62-4

AD-280 212

previous record of microfilm on file

report not announced by ASTIA

OPIC EFFECTS

OMMERCIAL

AIR TRANSPORT SOUND

ON BIRDS

CIVIL AEROMEDICAL RESEARCH INSTITUTE

7-p $1.10

62-4

FEDERAL AVIATION AGENCY
Civil Aeromedical Research Institute
AERONAUTICAL CENTER
OKLAHOMA CITY, OKLAHOMA

MARCH 1962

SONOTROPIC EFFECTS OF COMMERCIAL AIR TRANSPORT SOUND ON BIRDS

JOHN J. SWEARINGEN, M.S.

Chief, Protection and Survival Branch

Civil Aeromedical Research Institute

and

STANLEY R. MOHLER, M.D.

DIRECTOR

Civil Aeromedical Research Institute

62-4

FEDERAL AVIATION AGENCY
AERONAUTICAL CENTER
CIVIL AEROMEDICAL RESEARCH INSTITUTE
OKLAHOMA CITY, OKLAHOMA

March 1962

SONOTROPIC EFFECTS OF COMMERCIAL AIR TRANSPORT SOUND ON BIRDS

John J. Swearingen, M.S. and Stanley R. Mohler, M.D.

The Electra sound spectrum contains an audible chirp which appears identical in frequency and wave form to the chirp of field crickets. Field observations strongly indicate that the sound of the taxiing Electra exerts an attraction for starlings, and possibly other birds, particularly in the fall in the Northeast, when insects suddenly become less plentiful. The implications of this attraction, "positive sonotropism", for air safety, are discussed. Recommended approaches to alleviating this type of bird hazard are presented.

INTRODUCTION

In the fall of 1960, there were two major incidents in the Northeast U. S. (one severe crash and one aborted take-off) when Lockheed Electras ingested large numbers of starlings. On other occasions, large flocks of starlings gathering around Electras soon after engine starting, have forced the pilot to stop the engine to prevent bird ingestion.

Sounds from inanimate devices have been observed to exert a marked attraction for various animal species. For example, fish have been attracted by certain musical notes (Reference 1, page 618), and female crickets have been attracted by the telephone transmitted sounds of male crickets (Reference 8). Similarly, a high frequency sound simulating the flight song of the female mosquito has been broadcast in the Cuban swamps to attract male mosquitos (Reference 2, page 54). For centuries, bird watchers have attracted birds by twisting a rosin-coated pewter peg within a small birchwood block (the Audubon Bird Call, by Roger Eddy, Newington, Connecticut). Also, bird watchers make a high-pitched sound by kissing the back of their hand ("squeaking"), which attracts birds.

One of us (J. J. S.) noticed a twittering sound mixed with the other sounds generated by the Electra, and suspected that this relatively high frequency twitter in the Electra sound spectrum may for some reason actually attract starlings to the aircraft.

FINDINGS

Initially, to determine whether Electra sounds attract starlings, teams of investigators were assigned to field positions near the ends of the runway at a major airport (Will Roger Field, Oklahoma City). These teams, equipped with binoculars and portable tape records, observed and recorded notes describing bird flight patterns and activity during aircraft take-offs and landings. All major types of aircraft were monitored, including Lockheed Constellations, Douglas DC-6's and DC-7's, Viscounts, Boeing 707's, Convair 880's, Lockheed Electras, and other heavy and light aircraft.

The numerous observations made during December 1960, and periodically throughout 1961, indicate that during some portions of the year (when the natural sources of food for birds are scarce), starlings in the vicinity of an airport appear to be attracted by, or highly disturbed by, something in the sound spectrum of the Electra. The sound generated by other turbojet, turboprop, or conventional aircraft, did not induce a recognizable pattern of response in the starlings.

The following is a sample quote taken from notes of the field observers: "When the Electra was about halfway down the taxiway from the terminal, the sound became more noticeable. We noticed a relatively large flock of starlings rise up from the side of the runway. The birds maintained an airborne position to the rear (downwind) of the plane during its ground operation, at a height above the ground of less than 100 feet, with an angle of elevation of 45° from the ground with reference to the Electra. Birds seemed confused; flocks dipped and dived in various directions, but maintained their same relative position with refercence to the aircraft. During take-off, the birds followed the plane a short way and then settled back along the side of the runway."

It was observed (S. R. M.) that a large number of singing field crickets sound strikingly similar to a taxiing Electra. This is particularly so when one drives along a country road in the late summer at about 20-30 mph and experiences the fusion of individual cricket sounds into a sustained chorus. Starlings have been observed to cruise at 20-30 mph, and would experience a similar sustained exposure to the cricket sound sources.

These observations seemed to justify further study. The Electra sound spectrum and that of field crickets were recorded on an Ampex Model 970 tape recorder and fed into a Hughes "memoscope" oscilloscope model 105, for analysis. Crickets' chirping was found to be a mixture of two frequencies, namely 6000 and 2000 cycles per second (Figs. 1 and 2), and appears to consist of sets of three main vibration waves. The center wave of this triplet has a greater amplitude than the other waves, giving a "head and shoulder" appearance to the triplet. The Electra sound (Figs. 3 and 4) has a slow carrier wave (400 cycles per second), with pulses of high frequency waves of 2/1000ths to 6/1000ths of a second duration, superimposed intermittently, at a rate of 100 to 300 per second. This intermittent high frequency wave has the same "head and shoulders" appearance (Figs. 4) and is practically identical in frequency and wave form to that of the crickets. This explains the chirp or twitter in the Electra sound, which is mentioned earlier in this paper.

DISCUSSION

The Lockheed L-188 Electra was first flown on December 6, 1957. It is used for short and medium-range commerical transport (66-99 passenger). The L-188C model has four Allison 501-D13 single-shaft turboprop engines, each rated at 3,750 e. h. p.

Starlings in the U. S. now number in the hundreds of millions. We are experiencing a starling population explosion, a curious consequence of the placement in New York's Central Park of 100 starlings by the Englishman, Eugene Schieffelin, in 1890 and 1891 (Reference 5).

A large proportion of the diet of starlings (almost half) consists of crickets and other insects (Reference 7). Phonoreception in birds is highly developed, and provides for both accurate localization of sound and excellent frequency discrimination (Reference 3, page 490). These facts, coupled with the need of migrating starlings (as in the long north to south trips in the fall) for considerable amounts of food, enable the starling to learn to locate food by homing on singing insects.

Field crickets sing a great deal in the Midwest and South during the late summer and early fall mating period. Fields of singing crickets can set up a din which exceeds the seventy decibels of sound intensity common to busy streets (Reference 3, page 473).

For reasons not yet clear to ornithologists, a certain per cent of the birds in the Northeast who customarily migrate to the South in the winter, miss the fall signal and overwinter in the Northeast (See Reference 12 for a discussion of bird migration, with particular reference to newly expanded species in a new geographic area). For these stay-at-homes, the first cold-snap is quite a shock, in that the insects disappear, by and large, leaving the birds a meager available food supply. It probably takes several weeks for these birds to discover new and adequate food sources for the winter. In the process, numbers die in the cold of starvation. Should an early fall snow appear, the food situation for the starling becomes particularly acute.

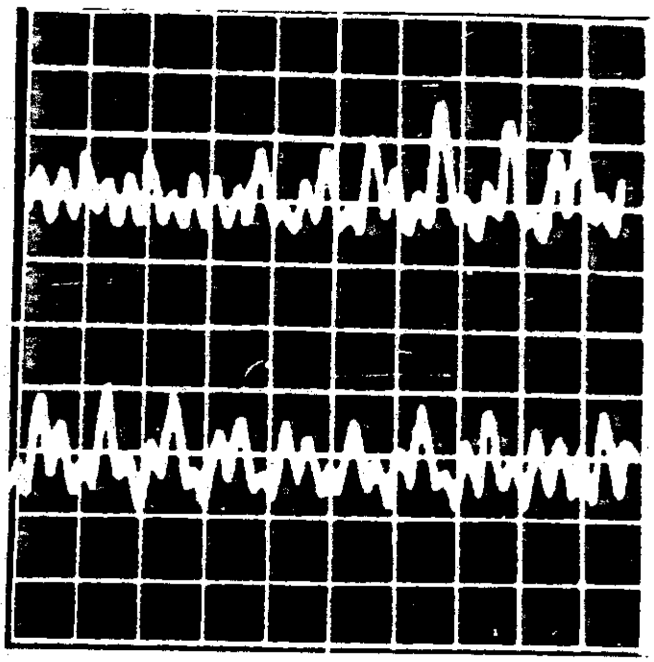

FIGURE 1. Two oscilloscope tracings of chirping field crickets (oscilloscope dial multiplier = 5). Two horizontal scale units = 0.0010 seconds. Frequency = 6000 cycles/second.

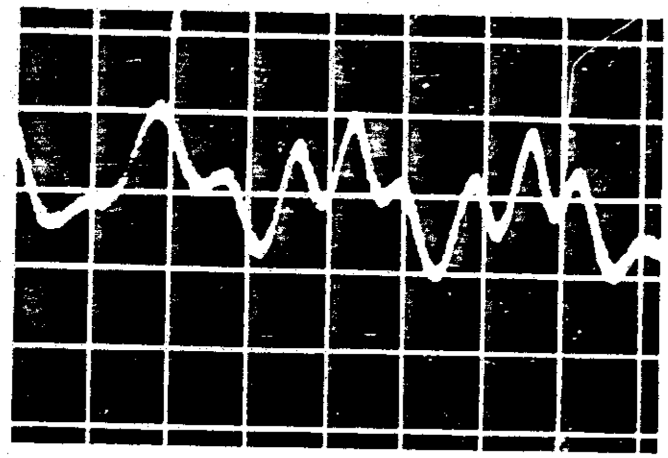

FIGURE 2. Faster trace of field cricket sounds (multiplier = 2). Five horizontal scale units = 0.0010 seconds. Note the head and shoulder wave form appearance of the three waves forming triplet sets.

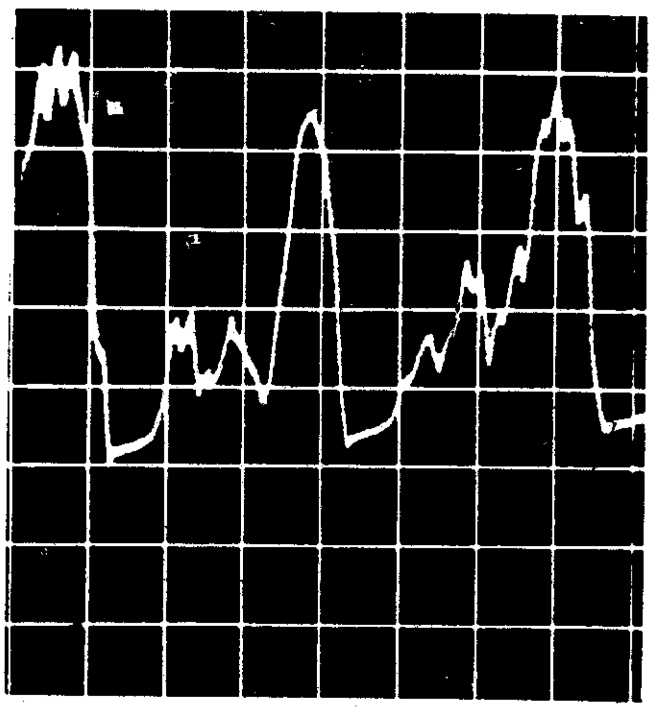

FIGURE 3. Tracing of a portion of the sound spectrum of the Lockheed Electra showing the low frequency carrier wave (about 400 cycles/seconds) with superimposed intermittent high frequency waves of 6,000 cycles/second. For this tracing, the oscilloscope multiplier is 8, and 1.25 horizontal scale units = 0.0010 seconds.

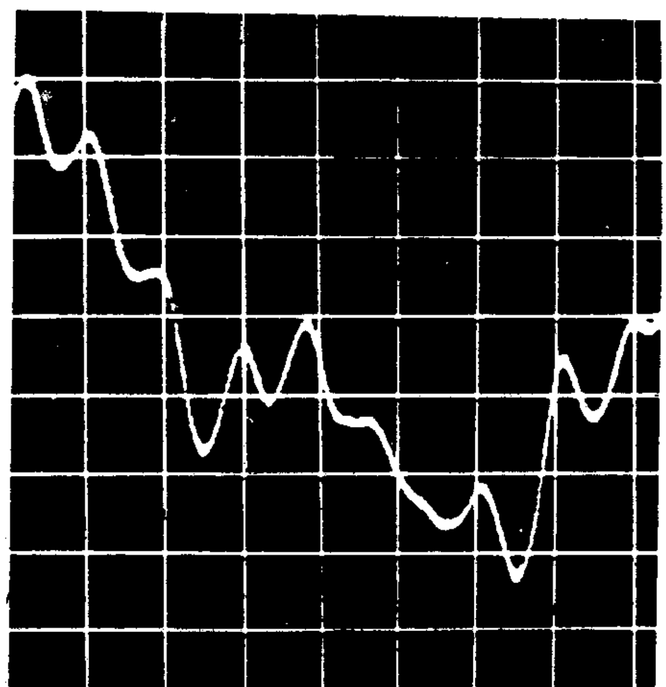

FIGURE 4. Fast trace of Electra sounds (multiplier = 2). Five horizontal scale units = 0.0010 seconds. Compare the wave form of these Electra triplets, with those of the crickets in figure 2. The oscilloscope sweep setting is identical in figure 2 and figure 4. Note that the individual triplets in this Electra tracing, receive a slight baseline distortion in accordance with whether or not the slow wave is descending or ascending.

It is understandable why, under conditions such as these, a sound which simulates a field fecund with singing crickets, would have a strong appeal for hungry starlings. Curiously, the elimination of certain garbage dumps could potentially aggravate the food stortage of these nonmigrating starlings.

The common field cricket is a leaping orthopterous insect of the family Gryllidae, genus Gryllus. The male cricket produces sounds through rubbing together his forewings which contain little files and scrapers (Reference 2, page 62). Other types of crickets, such as the snowy tree cricket, produce characteristic, easily recognized, tunes. This latter cricket is known as the "temperature cricket," since it varies its tempo, but not pitch, with temperature. The number of notes per minute, plus forty, divided by four, gives a rough estimate of the temperature in degrees Fahrenheit. The pitch of cricket sounds doesn't change very much with changes of temperature, since the pitch is determined by the mechanical characteristics of the exoskeleton. The tempo changes with temperature, since the cricket is cold-blooded, and its metabolic rate increases with increasing environmental temperature.

Insect music has been recorded by other workers (Reference 9), and they have noted that the field cricket chirps, lasting for a fraction of a second, consist of three pulsations, each pulsation consisting of a slur, with the pitch somewhat lower at the beginning and end of each chirp. Our findings confirm this past work. Also, crickets produce pure-tone sounds, in contradistinction to other insects, such as katydids, and the over-all pitch of the cricket chirp is in a range about one octave above the highest note on the piano (Reference 6, page 1442).

It is a curious fact that sounds produced by a number of mechanical devices have been noted to accidentally simulate very closely the singing of crickets. For example, it has been observed that the sounds of crickets are almost identical to the tinklings of little bells used by Far East priestesses in sacred dances (Reference 10). The shuttle used by weavers operating certain types of looms, has accidentally produced tones which closely imitate the sounds of crickets (Reference 2, page 72). The faraway jingling and ringing of the old-fashioned bridle bit simulates the song of the cricket, as does an electric bell heard from a distance (Reference 11).

Within the above framework, we begin to see a basis for the starling-Electra relationship, and the major reason why, as noted by other persons (Reference 4, page 2) the autumn period in the Northeast is the most hazardous time for Electra bird ingestion.

CONCLUSIONS

The Electra sound spectrum contains an audible chirp which appears identical in frequency and wave form to the chirp of field crickets.

Field observations of bird activity in the vicinity of the airport during Electra operations, strongly indicate an attraction of starlings and possibly other birds to the sound of the Electra.

Since over 40% of the starling's diet consists of insects (crickets, grasshoppers, etc.), it seems reasonable to assume that the starlings are attracted to the Electra by being misled into the belief that there is a field of crickets at the source of the Electra noise.

RECOMMENDATIONS

Since starlings are rapidly multiplying in the United States and the severe consequence of bird ingestion by a commercial carrier was clearly demonstrated by the October 4, 1960 Boston crash in which sixty-two persons died; and since this study has shown that starlings are quite likely attracted by the chirp in the Electra sound spectrum, consideration should be given to taking steps to eliminate the sound frequencies in these aircraft responsible for this chirping noise. This could probably be done through relatively minor structural changes in the Electra power plant package, or a change in the Electra's taxiing rpm.

The changes could encompass (1) *the elimination of the positive sonotropic vibrations*, (2) *masking of the positive sonotropic vibrations*, (3) *addition of frequencies which repel starlings (negative sonotropism)*, or (4) *other means which do not involve modification of the Electra (e.g., sound decoy of starlings to sites other than the airports, etc.)*.

In planes non-modified along the above lines, particular caution must be exercised during the autumn period in the Northeast, since this would be the time of the predicted greatest affinity for the Electra by the starlings.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance given by Mr. J. D. Garner and Mr. E. B. McFadden in field observations, and Mr. Jack Earley for the oscilloscope analysis.

REFERENCES

1. Heilbrunn, L. V., *An Outline of General Psysiology*, Second Edition, Revised, W. B. Saunders Co., Philadelphia, 1943.

2. Stillson, Blanche, *Wings, Insects-Birds-Men*, Bobbs-Merrill Co., New York, 1954.

3. Prosser, C. Lad (Editor), *Comparative Animal Physiology*, W. B. Saunders Co., Philadelphia, 1950.

4. Aldrich, J. W., Robbins, C. S., and Dykstra, W. W., *Bird Hazard to Aircraft*, Wildlife Leaflet 429, United States Department of the Interior, January 1961.

5. "Starling Menace Rises in Jet Age", The New York Times, Tuesday, May 23, 1961.

6. Glasser, Otto (Editor), *Medical Physics*, The Year Book Publishers, Chicago, 1944.

7. Kalmbach, Edwin Richard, "Economic Value of the Starling in the U. S.", U. S. Department of Agriculture Bulletin 868, U. S. Government Printing Office, 1921. (Kalmbach authored additional pamphlets; one in 1922 on "Food Habits of Starlings").

8. Regen, J., "Hearing in Gryllus," *Sitzungsh Akad, Wiss. Math-Nat.*, Kl. I., Wien, 132: 81-88, 1923.

9. Lutz, Frank E., *A Lot of Insects*, G. P. Putnam's Sons, New York, 1941.

10. Priest, Alan, "Insects: The Philosopher and the Butterfly", *The Metropolitan Museum of Art Bulletin*, Vol. 10, No. 6, 1952.

11. Hearn, Lafcadio, "Insect Musicians of Japan," *Exotics and Retrospectives*, Little, Brown and Co., Boston, 1908.

12. Sauer, E. G. F., "Further Studies on the Stellar Orientation of Nocturnally Migrating Birds", *Psychologische Forschung*, Vol. 26, No. 3, 224-244, 1961.