J. Field Ornithol., 63(1):26–31

COUNTING BIRDS: THE PROBLEM OF VARIABLE HEARING ABILITIES

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Abstract.—Bird counters are confronted with a conflict between their responsibility to the public for reliable information on avian population trends and a recognition of wide, age-related, differences in hearing and song detection abilities among themselves. In this paper the personal audiograms of bird counters are superimposed on the frequency-amplitude spectrograms of bird species and the indicated relationship is considered as a basis for developing correction factors that could compensate for variable hearing abilities. Some such procedure could permit the many hearing-impaired but enthusiastic older bird counters to continue in this personally rewarding and scientifically important activity.

CONTANDO AVES: EL PROBLEMA DE LA VARIABILIDAD EN LA CAPACIDAD AUDITIVA

Sinopsis.—Los que hacen censos de aves se confrontan con el conflicto entre su responsabilidad en ofrecer datos confiables sobre las tendencias poblacionales de aves y las diferencias (relacionadas con la edad) en su habilidad para detectar los cantos y sonidos producidos por los pájaros. En este trabajo se sobreimponen los audiogramas personales de estudiosos, en espectrogamas de amplitud-frecuencia del canto de aves. La relación entre éstos es considerada entonces como la base para desarrollar un factor de corrección que puede compensar para la variabilidad en capacidad auditiva. Este tipo de procedimiento puede permitir que muchas personas, que hayan perdido capacidad auditiva, puedan proseguir con esta importante actividad científica.

The rapid and accurate recognition of bird songs and calls in the field is a major source of enjoyment and pride for the amateur birder. For the serious birder it also provides an opportunity to participate in one or another of the several cooperative programs of bird counting such as the North American Breeding Bird Survey, tightly organized programs that provide important data on abundance trends in American bird populations including those for species now recognized as threatened or endangered (Robbins et al. 1986). Visual field marks can be useful in such surveys, but the detection of songs and calls by hearing is necessary for the speed, accuracy and completeness demanded of an efficient bird counter.

The special qualifications for effective bird counting depend not only on auditory identification skills acquired through personal experience and hard work, they also require a high level of hearing acuity across the full range of frequencies found in bird songs. Unfortunately not all of us can claim such full hearing proficiency (Mayfield 1966). Persons exposed to excessive loud noises often become partially deaf before they are even 20;

but particularly serious for bird counting, most will lose appreciable hearing in the critical bird song frequencies by the time they are 40 or 50 (Fig. 1). Furthermore, young people with good hearing rarely appreciate that deafness generally involves the quality and character of bird sounds as much as their loudness. Except at close range a Northern Cardinal's (*Cardinalis cardinalis*) series of clear whistles without their high frequency components become a chain of rather mechanical sounds, and a House Wren's (*Troglodytes aedon*) melodious warble becomes a sewing-machine like rattle. Old familiar songs become strange as the quality of their notes lose the high frequencies that give them their character. More and more sounds in nature become unidentifiable as bird songs are passed by or ignored as probably non-avian noises. A large part of deafness in human conversation is also due to the selective loss of high frequency sounds (the consonants) while vowel sounds continue to provide a fairly strong sound base.

Essentially all Americans lose large and critical portions of their hearing in the bird song range before they reach their 60s or 70s. Should birders still be counting bird songs for the scientific record at this age? And might corrective measures be found that could allow them to continue in this personally rewarding and scientifically important activity?

From the individual's point of view the answer might well be found in a hearing aid, but for the forseeable future these devices, because of their reduced and irregular sensitivity at the critical high frequencies, remain a poor substitute for the "full normal hearing" performance of most healthy young people. Realizing this, a project organizer compiling his report at the end of a season and responsible to the public for an "accurate" report worries over the large variability that he sees in the field records that have been turned in to him (Faanes and Bystrak 1981). In this paper we describe and explore an "audio-spectrogram" model matching the personal audiogram of a birder with the sound spectrogram of a specific bird's song and suggesting which sounds in the song will be audible to the birder and at what intensities they will be heard. Such data could provide an appropriate correction factor for each count submitted by cooperating counters.

THE ACOUSTIC STRUCTURE OF BIRD SONGS: SONAGRAMS AND F-A SPECTROGRAMS

The distinctive characteristics that serve to identify bird songs have been represented in traditional musical notation, phonic symbols, syllables, words, graphic representations and electronically produced transcriptions of sound structure (sonagrams). All of these representations trace the acoustic characteristics and patterns of the song along a horizontal time axis. Actually a bird's song varies in complex ways along not just two, but three primary dimensions: (1) the time axis (duration, tempo, phrasing, etc.), (2) frequency (perceived as pitch and varying in cadence, inflection and tone quality) and (3) intensity or amplitude (perceived as loudness, emphasis, etc.). The now familiar sonagrams reproduced in

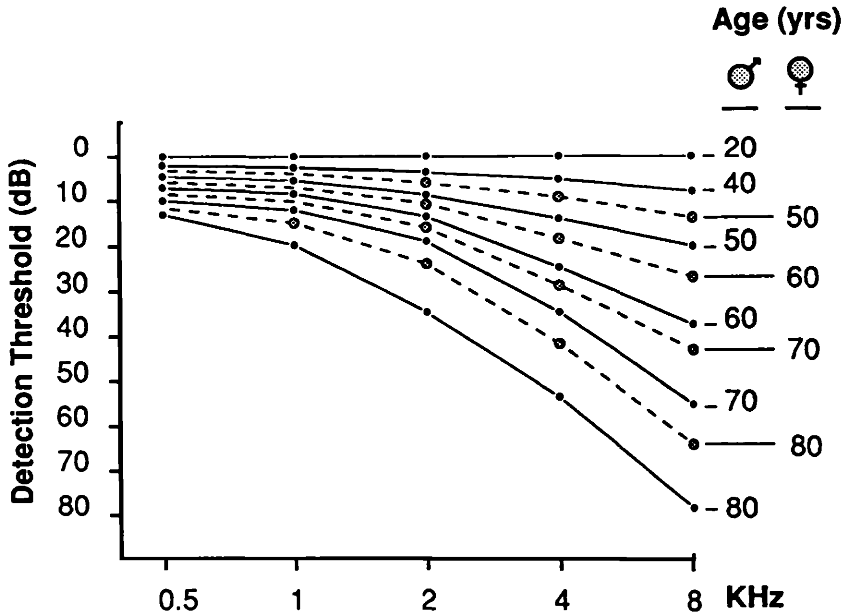

FIGURE 1. Average loss of hearing with advancing age as revealed in audiograms (thresholds for detecting pure-toned sound pulses at frequencies between 0.5 and 8.0 kHz) for a representative sample of North American men and women, 20–80 yr of age (data from Peterson and Gross 1974).

many scientific reports and as aids for identification in some field guides generally ignore intensity and plot the patterns of changing frequency scaled in kilohertz (1 kHz = 1000 cycles or vibrations per second) against a horizontal time axis scaled in tenths of seconds.

In this paper we are primarily concerned with sound intensity as it determines the distance to which a song can be heard. We have, therefore, substituted intensity for the time factor of a sonagram and plotted it against the spectrum of frequencies present in an entire bird song to create a frequency-amplitude (F-A) spectrogram. Such F-A spectrograms for six representative species are shown in Fig. 2. Each spectrogram traces on the vertical scale the intensity of the sound in decibels (dB) between the lowest and highest frequencies (horizontal scale) present in the song. The data for these spectrograms were taken from high quality audiotapes provided to us by the Cornell University's Library of Natural Sounds. They were analyzed for frequency distribution at the University of Wisconsin's Waisman Center by reading the tapes into a computer which measured the maximum intensity level occurring in each 2 kHz frequency band present across the song.

The peak of each species curve, i.e., the point with the highest intensity, was interpreted to reflect the distance in meters to the threshold of detection (DTD), a value determined earlier for each species by empirical

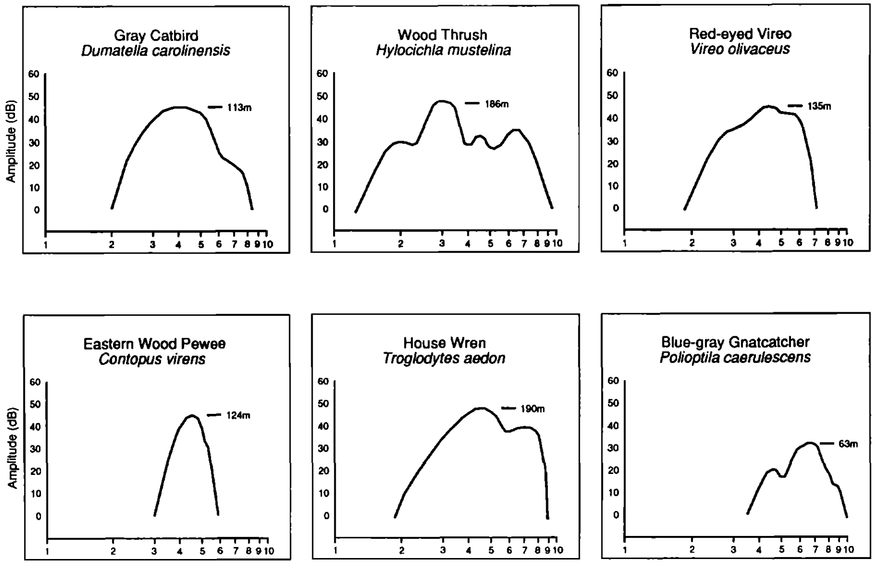

FIGURE 2. Frequency-amplitude (F-A) spectrograms for six common North American songbirds showing the frequency distribution and amount of sound energy in decibels (dB) at a point 5 m from the singing bird. See text for detail.

field tests (Emlen and DeJong 1981). The amplitude of the sound needed to reach these detection distances in forested habitat was calculated on the basis of a 10 dB reduction for each doubling of distance from the singing bird (Marten and Marler 1977). Recognizing the need for a positive base point for any logarithmic scale we selected 5 m as a convenient and acceptably small distance from the singing bird's actual position.

The scope and limitations of human hearing: audiograms.—A healthy human ear is adapted to hear sounds across about 10 octaves of sonic frequencies. The frequencies found in bird songs fall almost entirely within the upper four octaves of this audible range, between 0.5 (an octave above middle C on the piano) and 8.0 kHz. Hearing in many older persons tapers off in this range, however, obscuring or excluding important components or whole portions of many bird songs.

Curves depicting a human's hearing sensitivity across the frequency spectrum are known as audiograms (se Fig. 1). The equipment used to record them is standard in hearing and medical clinics; it consists of a pair of cushioned earphones connected to a beeper that produces brief, pulses of pure-tone sound at various intensities across the human frequency range. The test subject merely indicates which sound pulses he hears and hence reveals those he does not hear. The results are portrayed as a curve connecting the detection threshold points at each tested frequency in terms of decibels of sound energy required for the pulse to be heard. Sound intensities can range far below the detection threshold for

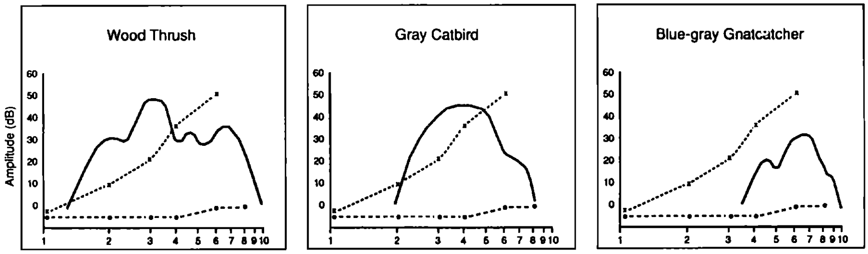

FIGURE 3. Inverted audiograms (sound intensity required for detection) for a 25 yr old with "full normal hearing" (dashed line) and a 70 yr old with the reduced hearing typical of his age class (dotted line) superimposed on frequency-amplitude (F-A) spectrograms (solid lines) for songs of a Wood Thrush, a Gray Catbird, and a Blue-gray Gnatcatcher (see Fig. 2). The space above the audiogram lines and under (within) the spectrogram arch indicates the frequency distribution and amount of sound available respectively to these two observers at a point 5 m from the singing bird.

a human ear, and the zero point on the intensity (vertical) scale is set at a level recognized by audiologists as the lower threshold of detection for a person with "full normal hearing." The cluster of audiograms in Figure 1 reveals a clear decline in hearing ability for the average man or woman, a loss developing in midlife and markedly affecting performance in the bird song frequencies in older people, especially in men.

For background reading on the physical properties of sound and the mechanisms of human hearing as it applies to bird song see a paper written specifically for birders (Mayfield 1966).

Evaluating a birder's hearing performance.—A birder's ability to hear the songs of a given species can be objectively evaluated by superimposing his or her audiogram (inverted for alignment) on the F-A spectrogram of the selected species (Fig. 3). Those portions of the songs of the Wood Thrush (*Hylocichla mustelina*), the Gray Catbird (*Dumetella carolinensis*) and the Blue-gray Gnatcatcher (*Polioptila caerulea*) that are available respectively to a 70 yr-old and a 25 yr-old observer (see Fig. 1) are indicated by the vertical distance upwards from the observers' dotted or dashed audiogram lines to the species' spectrogram curve arching above them. This portion includes areas of the lower frequencies and the higher amplitudes of the spectrogram. What lies below the observers' audiogram lines is out of reach for the indicated observer, a much larger area for the older than the younger observer.

RECOMMENDATIONS

As a large number of active bird counters obviously have deficiencies in their hearing in the bird song frequencies and are accordingly submitting incomplete and often seriously biased data to scientific surveys, we suggest that all contributors to such projects submit a standard clinical audiogram on registering in the program and every 5 yr thereafter, and that project coordinators maintain an up-to-date file of their cooperators including their audiograms as a basis for calculating and applying appropriate adjustments or correction factors to their reports.

For the present such adjustments would be crude, based on the nature and magnitude of the field observer's hearing deficiencies and the compiler's knowledge of the frequency characteristics of the birds' songs. In time, however, a central file of F-A spectrograms could be developed for all native species, available for reference and for matching with the song counter's audiograms. With modern computer technologies such a file should create no major problems and could produce rough but essentially objective correction factors for any observer submitting an audiogram.

CONCLUSION

At 80 yr old the senior author of this paper still enjoys frequent birding trips afield although he has not heard a gnatcatcher for over 10 yr, hears only half as many catbirds as he used to hear, and often fails to recognize the fragmented song of a distant Wood Thrush, while at 40 yr old the junior author is still unaware of any loss in his ability to detect and recognize the songs he encounters. Under such conditions we would consider it a responsibility for an older observer to provide an objectively based correction factor with his report and at some point to refrain from submitting reports.

ACKNOWLEDGMENTS

We acknowledge with thanks many helpful comments and suggestions on early drafts of this paper from Lang Elliott, Harold Mayfield, Samuel Robbins, Stanley Temple and Frederic Wightman.

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Received 29 Dec. 1989; accepted 23 May 1991.