The Condor 87:111-115

WINTER MORTALITY IN COMMON BARN-OWLS AND ITS EFFECT ON POPULATION DENSITY AND REPRODUCTION

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ABSTRACT.—Seventy-seven Common Barn-Owls (*Tyto alba*) were found dead in northern Utah during the winter of 1981–1982. These birds were severely emaciated; they weighed significantly less ($P < 0.001$) than 21 barn-owls killed in the same period by trauma, and 162 live, healthy owls. Apparent cause of death was starvation resulting from very cold weather and extensive deep snow cover. Mean temperatures were 2.4°C below normal when they died. Most detrimental, however, was a severe 2-week period during which the mean daily temperature was −9.7°C. At the same time, snow cover was 20–25 cm deep, interfering with the owls' ability to capture their most important prey (*Microtus* spp.). A 40% decline in breeding attempts occurred in the season following the die-off. Clutch size declined from a mean of 7.0 eggs ($n = 93$ clutches) in four previous years to 5.8 eggs per clutch ($n = 16$) in 1982. Only 1.5 young fledged per nesting attempt in 1982, compared to 4.1 per attempt in the four previous years. A strong recovery in 1983 produced the largest breeding population seen during seven years on the study area. This recovery was attributed to an immigration of owls (unbanded), augmented by the nesting of banded adults who had not attempted to breed in 1982.

Winter-weather mortality has been reported in the Common Barn-Owl (*Tyto alba*) for the United States (Errington 1931, Speirs 1940, Stewart 1952a, Keith 1964) and Europe (Honer 1963, Frylestam 1972). It has not been shown, however, how this mortality might affect population density or reproduction.

We have been studying the feeding, reproduction, dispersal, and survival of a barn-owl population in northern Utah for seven years. Here, we document a major winter die-off of barn-owls, present an analysis of dead owls from this period, and compare population density and reproductive success before and after the die-off.

STUDY AREA

Data were collected in the central valleys of Box Elder, Cache, Davis, Weber, Salt Lake, and Utah counties of northern Utah. Most land there is used for irrigation farming. Winters normally are not severe; snow cover seldom lasts for more than a few days in the valley bottoms.

Two of these counties, Davis and Box Elder, are the primary location of our continuing study, begun in 1977, on barn-owl population and feeding ecology. Most data collection sites were at nest boxes erected for barn-owls (Marti et al. 1979).

METHODS

We collected dead barn-owls during regular visits to our study sites; owls were also collected by officers of the Utah Division of Wildlife Resources and by cooperating landowners. During necropsy, general body condition was noted, the digestive system was examined for prey remains, sex was verified internally, and a sample of muscle tissue (pectoralis major) was taken for fat analysis. Muscle samples were oven-dried to constant weight, ground, and then agitated for 16 h in petroleum ether to extract fat. After agitation, the samples were filtered and re-washed with petroleum ether, oven-dried, and re-weighed to determine amount of fat lost. A sample of owls killed by trauma, mostly roadkills, was treated in the same manner for comparison with the starved birds.

Monthly checks of 30 nest boxes were made throughout the year. During these visits, we noted use of boxes for roosting and nesting, and movements and survival of color-marked owls.

Adults and young birds were distinguished by using banding records and by the pattern of wing molt (Peter Bloom, pers. comm.). All body weights were rounded to the nearest 5 g for statistical purposes because scales used to weigh live owls in the field were accurate only to 5 g.

We obtained weather data from official weather stations within our study area (Climatological Data Summary, National Climatic Center, Asheville, North Carolina).

We used the Mann-Whitney U-statistic to test for differences between means; one-tailed tests were employed because we determined, in advance, the direction of expected differences. Sex and age ratios were tested with Chi-square.

RESULTS

Seventy-seven barn-owls, apparently dead of starvation, were found in the winter of 1981–1982, 74 of them from 1 January to 28 February 1982. Age and sex distributions of this sample are in Table 1. Sex ratios were not significantly different from 1:1 ($\chi^2 = 0.08$, 1 df, $0.50 < P < 0.90$), suggesting that both sexes were equally vulnerable. Evaluating age-specific mortality was more difficult because we did not know the proportions of adults and juveniles in the population just prior to the die-off. The ratio of breeding adults to fledglings in 1981 (1:2.7; August–September) was used as an estimate of the population age ratio and was not significantly different from the age ratio in the starved birds ($\chi^2 = 0.25$, 1 df, $0.50 < P < 0.90$). Considerable mortality normally occurs among newly fledged young barn-owls (Stewart 1952b, Glue 1973), which would have reduced the numbers of immature birds even before winter. At least 42% of the fledglings on our study area would have had to die before January 1982, however, to yield a significant difference ($P < 0.05$) between the age ratio in the population and that in the sample of starved birds. Nonbreeding adults in the area could further confound this estimate. Assuming that few nonbreeding adults existed (we believe few did in that season), and that no more than 42% of the fledglings died before January, then adults and immatures starved in numbers roughly equal to their proportions in the population.

Fifty-four of the apparently starved owls were necropsied. All of the specimens showed severe atrophy of pectoral muscles (concave in cross section), no visible subcutaneous or intra-abdominal fat, atrophy of the digestive system and liver, and bile-staining in the abdominal cavity. Digestive tracts of 50 were empty, one contained a western harvest mouse (*Reithrodontomys megalotis*), and three contained small pellets. These birds weighed significantly less than healthy, live barn-owls captured in the same area between October and March, 1979–1983 (Table 2; females: $U = 2{,}144$, $P < 0.001$; males: $U = 1{,}316$, $P < 0.001$). Average difference in weight between live, healthy owls and starved ones was 31.3% for females and 29.6% for males. Owls killed by trauma in January and February 1982 were significantly lighter than healthy owls (Table 2; females: $U = 1{,}152.5$, $P < 0.001$; males: $U = 317.5$, $P < 0.001$), suggesting that much of the population was in poor condition. Owls killed by trauma were heavier than starved owls; this difference was significant for females ($U = 252.5$, $0.01 < P < 0.025$) and approached statistical significance for males ($U = 134.5$, $0.05 < P < 0.1$). Fat reserves also differed significantly between the starved birds and the roadkills (Table 2; $U = 793.5$, $0.001 < P < 0.005$). The percentage of reserve fat did not differ between males and females in the starved birds ($U = 366$, $0.2 < P < 0.25$).

Temperatures in the study area averaged 2.4°C below normal for January and February 1982 following a relatively mild autumn. Normal mean daily temperatures for January and February are −2.2° and 0.5°C, respectively. More important, however, were shorter periods of very cold weather. The first two weeks of January averaged −9.7°C daily, with an extreme low of −29°C. Another cold period occurred from 4–13 February; daily mean temperature was −13.6°C. Most recoveries of dead barn-owls corresponded with the first of these cold periods (Fig. 1). We believe that the first cold period killed the most vulnerable individuals and that those surviving this first period survived the second at a higher rate.

Snow depth may have caused further stress. Our field notes indicate that snow cover ranged

TABLE 1. Age and sex ratios of barn-owls dying in northern Utah in the winter of 1981–1982.

Cause of death	Male <1 year	Male >1 year	Female <1 year	Female >1 year	Sex/age unknown
Starvation	23	3	19	10	22
Trauma	5	2	11	3	0

TABLE 2. Body weight and fat reserves of barn-owls in northern Utah in winter.

Owl sample	Body weight, g n	Body weight, g $\bar{x}$	Body weight, g SD	% Body fat n	% Body fat $\bar{x}$	% Body fat SD
Starved						
Males	28	335.5	21.6	27	8.1	5.3
Females	25	392.4	45.7	24	6.6	3.9
Trauma-killed						
Males	7	361.1	47.0	7	10.4	5.9
Females	14	433.6	59.1	14	15.7	10.1
Live, healthy						
Males	53	476.5	28.9	—	—	—
Females	109	570.9	68.2	—	—	—

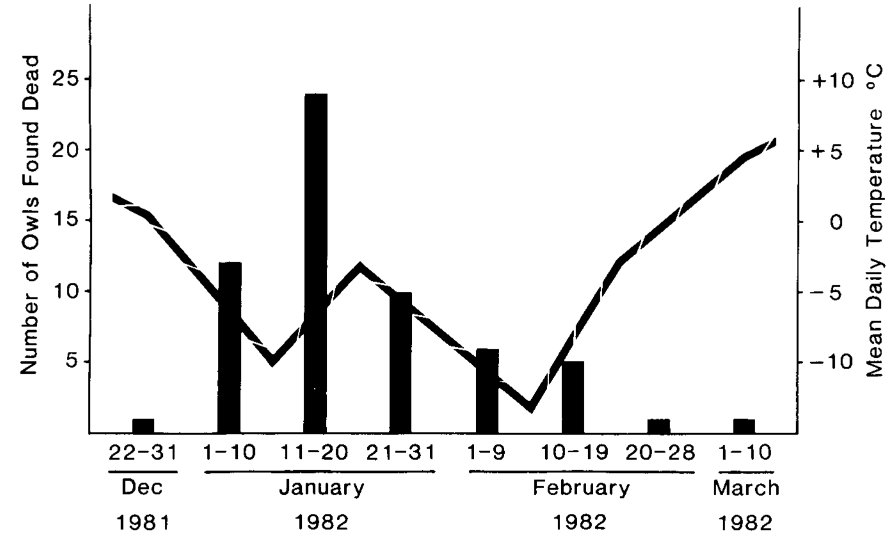

FIGURE 1. Barn-owl mortality in northern Utah (vertical bars) in relation to unusually cold mean daily temperatures (dashed line).

from 20–25 cm for much of January and well into February. Snow of that depth could interfere with capture of small mammalian prey, especially voles (*Microtus* spp.), the major dietary component of barn-owls in the study area (Marti, unpubl.). Voles tunnel under snow and vegetation and, even though barn-owls locate prey acoustically (Konishi 1973), it has not been shown that they can locate and capture prey under deep snow. Thus, the owls' need for higher caloric intake because of low temperatures was hindered by snow cover which made prey capture more difficult.

Some barn-owls on the study area survived relatively well. Eight females captured alive from mid-January to mid-February 1982 weighed an average of 534.4 ± 55.5 g, and one male weighed 470 g. Three vehicle-killed females collected during the same time were judged to be in good condition and had visible amounts of subcutaneous and abdominal fat. Although they weighed less than the mean for live females, they were considerably heavier than those in the starved group. In contrast, two breeding females killed in March and April 1983 weighed 615 and 638 g, respectively, and had subcutaneous fat measuring 3.5 mm thick on the breast.

An index of barn-owl population density obtained from nest box use is in Table 3. Fewer nest boxes were occupied by fewer owls in the winter of 1982 than in other years, despite the need for more protection against unusually cold temperatures (Johnson 1974). This finding suggests a greatly reduced population.

Barn-owls used 84.5% of nest boxes, on average, for nesting in 1978–1981; young fledged from 69.9% of available boxes in those years. Forty percent fewer boxes were used for nesting in 1982 (Table 4). The 1982 egg-laying season was also later than normal. In five previous years, 53% of egg-laying began in the first 10 days of March; latest date for beginning first clutches was 20 April. Only 18% of clutches were begun in early March 1982; 12% of first clutches were not started until the first third of May. Mean clutch size in 1982 was the smallest recorded in this study and fewer young fledged than in any previous year (Table 4). In 1983, however, 29 of 30 boxes were used for nesting and mean clutch size returned to the pre-1982 level. This recovery was largely due to the appearance of unbanded owls, probably immigrants from outside the study area. We tried to band all of the owls on our area each year so that we could document popu-

TABLE 3. Barn-owl use of nest boxes as winter roosts in northern Utah.

Year	Percent of boxes occupied*			
	Dec.	Jan.	Feb.	Mar.
1978–1979	—	95.4	65.4	89.3
	—	(81.8)**	(38.5)	(89.3)
1979–1980	75.0	74.0	66.6	83.3
	(50.0)	(55.5)	(55.5)	(83.3)
1980–1981	63.3	58.6	76.7	96.6
	(40.0)	(44.8)	(70.0)	(93.3)
1981–1982	43.3	44.8	43.4	66.7
	(13.3)	(13.8)	(16.7)	(50.0)
1982–1983	50.0	56.7	76.7	90.0
	(23.3)	(40.0)	(60.0)	(86.7)

* Number of boxes = 28 in 1978–1979, 30 in all other years.
** Number in parentheses indicates the percentage of boxes occupied by two owls.

TABLE 4. Reproductive performance by barn-owls in northern Utah nest boxes before and after major winter mortality occurring in 1982.

Year	% of boxes used (n = 30)	% of boxes from which young fledged	$\bar{x}$ size of clutch*	$\bar{x}$ number of fledglings**	Total number of young fledging*
1978	76.9	69.2	7.1	4.8	96
1979	84.6	73.1	7.2	3.8	84
1980	83.3	63.3	6.7	4.0	91
1981	93.3	73.3	7.0	3.6	100
1982	53.3	33.3	5.8	1.5	24
1983	96.7	60.0	7.2	1.6	44

* First clutches/broods only; mean of complete clutches.
** Per nesting attempt.

lation turnover. Nesting of banded adults that had not attempted to breed in 1982, possibly because they emerged from the severe winter in poor condition, also contributed to the recovery. Low fledging success in 1983 may have been caused by a long, cool and wet period following egg-laying; many clutches were abandoned.

DISCUSSION

It appears likely that some winter mortality of barn-owls occurs annually in northern Utah. Smith and Marti (1976) attributed mid-winter deaths of four barn-owls to severe weather, and we found from one to three dead barn-owls on our study area in each of four winters prior to 1981–1982. Even though these were not necropsied, circumstances were consistent with death caused by starvation/exposure corresponding to inclement weather.

Winter mortality for 1981–1982 appeared to have occurred irregularly in barn-owl populations across the northwestern U.S. Carroll Littlefield (pers. comm.) reported that many barn-owls died near Malheur National Wildlife Refuge, Oregon, between 11 and 18 January 1982; fifteen dead owls were found near the refuge headquarters and about 25 more in the general vicinity. Snow cover from late December 1981 through late January 1982 was nearly 60 cm deep. Temperatures were near normal but winds were unusually strong, creating a high wind-chill factor. Littlefield also noted that snow cover was only 5 cm deep 48 km south of the refuge headquarters and that barn-owls in that area survived. No mortality was seen in northwestern Oregon (Janet Hogue, pers. comm.). A few dead owls were found in the Snake River Canyon of southwestern Idaho (Marti, pers. observ.) but the effect on reproduction and population density could not be evaluated there.

Little winter mortality among barn-owls has been reported elsewhere in North America. Small numbers (2–4) of dead barn-owls were found at three other locations in the north-central U.S. in winter (Errington 1931, Speirs 1940, Stewart 1952a). Unusually cold temperatures and/or deep snow cover were features common to all cases. Low temperatures and heavy snowfall eliminated the breeding population of barn-owls from Martha's Vineyard, Massachusetts; ten dead owls were found (Keith 1964).

Frylestam (1972) found starvation associated with cold and snow cover to be the most common cause of death in northern European barn-owls. Several large die-offs (30–40 dead owls each) have been reported from England (Ticehurst and Hartley 1948, Dobinson and Richards 1964), Germany (Piechocki 1960, Weber 1969), and Switzerland (Güttinger 1965). All of these episodes were associated with cold temperatures and deep snow cover. Honer (1963) and Bunn et al. (1982) reviewed several other such cases in Europe.

Some raptors, including barn-owls, apparently can withstand periods of fasting without ill effects (Ligon 1969, Johnson 1974). Are barn-owls, nevertheless, more susceptible to starvation induced by severe weather conditions than are other raptors? Circumstantial evidence suggests that they are: 18 papers abstracted by Gessaman and Worthen (1982) mentioned 11 species of hawks and owls as having died from cold and/or snow cover. Barn-owls were listed in 12 of these papers while the next most commonly mentioned species, the Eurasian Tawny Owl (*Strix aluco*), appeared in only four. This could be because barn-owls seek refuge in buildings and thus are found more often than other species. The following evidence, however, implies that other factors are involved. Johnson (1974) concluded that although the metabolic rate of barn-owls is slightly less than that of similar-sized strigid owls, their thermoneutral zone (25–33°C) is narrower than in some other owl species. This would require barn-owls to expend more energy for thermoregulation than those species. In addition, the insulating quality of barn-owl feathers is much less than expected (Johnson 1974), and barn-owls may have lower fat reserves than several other owl species (Piechocki 1960). More heat would be lost through the sparsely feathered tarsi and bare toes of barn-owls than in more heavily feathered species.

Several estimates have been made of the rate of weight loss in starving barn-owls. Johnson (1974), in a laboratory study, measured a loss of 18 g/day resulting in a 16% loss over four days. Piechocki (1960) thought that barn-owls could die in eight days of fasting, and he estimated the rate of weight loss at 7.5 g/day.

Kirkwood's (1981) equation predicts that a bird with the mean weight of those in Piechocki's population (*T. a. guttata* = 294 g) would lose 25% of its weight in about 13 days (5.6 g/day); owls starting at the mean weight of those in Utah (*T. a. pratincola* = 523 g) would lose 25% of their weight in 15 days (8.7 g/day). The variation among these estimates suggests that confounding factors must operate; ambient temperature, thermal cover, degree of activity, and food intake would likely be important.

Henny (1969) found from banding records that barn-owls suffered higher mortality in the northern U.S. than in the southern, a fact he believed to be related to more severe northern winters. Our observations show that severe winter weather can adversely affect some barn-owl populations in the U.S.; note that our study area is near the northern limit of the species in North America (Robbins et al. 1983). Judging from reports in the literature, winter mortality in barn-owls occurs less commonly in North America than in Europe. Investigation of environmental differences between these regions and differences between barn-owl populations in each region may be worthwhile.

ACKNOWLEDGMENTS

We thank Don Paul and Dennis Shirley for help in collecting specimens and performing necropsies. Chris Cline and Darren Day also assisted with necropsies. Ed Walker and Darrell Graff provided valuable information on fat analysis. Peter Bloom graciously supplied his unpublished technique for determining age of barn-owls, and Carroll Littlefield and Janet Hogue kindly contributed their winter observations. A research and professional improvement grant to Marti from Weber State College funded portions of the study. The Nongame Section of the Utah Division of Wildlife Resources provided a variety of support to the project. Comments from Martha Balph, Charles Henny, Kathryn Wing, and Margaret Marti improved the manuscript.

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