Distribution Patterns of American Black Ducks Wintering in Tennessee

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Abstract: Since 1970, over 40% of all American black ducks (*Anas rubripes*) observed during mid-winter waterfowl surveys in the Mississippi flyway occurred in Tennessee. Local differences in distribution, migration chronology, and annual variation in abundance have not been investigated within the state. We used Tennessee recovery records from 1970–1987 to evaluate breeding locations of black ducks wintering in Tennessee and waterfowl survey data collected by Tennessee Wildlife Resources Agency and the U.S. Fish and Wildlife Service from 1955–1992 to evaluate trends in geographic distribution and abundance, migration chronology, and influence of winter temperature on numbers of black ducks wintering in Tennessee. The inland subpopulation of black ducks is primarily confined to the Mississippi flyway. The primary breeding areas of black ducks recovered in Tennessee were within the Mississippi flyway, especially Michigan, Wisconsin, and Manitoba, Canada. Black ducks in the state consistently winter in largest numbers on Cross Creeks National Wildlife Refuge (NWR) and Tennessee NWR in west-central Tennessee, but black ducks comprised a greater percentage of total dabbling ducks on reservoirs in eastern Tennessee. Black ducks wintering on state management areas have declined in recent decades, but those using NWRs have exhibited non-declining annual variation. Black ducks primarily winter in Tennessee from November to mid-February, and winter temperatures do not appear to influence number of black ducks wintering in Tennessee.

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American black ducks have declined recently in North America (Rusch et al. 1989). Hybridization and habitat competition with mallards have been implicated for these declines (Johnsgard 1967, Ankney et al. 1987). The North American black duck population is comprised of 2 fairly distinct subpopulations: the coastal subpopulation of the Atlantic flyway and the inland subpopulation of the Mississippi flyway (Wright 1954). Although most research efforts directed toward managing nonbreeding black ducks and reversing downward trends have been conducted in the Atlantic flyway (Jorde 1986; Conroy et al. 1988, 1989; Morton et al. 1989), 25%–33% of the continental black duck population winters consistently in inland habitats of the Mississippi flyway (Rusch et al. 1989). Since 1970, over 40% of all American black ducks observed during mid-winter waterfowl surveys in the Mississippi flyway occurred in Tennessee (U.S. Fish and Wildl. Serv. [USFWS] 1994). Local differences in distribution, migration chronology, and annual variation in abundance have not been investigated within the state.

The North American Waterfowl Management Plan (NAWMP) is a joint agreement among Canada, Mexico, and the United States that provides broad guidelines for habitat protection and management of migratory waterfowl (USFWS and Can. Wildl. Serv. 1986, Baldassarre and Bolen 1994). The NAWMP indicated that the inland black duck subpopulation should be given immediate "international priority," and called for additional protection of molting, breeding, and wintering areas. The Tennessee NAWMP Implementation Team specified evaluation of existing waterfowl resources in Tennessee as a high initial priority (T. Talley, Tenn. NAWMP Implementation Team leader, pers. commun.). Our objectives were to evaluate distribution and arrival and departure patterns of wintering black ducks in Tennessee over the past 4 decades. We also tested the following hypotheses: 1) differences did not exist in banding locations of blacks ducks recovered in Tennessee, 2) percentage black ducks did not differ among decades or wintering locations in the state, 3) arrival and departure chronologies of black ducks did not differ among wintering locations, and 4) winter temperatures did not influence peak black duck numbers at various locations in Tennessee.

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Methods

We obtained records of black ducks recovered in Tennessee from 1970–1987 from the USFWS Bird Banding Laboratory, Patuxent Wildlife Research Center, Laurel, Maryland, to determine primary breeding areas of black ducks wintering in Tennessee. For this assessment, we used only recoveries of wild ducks banded pre-hunting season. We also obtained records of black ducks recovered in Tennessee that were banded throughout the continent post-hunting season to assess winter site affinity. To reduce bias associated with differential banding effort, we derived indices of the proportion of recoveries from location *i*, adjusted for number of birds banded at *i*, using equation:

$$P_i = \frac{R_i/N_i}{\sum R_i/N_i}$$

where R_i is number of black ducks banded in location; and recovered in Tennessee and N_i is total number banded in location; between 1970–1987. We considered Manitoba and Ontario, Canada, as part of the Mississippi flyway and Canadian provinces farther east as part of the Atlantic flyway.

We chose 7 of the most important waterfowl wintering areas in Tennessee as study sites to analyze annual trends, migration chronology, and influence of winter temperature on black duck numbers. These areas were chosen primarily because they traditionally support a large number of wintering waterfowl and secondarily because they are distributed throughout the state. Study sites include 3 national wildlife refuges (NWR) (Cross Creeks, Reelfoot, and Tennessee NWRs) managed by the USFWS and 4 reservoirs (Cheatham, Chickamauga, Old Hickory, and Watts Bar reservoirs) jointly managed by TWRA, the U.S. Army Corps of Engineers, and the Tennessee Valley Authority.

Personnel from TWRA and the USFWS have inventoried waterfowl on state wildlife management areas and NWRs since the mid-1950s. Most surveys were conducted biweekly from August to April and consisted primarily of aerial reconnaissance, but they also included some ground counts. Surveys conducted in mid-January have been used to generate USFWS mid-winter waterfowl survey data. We developed a computerized waterfowl database that included all TWRA survey records from 1955–1992 to evaluate black duck trends in Tennessee.

We assessed annual differences in peak black duck numbers and percentage of total dabbling ducks (tribe Anatini) that were black ducks on the 7 study areas using analysis of variance models (Proc GLM) (SAS Inst. 1988). We used Duncan's multiple comparisons test to separate means if they were different in the GLM-ANOVA models. We also determined differences in peak black duck numbers by decades and arrival and departure patterns of black ducks on the 7 study sites. We derived mean annual early and late dates for observations when $\geq$500 black ducks were observed. Years in which peak numbers never exceeded 500 black ducks for individual study sites were omitted from this analysis. Gre-

gorian dates were converted to consecutive numbers using August 20 as day 1 because this was the earliest date that black ducks were observed in Tennessee. We used one-way ANOVA (PROC GLM) and Duncan's multiple comparisons procedure to test differences in peak numbers by decades and migration chronology among the 7 study sites.

We compared winter temperatures on northern areas to numbers of black ducks in Tennessee to test influence of winter severity upon migration. We obtained average monthly departure from normal (dfn) temperatures for December and January from the National Oceanic and Atmospheric Administration (NOAA) (U.S. Dep. Comm. 1954–90) for weather recording stations at the Cleveland or Toledo Ohio Express Airports (adjacent to the Lake Erie marshes, a primary fall staging area for inland black ducks). The relationship between dfn and peak number of black ducks observed during December and January at each of the 7 sites was tested by simple linear regression (SAS Inst. 1988). Positive and negative dfn temperatures were treated as positive and negative values in these analyses. We arcsine transformed non-normal percentage data before all analyses, and our significance level was 0.05 for all statistical tests.

Results

Of all black ducks recovered in Tennessee from 1970–1987 ($N = 904$), 45.1% had been previously banded in Tennessee. Of those banded elsewhere, >85% had been banded in the Mississippi flyway, although almost 4 times as many black ducks were banded in the Atlantic flyway (Table 1). When corrected for differential banding bias, proportional indices of black ducks banded in the Mississippi flyway (total = 0.937, winter = 0.976, summer = 0.876) were higher than black ducks banded in the Atlantic flyway (total = 0.063, winter = 0.024, summer = 0.124). The largest number of summer banded black ducks recovered in Tennessee were banded in Ontario (Table 1); however, this is because a much higher number were banded there. Based on our proportional indices, the most important breeding areas of black ducks wintering in Tennessee are Manitoba, Michigan, and Wisconsin (Table 1). Pennsylvania and New York are the most important breeding areas in the Atlantic flyway of Tennessee black ducks (Table 1). Only 5 black ducks recovered in Tennessee had been banded during summer in Massachusetts and Maine in the United States and Nova Scotia, New Brunswick, and Newfoundland, Canada, although 52,376 had been banded in these states or provinces. Most black ducks banded during winter and recovered in Tennessee were banded in nearby states of the Mississippi flyway (Table 1).

Mean annual peak black duck numbers from 1955–1992 was higher at Tennessee NWR than at Cross Creeks NWR, which was higher than means at the other 5 study sites ($P < 0.001$) (Table 2). Although peak numbers were lower on reservoirs in eastern Tennessee than on NWRs in west central Tennessee (Table 2), the highest mean percentage of black ducks occurred on Chickamauga and Watts Bar reservoirs in eastern Tennessee ($P < 0.001$) (Table 2). The

Table 1. Number of black ducks recovered in Tennessee by state or province banded, total number of black ducks banded in different states or provinces, and within flyway proportional indices, 1970–1987.

U.S. State or Canadian province	Recoveries in Tennessee			*N* banded			Within flyway proportional index[a]		
	Winter banded	Summer banded	Total	Winter banded	Summer banded	Total banded	Winter banded	Summer banded	Total banded
Atlantic flyway									
Pennsylvania	4	7	11	3,428	1,800	5,228	0.713	0.480	0.516
New York	7	19	26	14,905	5,413	20,318	0.287	0.434	0.314
Quebec	0	20	20	0	28,697	28,697	0	0.086	0.171
Total[b]	23	51	74	117,619	104,540	222,159	1.000	1.000	1.000
Mississippi flyway									
Alabama	14	0	14	2,369	9	2,378	0.104	0	0.053
Kentucky	22	0	22	2,761	33	2,794	0.140	0	0.071
Illinois	96	0	96	10,687	8	10,695	0.158	0	0.080
Indiana	24	0	24	2,041	13	2,054	0.207	0	0.105
Ohio	44	2	46	5,603	237	5,840	0.138	0.009	0.072
Michigan	10	53	63	1,941	3,499	5,440	0.091	0.262	0.152
Wisconsin	2	15	17	529	1,312	1,841	0.067	0.219	0.128
Ontario	5	113	118	930	21,666	22,596	0.095	0.134	0.090
Manitoba	0	11	11	0	785	785	0	0.376	0.250
Total[c]	228	194	422	28,349	27,810	56,159	1.000	1.000	1.000

[a]Derived by adjusting recoveries by number of bandings.
[b]Flyway total includes an additional 15 states and 4 provinces with <10 Tennessee recoveries.
[c]Flyway total includes an additional 6 states with <10 Tennessee recoveries; Tennessee bandings excluded.

Table 2. Mean maximum number and percentage of black ducks observed at locations in Tennessee, 1955–1992.

Area	Maximum *N* of black ducks		Percentage black ducks	
	$\bar{x}$	SE	$\bar{x}$	SE
Cheatham Res. (36)[a]	862 A[b]	917	23.1 C	1.6
Chickamauga Res. (38)	2,004 B	893	30.0 D	1.6
Cross Creeks NWR (26)	7,689 C	1,079	15.3 B	1.9
Old Hickory Res. (37)	2,322 B	905	24.5 C	1.6
Reelfoot NWR (28)	2,968 B	1,040	1.8 A	1.9
Tennessee NWR (27)	25,511 D	1,059	12.9 B	1.9
Watts Bar Res. (38)	1,334 A	893	31.2 D	1.6

[a](Sample size).
[b]Means with the same letter did not differ among study sites (Duncan's test) within specific criteria.

lowest annual mean percentage was observed at Reelfoot NWR, and next lowest percentages occurred at Tennessee NWR and Cross Creeks NWR (Table 2).

We detected differences in total black duck numbers among decades on Watts Bar ($P < 0.001$), Cheatham ($P = 0.001$), and Old Hickory ($P = 0.005$) reservoirs (Table 3). Wintering black duck numbers peaked during the 1960s or early 1970s on these 3 sites, but declined from the late 1970s through the early 1990s (Table 3). A similar non-significant trend was observed on Chickamauga Reservoir ($P = 0.212$). Peak black duck levels were erratic at Cross Creeks NWR, Reelfoot NWR, and Tennessee NWR, and decadal differences were not significant on these areas ($P = 0.198$, $P = 0.349$, and $P = 0.522$, respectively).

Black ducks were present in Tennessee primarily from November through February (Table 4), but migration chronology varied among study sites ($P < 0.001$). In general, large numbers (≥ 500) of black ducks were observed early in the season only on Cross Creeks NWR and Tennessee NWR (Table 4). Large numbers were observed on Reelfoot NWR several weeks later, while large numbers did not appear on the other areas until early December (Table 4). Less variability occurred in departure chronology, and black ducks generally migrated away from most Tennessee locations by mid-February (Table 4).

We did not detect a relationship between winter dfn temperatures on Lake Erie marshes and peak black duck numbers at 6 of the 7 study sites in Tennessee ($P > 0.124$). Winter dfn temperatures were correlated to peak black duck numbers only on Watts Bar Reservoir ($P = 0.012$), but the relationship explained little variability in black duck numbers ($r^2 = 0.140$).

Discussion

Our study indicates that black ducks wintering in Tennessee have a strong affinity for the Mississippi flyway and that the inland subpopulation of black ducks (Wright 1954) justifies subpopulation rank. Although some ducks banded

Table 3. Mean maximum number of black ducks observed at locations in Tennessee by decade, 1955–1992.

	1950s			1960s			1970s			1980s			1990s		
Area	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*
Cheatham Res.	375	631	5	646	701	10	1,729	396	10	631	342	10	267	39	3
	A[a]			A			B			A			A		
Chickamauga Res.	2,040	619	5	2,784	1,763	10	1,797	1,356	10	1,648	757	10	1,223	216	3
Old Hickory Res.	1,736	835	5	4,245	3,435	10	2,289	720	10	1,010	623	10	599	201	3
	A			B			AB			A			A		
Watts Bar Res.	1,560	702	5	2,052	1,341	10	1,317	1,374	10	282	195	10	122	37	3
	C			D			BC			AB			A		
Cross Creeks NWR			0	6,360	1,795	5	6,219	2,526	8	9,274	3,640	10	8,545	5,233	3
Reelfoot NWR	3,090	2,070	5	2,259	2,355	10	2,596	1,540	6	1,912	966	4	7,283	11,028	3
Tennessee NWR	4,000	—	1	27,504	11,090	3	28,861	14,184	10	25,931	15,827	10	18,125	18,646	3

[a]Means with the same letter did not differ among decades (Duncan's test) within study sites.

Table 4. Mean annual early and late dates when at least 500 black ducks were observed at locations in Tennessee, 1955–1992.

	Early		Late	
	$\bar{x}$ (date)	SE (days)	$\bar{x}$ (date)	SE (days)
Cheatham Res. (23)[a]	12/21 D[b]	5	02/01 B	5
Chickamauga Res. (36)	12/03 BC	4	02/14 BC	4
Cross Creeks NWR (23)	11/03 A	5	02/25 C	5
Old Hickory Res. (33)	12/10 CD	4	02/16 BC	5
Reelfoot NWR (26)	11/20 B	5	01/17 A	5
Tennessee NWR (22)	11/02 A	5	02/18 C	6
Watts Bar Res. (26)	12/06 C	5	02/11 BC	5

[a](Sample size).
[b]Means with the same letter did not differ among study sites (Duncan's test) within specific criteria.

in the Atlantic flyway were recovered in Tennessee, these numbers were low, especially when corrected for differential banding bias. Very few summer banded black ducks from the Atlantic flyway recovered in Tennessee were from the eastern portion of the flyway, indicating that the small amount of subpopulation mixing that does occur is occurring primarily in the western edge of the Atlantic flyway. Most winter banded black ducks recovered in Tennessee were banded in Tennessee or surrounding states, indicating a strong wintering site affinity. Diefenbach et al.'s (1988) observation that black ducks are more sedentary during winter than more mobile species, such as the mallard (*A. platyrhynchos*), supports this conclusion.

Greater numbers of black ducks winter at Cross Creeks NWR and Tennessee NWR than at other locations in Tennessee. The low percentages of black ducks on these areas as compared to locations farther east indicate that these sites are important general waterfowl wintering locations rather than areas that are more attractive to black ducks than other species. These 2 areas consistently support more species and total numbers of dabbling ducks than most other areas in the state (TWRA Waterfowl Database 1955–92). Black ducks are much less abundant at Reelfoot NWR than at these 2 locations, although other species of dabbling ducks are equally abundant. We suspect that black ducks in Tennessee prefer locations on the Tennessee and Cumberland rivers, compared to locations farther west, but we are unable to explain this apparent affinity to the Tennessee River Valley. Other waterfowl biologists in Tennessee have been aware of this affinity for some time (D. H. Orr, USFWS, pers. commun.; Bellrose 1980).

The high percentages, but low numbers, of black ducks in eastern Tennessee perhaps reflect the eastern origin of the species and poorer quality waterfowl habitat at eastern sites. Most locations in eastern Tennessee consist of impounded reservoirs with relatively small areas of shallow wetlands. The west to east pattern of increasing black duck percentages observed in this study is consistent with findings of Wright (1954) and Johnsgard (1967).

Considerable annual variation was observed in black duck numbers in this study. Variability generally increases with length of time over which variability is calculated (Pimm 1994), and migratory species are more variable in abundance than non-migratory species, possibly reflecting mortality associated with migration and/or variability in localized migration patterns (Pimm 1994). Variation in peak numbers of black duck observed in our study perhaps partially reflects annual variation in habitat conditions on areas throughout the state, thereby influencing localized movements.

Steady declines in abundance are indicators of possible environmental degradations (Pimm 1994). Decreasing black ducks at Watts Bar, Cheatham, and Old Hickory reservoirs may indicate declining black duck habitat on areas surrounding these reservoirs. Agricultural lands surrounding many Tennessee reservoirs, which may provide food resources for black ducks, have been converted to pastures, forests, and urban areas in recent years, perhaps influencing these declines. The role of eastern Tennessee reservoirs in providing habitat for wintering black ducks is currently unclear, and ecological studies are needed to determine importance of these areas and the reasons that black ducks are declining on reservoirs in the state.

We do not believe that these declines can be attributed to continental and flyway trends in black duck numbers, because black ducks in Tennessee have not declined on a statewide basis nor at NWRs, the areas that support the largest number of black ducks in the state. Managed impoundments on NWRs comprise a higher percentage of the land base than on reservoirs, and most black ducks on NWRs are perhaps able to find sufficient food to restrict their movements to managed waterfowl impoundments (White et al. 1993). We suspect that some black ducks are being attracted from reservoirs in Tennessee and areas in surrounding states where recent wetland degradation has been more severe. This hypothesis should be tested with field studies of marked individuals.

In our study, increased number of black ducks wintering at various locations in Tennessee were not associated with low temperatures on more northerly areas, suggesting that black ducks are able to cope with extremely cold weather and that other factors influence migration patterns and use of individual areas. Traditionally considered a hardy species, black ducks are able to withstand inclement conditions more efficiently than some other species (Wright 1954). Black ducks often wait until weather conditions improve rather than expending energy to migrate to more favorable locations (Diefenbach et al. 1988). Amount and types of foods possibly contribute more to annual differences in black duck migration patterns than winter temperatures (Brodsky and Weatherhead 1984).

Wintering black ducks in coastal Massachusetts made only short, localized flights and settled into small flocks around specific food sources during periods of extremely cold temperatures (Grandy 1972). Additional studies are needed to determine how food resources and winter severity influence movements of black ducks wintering in Tennessee.

Although we are confident our data provides general trends in black duck distribution patterns in Tennessee, we realize that survey methodology used over the past 4 decades were somewhat inconsistent on an annual, area, and individual observer basis. Statistical approaches are not available to check validity of these data because of a lack of standardization (Conroy et al. 1988). Conroy et al. (1988) used a stratified surveying method as an alternative to the mid-winter surveys to estimate wintering black duck numbers along the Atlantic Coast and indicated that their data were statistically defensible. A stratified approach for TWRA biweekly surveys would enhance the validity of future survey data.

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