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CAUSES OF MORTALITY, FAT CONDITION, AND WEIGHTS OF WINTERING SNOWY OWLS

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Abstract.—Necropsies of salvaged specimens and information from museum skin labels suggest that starvation is not as common among wintering Snowy Owls (*Nyctea scandiaca*) as previously suggested. Moderate to heavy fat deposits were found on 54 (45%) of 121 specimens. Traumatic injuries, including collisions with automobiles and wires, were the major cause of mortality of birds wintering in Alberta. Weights of healthy males ($\bar{x} = 1806$ g) and females ($\bar{x} = 2279$ g) were greater than weights reported in the literature.

CAUSAS DE MORTALIDAD, ACUMULACIÓN DE TEJIDO ADIPOSO Y PESO DE BUHOS DE LAS NIEVES (*NYCTEA SCANDIACA*)

Resumen.—Información obtenida de pieles de museo y necropsias de especímenes de buhos (*Nyctea scandiaca*) surgieren que la muerte por inanición de estos buhos, durante el invierno no es tan común como previamente se había sugerido. Depósitos considerables como moderados de tejido adiposo se encontraron en 54 (45%) de 121 especímenes examinados. Heridas y daño traumático causado entre otras cosas por colición con automóviles y alambres, resultaron ser la causa principal de mortalidad de los buhos que pasaron el invierno en Alberta, Canada. El peso de machos ($\bar{x} = 1806$ g) y el peso de hembras ($\bar{x} = 2279$ g) saludables resultó ser mayor que los previamente informados en la literatura.

Some authors have suggested that Snowy Owls (*Nyctea scandiaca*) migrate south from their arctic breeding grounds in a "semi-starved" condition (Gross 1927, 1946, 1947; Jewett et al. 1953; Roberts 1936). In addition, some writers have claimed that few owls survive to return to the arctic (Colinvaux 1973, Gross 1946, Lack 1954, Vaurie 1965). Although Gross (1946) noted that many wintering owls were shot (his study was done prior to widespread legal protection for owls), starvation has been suggested as an important cause of mortality (Gross 1946, Lack 1954). However, other workers have demonstrated that wintering owls can be quite fat (Keith 1960). Here we report on causes of mortality, fat condition, and body weight of Snowy Owls wintering south of their breeding range, and evaluate the importance of starvation as a mortality factor.

METHODS

Causes of mortality and fat condition were determined for 76 Snowy Owl carcasses obtained from the Alberta Fish and Wildlife Division between 1973 and 1983 (hereafter Alberta specimens). They included 32 adult females, 15 immature females, 17 adult males, and 12 immature males. Sex and age were determined by gonadal examination and the methods described by Kerlinger and Lein (1986). Causes of mortality

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were determined from specimen labels when available, or from body condition or types of injuries noted during necropsy. Starvation was implicated as the cause of death when birds were noticeably emaciated, or when fat reserves were absent and no injuries were visible. This method probably overestimated the importance of starvation as a cause of mortality because some of these birds may have died as a result of disease or other factors producing no conspicuous trauma.

During necropsies, we recorded the amount of abdominal fat present on birds. We categorized specimens as having either: (1) no fat to light fat deposits or (2) moderate to heavy fat deposits. For some analyses we further distinguished between those birds with no fat and those with light fat deposits. Labels on 49 museum specimens (see Kerlinger and Lein 1986 for a list of institutions) provided additional information on fat condition. Because terminology on museum labels was not consistent, we could only place specimens into the two broad categories.

To compute mean body weights we used: (1) birds live-trapped by M. R. Lein near Calgary, Alberta (n = 20); (2) specimens collected by Sutton (1932) from the Northwest Territories in the 1930s (n = 14); and (3) birds reported by Keith (1960) that were trapped or shot during winter at Delta Marsh, Manitoba (n = 12). We selected the latter two data sets because both Sutton and Keith reported how the birds were taken, that they were fresh when weighed, and were probably in healthy condition prior to collection. Two outliers (an adult male that was three standard deviations below the mean and one immature female that was nearly five standard deviations above the mean) were thought to represent errors in measurement and were not included in the analyses (see Tukey [1977] for methods of removing outliers). Because no significant statistical differences were detectable among the three data sets using non-parametric tests, they were pooled for subsequent analyses.

RESULTS AND DISCUSSION

Among 71 Snowy Owls from Alberta for which the cause of mortality could be determined (Table 1), most deaths were attributable to traumatic injury (61 birds, 86%). Starvation was the possible cause of mortality for only 10 birds (14%). The most common sources of traumatic injuries were collisions with cars, utility wires, and unknown objects (Table 1). Gunshot wounds accounted for nine fatalities, even though shooting of owls is illegal in Alberta. Personal observations of near collisions of flying Snowy Owls with utility wires, barbed-wire fences and automobiles during daylight hours corroborate the data in Table 1 and indicate that these sources account for many accidents. Conspicuous wounds on six of 20 Snowy Owls live-trapped by M. R. Lein (five wounds on wings, one on throat) also demonstrate that Snowy Owls regularly sustain injuries. Injuries on four of these owls were healed or nearly-healed and all birds flew well.

Of 121 specimens for which fat condition could be determined, 54 (45%) had moderate to heavy deposits (Table 2). Of the remaining 67

TABLE 1. Causes of mortality of wintering Snowy Owls from Alberta, Canada.

Cause of death or injury	Number of owls (%)
Collision with:	
Unknown object	33 (46.5)
Automobile	10 (14.1)
Utility line	3 (4.2)
Airplane	1 (1.4)
Total Collision	47 (66.2)
Gunshot wound	9 (12.7)
Electrocution	4 (5.6)
Fishing line and hook in wing	1 (1.4)
Starvation	10 (14.1)
Total	71[a]

[a] Total excludes 5 owls for which the cause of mortality could not be determined.

specimens (55%) in the no fat to light fat category, 24 (20%) had light fat deposits, with only 43 birds (36%) lacking fat. This does not mean that 36% of the owls succumbed to starvation. An examination of 22 Alberta specimens with no fat reserves revealed that 8 also had massive injuries (broken bones) and 4 more had slight to moderate injuries (i.e., "wound on neck," "wound on leg"). Thus, only 10 Alberta specimens lacked both fat and injuries.

There are several potential sources of bias that might affect the proportion of birds assigned to the starvation category. First, starving birds might be more likely to suffer traumatic injuries than non-starving birds. We consider this to be unlikely because of the demonstrated high frequency of such injuries in non-starving birds. Second, birds that died of starvation might be less likely to be recovered by humans than those that were killed by collisions or other factors. These two biases could cause an underestimate of the importance of starvation. Third, we may have overestimated the number of birds that starved because birds which had no fat, but which died from causes that produced no noticeable injuries (e.g., disease), would be assigned to this category. Fourth, starving owls may become incapacitated, or they may be forced by hunger to approach human dwellings where they may be killed or "collected" (e.g., Gross 1947). This would also lead to an overrepresentation of starving birds in a sample such as ours. Although it is impossible to evaluate the relative importance of these potential sources of bias, we believe that the latter two are more important, and that our conclusion regarding the low frequency of starvation in winter populations is probably a conservative one.

Birds with no fat or light fat deposits were not distributed randomly among age-sex classes (Table 2) (χ^2 for Alberta specimens = 6.88, df = 3, P = 0.08; χ^2 for museum specimens = 13.64, df = 3, $P < 0.01$). Although three of the expected frequencies in the analysis of museum specimens were <5, the minimum expected frequency recommended for

TABLE 2. Fat condition of Snowy Owls collected during winter from locations in southern Canada and the northern United States.

	Age-sex class				
Fat category	Adult female	Immature female	Adult male	Immature male	n
None–light fat					
Alberta specimens	13	8	7	10	
Museum specimens	1	8	5	15	
Subtotal	14 (20.9)[a]	16 (23.9)	12 (17.9)	25 (37.3)	67
Moderate–heavy fat					
Alberta specimens	18	5	9	2	
Museum specimens	8	7	2	3	
Subtotal	26 (48.1)	12 (22.2)	11 (20.4)	5 (9.3)	54
Total	40 (33.1)	28 (23.1)	23 (19.0)	30 (24.8)	121

[a] Figure in parentheses is % of row total.

chi-squared tests (Zar 1981), these cells did not influence the significance level of the χ^2 value. When data sets were pooled (Table 2), the results were similar ($\chi^2 = 16.24$, df = 3, $P < 0.01$). Immature males had no fat or light fat deposits more often than expected and moderate to heavy deposits less often. Adult females showed the opposite pattern, with moderate to heavy fat deposits more often than expected, and no fat or light fat deposits less often. Deviations for adult males and immature females together accounted for less than 15% of the χ^2 values.

In the sample of specimens that we used to determine body weight, females weighed, on average, 473 g (26.2%) more than males (Table 3; $F = 57.21$, df = 1,43, $P < 0.001$). Weights of adult and immature birds did not differ significantly. The owls reported by Sutton (1932) and Keith (1960) were fat and seemed to be in excellent body condition. Because the weights of live-trapped owls did not differ significantly from the weights of the other two data sets, birds in all three series undoubtedly had comparable amounts of fat.

The mean weights that we report (Table 3) are significantly greater than those frequently cited (Earhart and Johnson 1970, Karalus and Eckert 1974, Snyder and Wiley 1976). This discrepancy may result from the fact that these workers used data from labels of museum specimens, while we used weights of live birds, or of freshly-killed birds known to be in good condition. Many of the Alberta specimens were emaciated, or had undergone desiccation, or had suffered loss of blood and tissue due to injury, prior to their receipt from the Alberta Fish and Wildlife Division, resulting in erroneously low body weights. Mean weights from this collection of birds were similar to those reported by earlier authors. Because such "salvage" specimens of Snowy Owls are common in museum collections, we feel that weights from specimen labels probably underestimate the true population values.

TABLE 3. Summary of weights of Snowy Owls from this study and previous studies.

Source	*n*	Mean ± SE (g)	Range (g)
Present study			
Males	23	1806 ± 30	1606–2043
Female	21	2279 ± 57	1838–2951
Earhart and Johnson 1970; Snyder and Wiley 1976			
Males	27	1642 ± NA[a]	1320–2013
Females	30	1963 ± NA	1550–2690
Karalus and Eckert 1974			
Males	34	1613 ± NA	1448–1840
Females	40	1707 ± NA	1593–2003

[a] NA indicates that the value was not given.

Based on the weights and fat condition of freshly-killed birds reported by Sutton (1932) and Keith (1960), we estimate that approximate minimum weights of birds with at least moderate fat deposits are about 1950 g for females and 1575 g for males. The weights from museum labels of 185 birds collected south of the breeding range showed that 19 of 25 adult females (76%), 19 of 62 immature females (31%), 18 of 28 adult males (64%), and 24 of 70 immature males (34%) were greater than these cutoff weights. Thus, in this sample as well, adults tended to be heavier, and therefore fatter, than immature birds (χ^2 = 19.87, df = 1, $P < 0.01$). Overall, 80 (43%) of the museum specimens were above the cutoff weight and probably also had moderate to heavy fat deposits. These birds obviously were not starving.

Our findings suggest that Snowy Owls wintering in Alberta are in good body condition and that starvation is probably not a major cause of mortality in this region, which lies in the "core" of Snowy Owl winter range in North America (Kerlinger et al. 1985). It is possible that earlier studies emphasizing starvation as a mortality factor were biased because they were conducted near the periphery of the winter range (e.g., New England), where immature birds predominate (Kerlinger and Lein 1986).

In addition to their value in the interpretation of winter survival rates, data on weights and body condition can also be valuable to raptor rehabilitation programs. Fat reserves will assist a rehabilitated bird to survive after release until it is able to locate a suitable home range and to capture prey effectively. We recommend releasing Snowy Owls only if their weight exceeds about 2200 g for females and about 1800 g for males (approximate mean weights for healthy birds during winter).

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