cynomys gunnisoni* was found only in the western area, whereas the remaining study areas were within the range of *C. ludovicianus*. Although Davis (1966) cited at least a marginal record of the prairie dog from Terrell County, Texas, persons interviewed by us knew of no town in the vicinity of the nests in that area. This suggested that the absence of prairie dog remains in the nests examined may have resulted from a lack of availability of prairie dogs rather than from choice of the predator. This premise is substantiated by observations in other areas, where prairie dog remains occurred in nests, although prairie dog populations in the area were unknown or were found no closer than 10 miles from the nests.

In each of the study areas, some combination of the above species constituted the vast majority of the animals represented (Table 1), even though jack rabbits were most prevalent in nests in all of the areas. The percentages of each species, including jack rabbits, fluctuated in nests between study areas. Although we lacked censuses of prey populations in the study areas, these data nonetheless suggested effects of buffering among prey species in different areas. Carnie (1954) and Beecham (1970) reported similar observations. The results of our studies did not depart significantly from those of Gloyd (1925), Woodgerd (1952), Arnold (1954), and McGahan (1968), when the differences produced by buffer species between the various geographic areas were considered.

An effort to determine the possible effect of buffering by sheep and goats on natural prey populations was undertaken. Nests were separated into two groups, those with sheep and goat remains and those without (Table 2). These data suggested that jack rabbit populations were being buffered, but the interspecific effect of rock squirrel and sheep and goat was inconclusive.

From an analysis of the number and kinds of bony remains in the nests, some inferences on the feeding behavior of the golden eagle on key prey species may be made. By dividing the minimum number of animals into the total number of identifiable disarticulated items of each species (Table 1), a mean number of items recovered per individual was derived. For each species the figures are jack rabbit, 9.1 items; combined cottontails, 6.4; rock squirrel, 5.1; and combined prairie dogs, 4.1.

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Table 3. Number of bones of each type of four prey species found in 29 golden eagle nests.

BONE TYPES	JACK-RABBIT	COTTON-TAIL	ROCK SQUIRREL	PRAIRIE DOG
CRANIA				
Entire	20	11	81	72
Broken	54(121)[a]	18(45)	11(98)	1(80)
Maxillae/2	47	16	6	7
DENTARIES	154	82	76	115
RADII OR ULNAE, OR BOTH	297	34	13	6
HUMERI	332	24	32	7
SCAPULAE	117	12	9	4
SACRA	151	40	13	5
INNOMINATES	506	106	45	22
TIBIAE OR FIBULAE, OR BOTH	755	207	35	20
FEMURS	458	156	37	13

[a] Numbers in parentheses are the total crania and are the summation of entire, broken, and partial crania (maxillae/2).

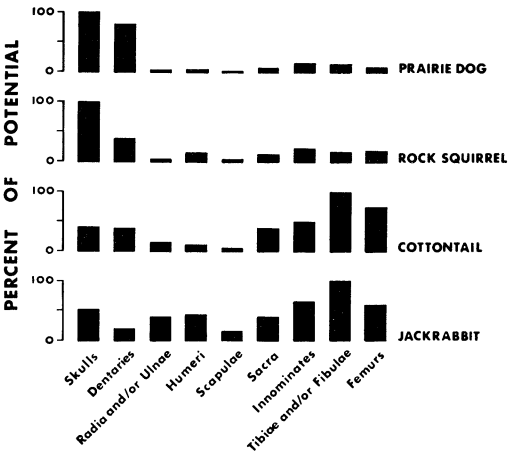

Fig. 2. Distribution of bone types of four prey species in 29 golden eagle nests expressed as a percentage of the element representing the greatest number of animals. Elements less than 100 percent are presumed, in part, to have been eaten.

These data showed that, per animal, twice as many jack rabbit bones remained in nests as bones of prairie dogs. These figures further suggested that a greater percentage of each animal representing smaller species was eaten than was eaten of the larger animals.

A survey of the kinds of bones left in the nest was made. To reduce sources of error attendant with small samples, only 29 nests having a combination of rabbits, rock squirrels, or prairie dogs that totaled at least five animals were utilized. Among rabbits, hindquarters (innominate, tibia–fibula, femur) were clearly the prevalent remains; in rock squirrels and prairie dogs, elements of the skull (cranium, dentary) were dominant (Table 3).

A more precise demonstration of the differential utilization of the prey species was made. Percentages were calculated (Fig. 2) after considering which of the elements occur one per animal (cranium, sacrum) and which occur two per animal (the remainder), and considering which elements potentially represent the greatest number of animals (jack rabbits, 755 tibiae–fibulae; cottontails, 207 tibiae–fibulae; rock squirrels, 98 crania; prairie dogs, 80 crania). These figures represent, respectively, the expected values (100 percent) for the other bone categories in each species. Marked similarities existed in the occurrence of bone types between jack rabbits and cottontails and between rock squirrels and prairie dogs. We do not infer that common bone types had not been partially eaten or stripped, but we do suggest that the majority of the bones poorly represented were probably consumed. This includes jack rabbit scapulae; cottontail scapulae, humeri, and radio-ulnae; and all of rock squirrels and prairie dogs except cranial elements. These items, having in common a size less than 70 mm in length, could have been swallowed. Or, they could have easily filtered through, been blown or bumped from the nests, or simply overlooked because of their small

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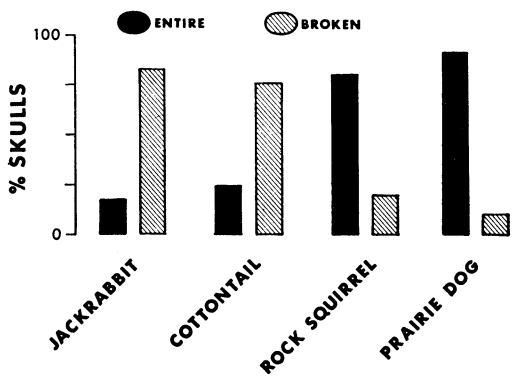

Fig. 3. A comparison of the occurrence of entire versus broken skulls of four prey species found in 29 golden eagle nests. Numbers of skulls in samples are jackrabbit, 121; cottontail, 45; rock squirrel, 98; and prairie dog, 80.

size. However, in most cases, the bony remains were found at the back of the nest toward the cliff face and would not have been likely to fall. Overlooking small food items is a valid source of bias, but careful attempts were made to avoid this.

Differences in the utilization of the content of skulls of different species are seen in a comparison of whole versus partial crania (Fig. 3). Crania were separated into two categories: (1) entire—rostrum, braincase, and maxillae intact; and (2) broken—some element of the cranium missing. As shown in Fig. 3, broken skulls were the rule among rabbit prey (at least 75 percent); the opposite trend was seen in rock squirrels and prairie dogs (less than 20 percent). Despite being larger, rabbit skulls are not as heavily constructed as those of rock squirrels and prairie dogs. Furthermore, because of their larger size, rabbit skulls would be more rewarding to an eagle than skulls of prairie dogs and rock squirrels.

Sheep and Goats

Most ungulate remains were of sheep and goats. However, bone fragments of young deer (*Odocoileus* spp.), antelope (*Antilocapra americana*), sheep, and goats are somewhat similar so that, based on isolated skeletal elements, a small portion (less than six elements) of large herbivore remains were not satisfactorily separated.

Of 41 nests, 29 (70 percent) were found to contain the remains of domestic sheep and goats (Table 1). Based on tooth eruption, relative ossification, and size of bones, two age-groups were established. Bones of young animals are typically cancellous. Elements most commonly preserved of this group, however, were the mandibles. Seldom were the front teeth fully erupted. Fifty-one (77 percent) of the sheep and goats were judged as young. The remainder were designated as adults.

In the Terrell region, all but two of the nests had some remains of sheep and goats. One nest had at least 14 individuals (11 young, 3 adults). The same nest produced an ear tag from a yearling sheep that apparently came from a neighboring ranch, because Roden had only goats. The Sierra Vieja had one nest with sheep or goat remains. These remains must also have been transported some distance, because Miller raised neither sheep nor goats. The Guadalupe district had 15 to 19 nests with some trace of livestock remains. The number of these animals per nest varied from one to five. Three nests on the Treat Ranch in the Capitan region contained sheep and goat bones, as did one of four nests on the Pfingston land. No sheep or goats were then known near the Pfingston nests. Neither of the nests on the Hubbell Ranch in the Western Area revealed any livestock bones, but this may be a result of a small sample size. Sheep and goat remains were found in the nest at the Narrows. No history of this nest or livestock in the area is known to us.

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Other Mammal Remains

Among this group, only the remains of the ringtail (*Bassariscus astutus*) appeared with any regularity. Other mammal species that were uncommon or not previously reported as food for eagles were hog-nosed skunk (*Conepatus mesoleucus*), kit fox (*Vulpes macrotis*), gray fox (*Urocyon cinereoargenteus*), badger (*Taxidea taxus*), yellow-faced pocket gopher (*Pappogeomys castanops*), and Texas antelope squirrel (*Ammospermophilus interpres*).

Bird and Reptile Remains

The bones and feathers of at least 40 individual birds were found. Of these, 14 eagles and one red-shafted flicker (*Colaptes cafer*) were identified. Reptile remains included one horned lizard (*Phrynosoma* spp.) and five snakes. Remains of a coachwhip (*Masticophis flagellum*), a bullsnake (*Pituophis melanoleucus*), and a rattlesnake (*Crotalus* sp.) could be distinguished.

DISCUSSION

Three species of lagomorphs appear to be the principal food items (Table 1), with rock squirrels and prairie dogs forming a highly variable, lesser portion of the diet. Despite the differences we assign to buffering effects, our estimates of the utilization of key prey species are in general accord with studies elsewhere. Most other methods of sampling food habits, including nest, stomach, and feces analyses, as well as field observations, appear to yield results that differ largely only in detail.

The percentages of recovered bones of rock squirrels and prairie dogs are generally less than the percentages of the same kind of bones of rabbits. This suggests a greater percentage of bones of individual rock squirrels and prairie dogs eaten than of rabbits. However, data reveal that rabbit skulls or contents, or both, are preferred over smaller, more compact rodent skulls.

Sheep and goat remains were commonly found in eagle nests. We are satisfied (1) that domestic stock in the areas studied do form a part of the eagle diet, (2) that the occurrence of bones of livestock in most of the nests suggests interest in sheep and goats by certain eagles, and (3) that the large accumulation of livestock bones in two nests represents at least two pairs of eagles actively interested in sheep and goats. It is impossible to determine from nest materials whether livestock remains were brought to the nest as carrion or as fresh-kills. Arnold (1954), reviewing other works, suggested that eagles eat livestock both as carrion and as fresh-kills. Although in many cases it cannot be established that an eagle seen feeding on a dead lamb or kid had not killed his prey earlier or that it had not been killed by some other predator, Spofford (1965) and Wiley and Bolen (1971) documented instances where dead lambs were erroneously reported as killed by eagles.

With particular regard to the nest data, there are limitations and possible sources of error of varying importance that merit consideration. Only one of 41 nests was utilized for raising young during the period of this study. The remainder had histories of last use ranging from the previous year to no use in the past 12 years. Age of a nest affects composition because of destruction and decomposition. Some nests might be older than 15 years and therefore not reflect current food habits.

Nest samples show only food materials brought to the nest (probably intended for the young) and do not necessarily indicate what the adult birds may be eating elsewhere. Because food habits vary seasonally, nest samples do not measure food items taken by fledged and adult birds through-

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out the greater part of the year. Sheep and goat raisers reported much depredation by golden eagles during the lambing and kidding season, when young are most vulnerable. Depending on latitude, lambing and kidding may occur from December to late May. Although the periods of eagle nesting and lambing and kidding may overlap, it is at a time when eaglets are small and require less food. Instead, lambs and kids may serve as food for wintering eagle populations at the time when populations of other prey species may be very low. In any event, wintering birds usually do not leave evidence of their food habits conveniently in one place, such as in a nest, for analysis by an investigator.

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