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AUTUMNAL MIGRATION OF EARED GREBES (*PODICEPS NIGRICOLLIS*) THROUGH SOUTHWESTERN WYOMING: A KEY TO ASSESSING THE SIZE OF THE NORTH AMERICAN POPULATION

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ABSTRACT.—In autumn the vast majority of the North American population of Eared Grebes (*Podiceps nigricollis*) congregates for several months at Great Salt Lake, Utah, and Mono Lake, California. Because the lakes are so large, it has not been possible to monitor grebe migration with sufficient accuracy to determine when peak numbers are reached. To clarify migration phenology, we analyzed data from 2 isolated wetland areas in southwestern Wyoming where grebes land en route between breeding areas in the interior and Great Salt Lake. Occasional birds, probably nonbreeders or failed breeders, begin moving southward as early as mid-June. Migration of postbreeding birds starts in late July, peaks in late August and September, and is largely completed by the end of October, with very small numbers arriving into November. The pattern of migration and number of birds encountered varied annually, but 95% of the migration was usually completed by 15 October. As a result, censuses at the major staging lake made on or after 15 October but before the grebes depart for wintering areas can be used to study trends in size of the North American population.

Key words: Eared Grebe, Podiceps nigricollis, *Great Salt Lake, Mono Lake, migration, population, monitoring.*

The Eared Grebe (*Podiceps nigricollis*) is by far the most common grebe in North America (O'Donnel and Fjeldså 1997, Jehl et al. 1999, Jehl unpublished). In autumn nearly the entire population concentrates for several months at hypersaline lakes in the Great Basin to exploit the abundant invertebrate prey. Great Salt Lake, Utah, and Mono Lake, California, are the major staging areas (Jehl 1988, Jehl et al. 1999). The influx begins in late July and continues for an unknown period into late fall. Grebes remain at staging lakes continuously until food becomes unavailable and then, sometime between late November and early January in most years, continue southward to their main wintering area in the Gulf of California, Mexico. The return migration northward may begin as early as January in some years and extends into May. During that time hundreds of thousands gather at the Salton Sea, California, with peak numbers occurring in March (Jehl and McKernan 2002). Most then move through the interior of the continent, including Great Salt Lake, to arrive on their breeding grounds in the north central U.S. and southwestern Canada from mid-April onward.

Major aspects of these annual movements have been well documented (Jehl 1988, 1993, 1994, 1997, Jehl and Yochem 1986, Cullen et al. 1999, Jehl et al. 1999, Jehl and McKernan 2002). Lacking from this picture is precise information on timing and intensity of the autumnal migration. Obtaining such information has been difficult because staging lakes are so large and numbers of birds are so enormous that it has not been possible to measure population size with sufficient frequency or precision to determine phenology in detail. During the fall arrival period at Mono Lake, for example (≈180 km^2; peak grebe population >1.5 million), an average of >20,000 grebes arrives nightly (revised from Jehl 1988). However impressive that may seem, the influx is not measurable because the birds land before dawn and become indistinguishable among the thousands already present. Great Salt Lake (≈2160 km^2; peak >1.0 million) is even less amenable to quantitative studies because of its enormity (Boyd and Jehl 1998, Jehl et al. 1999).

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In this paper we show that census data from migrating Eared Grebes that stop briefly when flying between breeding areas in the interior and major fall staging areas provide an exceptional opportunity to study the timing and intensity of migration, and that these data can be applied to the broader question of determining and monitoring the size of the North American population.

STUDY AREAS AND METHODS

We analyzed data on migrating Eared Grebes gathered over the entire fall migration period in 4 years at 2 isolated wetland areas in arid southwestern Wyoming (Fig. 1). The migrants involved were en route to Great Salt Lake, 150 and 225 km westward, but interrupted their migration to seek safe havens at dawn, as is characteristic of the species. One location, near Kemmerer, consisted of 11 ponds ranging in size from 10.3 to 33 ha spread over 3.9 km^2; the total surface area was 120 ha. The second, near Green River, consisted of a single 400-ha pond. Ponds at both locations were constructed to hold industrial waste water. Counts were made because of the actual or perceived risks to grebes and other migrating waterbirds due to poor water quality.

At Kemmerer fall observations were made by CJ and associates daily between 4 August and 22 November, and on 10 dates between 16 July and 3 August 1994. Counts were made between 0700 and 1000 hours, and barometric pressure was taken at dusk. The ponds' small size, configuration, and lack of screening vegetation made it possible to detect all birds. Spring counts at the same ponds were made at 3-day intervals between 22 March and 25 May 1994. At Green River the FMC company's waterfowl recovery and rehabilitation team gathered data on the following schedule: 1992, daily from 27 July through 3 December; 1993, on 7 dates between 9 and 29 July, and on all but 9 days (8 in August) between 2 August and 15 December; 1994, 6 days between 13 and 28 June, and daily from 1 July through 12 December; 1995, 5 days between 20 and 30 June, 7 days between 3 and 15 July, and daily from 17 July to 21 December. At least once each morning, all birds landing on the pond were counted from a small boat and the entire shoreline was surveyed for evidence of mortality. Given the size of the lakes, the open topography of the shoreline, and the diligence of the team (J. Jehl personal observation), we estimated the effectiveness of this technique in detecting grebes at >95%.

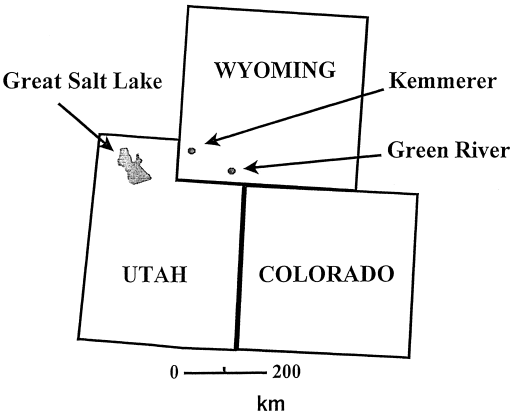

Fig. 1. The study sites lie 150 and 225 km east-northeastward of Great Salt Lake.

Daily numbers recorded at each locality can be considered to represent incursions of the previous night. Such conclusion is almost inevitable because grebes avoid migrating by day, and observations in Wyoming (R. McNalley personal communication, C. Johansson personal observation) and many other areas (J. Jehl personal observation) show that nearly all migrants arrive in the predawn hours and depart about dusk. Protracted stays of heathy birds at these ponds would not have been possible because all ponds were sterile and held no food suitable for any aquatic birds. Furthermore, at both sites, ponds contained high concentrations of several sodium salts (mainly sodium decahydrate), which might be considered toxic and would, under certain conditions, precipitate on feathers, thereby causing mortality through hypothermia and reduced buoyancy. Thus, at either location migrants that might attempt to remain through the day could become imperiled and quickly succumb.

RESULTS

GREEN RIVER.—The data set from Green River spans the entire autumnal migration period from 1992 through 1995. It indicates that a few grebes, almost certainly failed breeders or nonbreeders (Jehl 1988), begin moving toward staging lakes as early as late June. The regular and continuous migration of

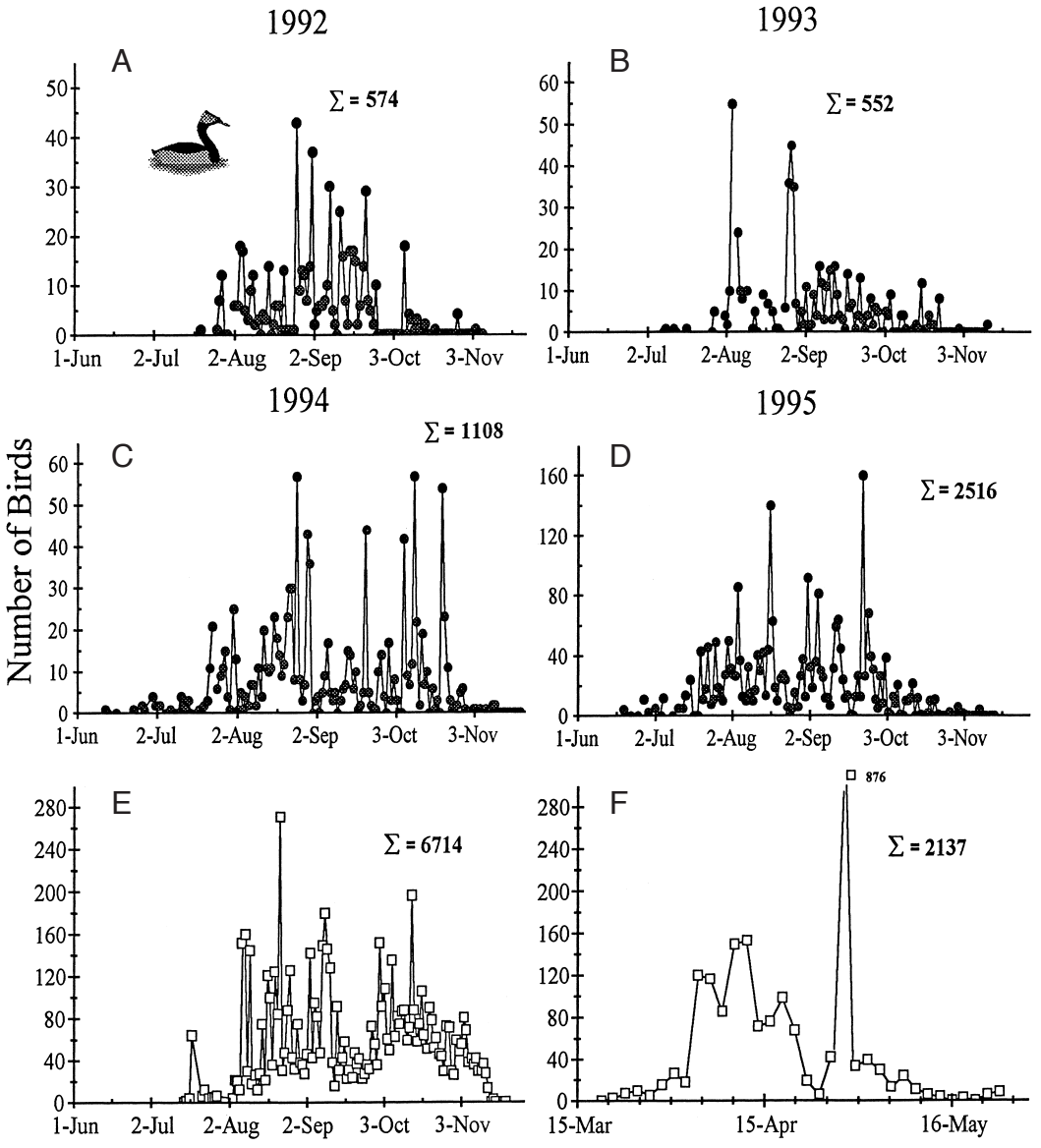

Fig. 2. Timing and pattern of Eared Grebe migration at Green River, Wyoming, in (A–D) autumn 1992–1995, and at Kemmerer, Wyoming, in (E) autumn 1994 and (F) spring 1994.

postbreeding birds and young begins in the last week of July and continues into early November. The pattern and number of birds encountered varied from year to year (Figs. 2 A–D). In some years major influxes were concentrated early in the season (1993), whereas in others they were concentrated in midperiod (1992, 1995) or skewed toward the latter half (1994). Phenology, however, was essentially constant. Migration was essentially over by 15 October, by which time 95% of the migrants had usually passed through (Fig. 3A); 1992, 98.9%; 1993, 95.6%; 1994, 89.3%; 1995, 98.0%.

As soon as the main migration began, migrants were encountered almost daily. In 1992 between 27 July and 27 September (63 days), grebes were seen on 55 of 61 (90%) days for which we have data; in 1993 between 27 July and 25 October (84 days), on 66 of 78

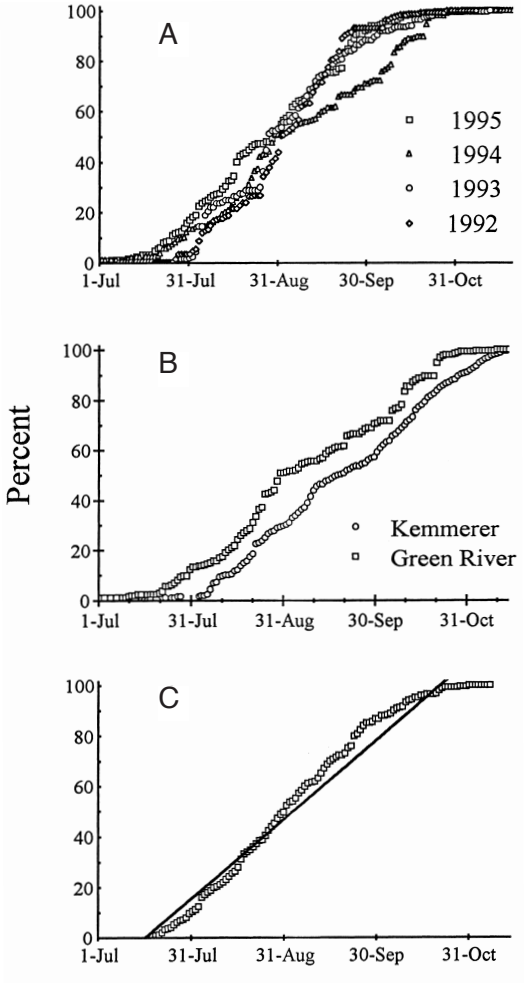

Fig. 3. (A) Cumulative percentage of Eared Grebes migrating through Green River, Wyoming, in 1992–1995 and (B) at Green River and Kemmerer in 1994. (C) The mean pattern at Green River (1992–1995), assuming 20 July as day 1 of the migration. Earlier migrants (assumed to be nonbreeders) were ignored.

days (85%); in 1994 between 1 July and 30 October (122 days), on 106 of 121 days (88%); and in 1995 on all 89 days (100%) between 21 July and 17 October.

KEMMERER.—Fall counts on 119 of 129 days from 16 July through 22 November 1994 showed that grebes arrived daily from 17 July through 17 November, except on 16 November; 97.5 % had passed through by 15 October (Fig. 2E). We recorded 6714 birds, with daily counts averaging 56.4 (range 1–270). Relatively large flights (>100) were spread out over 17 days between 8 August and 19 October.

On 34 spring counts between 22 March and 25 May, observers recorded 2137 migrants, with daily counts (excepting 29 April, see below) averaging 38 (range 0 [3 days] to 153). Peak migration (2023 birds, 94.5%) extended over 35 days from 1 April to 5 May. The pattern (Fig. 2F) approximated a slightly skewed, bell-shaped curve except for 29 April, when 876 birds (40%) arrived. That extreme concentration was associated with severe weather. Evidently, birds left Great Salt Lake on the evening of 28 April shortly after the eastward passage of a frontal system, but they reencountered the front and its associated freezing rain and snow along a line stretching from Pocatello, Idaho, to Kemmerer, to Grand Junction, Colorado, causing them to abort their flight at the first available open water (cf. Jehl 1993, 1994, Jehl et al. 1999).

METEOROLOGY.—Observations at Kemmerer indicated that fall flights might be associated with periods of relatively low barometric pressure. This was supported by a significant correlation between the number of birds recorded each morning and the local pressure measured the previous evening (Spearman rank order correlation, $N = 111$, Spearman $t = -0.205$, $P = 0.031$).

DISCUSSION

Comprehensive censuses in southwestern Wyoming provide unique insights into the migratory patterns of Eared Grebes away from the Great Salt Lake staging area in spring and toward the lake in fall. Spring migration through Kemmerer was relatively brief and concentrated in the first 3 weeks of April. Total number of birds observed (about half that detected in fall, when adjusted for observational effort and discounting the one exceptional flight) is surprisingly large because any grebes leaving Great Salt Lake around sunset should have been well past Kemmerer by dawn (a 2.5-hr flight at 60 km hr^{-1}; Cullen et al. 1999). It seems unlikely that spring migrants would fly only a few hours each night, in view of their need to cross large spans of inhospitable habitat to find safe landing sites, and because their extensive premigration reorganization of body composition (Jehl 1997) is suggestive of preparation for a long flight. The only apparent alternative is that some spring migrants transiting southern Wyoming do not

originate at Great Salt Lake but depart from farther south or east.

The autumn movement toward Great Salt Lake extends from late July into mid-November, with a broad peak stretching from early August through September. This pattern contrasts with that of most Northern Hemisphere migrants, in which the southward flight is concentrated over several weeks. A more concentrated period seems likely for local populations of Eared Grebes as well, but that is not detectable in Wyoming because transients to Great Salt Lake are derived from a source area that may involve most of the species' broad North American range (Jehl and Yochem 1986, Cullen et al. 1999), over which nesting can occur from early May to early August. Also, autumn migration from any area is protracted because of differential migration, with adults emigrating a week or two earlier than juveniles on average (Jehl 1988, Cullen et al. 1999).

We suspect that differences in breeding success account for much of the annual variation. In 1993, for example, when total numbers were low, there were no strong peaks after early September. Such a pattern would be consistent with poor production because juveniles migrate later on average. On the other hand, 1994 might have been a very successful year because total numbers were relatively high and flights persisted into late October. This relationship is hard to verify because of the grebes' widespread distribution and because we lack information on the age composition of migrants and their precise areas of origin. We simply note that in one major grebe breeding area, the Prairie Potholes, duckling production was poor in 1993 but good in 1994 (Caithamer et al. 1993, 1994, Krapu 2000).

Since the pattern of migration in all 4 years at Green River was similar to that recorded at Kemmerer in 1994, even though 6 times as many birds were recorded at the latter site (Figs. 2C–E, 3B), observations at either locality would provide a reasonable index to migration phenology and population composition through southwestern Wyoming in a particular year.

The influence of weather requires further study. Grebes arrive almost daily in both spring and fall. This suggests that migrants are not strongly affected by weather conditions. Yet, fall flights tend to be larger after periods of low pressure. Because the points of takeoff of migrants moving toward Great Salt Lake probably extend over hundreds of miles of longitude, we cannot assert whether synoptic low pressure stimulates migration or whether local low pressure causes grebes to drop out short of their destination.

APPLICATIONS.—The majority of the North American population of Eared Grebes congregates at Mono Lake and Great Salt Lake in fall and remains at those lakes until forced to depart by food shortages in early winter (Jehl 1988, Cullen et al. 1999). The size of these staging masses has been determined by aerial photography in mid-October (Boyd and Jehl 1998, J. Jehl, S. Boyd, D. Paul unpublished). Because photo-censuses later in the season are often precluded by adverse weather, studies at the staging areas had not definitively established when the migration period is over and peak numbers are achieved. Wyoming data resolve that issue by showing that the pattern of migration is broadly consistent from year to year and that >95% of the population has usually passed through by 15 October (Fig. 3C). Accordingly, censuses at the major staging areas on or after 15 October and before grebes leave for wintering areas should encounter virtually all of the population. Furthermore, because nearly all grebes migrate within an 80-day period (21 July–15 October) and the cumulative increase in the percentage of grebes passing through southwestern Wyoming is essentially linear (the cumulative increase is 1.2% day^{-1} through mid-October), it should be possible to extrapolate ultimate numbers from census data obtained earlier in autumn, so long as they were obtained sufficiently late in the season (say, after 25 September) to allow for the migration of young.

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