AN ANALYSIS OF MIGRATING BIRDS KILLED AT A TELEVISION TOWER IN EAST-CENTRAL ILLINOIS, SEPTEMBER 1955–MAY 1957

BY RICHARD BREWER AND JACK A. ELLIS

BIRDS killed at tall, dimly lighted structures such as television towers probably represent samples of nocturnal migration as nearly random as it is possible to obtain (see Tordoff and Mengel, 1956: 17–18). For this reason, study of these kills provides valuable data on such topics as relative numbers of each sex and age group of a species, time of migration of each group, fat condition, geographical patterns of migration, and total volume of migration. Information is presented on these topics in the following analysis of seven kills at the WCIA television tower located one mile west of Seymour in Champaign County, Illinois.

ACKNOWLEDGMENTS

Appreciation is due R. R. Graber, S. C. Kendeigh, T. G. Scott, and W. B. Robertson, Jr., all of whom either offered helpful comments on the manuscript or assisted in processing birds. The weather officer at Chanute Air Force Base, Rantoul, and the U. S. Weather Bureau, Champaign, supplied weather data. Thanks are especially directed to personnel of the WCIA tower who notified us of destruction of birds. The paper was written while the senior author held a fellowship from the National Science Foundation.

DESCRIPTION OF TOWER AND SURROUNDING AREA

The WCIA tower is located in the NE ¼ of Sec. 18, T. 19 N., R. 7 E., of the Mahomet, Illinois, quadrangle. It is on a slight rise of 10 to 15 feet above surrounding land and 720 feet above sea level. The height of the tower is 983 feet, the upper 103 feet of which form a transmitting antenna. The antenna is composed of six segments, each 10.5 feet high, separated from one another by about 8 feet. The segments are cross shaped in cross-section and are 9 feet on a side. The lower 880 feet of the tower is triangular in cross-section with one of the eight-foot-wide faces directed north. This part of the tower is constructed of steel tubes 4.7 inches in diameter. L-beams 3 inches wide connect the legs every 8 feet, and small rods form diagonals between each set of cross-beams. Three groups of guy wires extending S 2° 40′ E, N 62° 40′ W and N 57° 20′ E support the tower. Each group is composed of three 1-inch cables attached at 280, 560, and 880 feet and anchored 600 feet from the base of the tower. The tower is supplied with red lights at seven heights as follows: 140 feet (3 steady), 280 feet (1 flashing), 420 feet

(3 steady), 560 feet (1 flashing), 700 feet (3 steady), 840 feet (3 steady), and 983 feet (1 flashing).

A transmitter building is situated 30 feet east of the tower. Incandescent lights placed eight feet from the ground at each corner illuminate the white sides of the building. Corn and soybean fields occupy most of the surrounding land. The floodplain of the Sangamon River, 2.5 miles to the west, is the nearest forested area.

WEATHER CONDITIONS DURING PERIODS OF MORTALITY

Mortality occurred under conditions of 80–100 per cent cloud cover, a ceiling of 400–1600 feet, and obscured visibility resulting from fog or haze. In general, mortality both in spring and fall was associated with the arrival of a cold front within the previous 12 hours. Temperatures ranged from 43° to 66° F. Wind was variable as to direction; wind velocity was between 5 and 10 mph. These are the same meteorological conditions which have been described for other examples of mass mortality, except for the variability of wind direction. Howell, Laskey, and Tanner (1954) found prevailing north winds during periods of mortality.

PROCEDURE

Notification of the four largest kills was received within 12 hours after each had occurred. The tower was visited within 24 hours after three of these and about 60 hours after the other (September 1955). For two fall kills and one spring kill, the locations of dead birds were mapped. Distances were determined by pacing from landmarks. Mapping was completed in one day except for the October 1955 kill which required parts of four days. Samples as nearly complete as possible were taken and the birds were frozen. Later examination involved verifying doubtful field identifications, sexing whenever possible, aging by means of skull ossification (for passerines), and determining fat condition (McCabe, 1943).

BEHAVIOR OF BIRDS AT THE TOWER

The usual cause of death in nocturnal mortality is collision with solid obstacles (Howell, *et al.*, 1954; Johnston and Haines, 1957). From information supplied by WCIA personnel, the actions of birds at this tower are similar to those described by Overing (1936) at the Washington Monument. Many birds seem to be killed in flight by collision with the tower or guy wires, but others are only stunned or injured. Of these, some die in hitting the ground. Some of those which reach the ground alive are killed by flying against the brightly lighted sides of

the transmitter building, but many survive and may be found the next morning in fields surrounding the tower.

NUMBERS OF BIRDS KILLED

Destruction of birds occurred at the WCIA tower on at least seven dates between September 1955 and June 1957 (Table 1). Four hundred eighty-six individuals of 51 species were counted. Mortality was ten times greater in fall than in spring. The largest number of birds were killed on the night of October 6–7, 1955, when a rapidly advancing cold front passed the tower about midnight.

The taxonomic pattern was similar to that reported in previous studies (*e.g.*, Johnston and Haines, 1957). Of the 16 families represented, wood warblers (Parulidae) were most numerous with 17 species and 70 per cent of all individuals. Also numerically important were the Fringillidae (8 species; 8 per cent of all individuals), the Vireonidae (4; 6), and the Turdidae (4; 5). The five most numerous species were Myrtle Warbler, Ovenbird, Palm Warbler, Tennessee Warbler, and Red-eyed Vireo.

Certain changes in species composition between the September 23–24 and the October 6–7, 1955, kills were noticeable. Swainson's Thrush, Magnolia Warbler, Ovenbird, and Rose-breasted Grosbeak showed greater numbers in the earlier kill. The reverse was true of Tennessee Warbler, Myrtle Warbler, and Palm Warbler, which were more numerous in the later kill. These changes reflect observable differences in times of migration of the various species.

COMPARISON WITH OTHER KILLS

To compare the species composition of WCIA samples with that of other examples of mass mortality, the following procedure was used: The ten most numerous species at WCIA and the ten most numerous species at another point were listed, with the exception that no species represented by fewer than five individuals was considered. The number of species common to the two lists was divided by the total number of different species. If 5 species were common to the two lists, then a total of 15 species would be represented, and the quotient (x 100) would be 33.3. This figure is the percentage of species (among the most numerous species) common to the two localities. It may be used as an index to the similarity of composition of the samples, taking into account in a general way both presence and abundance. On the basis of this index value, the WCIA fall 1955 samples are most similar to those from Tennessee and Georgia and least similar to those from Kansas (Appendix).

TABLE 1. BIRDS KILLED AT WCIA-TV TOWER SEPTEMBER 1955–MAY 1957.

Species	*Sept. 23–24, 1955*	*Oct. 6–7, 1955*	*May 6–7, 1956*	*Oct. 1–2, 1956*	*May 15–16, 1957*	*May 19–20, 1957*	*May 21–22, 1957*	*Total*
Pied-billed Grebe, *Podilymbus podiceps*	1							1
American Bittern, *Botaurus lentiginosus*		1						1
Mallard, *Anas platyrhynchos*			1					1
Blue-winged Teal, *Anas discors*				9				9
Sora, *Porzana carolina*		4						4
Common Gallinule, *Gallinula chloropus*		1						1
Mourning Dove, *Zenaidura macroura*			1					1
Black-billed Cuckoo, *Coccyzus erythropthalmus*	1							1
Yellow-shafted Flicker, *Colaptes auratus*		1						1
Yellow-bellied Sapsucker, *Sphyrapicus varius*	2	3						5
Yellow-bellied Flycatcher, *Empidonax flaviventris*	1							1
Least Flycatcher, *Empidonax minimus*	1							1
House Wren, *Troglodytes aedon*	1		1					2
Mockingbird, *Mimus polyglottos*			1					1
Catbird, *Dumetella carolinensis*	7	1						8
Brown Thrasher, *Toxostoma rufum*			1					1
Wood Thrush, *Hylocichla mustelina*	1							1
Swainson's Thrush, *Hylocichla ustulata*	13	6						19
Gray-cheeked Thrush, *Hylocichla minima*	1	2						3
Veery, *Hylocichla fuscescens*			1					1
Yellow-throated Vireo, *Vireo flavifrons*	3	1						4
Solitary Vireo, *Vireo solitarius*		1						1
Red-eyed Vireo, *Vireo olivaceus*	7	5	1		1	2	10	26
Philadelphia Vireo, *Vireo philadelphicus*	1							1
Black-and-white Warbler, *Mniotilta varia*	6	2	1					9
Golden-winged Warbler, *Vermivora chrysoptera*			1					1

TABLE 1 *(Continued)*

	9/23-24/55	10/6-7/55	5/6-7/56	10/1-2/56	5/15-16/57	5/19-20/57	5/21-22/57	Total
Tennessee Warbler, *Vermivora peregrina*	12	26			1			39
Magnolia Warbler, *Dendroica magnolia*	17	7	1					25
Myrtle Warbler, *Dendroica coronata*	2	76	1					79
Black-throated Green Warbler, *Dendroica virens*	4	4						8
Blackburnian Warbler, *Dendroica fusca*		2						2
Chestnut-sided Warbler, *Dendroica pensylvanica*	1	1			1			3
Bay-breasted Warbler, *Dendroica castanea*	2	8			1			11
Blackpoll Warbler, *Dendroica striata*	1	2			1	2		6
Pine Warbler, *Dendroica pinus*		2						2
Palm Warbler, *Dendroica palmarum*	5	39						44
Ovenbird, *Seiurus aurocapillus*	45	10			2			57
Northern Waterthrush, *Seiurus noveboracensis*		3	2					5
Yellowthroat, *Geothlypis trichas*	11	13						24
Canada Warbler, *Wilsonia canadensis*						1		1
American Redstart, *Setophaga ruticilla*	11	10	1					22
Bobolink, *Dolichonyx oryzivorus*	3							3
Scarlet Tanager, *Piranga olivacea*	8	1	2		1			12
Rose-breasted Grosbeak, *Pheucticus ludovicianus*	11	2	1					14
Dickcissel, *Spiza americana*			1		1			2
Savannah Sparrow, *Passerculus sandwichensis*	1	1						2
Grasshopper Sparrow, *Ammodramus savannarum*			2		1		2	5
Sharp-tailed Sparrow, *Ammospiza caudacuta*	1							1
White-throated Sparrow, *Zonotrichia albicollis*	3	1	2					6
Swamp Sparrow, *Melospiza georgiana*	2	3	1					6
Song Sparrow, *Melospiza melodia*	1	1						2
Total Species	33	32	19	1	9	3	2	51
Total Individuals	187	240	23	9	10	5	12	486

The WCIA samples differed from most others in the large number of Myrtle Warblers present. This species has been scarce or absent everywhere except at the WCIA tower and at New York City where 117 were recorded on October 19, 1955 (Nichols, 1956: 11). The scarcity of Myrtle Warblers in other samples is difficult to explain. Higher than usual populations might have existed in 1955, or the fact that it is a late migrant might somehow contribute to its rare appearance. Why lateness of migration should affect mortality is uncertain, but it is also true that birds which migrate earlier than most suffer little destruction. The Lousiana Waterthrush *(Seiurus motacilla),* an early migrant, has been recorded no more than once or twice, although both the Ovenbird and the Northern Waterthrush are frequent victims.

SEX AND AGE COMPOSITION

Adult birds predominated in the fall kills. Seventy-nine per cent of the birds were adult in the September 1955 samples, and the preponderance was even greater (91 per cent) in the October sample (Table 2). All birds examined from spring accidents exhibited complete skull ossification.

Only two species were well-represented both in fall kills at Topeka, Kansas (Tordoff and Mengel, 1956: 14, 23) and those of the present study. These two, Ovenbird and Yellowthroat, showed greater per-

TABLE 2

AGE RATIOS OF 12 SPECIES OF BIRDS KILLED SEPTEMBER 23–24, 1955 AND OCTOBER 6–7, 1955

	September 23–24, 1955		*October 6–7, 1955*	
	Number	*Age Ratio*	*Number*	*Age Ratio*
Species	*Examined*	*Adult:Immature*	*Examined*	*Adult:Immature*
Swainson's Thrush	4	2:2 (1 ♀)	6	4 (1 ♂) :2 (1 ♀)
Red-eyed Vireo	5	4:1	2	2:0
Black-and-white Warbler	2	2 (1 ♀) :0	2	1:0
Tennessee Warbler	5	5:0	17	16 (1 ♂,5 ♀) :1
Magnolia Warbler	8	8:0	7	7 (2 ♀) :0
Myrtle Warbler	1	1:0	38	38 (4 ♂,6 ♀) :0
Bay-breasted Warbler	1	1:0	4	4:0
Palm Warbler			31	31 (2 ♂,8 ♀) :0
Ovenbird	16	14 (5 ♀) :1	10	7 (1 ♂) :3 (1 ♀)
Yellowthroat	11	9 (1 ♂,1 ♀) :1 (♂)	5	4:1
American Redstart	4	4:0	5	5 (4 ♂) :0
Swamp Sparrow	2	0:2 (♀)	2	1 (♀) :1
Totals (32 species)	78	59 (4 ♂,9 ♀):16 (1 ♂,6 ♀)	141	128 (15 ♂,22 ♀) :12 (2 ♂,1 ♀)

centages of adult birds in the samples from Illinois. The differences in both species were significant at the 1 per cent level (Table 3). An explanation of this apparent difference in age representation should await additional studies of mass mortality from other areas and other dates.

Deterioration of gonads of birds frozen for considerable periods made sexing impossible for much of the fall sample. Of the autumn-killed birds for which sex could be determined, the greater number were females. Males represented only 33 per cent of 24 birds from the September 1955 kill and only 44 per cent of 43 birds from the October kill (Table 2). Sex ratios differed greatly between the two spring kills. For the May 6–7, 1956, kill, 8 (73 per cent) of the 11 birds were males,

TABLE 3

COMPARISON OF THE RATIO OF ADULTS TO IMMATURES OF OVENBIRD AND YELLOWTHROAT IN FALL 1954 MORTALITY IN KANSAS (TORDOFF AND MENGEL, 1956:14,23) AND FALL 1955 MORTALITY IN ILLINOIS

	Number		*Number and Frequency Adults*				
Species	*Kansas*	*Illinois*	*Kansas*	*Illinois*	*Difference*	$S.E._{D\%}$	*P*
Ovenbird	30	25	10 (0.333)	21 (0.840)	0.507	0.134	0.00006
Yellowthroat	159	15	82 (0.516)	13 (0.867)	0.351	0.134	0.009

whereas nearly equal numbers (47 per cent males) were found among 15 birds killed May 15–22, 1957.

FAT CONDITION

Migratory birds generally undergo fat deposition in the fall and spring, presumably as an adaptation for sustaining migratory flight. The fact that most birds examined were rated from moderately to excessively fat (Table 4) is, therefore, expected. Of the four species well represented on both September and October 1955 kills, Ovenbird and Yellowthroat showed no change in fat condition, and Magnolia Warbler and Tennessee Warbler were judged to be fatter on the October kill. The same statement, that in the later kill there was either an increase in fat or no change, characterizes nearly all of the species common to the two kills.

A similar trend of increasing fatness later in the season may be present in the spring kills, but the samples are small, and the determinations for birds killed in 1957 were made by personnel other than the writers. The subjectiveness of the method makes comparisons uncertain both in this case and also between birds common to this study and

TABLE 4

FAT CONDITIONS OF 15 SPECIES OF BIRDS KILLED ON FOUR DATES, 1955-1957. NUMERALS REFER TO THE FAT CLASSES OF MCCABE (1943) AS FOLLOWS: 0—NO FAT; 1—LITTLE FAT; 2—MODERATE FAT; 3—FAT; 4—VERY FAT; 5—EXCESSIVELY FAT

	September 23–24, 1955		*October 6–7, 1955*		*May 6–7, 1956*		*May 15–22, 1957*	
Species	*Range*	*Modal Class*	*Range*	*Modal Class*	*Range*	*Modal Class*	*Range*	*Modal Class*
Yellow-bellied Sapsucker	3–5		5	5				
Swainson's Thrush	2–5		3–5	5				
Red-eyed Vireo	5	5	4–5		2		4–5	5
Black-and-white Warbler	2–5		2–4		4			
Tennessee Warbler	4–5	4	3–5	5			5	
Magnolia Warbler	0–5	2	4–5	5	2			
Myrtle Warbler			1–5	4	3			
Bay-breasted Warbler			4–5	4			5	
Palm Warbler			2–5	5				
Ovenbird	3–5	5	2–5	5			5	
Yellowthroat	1–5	4	2–5	4				
American Redstart	2–4		2–5	4	5			
Scarlet Tanager	4–5		4		1–3		5	
Rose-breasted Grosbeak	4	4	3	3				
Swamp Sparrow	0–3		3–4					

to that of Tordoff and Mengel (1956). In general, birds were rated fatter in Illinois than in Kansas. This was probably the true situation in such an extreme example as the Ovenbird: Of 30 Ovenbirds from Kansas, none was rated more than very fat, whereas 10 out of 26 from Illinois were considered excessively fat.

LOCATIONS OF DEAD BIRDS

The distribution on the ground of birds killed in flight depends on the speed, height, and direction of flight, the obstacle struck, and the velocity and direction of the wind. Mapping this distribution allows an assessment of the relative roles of the tower and the guy wires in accounting for mortality and may provide information as to what species were migrating together, or at least during the same period of time.

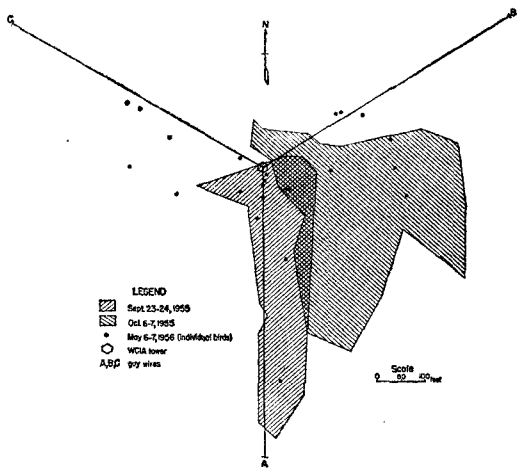

FIGURE 1. Distribution of dead birds around WCIA tower in 3 kills, 1955–1956. Birds separated by more than 100 feet from all other birds were not included in the September and October 1955 outlines.

The pattern of distribution in the September 1955 kills (Figure 1) is explainable by assuming that most of the birds were killed by striking the tower while they were flying south. The most reasonable explanation of the patterns found on the October 1955 and the May 1956 kills, however, is that a fair proportion of the birds hit the guy wires rather than the tower itself.

The greatest number of dead birds in the September 1955 kill were found between 75 and 150 feet from the tower, but a second area of concentration appeared between 450 and 525 feet. This bimodal dis-

tribution may have resulted from birds being killed high on the tower at two different times when wind velocities were different. It seems unlikely that the two areas of concentration represented birds flying at two different altitudes because if low-flying birds had been present, some should have collided with guy wires. If the two areas of concentration did result from differing wind velocities at different times during the night, then the species found together in an area of concentration should be a sample of those migrating at the same time. Under this assumption, Catbird, Swainson's Thrush, Red-eyed Vireo, Ovenbird, American Redstart, and Rose-breasted Grosbeak, all found in both areas of concentration, were migrating throughout the period when birds were killed. Palm Warblers, present only in the area of concentration 500 feet from the tower, were migrating at a different time from Black-and-white Warblers, Tennessee Warblers, Yellowthroats, and Scarlet Tanagers, which were found only in the peak 150 feet from the tower.

CALCULATIONS OF NUMBERS OF MIGRANTS

Under certain conditions, a satisfactory index value to the total volume of migration through an area during one night can be obtained from the numbers of birds killed at a television tower. One attempt has been made to obtain such a value. Tordoff and Mengel (1956: 18–20), using data from a 950-foot tower near Topeka, Kansas, have calculated the number of migrants passing through a plane extending one mile horizontally and from 450 to 950 feet from the ground. The procedure involves setting up a proportionality between (a) the number of birds killed and (b) the area of the tower and guy wires above 450 feet and (c) the total number of birds passing through the plane and (d) the total area of the plane. The 450-foot lower limit was chosen because during periods of mortality only a few birds struck a nearby 500-foot tower.

It is clear that the figure obtained by this procedure is subject to several sources of error. The following conditions tending to produce an erroneously low estimate were probably all present: (1) avoidance of the tower by birds flying toward it (see Tordoff and Mengel, 1956: 17), (2) recovery of birds merely stunned in striking the tower, and (3) failure of observers to find all of the birds killed. Based on the numbers of live birds around the WCIA tower on mornings after kills, 15 per cent of the individuals striking the tower may survive. That this figure may be sometimes much higher is suggested by observations of R. R. Graber (personal communication). On several occasions, he has heard birds collide with the tower (five or more during one night) and failed

to find any dead birds around the tower the following morning. We have estimated that only 85 per cent of all dead birds were found at WCIA, the rest being overlooked or lost to scavengers.

If these three were the only sources of error, the procedure followed by Tordoff and Mengel would provide a satisfactory index in the form of a minimum estimate. The estimate may be of a little value, however, if two conditions tending to produce erroneously high estimates are present. These conditions are: aggregation of birds in migration and attraction of them to the tower. Tordoff and Mengel have cited the work of Stone (1906: 250–251) and Lowery (1951: 409–413), indicating uniform distribution of night migrants, and have suggested that attraction of migrants by the tower is ruled out by the fact that tall towers do not cause mortality on clear nights and low ones do not cause mortality even on stormy nights.

Aggregation. We believe that aggregation of birds in migration may be pronounced. Ball has stated (see Lowery and Newman, 1955: 246) that in his study of migrating thrushes by means of flight-call counting, grouping did occur. Furthermore, Lowery's assertion that night migrants exhibit a uniform horizontal distribution was based for the most part on work done in the spring; Lowery and Newman have since stated (1955: 247) that the fall flight is not as consistently dispersed. It is interesting that nocturnal mortality is much more frequent and involves larger numbers in fall than in spring. (Undoubtedly, two other factors also enter: there actually are many more migrating birds in the fall, and cold fronts, which produce the weather conditions associated with mortality, slow rather than hasten migration in the spring.) Finally, the distribution of dead birds in the October 1955 kill, in which birds appeared to have struck the tower and guy wires to the east of the tower, but not the guy wires to the west (Figure 1), can be interpreted as indicating extreme aggregation.

Aggregation of birds in migration could be either of a "fly-line" sort, in which a stream of birds follows some topographic, or other, feature, or it could express itself as a clumping of migrants, with the clumps themselves randomly or evenly distributed. The problem in either case is an increase in the variation in numbers of birds killed. If birds are aggregated, some towers may kill many birds, others few, and still others none. If strictly accurate predictions could be made of nights when mortality should occur and if estimates of none or a few thousand birds were reported along with those of several hundred thousand, the combined results would give a relatively accurate index to the total volume of migration.

Attraction. The most serious potential source of error is attraction

of birds to the tower. Our only evidence concerning attraction is provided by personnel of the WILL-TV tower about five miles southwest of Monticello, Illinois. In climbing that tower during spring or fall, they often found dead birds lodged in the structure but these were always on levels away from the lights. It appears that, at least at short range, the birds tended to avoid the lights rather than to seek them. Cochran and Graber (1958), however, have presented evidence, based on flight-call counting and spot-lighting, which is strongly suggestive of a concentration of migrants around the WCIA tower. This concentration, occurring only on nights of low ceilings, appeared to decrease when the tower lights were extinguished.

Estimates. We have calculated the numbers of migrants through a plane one mile long, centered on the WCIA tower, for the nights of September 23–24, 1955, and May 6–7, 1956. Lower limits for the plane were 560 and 455 feet from the ground, respectively (based on positions of dead birds under the guy wires). For the September 1955 kill, the proportionality, in which X is the number of birds passing through the plane, is

$$187/1{,}027 = X/2{,}233{,}440.$$

The figure 1,027 is the square feet of solid surface above 560 feet which the tower, antenna, and guy wires would present to oncoming migrants (calculated from blueprints). On the basis of this proportionality, 406,670 birds passed through the mile-long plane between 560 and 983 feet from the ground on this night. Of these, 97,860 were Ovenbirds.

For the May 1956 kill, the proportionality is

$$23/1{,}437 = X/2{,}787{,}840.$$

The total number of birds passing through the one mile plane between 455 and 983 feet from the ground on this night, then, was 44,620.

The need for direct, quantitative information on aggregation of migrants and their attraction to towers cannot be over-emphasized. Until such information is available, caution should be taken in the use of index figures such as are presented here.

SUMMARY

1. On seven dates between September 1955 and May 1957, migrating birds were killed at the 983-foot WCIA television tower in Champaign County, Illinois. Mortality was ten times greater in fall than spring.

2. Kills occurred under conditions of 80–100 per cent cloud cover, a ceiling of 400–1600 feet, and obscured visibility. Generally, a cold front had passed the point of kill within the previous 12 hours.

3. 486 individuals of 51 species were counted. 267 were examined to determine fat condition and age and sex ratios.

4. Among the 16 families represented, wood warblers were most numerous both from the standpoint of total individuals and species. The five most numerous species were Myrtle Warbler, Ovenbird, Palm Warbler, Tennessee Warbler, and Red-eyed Vireo, in that order.

5. Changes in specific composition between two kills separated by 13 days in the fall of 1955 were related to observable differences in times of migration of the various species.

6. Based on percentage similarity of the ten most numerous species, the east-central Illinois sample is most similar to samples from Tennessee and Georgia, and least similar to those from Kansas.

7. Dead birds, even in the fall, were predominantly adults. Ovenbirds and Yellowthroats showed greater percentages of adult birds in samples from Illinois than in samples from Kansas.

8. Of the fall birds for which sex was determined, the greater number were female. Males predominated in the May 6–7, 1956, kill, and an approximate 1:1 ratio prevailed in the May 15–22, 1957, kill.

9. Most birds examined were moderately to excessively fat. Of species common to the two fall kills (September and October), there was either an increase in fat or no change on the later kill.

10. Index values to total volume of migration based on numbers of birds killed at television towers are subject to several sources of error. The values may be useful as minimum estimates, if there is no aggregation of birds in migration or attraction of them to the tower. In the absence of conclusive evidence that these conditions do not exist, figures so obtained should be used with caution.

LITERATURE CITED

[CARSON, L. B.] 1955. Untitled, unsigned article. Topeka Aud. News, **10** (2): 1–3.

COCHRAN, WILLIAM W. AND RICHARD R. GRABER. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bull., **70** (in press).

HOWELL, J. C. 1955. A comparison of ceilometer mortality at Knoxville and Nashville, Tennessee, in 1951 and 1954. Migrant, **26**: 53–57.

HOWELL, JOSEPH C., AMELIA R. LASKEY, AND JAMES T. TANNER. 1954. Bird Mortality at airport ceilometers. Wilson Bull., **66**: 207–215.

JOHNSTON, DAVID W. 1955. Mass bird mortality in Georgia, October, 1954. Oriole, **20**: 17–26.

JOHNSTON, DAVID W. AND T. P. HAINES. 1957. Analysis of mass bird mortality in October, 1954. Auk, **74**: 447–458.

KEMPER, CHARLES A. 1958. Destruction of birds at the TV tower. . . . Passenger Pigeon, **20**: 3–9.

LASKEY, AMELIA R. 1956a. Bird casualties at Smyrna and Nashville ceilometers. Migrant, **27**: 9–12.

LASKEY, AMELIA R. 1956b. Television towers and nocturnal bird migration. Migrant, **27**: 66–67.

LOWERY, GEORGE H., JR. 1951. A quantitative study of the nocturnal migration of birds. Univ. Kansas Pub. Mus. Nat. Hist., **3**: 361–472.

LOWERY, GEORGE H., JR. AND ROBERT J. NEWMAN. 1955. Direct studies of nocturnal bird migration. *In* "Recent Studies in Avian Biology": 238-263. Univ. Illinois Press, Urbana, Ill.

MCCABE, T. T. 1943. An aspect of collectors' technique. Auk, **60**: 550–558.

NICHOLS, CHARLES K. 1956. Hudson—St. Lawrence Region. Aud. Field Notes, **10**: 8–12.

OVERING, ROBERT. 1936. The 1935 fall migration at the Washington Monument. Wilson Bull., **48**: 222–224.

OVERING, ROBERT. 1937. The 1936 fall migration at the Washington Monument. Wilson Bull., **49**: 118–119.

OVERING, ROBERT. 1938. The 1937 fall migration at the Washington Monument. Wilson Bull., **50**: 146.

SPOFFORD, WALTER R. 1949. Mortality of birds at the ceilometer of the Nashville airport. Wilson Bull., **61**: 86–90.

STONE, W. 1906. Some light on night migration. Auk, **23**: 249–252.

TANNER, JAMES T., ROBERT J. DUNBAR, ALBERT F. GANIER, LEE R. HERNDON, AMELIA R. LASKEY, AND ADELE H. WEST. 1954. Bird mortality during night migration, October 1954. Migrant, **25**: 57–68.

TORDOFF, HARRISON B. AND ROBERT M. MENGEL. 1956. Studies of birds killed in nocturnal migration. Univ. Kansas Pub. Mus. Nat. Hist, **10**: 1–44.

Department of Zoology, University of Illinois, Champaign, Illinois and Illinois Department of Conservation, Urbana, Illinois.

APPENDIX

PERCENTAGE SIMILARITY OF SOME EXAMPLES OF MASS MORTALITY TO FALL 1955 MORTALITY AT THE WCIA-TV TOWER

Location	*Date*	*Percentage similarity*	*Reference*
Empire State Building New York, N. Y.	Sept. 10–11, 1948	26.6	Spofford 1949
Washington Monument Washington, D. C.	Aug. 28–Oct. 24, 1935	8.3	Overing 1936, 1937
Washington Monument Washington, D. C.	Aug. 17–Oct. 23, 1936	35.7	Overing 1937
Washington Monument Washington, D. C.	Aug. 27–Oct. 30, 1937	33.3	Overing 1938
Ceilometer Knoxville, Tenn.	Oct. 7–8, 1951	33.3	Howell 1955
Ceilometer Knoxville, Tenn.	Oct. 6–7, 1954	33.3	Howell 1955
Lighted parking lot Oak Ridge, Tenn.	Oct. 6–7, 1954	33.3	Dunbar, *in* Tanner *et al.*, 1954

Ceilometer Chattanooga, Tenn.	Oct. 6–7, 1954	33.3	West, *in* Tanner *et al.*, 1954
Ceilometer Nashville, Tenn.	Sept. 9–10, 1948	17.6	Spofford 1949
Ceilometer Nashville, Tenn.	Oct. 7–8, 1951	33.3	Howell 1955
Ceilometer Nashville, Tenn.	Oct. 6–7, 1954	26.7	Howell 1955
Ceilometers Nashville and Smyrna, Tennessee	Sept. 24–25, 1955	42.8	Laskey 1956a
TV tower Nashville, Tenn.	Oct. 5–19, 1956	15.4	Laskey 1956b
Ceilometer Smyrna, Tenn.	Oct. 6–7, 1954	21.4	Laskey, *in* Tanner *et al.*, 1954
TV tower Atlanta, Ga.	Oct. 6–7, 1954	25.0	Johnston 1955
TV tower Augusta, Ga.	Oct. 7–8, 1954	23.1	Johnston 1955
Ceilometer Warner Robins, Ga.	Oct. 6–8, 1954	42.8	Johnston 1955
Several sources Savannah, Ga.	Oct. 7–8, 1954	35.7	Johnston 1955
Ceilometer near Savannah, Ga.	Oct. 7–8, 1954	25.0	Johnston 1955
Radio tower Camp Cornelia, Ga.	Oct. 7–8, 1954	33.3	Johnston 1955
Ceilometer near Albany, Ga.	Oct. 7–8, 1954	33.3	Johnston 1955
TV tower Eau Claire, Wis.	Sept. 2–20, 1957	33.3	Kemper 1958
TV tower near Topeka, Kansas	Sept. 24–Oct. 23, 1954	11.1	Tordoff and Mengel 1956
TV tower near Topeka, Kansas	Sept. 10–Oct. 8, 1955	17.6	Carson 1955