

OBSERVATIONS ON THE FALL MIGRATION OF EARED GREBES, BASED ON EVIDENCE FROM A MASS DOWNING IN UTAH¹

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After the breeding season in North America, most Eared Grebes (*Podiceps nigricollis*) migrate to highly saline lakes in the Great Basin to molt and stage for several months. During this period they molt, undergo a cycle of breast muscle atrophy and hypertrophy, and accumulate huge fat deposits before flying to wintering areas (Jehl 1988, unpubl. manuscript; Gaunt et al. 1990).

On 10 December 1991 thousands of grebes departed Great Salt Lake en route to the Salton Sea, California, or Gulf of California, Mexico. Their route was southwesterly, and for the first 500 km—roughly between Salt Lake City and the Arizona border—paralleled Interstate Highway 15 and the Wasatch Mountains, which are slightly to the east. Several hours into the flight, over southern and central Utah, large numbers were forced down by a snowstorm along a 180 km stretch between Holden and Cedar City; a few were also reported in the Provo/Springfield area (Fig. 1). The birds did not fall uniformly, but apparently were attracted to lights from towns and highway intersections. Many died when they crashed to earth; others were hit by cars on the highway, which they evidently mistook for open water. Thousands more were captured alive and released on whatever local water bodies remained open.

Most of our current understanding about the biology of Eared Grebes in fall migration is based on studies of birds staging at Mono Lake, California (Jehl 1988). The data from this downing provided an opportunity to test and extend some earlier findings or inferences about the differential migration of age classes, duration of the flight to wintering areas, physical condition of departing and arriving migrants, the size of pectoral muscles needed for flight, and the risks of mortality along the migratory routes (Jehl 1988, Gaunt et al. 1990).

METHODS

I examined 517 downed grebes, including 184 that were killed on the night of 10 December in the vicinity of Cedar City and 51 killed near Minersville on the same date. In addition, on 12 December I banded 107 grebes that had been captured on 11–12 December in the Cedar City area, as well as 121 grebes from Fillmore that were transported to Cedar City by the Utah Division of Wildlife Resources on December 12. Further

data were obtained from 92 birds that were released on a small pond at Cedar City but died by 27 December, and 34 that died in transit from Fillmore to Cedar City. Data on timing of downings were based on information from local observers and provided by the Utah Department of Wildlife Resources (*vide* R. Friedell).

Most of the wrecked birds landed in snow and were kept cool until they could be frozen and transported to San Diego or Salt Lake City for processing. All were weighed to the nearest 0.1 g on a Mettler electronic balance and aged by plumage and soft-part characters. Because of the great number of birds involved, all birds could not be treated identically, and subsamples were used for determining fresh weight of pectoral muscles (one side), stomach contents, and sex ratio.

RESULTS AND DISCUSSION

Age and sex composition of the population. Adults comprised 97% of the sample. Of birds that were dissected, only five of 139 had a bursa; two of these were juveniles, and the other three, in which the bursa was very small, were likely second-year birds (Storer and Jehl 1985). Field observations and examination of photographs of about 500 grebes released at Cedar City also indicated that juveniles comprised about 2% of the downing.

Previous studies at Mono Lake had established that in fall adult grebes lay on much greater fat reserves than juveniles. After food supplies fail, therefore, juveniles should be the first to exhaust their reserves and emigrate (Jehl 1988). The notion of differential migration of age classes is supported by observations that juveniles greatly predominate among early migrants reaching southern California (Jehl, unpubl.) in fall, and by their virtual absence from the Utah sample.

The sex ratio in a subsample of 81 birds (45 ♂: 36 ♀) did not differ from the expected 1:1 (χ^2 test).

Origin of migrants, duration of flight. The grebes must have originated at Great Salt Lake, most likely near islands at roughly the latitude of Ogden, where aerial surveys revealed large concentrations in October and November (F. Howe, pers. comm.). There is no other area in the Intermountain West where large numbers of Eared Grebes stage so late in the year (Jehl 1988).

The downings occurred over a wide area and, for each locality for which there is information, continued for up to several hours. At Fillmore (256 km south of Ogden) the storm arrived at 21:10 hr and the first birds were heard thumping on rooftops at 21:30 hr (B. Olson, pers. comm.). Similarly, at Minersville (352 km south)

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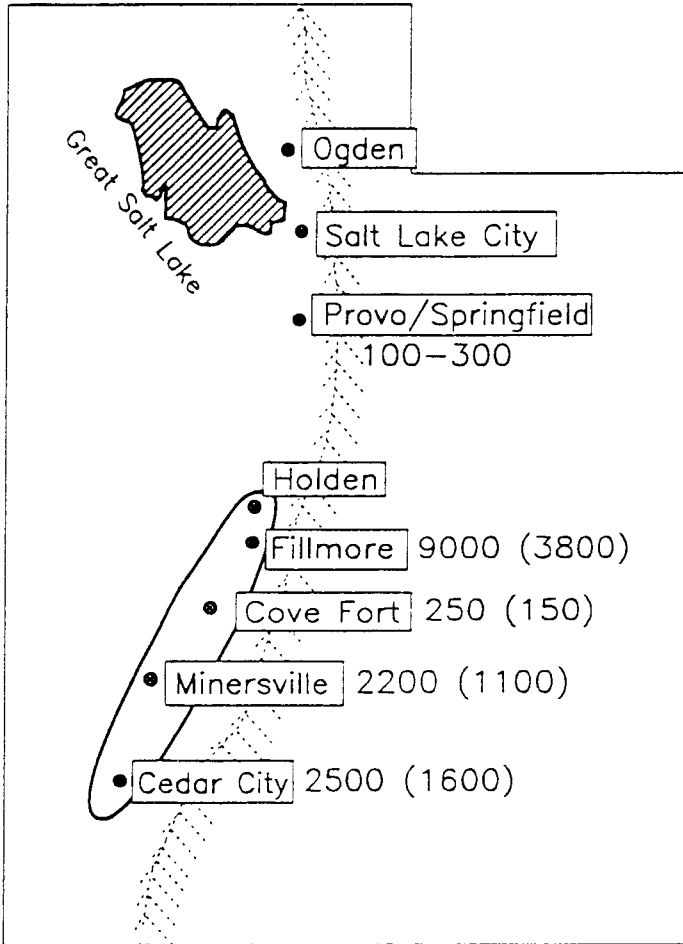


FIGURE 1. The state of Utah, with the major localities listed in the text. Dotted lines show the position of the Wasatch Front. The downing of grebes occurred mostly within the encircled area. The number downed and rescued (in parentheses) is given for each locality.

hundreds were noted at 21:30 hr by churchgoers, and there were unconfirmed reports between 18:00 and 22:00 hr (L. Chamberlain, pers. comm.). In Cedar City (400 km south), most of the mortality was evidently incurred at approximately 24:00 hr (R. Fridell, pers. comm.), when the ceiling suddenly lowered from 2,500–3,000 m to 850 m. Detailed weather reports from Salt Lake City and Cedar City showed that environmental conditions along the flight path were benign, except where visibility was impaired by snow. Through the evening at Cedar City winds ranged from 0–3 km hr⁻¹ from the west southwest to north northwest, and would not have been a significant factor in affecting ground speed. The temperature was around 0°C.

Tucker and Schmidt-Koenig (1971) reported that flight speeds of ducks exceed 58 km hr⁻¹. Eared Grebes fly about as fast as Ruddy Ducks (*Oxyura jamaicensis*; pers. observ.), and I have tentatively estimated their speed at 60 km hr⁻¹. Therefore, to reach Minersville

(352 km) by 21:30 hr, some would have had to leave by 15:00. To reach Fillmore (256 km) by 21:30 hr or Cedar City (400 km) by 24:00 hr, departures would have had to begin by 17:00. A late afternoon departure is consistent with observations that grebes released in Cedar City exhibited a burst of migratory activity between 15:30 and 16:00 hr, when groups of 2–4 would take flight and circle several times before returning to the pond or, less often, disappearing (pers. observ.; R. Fridell, pers. comm.). Late afternoon or early evening departure has been assumed for Mono Lake, but never observed.

The distance from Ogden to the Salton Sea is about 920 km, so birds leaving in mid-afternoon (15:00) should arrive by 06:30 the next morning. Arrival at the northern end of the Gulf of California (1,080 km, 18 hr) would occur around 09:00 hr. Although these arrivals are predicted to take place in daylight hours, they have not been observed.

TABLE 1. Masses of Eared Grebes killed in migration 10 December 1991.

	Minersville				Cedar City				<i>P</i> ^a
	<i>n</i>	Range	Mean	SD	<i>n</i>	Range	Mean	SD	
Body mass	51	303–462	397.2	34.2	184	285–464	389.1	33.2	0.065
Breast	24	20.2–29.0	23.5	2.31	33	17.9–30.7	24.1	2.78	0.216

^a One-tailed *t*-test.

Body mass and flight duration. Large samples of birds killed in flight were obtained from Minersville and Cedar City. I assume that both were derived from the same staging population and departed Great Salt Lake over the same several-hour span. As there were no consistent or significant differences between the samples with respect to the mass of pectoral, leg or stomach muscles (Jehl, unpubl. manuscript), the 8.1 g lighter average masses of grebes from Cedar City (Table 1) can be attributed to the catabolism of fat. Because Cedar City is 64 km farther south than Minersville, the average grebe on a direct flight would take 1.07 hr, which would require an average maximum fuel consumption of 7.6 g body mass hr⁻¹. Assuming energy expenditure in flight is constant, grebes would lose 137 g flying from Great Salt Lake to the Gulf of California. Their departure mass (based on the Minersville sample) would average 441 g (range 347–506 g) and their arrival mass 304 g (range 210–369 g).

The downing at Cedar City began 2.5 hr later than at Minersville. It is unknown whether birds killed at Cedar City represented a portion of the migrants that had negotiated the Minersville trap successfully, or whether they represented a different group that departed Great Salt Lake later in the afternoon. If the former, they must have been disoriented in their last hours, because their ground speed would have been only 25.6 km hr⁻¹ (64/2.5). This is an average mass loss of 3.24 g hr⁻¹ (8.1/2.5), apparently approximating a minimum rate of fuel expenditure. Under these conditions, grebes would lose 54 g flying to the Gulf of California. Departure mass would average 414 g (range 320–479 g), and arrival mass 360 g (range 249–408 g).

Either the maximum or minimum set of values is similar to previous estimates from Mono Lake, where arrival mass averaged 260–300 g and departure mass was estimated at 400–450 g (Jehl 1988, Gaunt et al. 1990). Adult grebes weighing less than 240 g are in poor condition and some do not recover (Jehl 1988, unpubl.). Accordingly, to reach the Gulf of California safely, birds expending 7.6 g hr⁻¹ should weigh at least 377 g before leaving Great Salt Lake, or 298 g at 3.2 g hr⁻¹. At the lower rate, this included all of the Minersville sample. At the higher rate, it included all but one, a juvenile.

Eared Grebes become obese (\approx 700 g) while staging and must lose excess mass before they can fly again. For the fattest birds, then, pre-departure loss may approximate 250 g, or over one-third of peak mass.

Pectoral muscles. During the staging period, the grebes' pectoral muscles undergo severe atrophy (some to 10–12 g), which must be reversed before the birds can depart (Jehl 1988, Gaunt et al. 1990). Previously, I (1988) estimated that grebes with muscles less than

16–18 g were probably incapable of flight, and that even those with muscles approximately 20 g were probably incapable of flight at typical departure mass (i.e., 440 g). This estimate was derived from morphological examination of breast muscles and from studies of dozens of non-flying grebes at Mono Lake whose breast muscles often exceeded 20 g. Data from Utah generally support a minimum mass of 20 g for migrants. Pectoral muscles from Minersville and Cedar City averaged 23.8 g (Table 1), and only one bird, the lightest in the entire sample (juvenile, 285 g), was under 20 g (17.9 g).

Stomach contents. The mass of stomach contents (feathers) of grebes killed on 10 December averaged 1.9 g (range 1.0–3.8 g, *n* = 22) compared to 2.7 g (range 1.9–4.7 g, *n* = 17) among birds released on a foodless pond and found dead on 16–17 December (*t*-test, *P* < 0.001). It follows that preening and ingesting feathers is independent of feeding and continues even when the birds are dying and unable to feed.

Mortality. Several hundred grebes that were released on 12 December, including 72 that had been banded, were found dead by 27 December. Post-mortem examination showed that the majority had suffered massive internal injuries and died from trauma within a few days. Indeed, in a subsample of 15 preserved as skeletons, only one showed no broken bones. The others had breaks in one or more sites including the skull (6 birds), humerus (3), radius (5), ulna (2), tibiotarsus (10), sternum (8), pelvis (9), and scapula (9).

The Utah Division of Wildlife Resources estimated that approximately 14,000 grebes were downed, of which 6,655 were captured and released (R. Fridell, pers. comm.). Indications of declining numbers at release points, as well as the observations of pre-migratory flights at Cedar City, indicate that some were able to resume migration. Many, however, were not. The percentage (\approx 33%) of banded birds found dead at Cedar City might indicate that as many as 4,500 birds survived the wreck. Skeleton evidence (above) as well as banding data indicate a much higher loss, as none of the 226 birds banded in Utah was recovered at the Salton Sea after a massive die-off later that winter, whereas four of 329 banded at Mono Lake were recovered. Rescue efforts for the downed birds, therefore, were largely ineffectual.

Southern Utah: a migratory gantlet? Large-scale die offs that occur sporadically in the migration period, or during migration itself, are suspected of causing most annual mortality in Eared Grebes (Jehl 1988). Downings are uncommon, though not in southern Utah. The 1991 downing occurred in the same general location as two smaller events in 1982 (2,000 on 9 December, 1,000 on 24 December; see Jehl and Bond 1983), a small but evidently undocumented wreck in ca. 1986

(Utah Division of Wildlife Resources), and a major one involving "many thousands" in southwestern Utah and eastern Nevada on 12 December 1928 (Cottam 1929). While detection of downings in this area is enhanced by the correspondent bearings of an interstate highway (not present in 1928) and the grebes' migration path, their frequency suggests that local meteorological and geographical conditions, perhaps related to basin-and-range topography and the proximity of the Wasatch Front, play a role. If these promote a fog and snow belt in early winter, forcing the grebes to run a hazy gantlet, this area may represent an especially hazardous but unavoidable sector of the fall migration route. An earlier departure could reduce the chance of encountering fog or snow, but the risk is probably trivial compared to the benefits of exploiting an abundant and uncontested source of food (brine shrimp) on the staging grounds for as long as possible.

R. Fridell, C. Jensen, B. Olson, D. Paul, F. Howe, R. Radant, and others from the Utah Division of Wildlife Resources alerted me to this event and took part in gathering and banding downed migrants, and arranging for further study. C. White and students from Brigham Young University, E. Sorensen, and P. Dutton helped greatly in processing hundreds of carcasses. S. I. Bond was invaluable in assisting in all phases of

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THE PREVALENCE OF ABDOMINAL LESIONS ON WOOD STORK NESTLINGS IN NORTH AND CENTRAL FLORIDA¹

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Key words: Wood Stork; *Mycteria americana*; ectoparasite; dermestid beetle, *Dermestes nidum*; soldier fly, *Hermetia illucens*; Florida.

The United States population of the Wood Stork (*Mycteria americana*) currently is decreasing and endangered (USFWS 1984, Kushlan and Frohling 1986, Ogdan and Patty 1981). Snyder et al. (1984) were the first to identify abdominal lesions on stork nestlings caused by larval dermestid beetles (*Dermestes nidum*, Dermestidae, Coleoptera), but were unable to determine precisely the degree of threat posed by dermestid infestation and whether the problem was confined to southern Florida. As part of a multi-year and multi-colony study of the reproductive biology of Wood

Storks, we collected data on the occurrence of lesions on nestlings. In this paper, we present information on the distribution and effect of abdominal lesions on Wood Stork nestlings in north and central Florida.

Eleven wading-bird colonies in northern and central Florida were visited at one- or two-week intervals during the breeding seasons of 1981–1985. See Nesbitt et al. (1982) and Rodgers et al. (1987, 1988) for specific colony locations, general vegetation characteristics, and total number of stork nests. Wood Stork nests were individually marked and nestlings were examined in hand (< 3 weeks of age) or at a distance with 7 × 35 mm binoculars (> 3 weeks of age). Lesions on young nestlings (< 2 weeks of age) were characterized by open wounds, especially in the upper and lower abdominal featherless tract. The lesions were 1–3 mm deep and surrounded by a raised region of swollen tissue. No penetration of the lower abdominal wall was noted. Older nestlings (2–6 weeks of age) exhibited evidence of lesions with red-brown, dried material that matted small feather regions (1–3 cm) on the upper and lower abdomen (see Snyder et al. 1984: Fig. 1B). These le-

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