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Productivity, food habits, and associated variables of Barn Owls utilizing nest boxes in north central Utah

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PRODUCTIVITY, FOOD HABITS, AND ASSOCIATED VARIABLES OF BARN OWLS UTILIZING NEST BOXES IN NORTH CENTRAL UTAH

Sandra J. Looman1, Dennis L. Shirkey2, and Clayton M. White3

Abstract.—Productivity and food habits of the Barn Owl (Tyto alba) utilizing nest boxes in Juab, Utah, and Salt Lake counties, Utah, during 1979–1984 were examined. Average clutch size was 5.8 eggs for the 6-yr period; mean number fledged was 3.9 young per successful nest. While severe weather during the 1981–82 winter did not result in a significant decrease in productivity during the 1982 breeding season, it may have resulted in a significant overproduction of female young. Barn Owls in north central Utah fed almost exclusively on mammalian species, particularly Microtus spp. Differences in clutch size between areas and years may be a response to availability as well as abundance of prey.

Key words: Barn Owl food, Barn Owl reproduction, nest boxes, Utah, Tyto alba.

The Barn Owl (Tyto alba) is a nearly cosmopolitan species that uses diverse nest sites, including man-made ones (Vouus 1988). Although Barn Owls were reported in Utah as early as 1899 (Smith and Marti 1976), they were considered uncommon and rare breeders prior to 1976 (Smith and Marti 1976). The first Barn Owl nesting record was reported by Behle (1941) near Kanab in Kane County. Woodbury et al. (1949) proposed that Barn Owls were probably residents and widely distributed in valleys and lower elevations throughout the state. Smith et al. (1972, 1974) and Smith and Marti (1976) presented information on Barn Owl food habits, nesting ecology, and distribution throughout the state. While these studies indicated prey was abundant in irrigated agricultural areas, nesting sites were not adequate in those areas to allow growth of the population (Marti et al. 1979).

Marti et al. (1979) installed 8 nest boxes in abandoned concrete silos in north central Utah during 1977 and an additional 22 in 1978 in an effort to increase numbers of nesting Barn Owls. Of those boxes, 50% were used by breeding owls in 1977 and 80% in 1978. A total of 154 young fledged from nest boxes during the 2 yr.

In 1979 a similar program of installing nest boxes in silos was adopted in central Utah by the Utah Division of Wildlife Resources (UDWR). Between 1979 and 1984, 41 nest boxes were installed in Juab, Utah, and Salt Lake counties. An ongoing investigation of Barn Owl population and feeding habits was undertaken in 1979. Herein we document reproductive activities, dispersal, survival, and food habits of Barn Owls utilizing these nest boxes from 1979 to 1984.

Study Area

This study was conducted on the 15- to 25-km-wide strip of farmland and suburban area between the Wasatch Mountains on the east and Utah Lake on the west. The climate is arid, characterized by hot, dry summers, cold winters, and cool, wet springs. Precipitation averages 40 cm annually, falling mainly as winter snow. Extensive agricultural irrigation and the presence of a large freshwater lake have created broad areas of habitat, especially for voles (Microtus spp.), a major Barn Owl prey. Trees occur sporadically along rivers and irrigation canals and on farmsteads.

Preliminary surveys by UDWR in 1979 revealed that 50 silos were used for roosts by Barn Owls, as indicated by presence of regurgitated pellets, fecal stain, and/or presence of owls. Silos were in rural or semirural areas throughout the counties and generally close to corn or alfalfa fields; a few were located in suburban areas within 2 km of an agricultural area (dairy or cattle ranch). Silos not used by farmers provided roosting owls protection from

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predation and disturbance; however, none provided adequate nest sites. Most barns and other structures in the area also lacked adequate nesting sites.

Forty-one wooden nest boxes were built, after Marti et al. (1979), and installed between 1979 and 1984 (18 installed in 1979, 6 in 1980, 5 in 1981, 9 in 1982, and 1 each in 1983 and 1984). Three nest cavities (2 in silos and 1 in a school building) were discovered and monitored during these years; data from these sites are included herein.

METHODS

All nest boxes were examined at least once monthly throughout the year to determine presence of adult owls or fresh regurgitated pellets. Behavior of adults was recorded on all visits, and adults were caught and banded if possible. Pellets were collected during each visit. Presence of cached food and prey remains inside boxes and on silo floors was noted.

Sites where nesting occurred were visited approximately every 2 wk throughout the breeding season, January–August, in 1979–1981 and 1984. During 1982 and 1983, a study to develop a sexing technique (Looman 1985) was started, and therefore we increased our efforts and visited active nest boxes more frequently (usually once a week) throughout most of the breeding season (May–August) during these years. Nests were considered active if an adult owl was observed in the nestbox or signs of recent occupation were evident (i.e., eggs, eggshells, fresh pellets in nestbox, nestlings). Onset of egg laying was determined by direct observation or by backdating from known-age nestlings or date of fledging. For backdating, we used 30 d as an incubation period (Smith et al. 1974, Marti 1992), with 2 d between individual eggs (Bunn et al. 1982). Clutch size and productivity (fledgling number) data were determined by direct observation.

Behavior of adults and nestlings was recorded at each visit. All young were banded when approximately 5–6 wk old, and during 1982 and 1983 each young was weighed at fledging (approximately 8 wk) and sexed according to the sexing method described by Looman (1985). While pellets collected during a 5-yr period (1979–1983) were available for food habit assessment, only pellets collected in 1982 and 1983 were separated into 4 time groupings, each representing a seasonal period of Barn Owl activity and roughly corresponding with 1 of the 4 seasons. The spring period (March–May) corresponded with early reproductive activities, summer (June–August) with adult attentiveness to fledgling but still dependent young. The autumn period (September–November) included abandonment and subsequent dispersal of most young, and winter (December–February) corresponded with the period that remaining owls moved into well-protected residential structures.

Pellet analysis followed Marti (1974). Vertebrate prey remains were identified by comparison with mammal (see Durrant 1952) and bird specimens at M. L. Bean Museum, Brigham Young University. Prey weights for estimation of biomass were means obtained from these specimens and from reported weight estimates (Marti 1974, Steenhof 1983). Estimated age of prey for use in biomass calculations was based on cranial features (ossification of sutures and auditory bullae and tooth eruption and wear).

Diversity of Barn Owl diet was determined using the multivariate statistical package MVSP (Kovach 1987). To allow comparisons with other published diversity indices of Barn Owl diet, diversity indices were calculated using the modified Shannon-Weiner diversity index formula

$$H = -\sum_{i=1}^{s} (p_i) \log p_i,$$

where \(s\) is the number of species and \(p_i\) is the proportion of the number of individuals in the \(i\)th species. Species evenness (\(E = H/\log s\); Magurran 1988) was also calculated.

RESULTS

Breeding Chronology

Dates of onset of egg laying range from early January (date obtained by backdating) through early August, with 36% commencing egg laying during the first half of March and 25% beginning in late February (Fig. 1). The earliest date on which eggs were observed in a box was February 12, the latest September 14 (eggs and nestlings observed).

Length of the nesting season for this population, defined as the period from deposition of first egg to fledging of last young, averaged 6.6 mon for the 5-yr period (range 4.0 mon in
ONSET OF EGGLAYING 1979-1983

NESTS
9-1979 n = 7
0-1980 n = 16
1-1981 n = 20
2-1982 n = 19
3-1983 n = 23

Fig. 1. Dates of first egg laying by Barn Owls in north central Utah, 1979-1983.

1979 to 9.8 mon in 1983). This is long compared to 5.3 mon in south Texas (Otteni et al. 1972) and in Utah (Smith and Marti 1976) during 1974 and 1975; no late autumn nests were found, however, as have been previously found in Utah (Smith et al. 1970). Individual nesting cycles, from deposition of first egg to fledging of last young in the nest, were approximately 3.3 (3.25 ± 0.2, n = 10) mon in length.

Where egg deposition intervals were known, the interval was 2 d between eggs (2.1 ± 3, n = 10); this is similar to deposition data (2.3 d) found for Barn Owls in Springville during 1973 (Smith et al. 1974). Known incubation times averaged 32.3 d (±3 d, n = 10). Fledging occurred at 62 d (±4 d), and young remained in the area until approximately 13 wk of age. Similar incubation and fledging times are reported for Barn Owls elsewhere (Pickwell 1948, Reese 1972, Smith et al. 1974).

Nests

Owls made no attempt at nest construction. However, prenesting behavior of adults, in which they spent a great deal of time at the nest site, resulted in a layer of broken down pellets, incidental feathers, and fecal material which produced a soft bed for eggs. Eggs were laid in a shallow area in the middle.

Productivity

Four hundred twenty-eight young were fledged from 104 (106 including 2nd broods) nest boxes over a 6-yr period (Table 1), averaging 3.9 young/box with a nest failure rate of 16.6%. Productivity ranged from 0.8 young fledged/box (2.0 young/active box) and a failure rate of 25% in 1979, to 4.37 young fledged/box (5.4 young/active box) and a failure rate of 9.1% in 1981.

Mean clutch size for the 5-yr period was 5.8 eggs/clutch (±1.72) and ranged from 5.3 (1979, 1983) to 6.5 (1981) (Table 2). Modal clutch size was 7 (22%); modal brood size was 7 (21%) (Table 3). Clutch size in 19 nests in 1982 ranged from 2 to 10 eggs and averaged 5.8 (±2.0); broods in these nests ranged from 2 to 7 and averaged 4.0 (±1.9) young hatched/nest. Thirty-one percent of eggs failed to hatch, and nestling mortality was approximately 8%. Productivity in 16 nests where young successfully fledged averaged 4.4 (±1.4); however, productivity fell to 3.7 (±2.1) young fledged/total nesting attempt.

Clutch size in 23 nests in 1983 ranged from 3 to 9 and averaged 5.3 (±1.8) (Table 2). Brood number ranged from 2 to 8 and averaged 3.95 (±2.1) young hatched/nest. Twenty-five percent of the eggs failed to hatch, and nestling
Table 1. Productivity of Barn Owls using artificial nest boxes in Juab, Utah, and Salt Lake counties, Utah, 1979-1984.

<table>
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<tbody>
<tr>
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<td>25</td>
<td>27</td>
<td>29</td>
<td>28</td>
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<td>3.44</td>
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<tr>
<td># boxes used as nests</td>
<td>8</td>
<td>16</td>
<td>22</td>
<td>19</td>
<td>23</td>
<td>17</td>
<td>108</td>
<td>17.5</td>
<td>5.39</td>
</tr>
<tr>
<td># fledged</td>
<td>16</td>
<td>63</td>
<td>71</td>
<td>80</td>
<td>80</td>
<td>428</td>
<td>713.1</td>
<td>33.04</td>
<td></td>
</tr>
<tr>
<td># fledged/box (x)</td>
<td>0.8</td>
<td>2.5</td>
<td>4.4</td>
<td>2.3</td>
<td>2.9</td>
<td>2.8</td>
<td>2.6</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td># fledged/used box (x)</td>
<td>2.0</td>
<td>3.9</td>
<td>5.4</td>
<td>3.7</td>
<td>3.5</td>
<td>4.7</td>
<td>4.0</td>
<td>1.16</td>
<td></td>
</tr>
<tr>
<td>% unsuccessful boxes</td>
<td>25</td>
<td>25</td>
<td>9.1</td>
<td>15.8</td>
<td>13.0</td>
<td>11.8</td>
<td>15.8</td>
<td>7.25</td>
<td></td>
</tr>
</tbody>
</table>

*Single nests at which 2nd broods occurred are counted twice.*

Mortality was 12.5%. Nests that successfully fledged young averaged 4.0 (±1.8) fledglings, but net productivity for total attempt was 3.5 (±2.2).

Lower clutch sizes (2, 3, 4 eggs/clutch) had a relatively higher percent success than larger clutches (>4 eggs/clutch); however, clutch sizes of 8 produced the highest number of fledglings (x = 5.3 ± 3.8, n = 3). Clutches with 5 (n = 8) and 10 (n = 1) eggs were least productive, with approximately 50% hatching and fledging success. Seven-egg clutches were among the more productive clutch sizes, fledging an average of 5 young (±2.3), with 82% hatching success and 71% fledging success.

Three instances of 2nd broods occurred (Table 1). One female (1982) produced 7 fledglings from 1 silo and then from another silo located approximately 200 m away produced 4 fledglings from a 2nd clutch. The "alternate" nest site was consistently used for roosting throughout the previous winter and spring by a male and during the latter part of the first nesting period by the nesting pair. Since only the female of the nesting pair was banded, it is not known whether the male using the "alternate site" during winter and spring was a member of the nesting pair, or whether the same male fathered both clutches. The 2nd and 3rd instances of 2nd brood occurred in 1983. Each female produced both clutches in the same box.

Of 19 Barn Owl nesting attempts in 1982 with known outcome, 3 failed to fledge young (15.8% failure); in 1983, 3 of 23 nests failed to fledge young (13.0% failure). Nest failures were believed to have occurred during incubation or shortly after eggs hatched, judging from the lack of accumulation of fecal matter and fresh pellets. Reasons for most nest failures are unknown, but 1 case of failure was due to human disturbance (use of silo for silage storage). Other probable causes were loss of 1 or more parents or desertion, particularly in 1983, when clutches were abandoned after a long, cool, wet period following egg laying.

Although reasons for all brood reductions are unknown, some may be attributable to human disturbance, particularly where there was evidence of human activity at silos. Fratricide may have accounted for at least 2 brood reductions, where remains of young were in the nestbox or in pellets. Two reductions were investigator related and occurred when nestlings fell from the nestbox after the adult female flushed.

**Sex Ratios**

Of 65 fledglings sexed in 1982, 26 were males and 39 females; this is a significant overproduction of females (x^2 = 2.6, 0.5 < P < 0.10; df = 1). However, the number of males and females produced during 1983 (of 49 fledglings sexed: 26 females, 23 males) was not significantly different from the expected 1:1 ratio.

**Dispersal**

Thirty-five juveniles banded in the study area between 1979 and 1983 were recovered. Of these, 61% were within 25 km of their natal site, 12% within 50 km, and the remainder within 350 km. Most recovered juveniles (54%) dispersing more than 25 km tended to fly northwest, with most live returns found occupying nestboxes in northern Utah. Twenty-three percent dispersed to the southwest.

Eleven (31%) recovered owls were less than 6 mon old; these were mostly within 1 km of the natal site and probably died while dispersing. Nineteen (54%) were approximately 1 yr old when recovered, 3 (9%) were recovered approximately 2 yr after banding, and 2 birds were 3 yr old when recovered alive. One was captured as a breeding bird at her natal site 3 yr in a row.
TABLE 2. Clutch sizes (%) of yearly total) of Barn Owls in Juab, Utah, and Salt Lake counties, Utah, 1979-1983.

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<td>0 0</td>
<td>0 0</td>
<td>1 (5)</td>
<td>1 (5)</td>
<td>2 (2)</td>
</tr>
<tr>
<td></td>
<td>3 0</td>
<td>0 1 (6)</td>
<td>0 1 (5)</td>
<td>1 (5)</td>
<td>5 (22)</td>
<td>7 (8)</td>
</tr>
<tr>
<td></td>
<td>4 2 (28.6)</td>
<td>2 (10)</td>
<td>3 (16)</td>
<td>3 (16)</td>
<td>4 (17)</td>
<td>12 (14)</td>
</tr>
<tr>
<td></td>
<td>5 2 (28.6)</td>
<td>3 (19)</td>
<td>1 (5)</td>
<td>4 (21)</td>
<td>4 (17)</td>
<td>14 (16)</td>
</tr>
<tr>
<td></td>
<td>6 2 (28.6)</td>
<td>5 (31)</td>
<td>4 (20)</td>
<td>2 (10)</td>
<td>4 (17)</td>
<td>17 (20)</td>
</tr>
<tr>
<td></td>
<td>7 1 (14)</td>
<td>5 (31)</td>
<td>5 (25)</td>
<td>5 (20)</td>
<td>3 (13)</td>
<td>19 (22)</td>
</tr>
<tr>
<td></td>
<td>8 0</td>
<td>0 1 (6)</td>
<td>7 (35)</td>
<td>1 (5)</td>
<td>1 (4)</td>
<td>2 (2)</td>
</tr>
<tr>
<td></td>
<td>9 0</td>
<td>0 0</td>
<td>0 0</td>
<td>1 (5)</td>
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<td>1 (1)</td>
</tr>
<tr>
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<td>0 0</td>
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</table>

Total eggs 37 95 130 111 121 494
Mean (s) 5.3 (1.13) 5.9 (1.29) 6.5 (1.67) 5.8 (2.03) 5.3 (1.81) 5.8 (1.72)

Mortality

Collision with automobiles, shooting, accidents, and severe winter weather coupled with food shortage have been cited as causes of mortality of adult Barn Owls (Henny 1969, Fleay 1972, Smith and Marti 1976). At least 12 road-kills were seen during summer and autumn 1982 in the study area, and accidental deaths occur frequently, particularly with dispersing juveniles (Smith and Marti 1976). Of 9 known accidental deaths of fledglings in 1982 and 7 in 1983, most were due to collisions with cars.

During the winter of 1981-82, at least 55 dead Barn Owls were found in north central Utah. During this same period, Marti and Wagner (1985) reported 77 dead Barn Owls in northern Utah. These birds were emaciated and death was attributed to starvation resulting from cold weather and deep snow. During the period most deaths occurred, mean temperatures were -9.7°C, 2.4°C below normal. Snow cover was estimated at 20-25 cm, and this likely interfered with capture of Microtus spp., the Barn Owl’s main prey.

Additional Observations

Adults and fledglings were not color marked; however, on 1 occasion, a banded fledgling from 1 silo was found among a same-age brood in a nearby (ca 0.75 km) silo. The fledgling was 9 wk old and was present at the nearby silo on 2 different occasions. Activity at the silo was monitored the night of the discovery; and the “foster” fledgling was observed accepting food brought by the adults. No territorial behavior was noted by adults or fledglings on this occasion. The only occurrence of territorial behavior noted during the 1982-83 period was aggressive behavior by a female Barn Owl nesting in a silo in Lehi toward an American Kestrel (Falco sparverius) nestling in a nearby building.

Pellet and Prey Analysis

A total of 2179 individual prey items were identified from 888 pellets and pellet fragments gathered from silo floors. An additional 44 prey items were identified from remains on silo floors (Table 4). At least 16 mammal species (94% of total prey), 11 bird species (4.8%), and 4 insect groups (0.5%) were identified. By individuals, Microtus spp. (ca 77%) and Peromyscus spp. (ca 7%) accounted for over 84% of total prey. Other important mammalian species included the western harvest mouse (Reithrodontomys megalotis), house mouse (Mus musculus), and pocket gopher (Thomomys spp.), although none constituted over 3% on an annual basis. The European Starling (Sturnus vulgaris) and Yellow-headed Blackbird (Xanthocephalus xanthocephalus) were the most frequently taken birds, each comprising 1% of the total prey.

Percent frequency of each class of food identified was strongly correlated with percentage biomass of the same class of food. Mammals (over 94% by number) made over 92% by biomass, while birds (over 4% by number) made over 7% by biomass. Microtus spp. made up a large proportion (73%) of the biomass, with M. montanus alone accounting for 38% of the biomass consumed (Table 5).

Seasonal comparisons of prey (Appendix 1) indicate that changes in relative abundance of prey items occurred during the study. Some
Table 3. Number of nestlings (% yearly total) fledged from artificial nest boxes in Juab, Utah, and Salt Lake counties, 1979–1984.

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<tr>
<td># fledged (%)</td>
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<tr>
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<td>0</td>
<td>1 (5)</td>
<td>1 (7)</td>
<td>3 (3)</td>
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</table>

Mean (s) 2.7 (1.4) 5.3 (1.8) 5.9 (1.6) 4.4 (1.5) 4.0 (1.8) 5.3 (2.0) 4.8 (1.9)

aCounts 2nd clutches in single nests twice.

changes appeared to be seasonal, while others may be of a long-term nature. While Microtus was the heaviest used group throughout the collecting period, it was used much more frequently during winter and spring. Peromyscus spp. and Thomomys spp. were more frequent in pellets collected during summer and autumn months. Sorex spp. were present in pellets during autumn, winter, and spring but not summer.

Birds were used throughout the year but were least represented during summer. No single bird species was represented in pellets from all 4 seasons; however, the European Starling, House Sparrow (Passer domesticus), and Red-winged Blackbird (Agelaius phoenicus) were represented in 3 seasons.

Analysis of prey diversity (Table 5) gives further characterization of the Barn Owl prey base. Prey species diversity of Barn Owls in north central Utah was 2.96; maximum diversity possible was 3.434. While this shows some variation and an ability to take locally abundant prey species, it indicates a degree of singular specialization on Microtus spp. Diversity of north central Utah Barn Owl's food habits is roughly similar to recorded values observed in other areas in North America and Europe (Selleck and Glading 1943, Hawbecker 1945, Evans and Emlen 1947, Utten­dorfer 1952, Glue 1974, Marti 1974), but it is higher than values reported from the same area in 1976 (Smith and Marti 1976; Table 5). Evenness, the actual diversity of prey base as a percentage of maximum diversity possible, was 59%; this indicates Barn Owls were not sampling possible prey evenly, but rather were taking a higher percentage of more common species.

Food Brought to Nest

Food stockpiles were found at most nests during the incubation period. Stockpiling began slightly before deposition of the first egg and continued throughout the hatching period. Initial stockpiles were small, 2–5 prey items, but stockpile sizes increased as the season progressed. The largest stockpile consisted of 23 microtines, 3 starlings, and 16 Yellow-headed Blackbirds. Wallace (1948) reported a stockpile of 190 mammals, primarily rodents.

At least 9 prey species were recorded: 53% microtines, 28% Yellow-headed Blackbirds, 6% starlings, and 3% each of Red-winged Blackbirds and deer mice. Other species were the Brown-headed Cowbird (Molothrus ater, 1.5%), Black-billed Magpie (Pica pica, 1.5%), vagrant shrew (Sorex vagrans, 1%), and Norway rat (Rattus norvegicus, 1%).

Discussion

Breeding and Productivity

It appears that variability of clutch size in Barn Owls is more closely related to factors other than latitude. The 5-yr mean clutch size (5.8 eggs/clutch) for north central Utah (Lat. 39°–40°N) reported herein was much higher than average clutch size of 4.2 eggs reported for areas of higher latitude, as well as for a breeding colony studied in the same area in 1973 (Smith et al. 1974); however, this was much lower than the 4-yr mean clutch size of 7.0 eggs reported by Marti and Wagner (1985) for northern Utah Barn Owls (Lat. 41°N). Additionally, there was a wide discrepancy between the modal clutch and brood sizes.
Table 4. Total prey identified for Barn Owls utilizing artificial nest boxes in Juab, Utah, and Salt Lake counties, Utah, 1982-83.

<table>
<thead>
<tr>
<th>Prey species</th>
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<th>Percent total biomass</th>
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<td>8600.0</td>
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<td>35480.0</td>
<td>38.7</td>
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<td>15.4</td>
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</tr>
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<td>Microtus spp.</td>
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<td>10.9</td>
<td>9560.0</td>
<td>10.4</td>
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<td>Mus musculus</td>
<td>31</td>
<td>1.3</td>
<td>969.0</td>
<td>1.1</td>
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<td>9</td>
<td>0.4</td>
<td>2493.0</td>
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<td>102</td>
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<td>2.3</td>
</tr>
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<td>2</td>
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<td>42.0</td>
<td>&lt;1</td>
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<td>1223.0</td>
<td>1.4</td>
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<td>6</td>
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<td>30.0</td>
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<td>177.0</td>
<td>&lt;1</td>
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<td>Rattus norvegicus</td>
<td>5</td>
<td>0.2</td>
<td>1100.0</td>
<td>1.2</td>
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<tr>
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<td>35</td>
<td>1.5</td>
<td>350.0</td>
<td>0.4</td>
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<tr>
<td>Thomomys bottae</td>
<td>50</td>
<td>2.3</td>
<td>4250.0</td>
<td>4.6</td>
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<tr>
<td>Thomomys talpoides</td>
<td>1</td>
<td>tr. 0.1</td>
<td>85.0</td>
<td>&lt;1</td>
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<td>5</td>
<td>0.2</td>
<td>4110.0</td>
<td>4.5</td>
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<td>94.6</td>
<td>86236.0</td>
<td>92.4</td>
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<tr>
<td><strong>Birds</strong></td>
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<td></td>
</tr>
<tr>
<td>Agelaius phoeniceus</td>
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<td>0.4</td>
<td>432.0</td>
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<tr>
<td>Columba livia</td>
<td>1</td>
<td>tr. 0.1</td>
<td>332.0</td>
<td>&lt;1</td>
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<tr>
<td>Icterus galbula</td>
<td>7</td>
<td>0.3</td>
<td>231.0</td>
<td>&lt;1</td>
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<tr>
<td>Molothrus ater</td>
<td>1</td>
<td>tr. 0.1</td>
<td>41.0</td>
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<td>Passer domesticus</td>
<td>8</td>
<td>0.4</td>
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<td>&lt;1</td>
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<tr>
<td>Passeroculus sandwichensis</td>
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<td>0.1</td>
<td>42.0</td>
<td>&lt;1</td>
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<td>Pica pica</td>
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<td>0.1</td>
<td>360.0</td>
<td>&lt;1</td>
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<td>1.0</td>
<td>1817.0</td>
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<td>Turdus migratorius</td>
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<td>Xanthocephalus xanthocephalus</td>
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<td>93273.0</td>
<td>99.9</td>
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<td><strong>Invertebrates</strong></td>
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<td></td>
<td></td>
<td></td>
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<td>Carabidae</td>
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<td>4.0</td>
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<td>Tenebrionidae</td>
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<td>Orthoptera</td>
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<td>6.0</td>
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<td><strong>Total prey individuals</strong></td>
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<td>100.0</td>
<td>93281.0</td>
<td>100.0</td>
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</tbody>
</table>

*tr = trace*

Lack (1949) found mean clutch size of owls to increase with latitude and abundance of rodents. Otteni et al. (1972) found that clutch size for 112 clutches in southern Texas (Lat. 28° N) averaged 4.9 and was identical to average clutch size for 68 Maryland clutches (Lat. 38°–43° N; Henny 1969). A mean clutch size of 5.3 eggs for Barn Owls nesting in Switzerland (Lat. 46°–47° N) was also reported by Henny (1969); Glue (1974) reported an average clutch size of 4.7 in Great Britain (Lat. 50°–55° N).

Lack (1954) suggested the number of eggs laid by each species has been established to correspond with the number of young that can
Table 5. Diversity indices of Barn Owl predation for Utah and other areas.

<table>
<thead>
<tr>
<th>Location</th>
<th># prey items</th>
<th># prey species</th>
<th>Diversity*</th>
<th>Source</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Mammals</td>
<td>Birds</td>
<td></td>
</tr>
<tr>
<td>Utah</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North central</td>
<td>2173</td>
<td>16</td>
<td>11</td>
<td>2.96</td>
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<td>Box Elder Co.</td>
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<td>8</td>
<td>1</td>
<td>2.31</td>
</tr>
<tr>
<td>Utah Co.</td>
<td>3004</td>
<td>12</td>
<td>12</td>
<td>1.45</td>
</tr>
<tr>
<td>California</td>
<td></td>
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<tr>
<td>Southern</td>
<td>933</td>
<td>10</td>
<td>13</td>
<td>2.19</td>
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<tr>
<td>Central</td>
<td>945</td>
<td>20</td>
<td>11</td>
<td>3.10</td>
</tr>
<tr>
<td>Sierras</td>
<td>513</td>
<td>8</td>
<td>0</td>
<td>1.95</td>
</tr>
<tr>
<td>Northern</td>
<td>733</td>
<td>8</td>
<td>6+</td>
<td>2.41</td>
</tr>
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<td>Colorado</td>
<td>4366</td>
<td>6</td>
<td>16</td>
<td>2.76</td>
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<tr>
<td>Idaho</td>
<td>202</td>
<td>9+</td>
<td>1+</td>
<td>1.79</td>
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<td>Michigan</td>
<td>6815</td>
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<td>0.98</td>
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<td>1060</td>
<td>9</td>
<td>5</td>
<td>0.98</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>6165</td>
<td>7</td>
<td>17</td>
<td>1.46</td>
</tr>
<tr>
<td>Texas</td>
<td>2056</td>
<td>6+</td>
<td>10</td>
<td>3.35</td>
</tr>
<tr>
<td>Chile</td>
<td>3417</td>
<td>13+</td>
<td>0</td>
<td>2.82</td>
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<td>England</td>
<td>47865</td>
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<td>17</td>
<td>2.29</td>
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<tr>
<td>Germany</td>
<td>3546</td>
<td>8</td>
<td>0</td>
<td>1.60</td>
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<td>Spain</td>
<td>76694</td>
<td>51</td>
<td>32</td>
<td>2.69</td>
</tr>
<tr>
<td></td>
<td>12351</td>
<td>11+</td>
<td>0</td>
<td>2.11</td>
</tr>
</tbody>
</table>

* Diversity calculated using Shannon-Weiner's diversity index (H): $H = -\sum P_i \log P_i$.

...be successfully raised, and successful rearing is based on the amount of food available and provided to young by adults. Otteni et al. (1972) found that southern Texas Barn Owls seemed to adjust reproductive efforts to rodent population fluctuations. They produced slightly lowered mean clutch size and number of complete clutches during periods of lower rodent prey population sizes and increased the number of young raised/pair during periods of abundant rodent prey populations. Similar findings were reported in Europe by Glue (data from Bunn et al. 1982) and Baudvin (1975), whose studies indicated that variations in fledging success were entirely linked to vole numbers. Marti and Wagner (1985) reported that a winter die-off of northern Utah Barn Owls in 1981–82 resulted in a later egg-laying season, a 40% decline in breeding attempts, and a decline in average clutch size from 7.0 to 5.8 eggs; however, decline in productivity was not paralleled in our study area during this period. These findings indicate that Barn Owl productivity may be closely tied to availability of prey, and that differences between clutch and brood sizes reported herein, and those reported in the same and in different areas of the Barn Owl range are likely correlated with fluctuations in prey populations and weather as they affect prey availability.

Production of 2nd broods by Barn Owls is thought to be triggered by an abundance of prey (Honer 1963). All 3 pairs producing 2nd clutches during this study, 1 in 1982 and 2 in 1983, successfully fledged young from their 1st brood. In these cases, deposition of the 1st egg of the 2nd brood occurred several weeks after the last young of the 1st brood fledged. Second broods are often less successful than 1st broods, since prey numbers decline later in the season when hatchlings still require feeding (Bunn et al. 1982). This was not the case with our observations. All 3 second nests were successful, with 2 nests 100% successful in hatching and fledging, and 1 sustaining 60% mortality of eggs but 100% success in fledging young. Furthermore, the 3 pairs successfully fledged 27 young for the breeding season, an average of 9 young per pair.

Henny (1969) suggested that in northern environments high biotic potential of Barn Owls may serve as a "built-in compensating factor" that affords protection against low years in rodent cycles and allows rapid restoration of Barn Owl populations to previous "good rodent year" size. Second-clutching during
1982 and 1983 may be a response to lowered population numbers resulting from the winter die-off of 1982 and abandoned clutches resulting from cool, wet weather following egg deposition in 1983.

**Food Habits**


Webster (1973) and Wallace (1948) noted that numbers of secondary prey species captured by Barn Owls are inversely proportional to numbers of microtines captured, particularly when Soricidae spp. form the main alternative to Microtinae. Although *Sorex* spp. were utilized frequently by Barn Owls in north central Utah, no inverse relationship could be seen between proportions of *Sorex* spp. and *Microtus* spp. An inverse relationship was noted for proportions of *Alicrotus* spp. and *Peromyscus* spp. *Peromyscus* spp. were clearly the main alternative to *Microtus* spp. In studies where numbers of secondary prey species are inversely proportional to numbers of microtines, the correlation has been linked with relative proportions of woodland and open areas in the owls’ territories (Bunn et al. 1982). Woodlands exist in isolated areas throughout the study area, adjacent to lakes, streams, and foothills, but open field areas are more common. Thus, during summer and autumn, one or both adults may have been foraging more frequently in woodland areas (represented by *Peromyscus* spp.) than in open field areas (represented by *Microtus* spp.). During winter and spring, foraging may have shifted more to open field habitats. Alternatively, increased occurrence or availability of *Peromyscus* spp. resulting from increased reproductive activity during summer and autumn months may account for the shift in diet.

Only a few unusual prey items are noteworthy: predation on a group of striped skunks (*Mephitis mephitis*: 2 adults, 3 juveniles) at a silo in Nephi [C. Marti (personal communication) doubts that the owl would have killed so large an animal, but the evidence found clearly indicated that owls nonetheless fed on skunks]; presence of a stockpiled rock squirrel (*Spermophilus variegatus*) and a sora (*Porzana carolina*); cannibalism indicated by presence of a juvenile Barn Owl skull among loose pellets collected in autumn, as well as the discovery of what looked like a partly consumed juvenile Barn Owl in another nestbox.

Cannibalism has been reported in California (Henny 1969) during years when food supplies were low, and Baudvin (1975) reported cannibalism as the major source of Barn Owl nestling mortality in France. Often during this study, owlets (as well as eggs) seem to have “disappeared” without a trace. These may have been cannibalized, they may have died and been moved to another site, they may have been eaten by an adult or a sibling, or they may have been predated by another species. While asynchronous hatching characteristic of Barn Owls is thought to facilitate cannibalism (O’Connor 1978), care should be taken in ascribing Barn Owl remains in pellets to cannibalism.

**Sex Ratios**

Mendenhall (1983) reported an equal production of sexes in captive Barn Owls at Patuxent Wildlife Research Center, Maryland, but data from the wild are few. The higher proportion of female fledglings observed in north central Utah during 1982 was significant ($\chi^2 = 2.6, P < 0.10; \text{df} = 1$), particularly in view of the high adult winter-kill observed during the severe winter of 1981-82, and the hypothesis of sex-biased brood reduction favoring female offspring during periods of food (or other environmental) stress (Howe 1977, Newton 1979, Bildstein 1981) is supported. While a single season’s deviation from expected unity could well be stochastic, differential production of sexes during environmentally stressful periods has been observed in a number of vertebrate groups (Howe 1977, Bull 1980, Charnov 1982).

Polygynous behavior by Barn Owls (Baudvin 1975, Bunn et al. 1982, Marti 1990) should be considered when addressing the differential sex ratio. Differential sex ratios among polygynous birds are fairly well established (Newton...
1979, Fiala 1981, Charnov 1982). Polygynous species tend to show differential production of sexes more frequently than monogamous species (Lack 1954, Verner 1964, Zimmerman 1966), although hypotheses regarding proximate and ultimate causes vary. Olsen and Cockburn (1991) have shown that raptors frequently have a naturally biased sex allocation toward females. The reasons for such an allocation were not clear although their data did not implicate polygyny. No verified pollygynous behavior was noted during this study; however, the close association between the “foster” fledgling and parents of a separate brood reported herein indicates a possibility of shared parentage, particularly since the foster fledgling’s natal site was so close. Unfortunately, adult males from either silo were never captured for banding, so pairing was unknown. An alternative explanation of the “foster” fledgling behavior is that the dispersing fledgling observed adults leaving and entering the adjacent silo, and in stereotypical behavioral fashion it followed the adults. Once near the nest, normal brood begging would have elicited feeding response from the adults.

Further information on Barn Owl mating behavior and dispersal is needed to elucidate the differential production of females observed during this study. More importantly, documentation of sex ratios, both at birth and fledging, over many years is required to place the observed skewed sex ratio into perspective.

**Addendum:** Since the final editing of this paper a major review of Barn Owls by Marti (1992) appeared. One should consult that paper for recent details relevant to our findings.

**Acknowledgments**

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**Literature Cited**


BARN OWLS IN NORTH CENTRAL UTAH


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(Appendix 1 begins on the following page.)
Appendix 1. Vertebrate food items taken seasonally by Barn Owls in Juab, Utah, and Salt Lake counties, Utah, 1982-83.

<table>
<thead>
<tr>
<th>Season</th>
<th>Spring&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Summer&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Autumn&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Winter&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Total %&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Total %&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Total %&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>MAMMALS</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>191</td>
<td>87</td>
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<td>50</td>
</tr>
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<td>100</td>
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<td>—</td>
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<td>0</td>
</tr>
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<td>Pica pica</td>
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<td>Sturnus vulgaris</td>
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<td>Turdus migratorius</td>
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<td>Xanthocephalus xanthocephalus</td>
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<tr>
<td>Unidentified birds</td>
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<td>—</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Total avian individuals</td>
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<td>—</td>
<td>5</td>
<td>—</td>
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<tr>
<td>Total vertebrate individuals</td>
<td>1140</td>
<td>197</td>
<td>716</td>
<td>160</td>
</tr>
</tbody>
</table>

<sup>a</sup>Total pellets collected: 467, total nests surveyed: 15
<sup>b</sup>Total pellets collected: 61, total nests surveyed: 6
<sup>c</sup>Total pellets collected: 987, total nests surveyed: 11
<sup>d</sup>Total pellets collected: 76, total nests surveyed: 3
<sup>e</sup>Total individuals identified
<sup>f</sup>Frequency of occurrence in nests surveyed