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AUTUMN BIRD CASUALTIES AT A NORTHWEST FLORIDA TV TOWER: 1973-1975

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Accounts of nocturnal accidents to migrating birds at tall, lighted structures are numerous (Nisbet 1970) but most represent species listings covering 1 or 2 night kills. Tordoff and Mengel (1956), Goodpasture (1963a,b), and Taylor (1972, 1973) showed that more detailed analyses of tower kills contribute much to our understanding of many aspects of avian migration, particularly to the differential migration of age and sex classes. Even so, Johnson's (1973) statement ". . . the temporal and geographic complexities of migration . . . are only beginning to be understood" probably applies to most migratory species. Many more data from different sites are needed. This paper presents age and sex data for 3223 birds killed at the WCTV tower in northwest Florida during the autumns (August-November) of 1973-1975. Comparisons with other studies, particularly to the one by Taylor and Anderson (1973) in central peninsular Florida are made.

METHODS

Stoddard (1962), Stoddard and Norris (1967), and Crawford (1974) gave the species, numbers, and seasonal variation of birds killed at the WCTV tower on Tall Timbers Research Station, Leon County, Florida, and complete descriptions of the 308 m tower and its 14 ha cleared site. In 1973, the grounds were checked for dead birds daily at 07:30 and the control of predators that eat the dead birds was essentially limited to experiments (Crawford 1971, 1974). In 1974 and 1975, the tower grounds were checked at daybreak and a more rigorous program of predator control was instituted that included both trapping and poisoning. In all years the birds were frozen soon after collection and within 3 months of death were thawed and dissected to determine the age and sex by examination of the skull and gonads (Miller 1946, Goodpasture 1963b). I kept notes on plumage abnormalities, stomach contents, molt, and other physical aspects of most of the specimens.

RESULTS

Numbers and species recorded during the study.—In the autumn of 1973, 261 individuals of 57 species were collected. For the same period in 1974,

1832 individuals of 87 species, and in 1975, 1771 individuals of 90 species were found. The total for the 3 autumns was 3864 individuals of 109 species. The disparity between the number of birds recorded in 1973 and subsequent years is due primarily to the reintroduction of predator control at the tower. Compared to 3 predators removed in 1973, 42 were removed from the tower grounds in 1974–1975 and there was evidence that 28 others were eliminated. Most of those handled were Virginia opossums (*Didelphis virginiana*), feral domestic cats (*Felis catus*), and Great Horned Owls (*Bubo virginianus*).

On 6 nights during the study period, more than 100 dead birds were recorded: 17 October 1973 (133), 5 September 1974 (134), 23 September 1974 (220), 17 October 1974 (971), 14 September 1975 (636), and 15 September 1975 (486). These are 66.7% of the grand total and all were associated with the onset and passage of cold fronts.

Physical aspects of the tower casualties.—Plumage abnormalities were rare. Partial albinism was observed in an adult ♀ Yellow-rumped Warbler (*Dendroica coronata*) and an unsexed adult Field Sparrow (*Spizella pusilla*). An adult ♀ Bay-breasted Warbler (*Dendroica castanea*) with an abnormally pale-yellow head appeared to be partially xanthochroistic (Tall Timbers Res. Sta. #3267). Molting individuals were also rare but nearly one-half of the Gray Catbirds (*Dumetella carolinensis*) examined, including all age and sex classes, were in body molt. One immature ♂ Ovenbird (*Seiurus aurocapillus*) had sheathed rectrices when found on 15 September 1975.

I examined the stomachs of all the birds from 1973 and those found from August–September of 1974 and found virtually all to be empty. Other workers have recorded similar results for migrating birds (Tordoff and Mengel 1956:8). I did find, however, that Yellow-billed Cuckoos (*Coccyzus americanus*) and Black-billed Cuckoos (*C. erythrophthalmus*) consistently had full stomachs.

Sex and age ratios.—Sex and age data from the WCTV tower samples are in Table 1 and the species included are only those with large sample sizes (usually ≥ 10). The total male:female ratio is virtually 1:1 (50.2% ♂♂) and the 46.2% adult proportion is essentially what others have found for adult survival rates (Ricklefs 1973:404). Individual species often do not have these expected ratios and this may be due to real inequalities within the populations, year-to-year variation, or to differential migration by age or sex classes.

Murray (1966) defined 3 types of differential migration: *non-overlapping asynchronous* in which all individuals of one age or sex class precede the others (or vice versa); *overlapping asynchronous* in which the timing of the age and sex classes overlap, but one peaks before the others; and

TABLE 1
SEX AND AGE RATIOS OF BIRDS KILLED AT THE WCTV TOWER: AUTUMNS 1973-1975

Species	Total examined	Ad:Im	♂♂:♀♀	A♂♂:I♂♂	A♀♀:I♀♀
Yellow-billed Cuckoo <i>Coccyzus americanus</i>	14	—:—	5:7	—:—	—:—
Acadian Flycatcher <i>Empidonax virescens</i>	17	12:4 ¹	4:10	2:1	9:1
House Wren <i>Troglodytes aedon</i>	38	14:24	16:15	7:9	5:10
Short-billed Marsh Wren <i>Cistothorus platensis</i>	20	1:19	4:9	0:4	1:8
Gray Catbird <i>Dumetella carolinensis</i>	89	39:50	48:34	24:24	12:22
Wood Thrush <i>Hylocichla mustelina</i>	26	9:17	11:11	2:9	7:4
Swainson's Thrush <i>Catharus ustulatus</i>	76	20:56	42:15	11:31	5:10
Gray-cheeked Thrush <i>Catharus minimus</i>	19	7:12	6:8	2:4	3:5
Veery <i>Catharus fuscescens</i>	125	73:46	61:58	35:22	37:19
14 Sept. 1975 ²	68	38:30	29:37	16:13	22:15
15 Sept. 1975	27	12:10	15:10	5:7	6:2
Ruby-crowned Kinglet <i>Regulus calendula</i>	35	—:—	9:24	—:—	—:—
White-eyed Vireo <i>Vireo griseus</i>	27	17:7	11:12	6:3	8:3
Yellow-throated Vireo <i>Vireo flavifrons</i>	10	0:10	3:5	0:3	0:5
Red-eyed Vireo <i>Vireo olivaceus</i>	896	452:444	370:357	183:187	244:113
5 Sept. 1974	54	15:39	24:22	7:17	7:15
14 Sept. 1975	251	168:83	107:112	75:32	90:22
15 Sept. 1975	237	123:114	94:99	52:42	61:38
23 Sept. 1974	60	40:20	26:24	14:12	21:3
17 Oct. 1974	98	8:90	29:20	0:29	8:12
Philadelphia Vireo <i>Vireo philadelphicus</i>	6	2:4	3:3	2:1	0:3
17 Oct. 1974	6	2:4	3:3	2:1	0:3
Black-and-white Warbler <i>Mniotilta varia</i>	90	29:59	44:32	14:29	13:17
Prothonotary Warbler <i>Protonotaria citrea</i>	25	9:16	11:11	5:6	4:7
15 Sept. 1975	14	5:9	8:6	4:4	1:5
Swainson's Warbler <i>Limnothlypis swainsonii</i>	8	7:1	4:4	3:1	4:0

TABLE 1 (continued)

Species	Total examined	Ad:Im	♂♂:♀♀	A♂♂:I♂♂	A♀♀:I♀♀
Worm-eating Warbler <i>Helminthos vermivorus</i>	26	7:19	5:15	3:2	3:12
Tennessee Warbler <i>Vermivora peregrina</i>	56	12:44	21:20	5:16	6:14
17 Oct. 1974	29	8:21	11:11	3:8	4:7
Northern Parula <i>Parula americana</i>	83	54:29	36:20	26:10	12:8
14 Sept. 1975	17	13:4	8:5	7:1	4:1
17 Oct. 1974	31	19:12	13:11	10:3	6:5
Yellow Warbler <i>Dendroica petechia</i>	18	4:14	8:5	2:6	2:3
Magnolia Warbler <i>Dendroica magnolia</i>	140	73:67	47:52	25:22	32:20
17 Oct. 1974	106	52:54	37:43	20:17	25:18
Black-throated Blue Warbler <i>Dendroica caerulescens</i>	13	2:11	9:3	2:7	0:3
Yellow-rumped Warbler <i>Dendroica coronata</i>	55	30:24	18:22	11:6	12:9
Cerulean Warbler <i>Dendroica cerulea</i>	17	7:10	6:5	4:2	3:2
Blackburnian Warbler <i>Dendroica fusca</i>	98	23:75	29:32	10:19	9:23
14 Sept. 1975	22	7:15	14:6	6:8	1:5
17 Oct. 1974	16	2:14	1:11	0:1	1:10
Chestnut-sided Warbler <i>Dendroica pensylvanica</i>	83	45:38	33:26	18:15	16:10
17 Oct. 1974	55	29:26	21:23	12:8	14:9
Bay-breasted Warbler <i>Dendroica castanea</i>	105	69:35	26:50	19:6	34:16
17 Oct. 1974	70	44:25	17:35	13:3	22:13
Prairie Warbler <i>Dendroica discolor</i>	15	10:5	5:5	3:2	4:1
Palm Warbler <i>Dendroica palmarum</i>	72	53:19	26:19	20:6	15:4
17 Oct. 1974	45	32:13	19:17	15:4	13:4
Ovenbird <i>Seiurus aurocapillus</i>	219	62:157	74:84	30:44	27:57
14 Sept. 1975	31	13:18	12:17	6:6	7:10
15 Sept. 1975	42	12:30	16:15	8:8	4:11
17 Oct. 1974	105	19:86	34:42	8:26	8:34
Northern Waterthrush <i>Seiurus noveboracensis</i>	55	21:34	22:23	10:12	10:13

TABLE 1 (continued)

Species	Total examined	Ad:Im	♂♂:♀♀	A♂♂:I♂♂	A♀♀:I♀♀
Common Yellowthroat <i>Geothlypis trichas</i>	159	47:111	55:66	21:34	23:43
14 Sept. 1975	29	3:26	6:18	1:5	2:16
17 Oct. 1974	32	12:20	12:13	6:6	6:7
Hooded Warbler <i>Wilsonia citrina</i>	83	48:35	40:30	23:17	19:11
American Redstart <i>Setophaga ruticilla</i>	90	39:51	33:35	20:13	17:18
17 Oct. 1974	39	19:20	14:19	8:6	11:8
Bobolink <i>Dolichonyx oryzivorus</i>	32	26:5	12:12	10:1	9:3
Northern Oriole <i>Icterus galbula</i>	11	4:7	2:7	1:1	3:6
Scarlet Tanager <i>Piranga olivacea</i>	13	8:5	7:6	4:3	4:2
Summer Tanager <i>Piranga rubra</i>	7	3:4	3:4	2:1	1:3
Indigo Bunting <i>Passerina cyanea</i>	47	29:18	23:18	17:6	11:6
Savannah Sparrow <i>Passerculus sandwichensis</i>	21	6:15	9:9	2:7	3:6
Grasshopper Sparrow <i>Ammodramus savannarum</i>	7	3:4	3:2	1:2	2:0
Other species	177	79:89	74:80	32:35	41:35
Total	3223	1455:1694	1278:1267	617:629	672:546

¹ Italicized ratios are significantly at variance from equality ($P < .05$ by χ^2).

² Dated entries are from single night kills.

synchronous in which the timing and numbers of the sex and age classes are the same. Differential migration behavior may be temporal, geographical, or both (King et al. 1965).

Seven species exhibited evidence of temporal differential migration at the WCTV tower (Table 2) and all cases involved age classes only. The significance (at the $P < .05$ level) was determined by the variance test for homogeneity of the binomial distribution (Snedecor and Cochran 1967:240). For the Red-eyed Vireo, Tennessee Warbler, and Ovenbird there was an early peak by the adults, and for the Gray Catbird, Wood Thrush, Black-and-white Warbler, and Common Yellowthroat the immatures peaked early. All represent an overlapping asynchronous migration pattern.

Taylor and Anderson (1973) studied autumn bird casualties at the

TABLE 2
SEASONAL VARIATION IN AGE CLASSES AT THE WCTV TOWER, AUTUMNS 1973-1975¹

Species	August		September		October		November
	16-31	1-15	16-30	1-15	16-31	1-15	
* Gray Catbird	0:0	0:5	9:14	18:15	12:15	0:0	
* Wood Thrush	0:0	0:0	0:4	2:3	7:10	0:0	
** Black-and-white Warbler	1:2	9:39	2:3	4:1	13:14	0:0	
* Tennessee Warbler	0:0	0:0	2:2	3:5	7:34	0:3	
** Ovenbird	0:0	35:53	2:9	6:4	19:89	1:2	
** Common Yellowthroat	0:0	4:42	11:31	17:17	14:20	1:2	
Red-eyed Vireo							
** Ad ♂ ♂ : Im ♂ ♂	1:3	146:98	33:30	3:26	0:30	0:0	
** Ad ♀ ♀ : Im ♀ ♀	0:2	170:72	60:14	6:11	8:14	0:0	
** Ad?:Im?	0:0	15:68	9:25	0:0	1:51	0:0	
** Ad:Im	1:5	331:238	102:69	9:37	9:95	0:0	

¹ Unless otherwise noted, numbers are adults:immatures.

* Not significant ($P > .05$).

** Significant ($P < .05$).

WDBO tower in Orange County (central peninsular), Florida for the years 1969-1971, and their data seem an appropriate comparison with those from the WCTV tower for determining evidence of geographic variation in differential migration. Table 3 compares those species from WCTV and WDBO which had age or sex ratios significantly different from equality by simple chi-square tests. Intertower comparisons were based on the arcsin test for the equality of 2 percentages (Sokal and Rohlf 1969:608). The species in Table 3 are of 2 classes: (1) those that have age or sex classes significantly at variance from equality the same way at both towers, and (2) those that show a difference in ratios between the towers. The Acadian Flycatcher is an exception that fits neither class. Of those species in the first class, the Swainson's Thrush, Tennessee Warbler, and Blackburnian Warbler show a preponderance of immature birds at both towers, while the Veery, White-eyed Vireo, Swainson's Warbler, Northern Parula, Palm Warbler, and Bobolink show a preponderance of adults at both sites. The Bay-breasted Warbler and the Ruby-crowned Kinglet had high percentages of females, while the Northern Parula had a preponderance of males. The species making up the second class had different age ratios at the 2 towers and all but the Red-eyed Vireo and the Yellow-rumped Warbler had a higher percentage of immature birds at the WCTV tower. The exceptional species (Acadian Flycatcher) had a preponderance of adults at the WCTV tower but none of this species was recorded at the WDBO site.

TABLE 3

SPECIES SHOWING SIGNIFICANT DIFFERENCES FROM EQUALITY IN AGE OR SEX CLASSES AT THE WCTV TOWER (THIS STUDY) AND AT THE WDBO TOWER (TAYLOR AND ANDERSON 1973)

Species	Adults:Imm.'s		♂♂:♀♀	
	WCTV	WDBO	WCTV	WDBO
Acadian Flycatcher	<i>12:4¹</i>	0:0	<i>4:10</i>	0:0
Short-billed Marsh Wren	<i>1:19</i> ** ²	24:21	4:9	15:25
Gray Catbird	39:50 **	<i>100:41</i>	48:34	60:70
Swainson's Thrush	<i>20:56</i>	3:11	<i>42:15</i>	—:—
Veery	<i>73:46</i>	11:7	61:58	9:6
Ruby-crowned Kinglet	—:—	—:—	9:24	9:31
White-eyed Vireo	<i>17:7</i>	<i>41:17</i>	11:12	25:33
Yellow-throated Vireo	<i>0:10</i> **	8:0	3:5	—:—
Red-eyed Vireo	452:444 **	<i>15:76</i>	370:357	43:33
Black-and-white Warbler	<i>29:59</i> **	60:48	44:32	47:61
Swainson's Warbler	<i>7:1</i>	19:8	4:4	11:16
Worm-eating Warbler	<i>7:19</i> **	20:5	5:15 **	15:10
Tennessee Warbler	<i>12:44</i>	6:8	21:20	8:6
Northern Parula	<i>54:29</i>	<i>211:114</i>	<i>36:20</i> **	160:127
Yellow Warbler	<i>4:14</i> **	8:2	8:5	5:5
Black-thr. Blue Warbler	<i>2:11</i> **	<i>417:352</i>	9:3	417:352
Yellow-rumped Warbler	30:24 **	<i>42:11</i>	18:22	<i>11:26</i>
Blackburnian Warbler	<i>23:75</i>	3:10	29:32	8:5
Bay-breasted Warbler	<i>69:35</i>	6:7	<i>26:50</i>	<i>3:10</i>
Palm Warbler	<i>53:19</i>	<i>305:175</i>	26:19 **	168:253
Ovenbird	<i>62:157</i> **	<i>309:196</i>	74:84	<i>255:302</i>
Northern Waterthrush	21:34 **	<i>84:45</i>	22:23	<i>51:78</i>
Common Yellowthroat	<i>47:111</i> **	<i>1463:789</i>	55:66	1216:1236
American Redstart	39:51 **	<i>309:210</i>	33:35	219:282
Bobolink	<i>26:5</i>	<i>111:23</i>	12:12	68:63
Savannah Sparrow	<i>6:15</i> **	20:8	9:9	11:15

¹Ratios in italics are significantly at variance from equality ($P < .05$ by χ^2).

²Asterisks between ratios indicate significantly different ($P < .05$) percentages of either adults or males (see text).

DISCUSSION

The different age and sex ratios revealed in this study may be due to differential migration, variance within the populations, or year-to-year variation. Some age and sex data from birds killed at the WCTV tower in previous years are available in appropriate form for comparison with the results of the present study. Gifford and Odum (1965) found 102 of 186 Bobolinks to be males, a ratio that is statistically insignificant, and D. W. Johnston (pers. comm.) examined 32 Bobolinks from September 1966 and found them all

to be adults evenly divided for sex. These results are essentially what I found for that species. Johnston and Downer (1968) and Johnston (1970) examined Indigo Buntings killed in the 1960's and found, as I did, slightly more adults than immatures, but consistently there were more females than males. I found slightly more males (23) than females (18) but neither my ratios nor those of Johnston are significant. Nolan and Mumford (1965) examined 286 Prairie Warblers killed in the late 1950's and early 1960's and found 73% to be adults and 50.3% to be males; my figures are 75% and 50%, respectively. W. K. Taylor (pers. comm.) examined 188 Common Yellowthroats killed between 1960 and 1967 and found 50 (26.6%) to be adults which is virtually the same as the 29.4% reported here. Thus species for which WCTV data are available from earlier years show essentially the same age and sex ratios found in this study.

The data in Table 2 generally agree with the literature on these species. Tordoff and Mengel (1956), Goodpasture (1963a,b), Murray (1966), and Taylor and Anderson (1973) all recorded an early peak of adults for the Red-eyed Vireo. The age ratio, however, for this species killed at WCTV on 5 September 1974 (Table 1) has a high percentage of immatures on an early date which indicates there may be some yearly variation in the basic pattern. Tordoff and Mengel (1956) indicated that Gray Catbirds showed an overlapping asynchronous pattern with the adults peaking first, but this was based on a sample from one night. My data for this species seem to agree more closely with those of Barry (1971), for in both cases the adult peak occurred well after the immatures had begun an apparently *peakless* migration. Tordoff and Mengel (1956) also indicated that in Common Yellowthroats the adults peaked first, while Barry (1971) found a synchronous pattern for this species. W. K. Taylor (pers. comm.) found that in peninsular Florida, the immatures of this species probably peak first which is also the case at the WCTV tower. Goodpasture (1963b) noted an early peak in immature Black-and-white Warblers and an early peak in adult Tennessee Warblers. Taylor (1972) indicated an early peak by adult Ovenbirds. The remaining species (i.e., those not in Table 2) show apparently synchronous patterns but in many cases the sample sizes are too small to allow decisions one way or the other.

Some of the data in Table 3 may well indicate cases of differential migration, but for some of the species other factors may be affecting the results. One bias that tower kills share is that they are dependent on severe weather for large kills. Since the frequency and severity of cold fronts that usually cause such weather in autumn increase from August through October, those species (or age and sex classes) that migrate very early will be absent or poorly represented (Nolan and Mumford 1965). Thus, such relatively

common nocturnal migrants as the Louisiana Waterthrush (*Seiurus motacilla*) and Orchard Oriole (*Icterus spurius*), both of which are early migrants, are poorly represented at both the WCTV and WDBO towers. Similarly, there is only one record of an early migrating adult of the "Traill's Flycatcher" complex (*Empidonax traillii* and *E. alnorum*) at WCTV (Crawford 1976). An early and relatively unsampled age or sex class might account for some of the unequal ratios found at either WCTV, WDBO, or both. Species that might fall into this category are the Northern Parula (with a high percentage of males at both towers) and the Veery, White-eyed Vireo, Swainson's Warbler, Northern Parula, and Bobolink (all with a preponderance of adults at both towers). However, this seems an unlikely explanation for the preponderance of adults in the Palm Warbler or the larger number of females in the Bay-breasted Warbler, since both species are rather late migrants. The high percentage of females for the Ruby-crowned Kinglet at both sites is probably due to sexual displacement geographically on the wintering grounds with the males occupying the northernmost part of the winter range (S. A. Gauthreaux, Jr., pers. comm.). This behavior would confer a selective advantage for early arrival of the males on the breeding grounds in the spring to secure choice territories; it would also serve to reduce intersexual competition during the rigorous winter months (Selander 1966). Since in the eastern portion of its range the kinglet winters entirely within the United States, individuals killed at WCTV and WDBO would mostly be the more southerly wintering females.

Fourteen species in Table 3 had different age ratios at the 2 towers and all but the Red-eyed Vireo and the Yellow-rumped Warbler had a preponderance of immatures at WCTV. The relatively high number of adult Red-eyed Vireos at WCTV is most likely a result of the 2 large kills on 14 and 15 September 1975 (Table 1) which is early in the season when normally there are more adults aloft than immatures (references cited earlier). For the remaining 12 species, the evidence suggests that the adults and immatures follow largely different migration routes in the southeastern United States. The 2 towers are sampling different migration systems: the birds killed at WCTV in autumn are primarily trans-Gulf migrants, i.e., most make a non-stop flight across the Gulf of Mexico to Central America (Odum 1960) whereas those killed at WDBO are primarily circum-Gulf migrants, i.e., most fly from the Atlantic coast to South America or island-hop through the West Indies after leaving the Florida peninsula (Taylor 1973). Allopatry of age classes on the wintering grounds, a well known phenomenon (Lack 1954:245, King et al. 1965), would account for the significantly different ratios found at the 2 towers, for as the birds move south, the age classes

would tend to segregate into the different migration systems to reach their separate wintering areas.

SUMMARY

Ages and sexes were determined for 3223 birds killed at the 308 m WCTV tower in northwestern (Leon County) Florida in the autumns of 1973–1975. The data are compared with those from other studies, especially one at a tower in central peninsular Florida. The ♂♂:♀♀ ratio at WCTV was 1278:1267 (50.2% ♂♂) and the adult:immature ratio was 1455:1694 (46.2% adult). Seven species showed differential migration of age and sex classes temporally at the WCTV tower. For 12 species, the trans-Gulf migrants killed at WCTV had significantly more immatures than did the circum-Gulf migrants killed in peninsular Florida. The peninsular migrants had significantly high ratios of adults when compared with those from WCTV. It is suggested that adults and immatures of some species follow largely different migration routes as a result of allopatry on the wintering grounds.

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