BIRD MORTALITY AT AIRPORT CEILOMETERS[1]

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THE first reported mass mortality of migrating birds at an airport ceilometer occurred in September 1948 (Spofford, 1949a and 1949b). In October 1951 we observed the aftermaths of similar but even larger accidents, and this stimulated us to assemble all available information on the subject. Other incidents, some previously unpublished, were discovered. We now know of twelve instances at ten widely scattered localities of bird mortality at ceilometers, the number of birds killed in the different instances varying from three to about a thousand. Observations have been made by us and by others on the behavior of birds around a ceilometer. The general pattern of events in these accidents is now clear, we think, although some of the causes leading to mortality are still not known.

Behavior of Birds Around a Ceilometer Beam

A ceilometer is an instrument used at airports to measure the height of the cloud ceiling. It consists of a beam of light and a receiver. The beam is produced by a mercury-vapor lamp and parabolic reflector usually mounted from five to ten feet above the ground and placed from 500 to 1000 feet away from buildings and similar structures. The candlepower of the light is about 25 million. The light is focused into a very narrow (about two degrees wide) vertical beam. It is so brilliant that the spot of light produced on low clouds at night can often be seen from several miles away and objects passing through the beam appear shining blue-white. Around the beam is an inverted cone of dim light that spreads upward within an angle of about 45 degrees from the vertical. The receiver, located on an airport building, scans up and down, detects the light when reflected from clouds, and automatically converts the angle of reception into the height of the cloud base above the ground. The ceilometer operates continually, day and night. Ceilometers have been in operation at major airports in this country since 1946.

On cloudless nights the beam is relatively inconspicuous, depending on the amount of dust or mist in the air, and at such times few birds are seen passing through the beam. On the night of October 1–2, 1952, the sky was clear at Knoxville, Tennessee, and the moon was almost full. Tanner, watching the Knoxville ceilometer for about an hour around midnight, saw only two possible birds pass high and rapidly through the beam. At the same time observers in Knoxville, eleven miles away, were counting birds seen through a telescope pointed at the face of the moon, and during the same period when

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the ceilometer was watched, eight birds were seen against the face of the moon. In September and October, 1952, Bartlett (1952) watched at ceilometers on eight different nights when a cloud ceiling was either absent or high and saw from none to about six birds on each occasion; judging by the absence of chip notes, there was little migration on these nights.

On overcast nights the ceilometer beam produces a bright spot of light on the bottom of the clouds. Large numbers of birds have been observed in the ceilometer beam only on such nights, and only during migration seasons. The following generalized description of the behavior of birds in and about the beam on an overcast night is based upon the reports of Bartlett (1952), Mrs. J. J. Hickey (in letter), B. F. McCamey (in letter), and the authors.

Birds seen in and near the beam can be divided roughly into two groups. At the upper levels, up to the bottom of the clouds, birds pass through the beam rapidly, appearing like shooting blue-white sparks, and moving in the general direction of migration, from the north in the fall. Below these, and sometimes down almost to the ceilometer light, are more slowly flying birds, circling around in the dimly lighted area, passing quickly through the beam, or sometimes fluttering up or down in the beam. The longest that any individual bird has been observed fluttering in the beam is twelve seconds (Hickey). Sometimes a bird will fly rapidly into the dimly lighted cone and swerve sharply to avoid passing through the brilliant beam. The highest number of birds that has been reported at one time is 1200 at Albany, New York, by Bartlett (1952); on the following night he estimated a maximum of 600 at one time. An observer at Louisville, Kentucky, estimated 900 birds circling at one time (Lovell, 1952).

Bartlett (1952) made some interesting observations showing that the birds fluttering through and around the beam must have come down from higher elevations. On a night when many birds were in the light, he had the operator of the weather bureau station turn off the light for twenty minutes, during which time the number of chips and call notes decreased from a large to a relatively small and normal number. "After one minute from the time the beam was turned on there were about 30 birds high in the beam, and none had yet been seen at 300 feet or less. By then the circling flight was apparent, and the direction of entering was no longer ascertainable. Not until after the fourth minute were birds seen to enter the cone at low levels; they came in from all directions. They might have been birds that dropped from the higher level; chip notes did not indicate low migrants" (Bartlett, 1952). On the following night he began observations before darkness, and the same pattern, although building up more slowly, was seen.

Several observers have remarked on the great number of chips and calls heard from the birds in the light and from the darkness nearby. In May, Mrs.

Hickey heard the full song of Scarlet Tanager (*Piranga olivacea*), Yellow-throat (*Geothlypis trichas*), and Indigo Bunting (*Passerina cyanea*).

Records of Mortality

Table 1 summarizes the important facts about nine of the twelve known instances of bird mortality at ceilometers. The weather information included in this table came from the published accounts or letters describing each incident supplemented by U.S. Weather Bureau Daily Weather Maps. These maps detail the weather conditions at 1:30 a.m., Eastern Standard Time, for each date. We are indebted to personnel of the Craig Air Force Base, Selma, Alabama, and of the Weather Bureau Records Center for supplying additional information about the weather conditions at Selma.

At the times when mortality has occurred, there has apparently been no difference in the behavior of the birds or the pattern of movement around the light from that observed on other overcast nights. There have been few witnesses of the actual killing of birds in these accidents. After the largest, at Knoxville, Tennessee, some of the airport personnel described seeing birds fall or fly into the ground. Mrs. Laskey was at the ceilometer in Nashville during the accident of October 7–8, 1951, and although she watched around the ceilometer and along adjacent runways, she did not see any birds come down. Neither did Mrs. Hickey see any birds killed or falling at the Madison accident. Mr. McCamey is apparently the only ornithologist or careful observer who has actually made close observations during such an accident; and parts of his letter are quoted here because of their interest: "[At 11:00 p.m.] it was a damp, foggy night, with a weak warm front approaching from the south. The ceilometer was on top of the vertical side of a hangar, with the arched roof of the hangar extending up and away from it. . . . The ceiling was at about 300 feet, the visibility one-half mile or less at the time. The birds were passing through the beam at 100 to 300 feet above the ground. Most of them flew straight through without hesitation, but every once in a while one would halt in the beam, fluttering, seeming to lose his sense of direction, and gradually dropping lower and lower as he fluttered in and out of the beam. . . . A few settled on perches or projections of the building. I could see them sitting motionless in the shadows . . . . The tragedies occurred when fluttering birds struck parts of the hangar and knocked themselves out, falling to the ground. . . . Occasionally I heard one strike the glass or metal sides of the building in the half hour I watched. . . . Next morning I got back soon after daylight; the weather had cleared with a cold front passage and the temperature had dropped. I started picking up birds, collecting them from an area extending 150 feet on all sides of the light position. Most were near the side of a building where they had dropped, only two or three out on the open lawn, in the clear. I picked up sixteen good specimens, throwing

TABLE 1
BIRD MORTALITY AT CEILOMETERS

Date	Locality	WEATHER					BIRDS KILLED		Authority
		Cloud Type	Ceiling Height (Feet)	Wind Dir. & m.p.h.	Visibility (miles)	Remarks	Species	Individuals	
Sept. 1-2, 1952	Scott A. F. Base, Ill.	?	?	N 9-24	?	Cold front over area on preceding day; thunderstorms, raining ceasing at 10 p.m.	3	3	Ziegler (1952)
Sept. 9-10, 1948	Nashville, Tenn.	Stratocum.	2400 to 9700	N 4-7	6-10	Cold front over area on preceding day; temperature fell.	33	300 (approx.)	Spofford (1949a, 1949b)
Sept. 19-20, 1950	Mitchell A.F. Base, Long I.	Stratocum.	800 & higher	N 13-18	4	Cold front had moved over Long Island and New Jersey within 12 hours; temperature fell.	9+	17	Arbib (1950)
Sept. 19-20, 1950	McGuire A. F. Base, N. J.	?	?	?	?		?	?	Arbib (1950)
Fall, 1950	Westover A. F. Base, Conn.	?	?	?	?		?	500 (estim.)	McCamey (letter)
Fall, 1950 10 days later	Westover A. F. Base, Conn.	?	300	?	½	Foggy, weak warm front from south, cold front later that night, clearing.	8+	20+	McCamey (letter)
Oct. 7-8, 1951	Louisville, Ky.	Stratocum.	2000-3000	NW 12-18	10	A cold front had moved over the entire Kentucky-Tennessee area 12 to 24 hours before; temperatures fell.	13+	96+	Lovell (1952)
Oct. 7-8, 1951	Knoxville, Tenn.	Stratocum.	3600-4200	NNW 8-12	10		46	1044	Howell & Tanner (1951)
Oct. 7-8, 1951	Nashville, Tenn.	Stratus	2300-5000	NNW 4-7	?		40	476	Laskey (1951)
Oct. 7-8, 1951	Smyrna, Tenn.	Conditions same as at nearby Nashville					11+	1000 (estim.)	Laband (1951)
April 25-26, 1950	Selma, Ala.	Stratocum.	2000-4000	N or NW 6-12	10	Cold front from west on previous day; moderate and continuous rain.	8+	300 (approx.)	Mrs. J. P. Parrish (letter)
May 23-24, 1952	Madison, Wisc.	?	100-2500	NW-E 6-10	⅛	A stationary front south of Wisconsin; foggy or misty.	11	18	Mrs. J. J. Hickey (letter)

away a few that were too bedraggled, and undoubtedly missing more that lay on top of some of the buildings. A clean up detail appeared . . . and told me that they frequently found birds at this spot. The non-com in charge said they had half-filled a 55 gallon drum with birds ten days before, and that it was usual to pick up several handfuls, but that many times there were none . . . ." The position of the ceilometer described in Mr. McCamey's letter is unusual in being on the roof of a building, rather than near the ground and in the open; thus there were buildings near the light which the birds could and did strike.

Much of the information on mortality of birds at ceilometers has been acquired by examination of the area and of the dead birds on the morning after an accident. The dead birds have been picked up in the vicinity of the ceilometer, but not always evenly scattered about it. At Knoxville most of the dead birds were south of the ceilometer, some as far away as 470 yards. At Nashville on October 8, 1951, most of the dead birds were south or southwest and up to 300 yards from the ceilometer. At Mitchell Air Force Base the birds were found south of the light and within 75 yards, and at Scott Air Force Base the three birds lay within 25 feet of each other and 70 yards south-southeast of the light. At Madison, all of the dead birds were within a sector lying northwest of the ceilometer light and as far away as about 250 yards. In each of these cases the majority of dead birds was found in the direction from the ceilometer in which most of the migrants probably were travelling, south-southeast to southwest in fall and northwest in spring. At Nashville and Knoxville more birds were found on the concrete runways and parking areas than on the grassy areas.

Injuries to the head were found in a number of the dead birds. At Knoxville 315 Ovenbirds (*Seiurus aurocapillus*) were examined and about 80 per cent of them showed a blood clot beneath or within the skull or had a broken bill: no injury was evident on the remaining 20 per cent. Individuals of other species had broken bills. At Nashville in 1951 there were many instances of brain injuries. Mrs. Hickey observed the same kind of injury on birds that were found on the hard runways.

Not all of the birds that come down are killed. At Nashville in 1951 thirty living birds were picked up and given to Mrs. Laskey who banded and released them. Some of the airport personnel at Knoxville told of picking up birds and then letting them fly away; on the following afternoon there were still a number of birds on the ground or around buildings, some crippled and others apparently not.

The number of species of birds killed in each accident reported in Table 1 is a minimum number; five of the reports state that the list of species is incomplete for one reason or another. A total of 69 species of birds has been

identified and reported as being killed at ceilometers. They are widely scattered in a taxonomic sense. Non-passerine species are Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), Sora (*Porzana carolina*), Virginia Rail (*Rallus limicola*), Wilson's Snipe (*Capella gallinago*), Mourning Dove (*Zenaidura macroura*), Yellow-billed Cuckoo (*Coccyzus americanus*), Black-billed Cuckoo (*C. erythropthalmus*), and Whip-poor-will (*Caprimulgus vociferus*). The following families of passerine birds are represented by the indicated number of species: Tyrannidae, 4; Troglodytidae, 2; Mimidae, 2; Turdidae, 4; Sylviidae, 1; Vireonidae, 5; Parulidae, 33; Icteridae, 2; Thraupidae, 2; Fringillidae, 5. In Nashville on September 10, 1948, the largest number of individuals of one species were Red-eyed Vireos (*Vireo olivaceus*), making up 38 per cent of the total. At Knoxville on October 8, 1951, 37 per cent of the birds killed were Ovenbirds. On the same date at Nashville, Tennessee Warblers (*Vermivora peregrina*) were commonest, 21 per cent of the total. On the other hand, at the accidents where large numbers of birds were killed, many species were represented by only from one to five individuals.

The species and numbers of dead birds found are about what would be expected in the migratory flights for each place and time; they are nocturnal migrants that nest in large numbers, with few exceptions, to the north of the location of the accident and that are migrating at that time of the fall or spring. The birds killed appear to be a random sample of the migratory flight. There is no indication that any species is relatively more susceptible to ceilometer accidents than any other species present in the same migratory flight.

Some species of birds have been seen or heard around ceilometer beams but have apparently not suffered mortality there. Mrs. Hickey reported the following species heard at Madison: Green Heron (*Butorides virescens*), Spotted (*Actitis macularia*) and Solitary (*Tringa solitaria*) sandpipers, Black Tern (*Chlidonias niger*), and Kingbird (*Tyrannus tyrannus*). Bartlett (1952) reported seeing Screech Owl (*Otus asio*) and Starling (*Sturnus vulgaris*) fly through the dimly lighted cone at Albany. Tanner at Knoxville heard Killdeers (*Charadrius vociferus*) and Black-crowned Night Herons (*Nycticorax nycticorax*) and saw the latter fly through the beam.

Discussion of Possible Causes

In most cases of bird mortality at airport ceilometers in the fall, the weather conditions have been similar (see Table 1); the same general conditions have been present when medium to large numbers of birds have been observed around the light but no mortality occurred. A cold front has moved over the area within twenty-four hours or less, winds have been gen-

erally from the north, an overcast of stratocumulus or stratus clouds has been produced by the cold front pushing under warmer air, there frequently has been a trace of rain, and visibility on the ground has been between four and ten miles.

Only two of the twelve reported instances of bird mortality have occurred in the spring. In these the conditions seem to be about as follows; a large spring migration started (Mrs. Hickey stated in her letter that there was no wave of May migrants at Madison in 1952 until the night of May 23), then a cold front moved in from the north or northwest producing rain and an overcast or mist. The reason for these accidents occurring more frequently in the fall as compared with spring apparently is that the cold front which causes the low cloud ceiling also precipitates a large migration in the fall, while in spring a cold front slows or stops migration.

These weather conditions set the stage, and then somehow birds are attracted to the ceilometer light. This may be caused by any one or a combination of the following factors. An overcast, with the ceiling between 300 and 5000 feet, may push the migration to lower than usual levels. The bright spot of light on the base of the clouds may attract birds, and so may the light itself on the ground. Once birds have begun to circle and flutter through the beam, the reflection of light from their bodies may attract other birds toward the light. As the number of birds in the beam increases, the beam will become correspondingly conspicuous, and still more birds may be attracted to it, resulting in a geometric increase of the number around and in the beam.

When bird mortality at ceilometers was first reported, it was suggested that the light itself, being produced by a mercury-vapor lamp which generates a fair amount of ultraviolet, might be the cause of death. But L. J. Buttolph of the General Electric Company wrote us that, "The plate glass over the lamp would limit the ultraviolet to about the same as that from an ordinary incandescent lamp . . . ." Except for its great intensity, the light may be considered harmless. This conclusion is supported by the many observations of birds flying through the beam and continuing in level flight and of bats repeatedly flying through the beam only a few feet above its source.

All the evidence indicates that the cause of death is impact with the ground, another bird, or occasionally with a building. The problem remains of what causes the birds to lose their faculties and fly into or fall to the ground, or strike one another, or hit a building. Any satisfactory explanation of this problem will have to explain why there is mortality on some occasions and not on others, and when there is mortality why only part of the birds present around the light are killed.

The fact that most of the dead birds have been found in the direction from the ceilometer in which the migration was moving suggests that it is the

birds in swift flight that are affected and not those that are circling and fluttering around the beam. The distance at which many dead birds were found from the ceilometer can only be explained by those birds having flown most of that distance; even allowing for the wind and a high flight speed, they could not have been carried to those distances by their momentum alone.

One obvious explanation is that the birds are blinded by the brilliant light, lose their equilibrium because of this, and fly into the ground. This would not explain why many birds fly through the beam apparently unaffected; that is, why the light would blind some and not others.

Another possible explanation is that birds collide with each other, and fall stunned or fly dizzily against the ground. This explanation fits most of the observed facts. Collision would be most likely to occur when there are large numbers of birds passing through the beam, and mortality would therefore be dependent upon the density of birds in the air. Occasions when birds were observed in the beam but no mortality was evident could be explained on the basis of the numbers being too low for collisions to be likely. This explanation is simple, and most of the observations agree in that on nights when mortality occurred there were more birds in and around the beam than on other nights. The observations of Bartlett (1952), however, are contradictory in that he observed very large numbers of birds in the light at one time (1200 maximum on one night and 600 on the following night) but could find no sign of birds having been killed.

Summary

Twelve instances of bird mortality at airport ceilometers have been reported, the number of birds reported killed in each varying from three to over a thousand. All instances occurred during a migration season, ten in the fall and two in the spring. Mortality has occurred only when there has been a large migration and a cloud ceiling of 5000 feet or less; weather producing this combination is more frequent in the fall.

The species of birds killed seem in each instance to be a random sample of the migrants to be expected at that time and place. In size they range from the smaller warblers up to an American Bittern. Most of the birds killed were passerines, but a number of non-passerines was represented.

The dead birds examined have almost certainly been killed by impact, either with the ground, or with another bird in mid-air, or with a building as observed at the Westover Air Base. The ceilometer beam itself is not believed to be a direct cause of death.

The following is an outline of how bird mortality at a ceilometer may occur. On a night when there is a large migration and a relatively low cloud ceiling, birds are attracted to the ceilometer light. On reaching the beam they first

fly through it, but some circle back to fly slowly or flutter in and about the beam. The brilliant light reflected from these birds may attract other migrants toward the beam. Mortality may result from birds being blinded and hitting the ground or rarely a building, or colliding with each other and then hitting the ground, or directly from mid-air collisions.

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