CHRONOLOGY OF MIGRATION BY AMERICAN COOTS IN OKLAHOMA

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Abstract: American coots (*Fulica americana*) were studied on large reservoirs in north-central Oklahoma in 1979–82 to determine chronologies of migrations by age- and sex class. Coots began migrating into Oklahoma in mid-September, numbers peaked in early to mid-October, and few birds were seen after 1 November. Some late migrants appeared in mid-December. In spring, coots began migrating in late February, numbers peaked in mid-April, and the last birds were seen in mid-May. Generally, adult and juvenile males and juvenile female coots migrated simultaneously in autumn, but adult females completed migration by 1 November. A few juveniles and adult males migrated in December. Adult coots preceded yearlings in spring. Despite annual and between-lake differences in chronology of autumn migration, most coots migrated before waterfowl hunting seasons in Oklahoma. Coot hunting seasons in mid-latitude states should commence before the general waterfowl season where management goals are to increase hunter interest and the harvest of birds.

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Information on the chronology of movements by migratory game birds is essential to regulating harvest (Crissey 1965). Changes in regulations have provided hunters with greater harvest opportunities for waterfowl species migrating earlier than others (Martinson et al. 1966) or species not as vulnerable to shooting pressure (Crissey 1965). The chronology of migration of American coots has received little attention relative to harvest regulations and migration of different age- and sex classes, presumably because hunters have little interest in harvesting coots (Fredrickson et al. 1977:143, Gorenzel 1979:69). Nevertheless, annual harvest of coots averaged 1.17 million birds for 1964–76 (Martin 1979:33), and biologists believe the harvest can be increased (Fredrickson et al. 1977:138). Specific data on general and age-specific chronology of migration by coots are therefore necessary to determine potential changes in regulations to allow increased harvest of coots, the effects of such changes on different segments of coot populations, and the timing of habitat manipulations to attract migrating coots (Fredrickson and Taylor 1982).

We determined chronology by age and sex of coots during autumn and spring migrations in Oklahoma to determine the overlap between coot migration chronology and waterfowl season dates and to elucidate patterns of differential migration by age and sex.

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STUDY AREAS

Fieldwork was conducted in Payne, Noble, and Pawnee counties of north-central Oklahoma. The principal upland vegetation types are tallgrass prairie and post oak (*Quercus stellata*)–blackjack oak (*Q. marilandica*) forest (Duck and Fletcher 1943). Cattle grazing is the principal land use. Migration chronology of

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coots was studied on Sooner Lake, a 2,168-ha lake in Noble and Pawnee counties; Lake Carl Blackwell (1,320 ha, Payne and Noble counties); Perry Lake (137 ha, Noble County); Lake McMurtry (468 ha, Noble County); Boomer Lake (105 ha, Payne County); Cushing Lake (178 ha, Payne County); and Ham's Lake (45 ha, Payne County). Intensive studies were conducted at Lake Carl Blackwell and Sooner Lake. Lake Carl Blackwell is a turbid reservoir 12 km west of Stillwater, Oklahoma. At the time of the present study the principal aquatic vegetation at Lake Carl Blackwell was filamentous algae (*Cladophora* sp.), southern naiad (*Najas guadalupensis*), and stands of flooded smartweeds (*Polygonum* spp.). The abundance of these species varied seasonally; filamentous algae was the principal vegetation in spring (Patterson 1982:5). Sooner Lake, 40 km north of Stillwater, provides cooling water for the coal-fired Sooner Generating Station. During our study, filamentous algae was common along shore in autumn 1979 and spring 1980, growing on submerged grasses and other vegetation. Sparse beds of naiad were found along the shore. In autumn 1980, the level of Sooner Lake was lowered and only sparse beds of naiad were present. In spring, aquatic vegetation was algae, with stands of Johnsongrass (*Sorghum halepense*), curly dock (*Rumex crispus*), sunflowers (*Helianthus* spp.), and grasses occurring frequently along the shoreline. Three large ponds near Sooner Lake also were surveyed. Aquatic plants in these ponds were naiad, pondweeds (*Potamogeton* spp.), muskgrass (*Chara vulgaris*), and filamentous algae.

METHODS

Coots on Lake Carl Blackwell were counted during the autumns of 1979–81 and springs of 1980–82. Coot migration was monitored on Sooner Lake in autumn 1979 and 1980 and spring 1980. During autumn 1979 and 1980, all lakes were surveyed by aircraft every 5 days to count coots. Correction factors (Bartelt 1977:5) were not used because no lake surveyed had emergent cover capable of concealing birds. Aerial counts were supplemented with ground counts at Lake Carl Blackwell and Sooner Lake every 1–5 days. In spring, ground counts were made on Lake Carl Blackwell and Sooner Lake every 1–7 days.

To determine the age and sex of migratory coots, we collected birds from migrant flocks every 5–7 days in autumn 1979–80 and spring 1980 and 1982 on Lake Carl Blackwell and autumn and spring 1980 on Sooner Lake. Whenever possible, coots were sampled from all habitats and all flocks on the lakes on each collection date. Birds were taken to the laboratory and dissected, sex was determined by internal examination, and age was determined by examination of the bursa of Fabricius (Fredrickson 1968) and plumage (Gullion 1954).

To test the hypothesis of no difference in migration chronology between lakes and between years on the same lake, we used two-sided two-sample Smirnov tests to compare cumulative frequency distributions of the proportions of total coots seen vs. date (Conover 1980:369). Cumulative frequency distributions of birds of different age (AHY—after hatching year, hereinafter referred to as adult; HY—hatching year, hereinafter referred to as juvenile in autumn; and 2nd year, hereinafter referred to as juvenile in spring) and sex were compared using the Smirnov test to determine differential migration. Because statistical tables were not available to compare cumulative frequency distributions of four samples of unequal size (Conover 1980:384), we compared migration chronology of all four age- and sex classes using chi-square tests for independence.

RESULTS

Data from Perry Lake, Lake McMurtry, Boomer Lake, Cushing Lake, and Ham's Lake were not analyzed separately because <100 birds or <10 flocks were observed during autumn on each of these lakes. Autumn migrants first appeared in mid-September (Fig. 1); successively larger peaks in numbers occurred until early October in 1979 and 1980 and mid-October in 1981. Peaks in numbers of birds were on days immediately following the passage of cold fronts; most coots stayed only 1–4 days before departing, as indicated by rapid disappearance of flocks (Fig. 1). Because coots are night migrants (Ryder 1963), these birds merely stopped for 1 or 2 days and continued migrating south on subsequent nights if northerly winds prevailed. Most coots departed before 1 November (Fig. 1), although a few migrated in mid-December. A total of 77.7% of all coots was observed before the opening of the general waterfowl season in Oklahoma (Fig. 1).

Coots began arriving during spring migration in late February (Fig. 2). Birds arrived af-

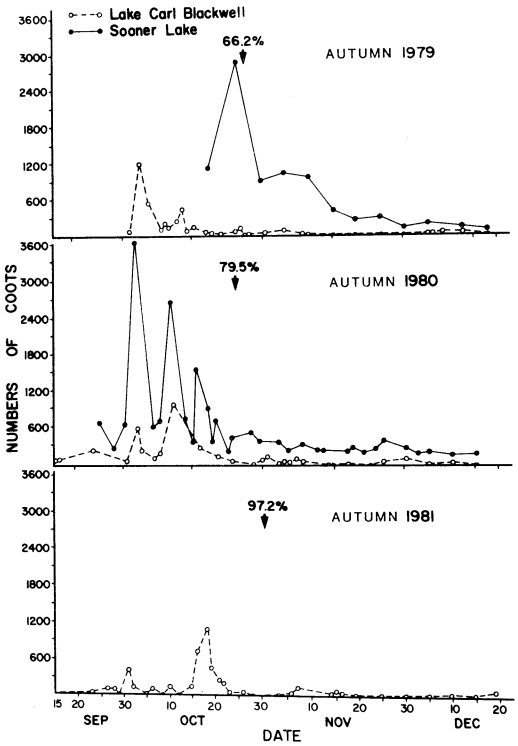

Fig. 1. Migration chronology of American coots in autumn 1979–81 on Sooner Lake (solid line) and Lake Carl Blackwell (dashed line), Oklahoma. Arrows denote opening date of the general waterfowl season for each year. Early teal season ended prior to 25 September in all 3 years. Percentages of coots observed before the general waterfowl season are indicated above the arrow.

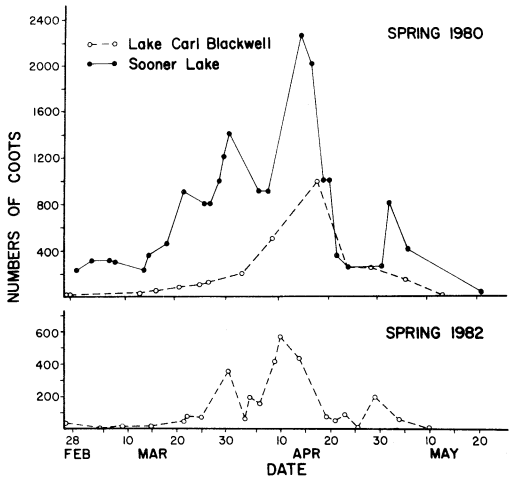

Fig. 2. Migration chronology of American coots in spring 1980 and 1982 on Sooner Lake (solid line) and Lake Carl Blackwell (dashed line), Oklahoma.

ter southerly winds prevailed on previous nights. Numbers of birds increased slowly until late March, peaked in mid-April, and declined until mid-May. Migrational movements appeared more leisurely in spring, without obvious turnover of flocks.

Because chronology of migration differed between lakes and between years on the same lake (Table 1), data on age and sex samples collected during each season and on each lake were analyzed separately to determine the presence of differential migration. Coots of all age- and sex classes except adult females migrated simultaneously in autumn (Table 2). A difference was found between age-classes in 1979 ($\chi^2 = 52.412$, df = 30, $P = 0.007$), but this may be attributed to the predominance of juveniles of both sexes in December 1979 samples. The number of migrants present in December, however, was small relative to the total number of autumn migrants. Extrapolating the age and sex ratios of samples to the total number of coots present on Lake Carl Blackwell for all collection dates in autumn 1979, and graphing the percentage of all birds of that age- and sex class seen on a

Table 1. Between-year and between-lake comparisons of coot migration chronology, autumn 1979–80 and spring 1980 and 1982, Oklahoma.

Lake(s)	Season(s)-year(s)	N_1/N_2[a]	Test statistic[b]	P
All	Autumn 1979 vs. 1980	14,147/23,940	0.4472	<0.01
All	Spring 1980 vs. 1982	20,986/2,944	0.3311	<0.01
Carl Blackwell	Autumn 1979 vs. 1980	3,452/3,347	0.2984	<0.01
Sooner	Autumn 1979 vs. 1980	8,548/19,085	0.6420	<0.01
Carl Blackwell	Spring 1980 vs. 1982	2,666/2,815	0.4693	<0.01
Carl Blackwell vs. Sooner	Spring 1980	2,666/18,320	0.3978	<0.01
Carl Blackwell vs. Sooner	Autumn 1979	3,452/8,548	0.8942	<0.01
Carl Blackwell vs. Sooner	Autumn 1980	3,347/19,085	0.2483	<0.01

[a] Sample sizes are for 1st year/2nd year for comparisons of years, first lake/second lake for comparison of lakes.
[b] Two-sided two-sample Smirnov test.

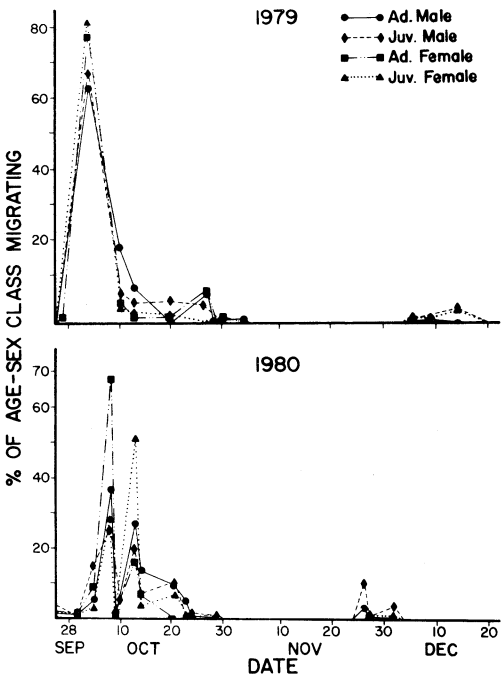

Fig. 3. Chronology of migration of American coots in autumn 1979 and 1980 at Lake Carl Blackwell, Oklahoma, based on age and sex ratios of collected birds extrapolated to censuses.

given day (Fig. 3), revealed that migration of the age- and sex classes was synchronous, although no adult females were collected in December. The same analysis of autumn 1980 data for Lake Carl Blackwell inferred the early migration of adult females (Fig. 3).

Comparisons of each pair of age- and sex classes indicated no differences in migration chronology between juvenile males and females or between adult males and females in autumn (Table 2). Differences between adult females and juveniles of both sexes confirmed the earlier migration of adult females. Only 2 of 72 (2.8%) adult females were collected after 1 November from both lakes in all years, further suggesting earlier autumn migration of adult females.

In contrast to autumn, adult coots migrated before juveniles in spring (Table 2). Adults predominated in February and March samples; few juveniles were present. Age ratios shifted gradually until juveniles predominated in late-April and May samples. Analysis of the six pairs of age- and sex classes (Table 2) confirmed that adults migrated before juveniles in each year except 1982. A simultaneous consideration of all four age- and sex classes indicated differential migration by age in spring 1982 (χ^2 = 38.272, df = 24, P = 0.033). However, only 10 juveniles of each sex were collected in the spring of 1982.

DISCUSSION

The general chronology of autumn coot migration in Oklahoma is within the range of peak migrations observed in other studies, although peak numbers may be up to 3 weeks later than in some mid-latitude states (Gorenzel et al. 1981). The spring peak in mid-April in Oklahoma corresponds to that in Colorado (Gorenzel et al. 1981).

Because coots did not nest on our study lakes and <150 wintered on Sooner Lake each year, virtually all coots we observed were migrants. Timing of counts may affect observed migration chronology. If our autumn counts had been timed at intervals of every 5 days or more, large numbers of migrating coots would have been

Table 2. Comparison of migration chronology for all four age- and sex classes of coots, autumn 1979–80 and spring 1980 and 1982 (two-sided two-sample Smirnov tests), Oklahoma.

Lake	Season	Age- and sex classes compared						
		AM–AF	AM–JM	AM–JF	AF–JM	AF–JF	JM–JF	N_1, N_2, N_3, N_4[a]
Carl Blackwell	Autumn 1979	0.1809	0.2337	0.4783[b]	0.2379	0.5217[c]	0.3134	23, 31, 24, 23
Carl Blackwell	Autumn 1980	0.4182	0.2000	0.1130	0.5039[b]	0.4269	0.1379	20, 11, 35, 23
Sooner	Autumn 1980	0.4167	0.4167	0.1429	0.6667[d]	0.4524	0.4206	16, 6, 9, 14
Carl Blackwell	Spring 1980	0.1964	0.4574[c]	0.4478[c]	0.4111[c]	0.3611[c]	0.1552	49, 64, 29, 36
Carl Blackwell	Spring 1982	0.1771	0.3188	0.4375	0.4333	0.5333[b]	0.3000	32, 42, 10, 10
Sooner	Spring 1980	0.1688	0.4788[b]	0.6480[c]	0.5762[c]	0.7692[c]	0.2359	33, 14, 15, 13

[a] Sample sizes are numbers of adult males (N_1), adult females (N_2), juvenile males (N_3), and juvenile females (N_4).
[b] $0.01 < P < 0.02$.
[c] $P < 0.01$.
[d] $0.02 < P < 0.05$.

missed. Daily counts or counts taken immediately after the passage of cold fronts would most accurately reflect the pattern of coot migration. Yearly variations in weather conditions, availability of food resources, continued presence of breeding or wintering birds (Ward 1953, Brisbin 1974), and physiological condition of individual birds (Cherry 1982) could also cause shifts in abundance or mask movements of migrants.

We found no evidence for segregation of coots of different age or sex during autumn migration in Oklahoma. Previous studies had suggested adult males and nonbreeders may move south earlier than females and juveniles (Ward 1953, Ryder 1963), which is inconsistent with our observations. Juveniles represented 92% of October band recoveries from Wisconsin (Burton 1959), suggesting differential habitat use (Thompson 1973) or differential vulnerability to harvest. Juvenile female coots arrive on breeding areas later than adults (Alisauskas 1982: 19), confirming the pattern of differential spring migration that we saw in Oklahoma.

States with annual harvests of >100,000 coots have waterfowl seasons corresponding to the peak of autumn migration (Wisconsin), have substantial wintering populations present during waterfowl season (Louisiana), or have special seasons for coots (California) (Fredrickson et al. 1977:139). These data suggest a change in timing of coot seasons may be one technique for increasing harvest in other states with large numbers of migrating coots.

Because 77% of coots that we observed each autumn migrated before the waterfowl hunting season that year, the opportunity for harvest of coots is reduced in mid-latitude states such as Oklahoma. Resource management agencies might consider adjusting harvest-season opening dates to increase harvest of birds and, thereby, stimulate interest in coot hunting. Harvest of coots could be allowed during both teal season and general waterfowl seasons, or a separate coot season could begin earlier than, and continue through, the waterfowl season. Both options would necessitate monitoring on an experimental basis, because local overharvest is possible (Burton 1959). Ultimately, a special coot season may increase shooting pressure on waterfowl that migrate early (Geis and Crissey 1973). However, coots are easily identified aquatic game birds (Evrard 1970), and misidentification should be less of a problem than for other species.

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MORPHOMETRIC VARIATION OF SANDHILL CRANES FROM MID-CONTINENTAL NORTH AMERICA

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Our purpose was to determine if subspecies of migrating and wintering sandhill cranes (*Grus canadensis*) from mid-continental North America could be discriminated on the basis of three morphological characteristics used to describe the three subspecies. Mayr (1970) defined subspecies and described taxonomic differences as differences in diagnostic morphological characters.

A committee of the American Ornithologists' Union (1959) recognized three subspecies of sandhill cranes: *G. c. canadensis*, *G. c. tabida*, and *G. c. pratensis*. However, more recent literature recognized six subspecies (e.g., Lewis 1977). Three of the six subspecies (*G. c. pratensis*, *G. C. pulla*, and *G. c. nesoites*) are nonmigratory (Lewis 1977) and are beyond the scope of this paper. Further, four populations of *G. c. tabida* (Eastern, Rocky Mountain, Colorado River Valley, and Central Valley) nest and winter in eastern or western North America (Lewis 1977) and were not included in this study. Our study centered on the 500,000 sandhill cranes that migrate through the Great Plains of North America, winter primarily in Oklahoma, Texas, New Mexico, and Mexico (Tacha et al. 1984), and are referred to as mid-continent sandhill cranes. Mid-continent sandhill cranes have been considered to represent three subspecies: *G. c. canadensis*, which has the smallest body size; *G. c. rowani*, which is intermediate; and *G. c. tabida*, which has the largest body size (Johnson and Stewart 1973, Lewis 1977, Aldrich 1979). The ability to recognize members of discrete subspecies of mid-continent sandhill cranes during migration and wintering periods is important if subspecies are to provide a basis for management.

Currently (1983) sandhill cranes are hunted in 10 states and Canada, with most of the harvest occurring at migration stops and wintering areas of mid-continent cranes in the Central Flyway (Lewis 1977). Knowledge of the presence, distribution, and relative abundance of cranes by subspecies in the mid-continent area has been identified as being important to the management of these birds (Johnson and Stewart 1973, Aldrich 1979). For example, *G. c. tabida* was officially designated as rare by the U.S. Bureau of Sport Fisheries and Wildlife until 1971 (Johnson and Stewart 1973). Subspecies designations constitute legal entities under current endangered species laws. Management by subspecies among mid-continent sandhill cranes could result in the need to justify hunting of specific subspecies.

METHODS

Identifying the subspecies of a sandhill crane based on morphometry is dependent upon knowing its age and sex (Johnson and Stewart 1973, Aldrich 1979). Juveniles (young of the year) do not reach full growth until 10–12 months of age (Walkinshaw 1949) and cannot be accurately assigned to subspecies using mor-

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