SOUNDS OF SHOREBIRDS 1. INTRODUCTION AND METHODS OF ANALYSIS

by E.H. Miller

Our basic knowledge of shorebird sounds has increased sharply with the publication of the third volume of "Birds of the Western Palearctic" (Cramp et al. 1983). This book includes more than 200 sound spectrograms for 54 species, 14 presented for the first time. Included in this group are stone curlews (Burhinidae), a family for which no spectrographic analyses were previously available, plus several new species of coursers and pratincoles (Glareolidae), sandpipers (Scolopacidae), and plovers (Charadriidae). European readers might be astonished to learn that the "firsts" include Greater Golden Plover (Pluvialis apricaria), Ruff (Philomachus pugnax) and Dotterel (Charadrius morinellus). In addition, many kinds of sounds are analyzed and illustrated for the first time, even for well known species. The value of the material is high because of the overlain frequency scales and the detailed quality of the sound spectrograms - far superior to most published spectrograms - and because of the painstaking written accounts in which onomatopoeic renderings are critically discussed and summarized. In this and two subsequent articles, I shall outline the importance of knowledge about shorebird acoustics, and describe the main ways in which sounds are depicted graphically (this part). In the following articles, I shall discuss diversity in acoustic communication within and among species of shorebirds, with reference to social systems and ecology.

Bird sounds are diverse and complex, reflecting at once socially important characteristics such as age, sex, or pairing status, as well as phylogenetic relationships, geographic origins, short-term behavioural tendencies, and mechanisms of sound production. There are correspondingly diverse research areas which explore the social dynamics of acoustic communication, the taxonomic and evolutionary importance of sounds, and so on. Shorebird sounds have been studied relatively little, but already have led to important findings about the behaviour significance of subtle variation in short-range communication (Northern Jacana, Jacana spinosa; Mace, 1981), about species-specificity (calidridine sandpipers; Miller, 1983), and about geographic uniformity (Short-billed Dowitcher, Limnodromus griseus; Miller et al. 1983). Some of these findings contrast with general trends for songbirds, and suggest that shorebirds will provide rich material for comparative bioacoustic research.

Sound signals vary in frequency and amplitude over time. Animals hear frequency variations as variations in pitch, roughly speaking, and amplitude variations as variations in loudness. Pitch and loudness refer to perceptual characteristics, not to physical characteristics of a sound, and there is no simple correspondence between them. This is one reason why it is impossible to get a good mental image of a sound by looking at a conventional graph of its physical characteristics. The three attributes - frequency, amplitude, time - are the axes on most such graphs. Frequency is usually shown in cycles per second (cps, or Hertz, abbreviated as Hz) or thousands of cycles per second (kiloHertz, abbreviated as kHz); amplitude is related to "sound pressure level" (relative to a standard level, in a logarithmic power ratio; units in decibels, abbreviated as dB); and time is in seconds or milliseconds.

The simplest kind of graph shows amplitude against time; this is an oscillogram such as can be viewed (for brief periods of time) on an oscilloscope. Other kinds of equipment produce oscillograms with much longer times bases, which are more useful for research on bird sounds. Figure 1 illustrates a Short-billed Dowitcher song as oscillograms. The upper part shows an entire song with parts 1, 2 and 3 shown in more detail in the lower parts (the time markers are in milliseconds). Note particularly the last element (part 3), which shows strong, rhythmic amplitude modulation (AM).

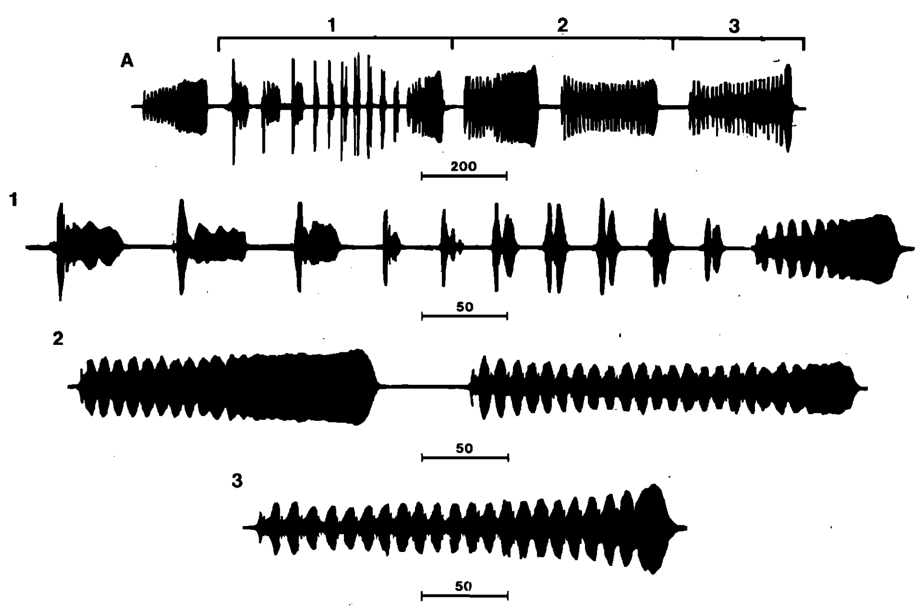

Figure 1. Oscillogram of song of Short-billed Dowitcher Limnodromus griseus. See text for description and discussion.

The same song is shown in a second kind of graph in Figure 2. This is a sound spectrogram (sonagram, sonogram, audiospectrogram) with frequency on the vertical scale and time on the horizontal. Sound spectrograms are the most widely used form of graph for bird sounds, and the only kind in the important compilations by Cramp et al. (1983) and Glutz von Blotzheim et al. (1975, 1977). The upper two parts of the figure (A, B) are songs on different time scales (time markers are 125 milliseconds): A shows a lead element, then two "song units" (I, II; terminology of Miller et al., (1983). Only the second song unit is shown in B, and this unit is the one also shown in Figure 1. Notice the last element in part B; it shows strikingly regular frequency modulation (FM), which is coupled to the prominent AM shown in Figure 1. The physics of sound analysis necessitate a smearing in the vertical (frequency) dimension to bring temporal characteristics into focus, and this kind of wide-band sound spectrogram is the one usually shown (as Figure 2A, B). To show frequency characteristics more clearly, some temporal resolution must be sacrificed, and narrow-band analysis yields pictures like Figure 2C (here on a modified time scale). Now the last element can be seen as a regular "warble" which ends with a brief, constant-frequency bit (at higher amplitude; compare Figure 1). One advantage of sound spectrograms is that they show where energy is distributed across the frequency range. Look at the first few elements in Figure 2B (= the first few in part 1 of Figure 1). These all have energy in the fundamental frequency as well as in its first harmonic overtone (at double the fundamental frequency), but such information cannot be seen in Figure 1.

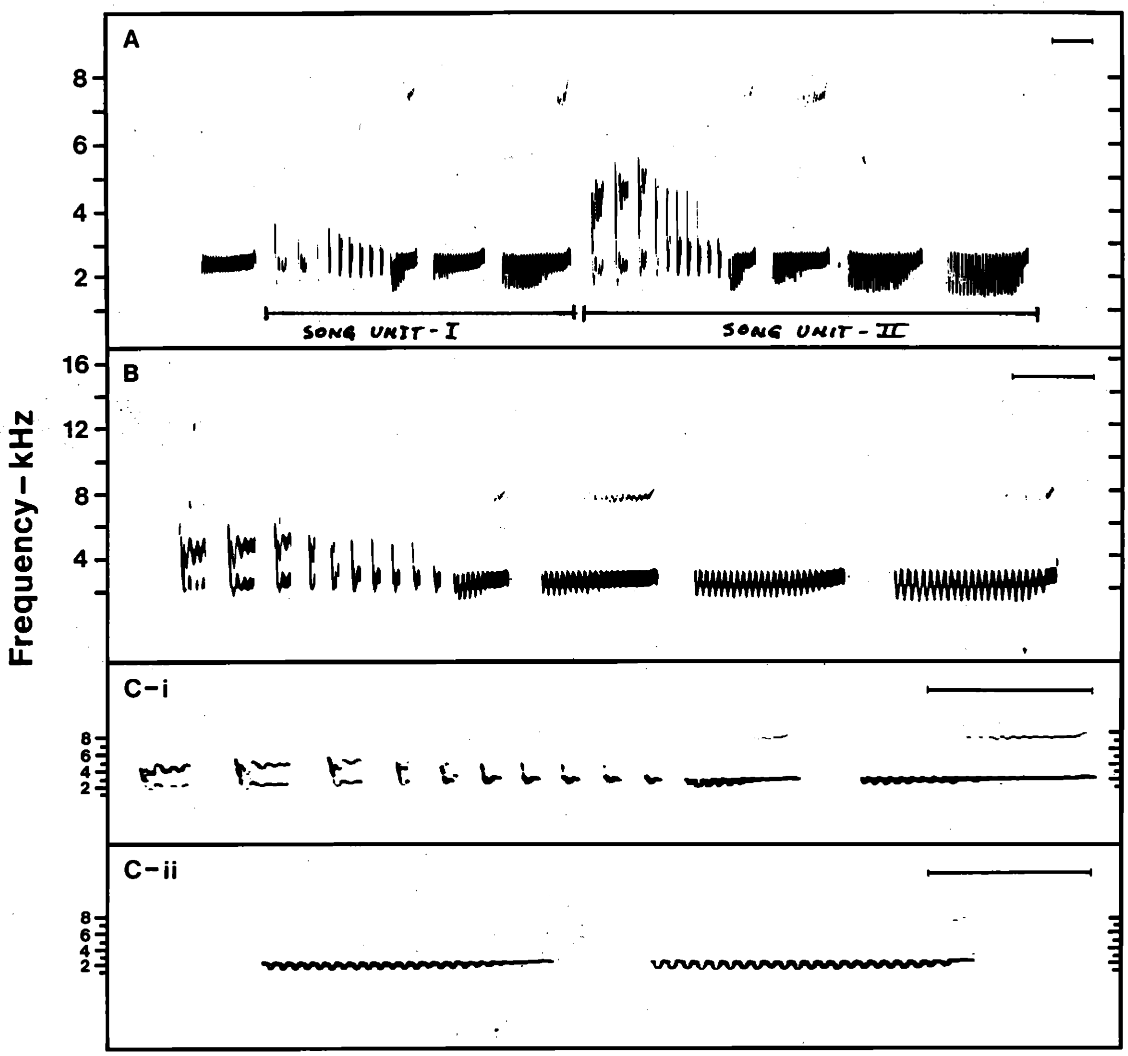

Figure 2. Sonogram of song of Short-billed Dowitcher *Limnodromus griseus*. See text for description and discussion.

Finally, it is often important to know more precisely how energy is apportioned across the frequency spectrum. The usual way this is shown is with some measure of amplitude, intensity, or sound pressure on the vertical axis, and frequency on the horizontal. Figure 3 shows a typical plot for nuptial calls of three male Least Sandpipers (Calidris minutilla).

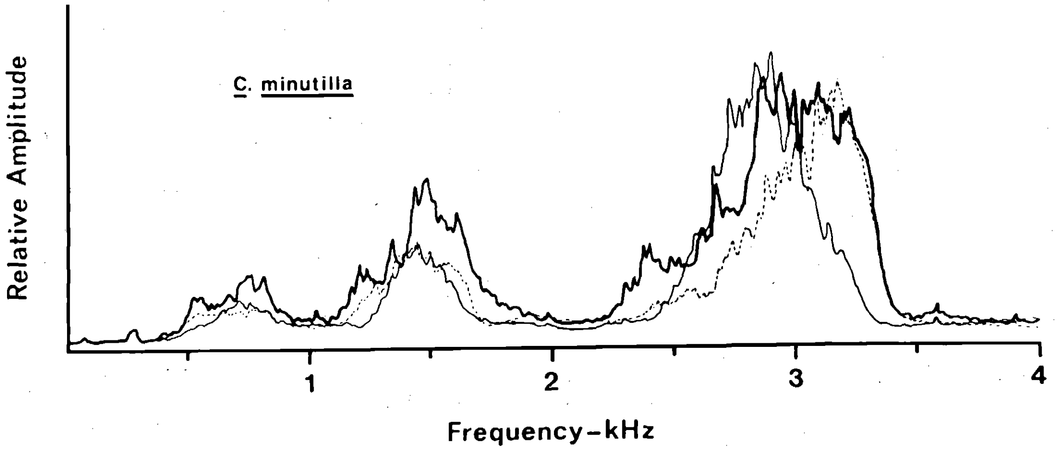

Figure 3. Plot of relative amplitude versus frequency for nuptial calls of three male Least Sandpipers Calidris minutilla. See text for discussion.

Physical description is a necessary first step toward our understanding of the biological significance of shorebird sounds. A glance through Cramp et al. (1983) or Glutz von Blotzheim et al. (1975, 1977) should be sufficient to impress one with the sensitivity of such description in pointing to differences among species, and to the diversity of call types within species. In the next article, I shall discuss the extent and importance of some species-specific calls. Further information on analysis and description can be found in Marler (1969) and Watkins (1967). A good reference concerned with tape recording is Wickstrom (1982).

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SHOREBIRD MIGRATION AT MONTREAL, CANADA

by S. Holohan

Montreal (45° 30'N 73° 36'W) is situated on islands in the St. Lawrence River, 145 km from the nearest area of tidal influence and at least 330 km overland from the closest ocean area. The district has an average of 112 days snow cover per year and 157 frost free days (Powe 1969). The part of the St. Lawrence Valley where the city is situated has several hundred kilometres of river and lakeside habitat but only a small fraction of this is suitable for shorebirds. Only a small portion of shorebird habitat is studied by ornithologists, usually at weekends. Most habitat in the Montreal district can be considered marginal for shorebirds, with the best areas available as melting snow causes the rivers to flood from April to June and on the wave washed shores of the 110 islands in the St. Lawrence between Montreal and Lac St. Pierre. One of these islands, Ile du Moine, near Sorel, has been visited on a regular basis.