Avian Mortality at Communications Towers

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Presentation Number 2

The bird brain: magnetic cues, visual cues, and radio frequency (RF) effects

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Al Manville's introduction of the second speaker, Robert Beason.

Our next speaker is Alumni Professor of Biology at the State University of New York at Geneseo. He has been a previous consultant for the New York State Department of Environmental Conservation, as well as a consultant for Deutsch Telecom, NASA, the Kennedy Space Center, the FAA, and the United States Air Force. His research areas of interest include magnetic sensory perception in animals, especially in birds. He has done studies on visual pigments and oil droplets in birds and the mechanisms of avian color vision, animal orientation and migration, navigation, bird migration, radar ornithology, and the evolution of nearctic and neotropical bird migration. Dr. Bob Beason is going to be talking about the bird brain, the magnetic cues, visual cues and radio frequency affects.

Robert Beason

As Bill pointed out at the beginning of this workshop, avian mortality at communication towers occurs when the birds hit a tower or its guy wires. The rate of collision increases as birds are attracted to the tower or become disoriented near the tower and fly in circles around it, getting repeated chances at hitting the guy wires. Two aspects of the tower that might potentially affect its attractiveness are its illumination and the RF signal that is transmitted by the antenna itself. Light can have behavioral effects on the birds through two sensory systems: the visual system and the magnetic perception system - the magnetic compass. Color perception in birds is much more complex than it is in humans. Birds have 4-6 different types of color receptors, or cones, where as humans have only 3. The avian photoreceptor itself is more complex than in humans and other mammals. In addition to the visual pigments, birds also have an oil droplet in their inner eye segment that acts as a filter determining which light reaches the photo pigments themselves. Each photoreceptor has one oil droplet and one photo pigment or visual pigment. So far, of all the avian species that have been examined, all of them have a very narrow, very sensitive channel in the red spectrum. This is of interest because most of the illumination that is put on towers is in the red region. This red cone has a peak sensitivity of about 600 nm, which is what we call a reddish orange. By comparison, the human red cone has a peak sensitivity of about 560 nm. Depending upon the species of the bird, they either have an ultraviolet sensitive cone, or a violet sensitive cone that is totally missing in humans and most mammals. In fact, humans have oil droplets in the lens that filter out the ultraviolet. So birds can see ultraviolet and apparently have specialized receptors for detecting it. It varies from species to species, but there are 2 or 3 additional receptors that might be analogous to what we call blue, the green and the yellow wavelengths. In the Bobolink, one of the species I work with, these peaks are at 460, 535 and 570 nm. Humans, for comparison, in addition to the red cones have the blue and green cones that are at 430 and 530 nm.

Of the 10,000 species or so of birds, depending on whose taxonomy you want to deal with, we know the photo pigments or the visual pigments and associated oil droplets for exactly 11. Only two of these are nocturnal migrants in the Western Hemisphere: the Bobolink, again the species I work with, and the Mallard. Another is considered to be a diurnal migrant: the European Starling. Partial information is available for a few other species, but for very, very few, and most of this is simply limited to oil droplets information.

We don't know the spectral sensitivities of the visual pigments with which they are associated. Consequently, we know very little about what colors birds can actually detect and how well they can differentiate between colors. The visual pigment of the rod for comparison is very similar to the human rod pigment with a peak of around 500 to 510 nm, in the green range. Birds have very large rods, at least the species that I have looked at so far, which means that they have very good night vision – they have very good sensitivity to moving around at night. The rods lack the oil droplets; they have only the visual pigments, which makes sense if you want to have something that is very sensitive to light. Illumination at specific wavelengths of light might affect a taxis-like response, whereby the bird is attracted to the light or the communication tower. There are anecdotal reports that the attraction of birds to lights is strongest in adverse weather especially in fog, as Todd pointed out previously. The attraction of birds to these lights might simply be an escape response, whereby the bird flies towards the brightest part of the night sky, which under natural conditions would represent the moon. Flying towards the moon would simply get the bird above any fog or low-lying clouds and out of any potential problems.

Two aspects of tower lighting that can attract birds are its color (white lights, ultraviolet, or specific wavelengths) and the duration of light (strobes, flashing lights, or steady lights) as pointed out previously. Both these aspects remain unresearched. Unfortunately, there have been no controlled experiments as to which colors birds find most or least attractive. Anecdotal reports, again as Al has pointed out earlier, are that white lights seem less attractive that red lights, and strobes might even be less attractive, but we really don't know.

A second avenue of the influence of light is disorientation that is caused by the disruption of the magnetic compass. Long wavelengths of light in the red and orange part of the spectrum have been shown to produce disorientation, or a change in the direction of orientation, in the 5 species of migratory birds that have been tested. This long wavelength illumination interferes with the magnetic compass of the species, but it isn't known what the birds might do if other sources of information, such as stars, were available at the same time. The mechanism by which the wavelengths of light influence magnetic orientation is not known either. There are a couple models put out, but no one has been able to validate or invalidate any of them. All experiments that have been tested with migratory birds have been done with very narrow band filters or LEDs and researchers have only looked at the particular wavelengths that were of interest. These might resemble the conditions that a bird would encounter during fog or inclement weather when it was flying very near to a communication tower that was illuminated by say, red lights. Under normal conditions, in addition to this red light from the tower, the birds would also have starlight and perhaps even moonlight. Whether this additional illumination would simply cancel out or negate the effects of the red illumination on the magnetic compass isn't known. No one has looked at it. Disruption of the bird's navigation system and the magnetic navigation system might occur with either red lights or the RF signal if it were to interfere with the bird's ability to detect the magnetic field. If this resulting disorientation causes the birds to circle, to be unable to establish its directional cues, it would increase the probability of striking either the tower or the guy wires.

Most of the research on the RF signal has shown no behavioral affect on the birds. With one exception, all the reports that have found a response have been with tracking radars. The responses have been deviations in the headings of the birds that persisted only in a short distance from the radar antenna. Most of these effects were not consistent and attempts to replicate them were unsuccessful. The most recent report that there was no affect or little effect on migratory birds was published by Bruno Bruderer just a few months ago, along with his colleagues in Switzerland. There is only one report of a continuous transmission RF signal producing disorientation in birds.

This is work that was done several decades ago by Bill Southern working with gull chicks when the chicks were placed in a test arena immediately above a very powerful low frequency Navy transmitter that was used to communicate with submarines. When the transmitter was energized, the birds were disoriented. So at this time, it seems the RF signals produced by communication towers have no general disorientation effects on migratory birds. But again, controlled experiments in which towers were energized or non-energized and the affects on the birds transiting the area have not been conducted.

On the other hand, Peter Semm and I have found that a pulsed microwave signal results in changes in the rate of spontaneous activity of superficial neurons in the avian brain. The signal in this case was a tenth of milliwatt per square centimeter. This is about 10 times as powerful as a cellular telephone puts out when it is right next to your head. About half the spontaneously active neurons that we have recorded, responded to this pulsed gigahertz signal. Most of the cells respond with an acceleration of their activity, that is, they were stimulated. A few responded with a depression of their activity or inhibition. Whether these changes in the nervous system were reflected in behavioral changes, we have no idea. It is unlikely that the effects we observed were the result of thermal excitation, such as microwaves exciting water molecules, because we were one one-thousandth of the signal intensity that is needed to raise the tissue 1/2 of a degree. So thermal excitation wasn't a factor.

These high frequency fields produced a response in many different types of neurons that we recorded. There is no indication that there were specialized receptor cells that were responding to the signal. Consequently, these responses are occurring in higher centers of the brain, not in the lower centers where they could be filtered out.

In conclusion, there are numerous questions related to the features of communication towers for which we lack basic knowledge of either the neural or the behavioral responses of the birds. Gaining this type of information is paramount in determining what features of these towers can be modified in such a way to decrease their attractiveness to birds to allow communication field engineers to design and construct these towers in such a way to reduce the impact on migratory birds.

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