The Condor 89:406–412

BREEDING VOCALIZATIONS OF THE SURFBIRD[1,2]

EDWARD H. MILLER
Collections Management Program, British Columbia Provincial Museum, Victoria, British Columbia V8V 1X4, Canada and
Biology Department, University of Victoria, Victoria, British Columbia V8W 2Y2, Canada

WILLIAM W.H. GUNN[3]
P.O. Box 738, Bobcaygeon, Ontario K0M 1A0, Canada

STEPHEN F. MACLEAN, JR.
Department of Biology, University of Alaska, Fairbanks, AK 99701

Abstract. Breeding Surfbirds (*Aphriza virgata*) were studied in the Yukon Territory and Alaska. They utter three common call types: *Song, Rhythmically Repeated Call* (*RRC*), and *Laugh. RRC*s are emitted as bouts during wide-ranging aerial displays, presumably by males. Each *RRC* is composed of a few brief pulses followed by a long, nearly constant-frequency portion. Bouts average 5.1 *RRC*s in length; each *RRC* averages 326 msec long with intervals between of 109 msec. *Song* is a complex vocalization associated with aerial displays, courtship, and agonistic ground displays. It has a harsh buzzy quality because it contains rapidly repeated broad-band pulses. The *Laugh* is a train of simple brief elements and is uttered in response to mild disturbance such as approach by a human. *Laughs* average 929 msec long and contain an average of 3.8 elements. The three call types are similar in structure, temporal organization, and function to those described for other Calidridini and indicate that certain aspects of acoustic organization in the group are phylogenetically old.

Key words: Surfbird; Aphriza virgata; *vocalization; bioacoustics; systematics.*

INTRODUCTION

The Calidridini is a homogeneous group of 24 or 25 species of sandpipers, most of which nest in the arctic or subarctic (Gochfeld et al. 1984, Hayman et al. 1986). Affinities among them are not resolved, though certain species groups seem well defined (e.g., *C. alpina–C. ptilocnemis–C. maritima*) and affinities among others will probably be clarified through ongoing work on biochemical genetics (Baker et al. 1985; Baker and Strauch, in press). Relationships of the Surfbird (*Aphriza virgata*) to the Calidridini remained unsettled until Jehl (1968) emphasized its similarity to the Great Knot (*Calidris tenuirostris*). The species are similar in morphology and plumage and have similar arctic-alpine breeding habitat; *C. tenuirostris* in northeastern Siberia (Johnsgard 1981, Myers et al. 1982, Prater and Grant 1982, Cramp 1983, Marchant 1986), and *A. virgata* in stony mountain heath of Alaska and Yukon Territory (Bent 1929; Frisch 1978, 1982; Kessel and Gibson 1978; Kessel 1979). The similarity in range and habitat of the two species reflects a probable Beringian origin (Jehl 1968). Both species nest at low densities in relatively inaccessible habitat so it is not surprising that breeding biology and behavior are virtually unknown. In this paper we describe some prominent types of vocalizations used by breeding Surfbirds, based on our observations in Alaska and Yukon Territory. These are the first acoustic analyses for the species, and contribute to our knowledge of acoustic differentiation in the Scolopacidae, a poorly known group in this regard (review by Miller 1984).

METHODS AND MATERIALS

Field recordings and observations were made at Eagle Summit, Alaska (June 1979 and 1980), and in the Ogilvie Mountains, Yukon Territory (June 1979). Miller made recordings with a Nagra IS recorder and Sennheiser MKH816 "shotgun" microphone with Scotch 208 tape at a speed of 19 cm per sec; details of Gunn's equipment are not available, though he generally used a Nagra recorder, parabola of large diameter, and high-quality tape. Sound spectrograms were prepared on a Kay Elemetrics Digital Sona-Graph 7800.

[1] Received 1 July 1986. Final acceptance 2 January 1987.
[2] Dedicated to the late Bob Frisch, whose passion for "las palomitas" led to this paper.
[3] Deceased.

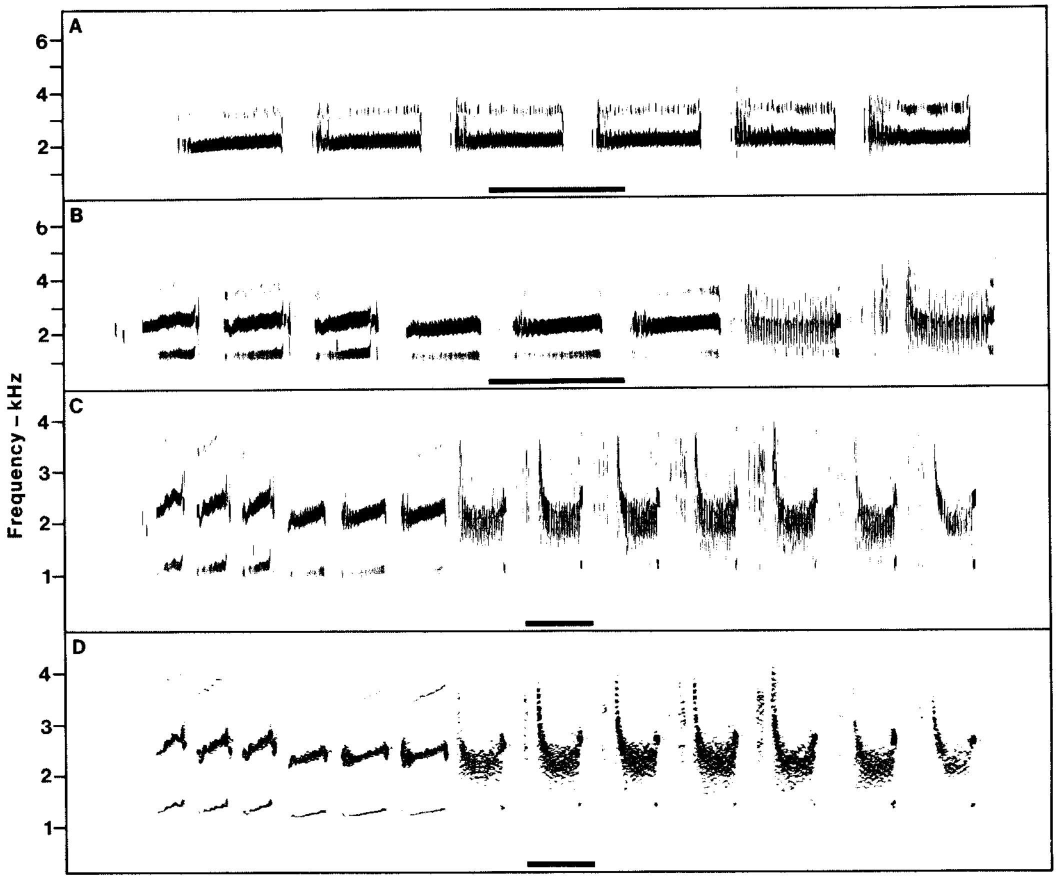

FIGURE 1. Sound spectrograms of a sequence of *Rhythmically Repeated Calls* (*RRC*s), and of a *Laugh-RRC-Song* sequence. The last two *Laugh* elements and the last two *RRC*s of panels B–D are also shown in Figure 2 (see also Figs. 3, 4, 6). A. Complete bout of six *RRC*s (Eagle Summit). The fundamental frequency was extremely weak on the original spectrograms and cannot be seen here. B. Three-part *Laugh* followed by three *RRC*s and the first two parts of a seven-part *Song* (Ogilvie Mountains). The fundamental frequency of the *RRC*s is visible here. The complete sequence is shown in panels C and D. C, D. Complete *Laugh-RRC-Song* sequence, part of which is also shown in B. Time markers, 500 msec. Analyzing filter bandwidths, 300 Hz (A, B), 150 Hz (C), and 22.5 Hz (D).

Temporal measurements were made on spectrograms prepared over the range 80–8,000 Hz with a 300-Hz analyzing filter bandwidth. Frequency spectra were computed with Micro Speech Lab (MSL, version 2.2, available from the Speech Technology Research Centre, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2, Canada) using an IBM XT Personal Computer. Spectra illustrated below were traced from plots made on a Hewlett-Packard Thinkjet printer. MSL is a software package that permits rapid analog-to-digital conversion of sounds from a microphone or from audio tape input. It has an array of options for analyzing waveforms and spectra, as well as for altering signals. For the application here, I digitized signals at a rate of 20,000 Hz (it is desirable to digitize at a rate at least 2.5 times the maximal frequency of the signal), and used a Hamming window, no pre-emphasis, low smoothing (using a moving average incorporating four bins on either side of the current bin), and 1,024 points for each analysis (except as noted in Fig. 3).

RESULTS

RHYTHMICALLY REPEATED CALLS (RRCs)

Surfbirds engaged in stereotyped aerial displays during which they uttered several kinds of calls, *RRC*s being the commonest. Displaying birds

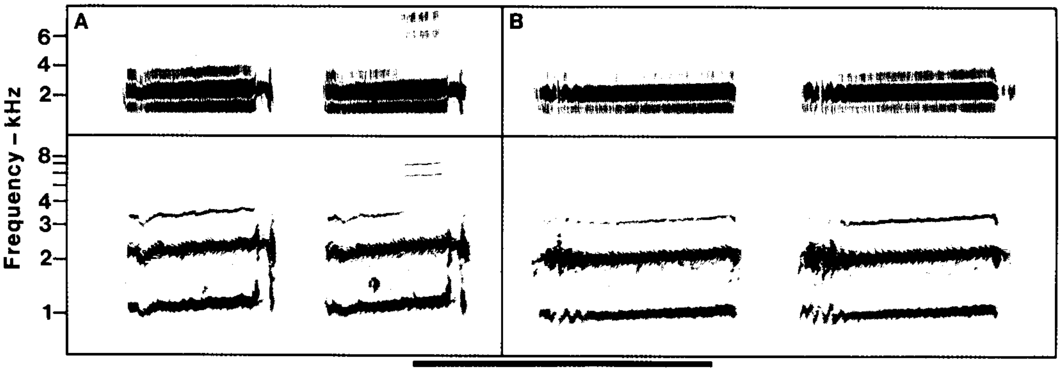

FIGURE 2. Sound spectrograms of *Laugh* and *Rhythmically Repeated Calls* (*RRC*s) shown in Figures 1B–D (see also Fig. 4). A (left panels). Last two elements of *Laugh*. B (right panels). Last two *RRC*s. Time marker, 500 msec. Analyzing filter bandwidth 600 Hz (top panels) and 90 Hz (bottom panels). Note that the bottom panels are depicted on a logarithmic frequency scale.

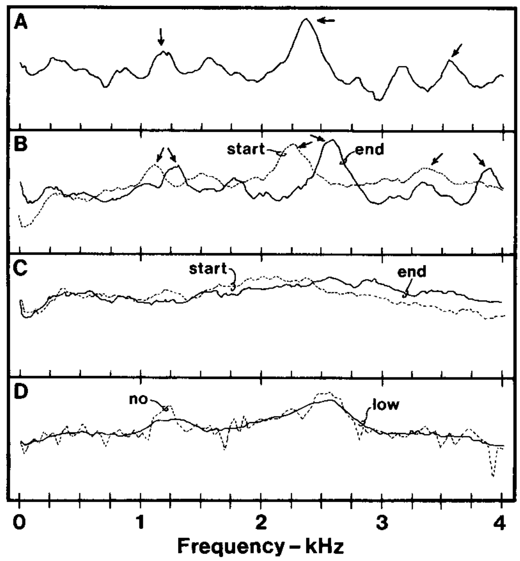

FIGURE 3. Power spectra of representative calls. A. *Rhythmically Repeated Call (RRC)*: last 50 msec of the second *RRC* in Figures 1B–D. The arrows indicate the weak fundamental frequency, the strong second harmonic and the weak third harmonic. B. *Laugh:* 50 msec at the start and end of the continuous part of the third element of the *Laugh* in Figures 1B–D (thus excluding the brief terminal part). The arrows have the same meaning as in A. C. *Song:* 50 msec at the start (incorrectly labelled "end") and end (mislabelled "start") of the main pulse burst of the fourth *Song* unit in Figures 1C–D (thus excluding the brief terminal tonal part; see panel D). D. *Song:* terminal tonal part of the fourth *Song* unit in Figures 1C–D (512-point analysis). Spectra with no smoothing and low smoothing are shown.

had long, level flight paths that took them out of sight of the observer. They flew fairly close to the nearby alpine ridges but were typically high (hundreds of meters) above intervening valley bottoms. Display flights were characterized by gliding with wings outstretched during vocalization, and gliding or continuous loose fluttering with deep wingbeats between call sequences.

*RRC*s were uttered rhythmically in bouts separated by long silences. Twenty-two bouts that we recorded consisted of no other call types and 15 were followed immediately by *Song* (see next section). Bouts ranged from two to 12 *RRC*s in length, averaging five (Table 1). Each *RRC* started with one to several brief frequency-modulated elements which sometimes merged into a much longer portion. The latter began with rhythmic frequency modulation and gently increased in frequency, ending in a slight frequency drop (Figs. 1, 2). The fundamental frequency was around 1 kHz. The second harmonic contained much more energy than the fundamental, and there was less energy in higher harmonics (Figs. 1, 2, 3).

The brief introductory elements of *RRC*s were slightly lower in amplitude than the main part of the call and were amplitude-modulated. Amplitude was rhythmically modulated at the start of the main portion of each *RRC*, changed little over its course, but tended to be highest at or near the end (Fig. 4).

Temporal characteristics of *RRC*s and the intervals between them varied somewhat among individuals. The first *RRC* of a bout tended to be slightly briefer and lower in amplitude than

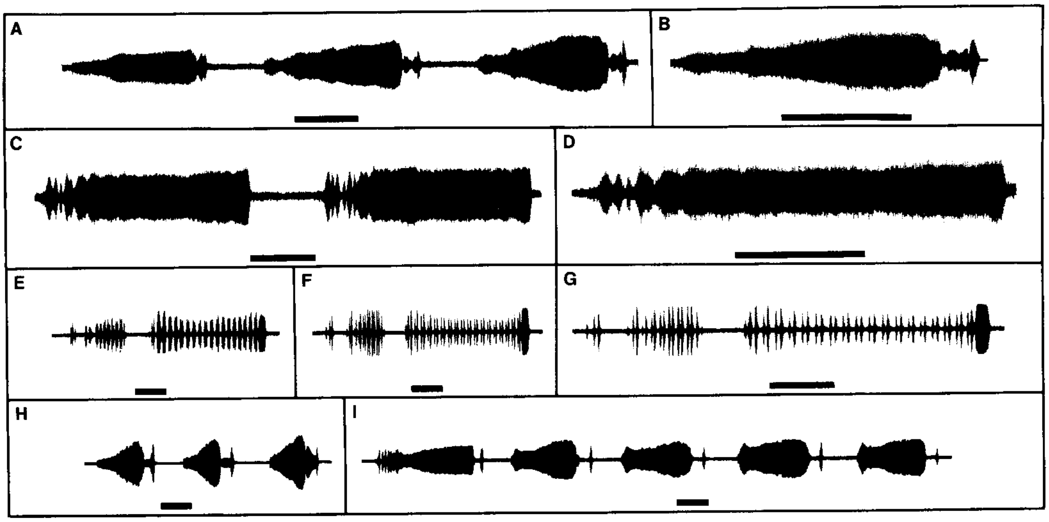

FIGURE 4. Oscillograms of *Laughs, Rhythmically Repeated Calls* (*RRC*s), and *Song*. A. *Laugh* of Figures 1B–D. B. Last element of *Laugh* in panel A. C. Last two *RRC*s of Figures 1B–D. D. First *RRC* of panel C. E. Third *Song* unit of Figure 5C. F, G. Last *Song* unit of Figure 5B. H. *Laugh* of Figure 6A. I. *Laugh* of Figure 6C. Time markers, 100 msec.

subsequent ones (Fig. 1, Table 1). *RRC*s averaged about a third of a second long, with intervals between of about a tenth of a second (Table 1).

SONG

Song was a harsh-sounding complex call composed of repeated units (Figs. 1, 5). It was uttered after *RRC* bouts and during fights or chases. The beginning of *Song* was variable and was often marked by irregular bursts of broad-band pulses (e.g., Fig. 5A top). The main course of *Song* was highly structured, however, with repetitions of a unit comprising several bursts of broad-band pulses (Figs. 1, 5). The first few bursts were brief and contained rapidly repeated pulses; after an interval they were followed by a longer pulse-burst, which showed a pronounced drop in carrier frequency over the first third or so, and a slight rise at the end (Figs. 1, 3, 5). In each burst the pulses were organized as couplets (Fig. 4, see especially parts F and G).

LAUGH

Birds that appeared to be mildly disturbed, as when approached by a human observer or flying by one, frequently uttered a medium-loud call, the *Laugh*. *Laughs* were distinctively higher pitched and had a faster cadence than *RRC*s. They averaged about four elements long, with a range from one to 15 in our sample (Table 2). Elements generally increased in frequency over their length, showed irregular modulations at the beginning or throughout, and ended in a sudden shift to a brief element (Figs. 1, 2, 6). Frequency characteristics varied little among elements of a *Laugh*. The fundamental was around 1 to 1.5 kHz and increased to 2 to 3 kHz or higher at the end, then dropped suddenly; it contained less energy than the second harmonic, and either slightly more or less than the third (Figs. 1, 2, 3, 6). Higher overtones contained progressively less energy.

TABLE 1. Temporal attributes of *Rhythmically Repeated Calls* of *A. virgata*.[a]

Attribute	$\bar{Y}$	SE	*n*
No. of calls per bout[b]	5.12	0.450	34
Call duration			
First call	295	9.7	11
Following calls	330	2.9	96
Total calls	326	3.0	107
Interval duration			
First interval	105	1.6	16
Following intervals	110	0.9	79
Total intervals	109	0.8	95

[a] All durations are in msec. The unequal sample sizes resulted from faint recordings, poor recordings resulting from wind or other sounds, etc.

[b] The frequency distribution of number of elements per bout, represented as number of elements per bout–number of bouts, is: 2–3, 3–8, 4–7, 5–4, 6–4, 7–3, 8–0, 9–3, 10–0, 11–0, 12–2.

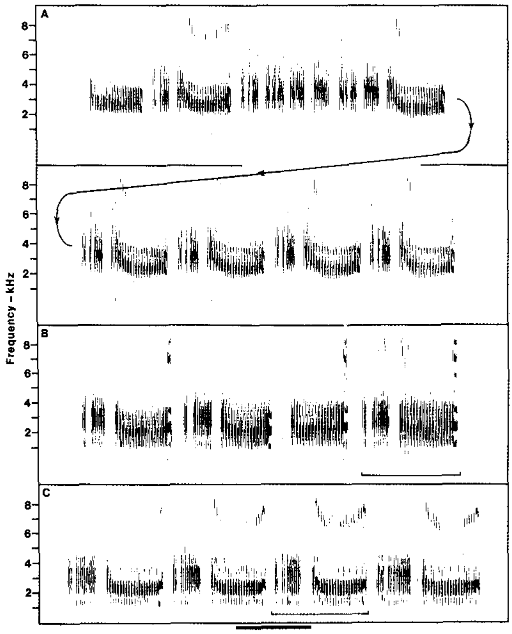

FIGURE 5. Sound spectrograms of parts of *Songs* (all from Eagle Summit). A (top two panels). Part of a song sequence immediately following a bout of *Rhythmically Repeated Calls*. B, C. Partial song sequences from two other birds. The last song unit in panel B and the third song unit in panel C (marked by horizontal lines) are shown as oscillograms in Figures 4E–G. Time marker, 500 msec. Analyzing filter bandwidth, 300 Hz.

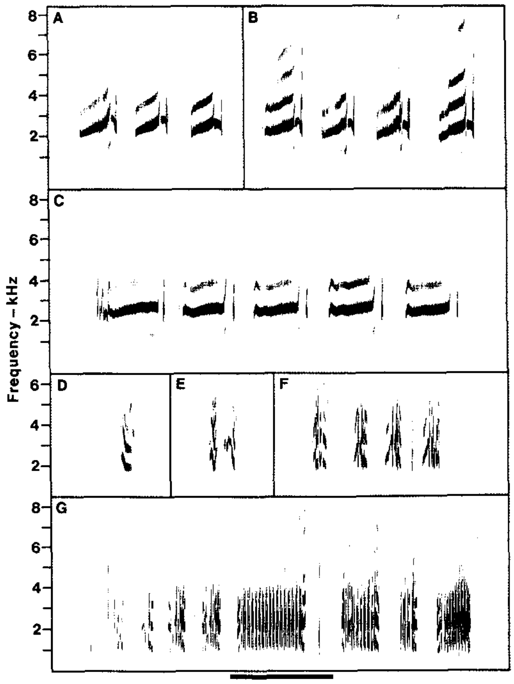

FIGURE 6. Sound spectrograms of *Laughs* and miscellaneous calls (all from Eagle Summit). A. Three-part *Laugh* (see also Fig. 4H). B. Four-part *Laugh* by the same bird. C. Five-part *Laugh* by a different bird (see also Fig. 4I). D, E, F, G. Miscellaneous ground calls by an agitated bird. They appear to grade into *Song* in part G. Time marker, 500 msec. Analyzing filter bandwidth 300 Hz.

TABLE 2. Temporal attributes of *Laughs* of *A. virgata*.[a]

Attribute	$\bar{Y}$	SE	*n*
No. of elements[b]	4.21	0.288	81
Total duration	929	83.9	41
Element durations			
First	198	5.5	43
Second	171	5.1	45
Third	172	6.7	37
Fourth	188	8.6	22
All	186	3.0	175
Interval durations			
First	87.9	3.26	44
Second	99.6	4.86	37
Third	104	5.5	23
All	95.7	2.21	132

[a] All durations are in msec. The unequal sample sizes resulted from faint recordings, poor recordings resulting from wind or other sounds, etc. (sample includes some which were not taped, but for which we counted the number of elements "by ear").
[b] The frequency distribution of number of elements per *Laugh*, represented as number of elements per *Laugh*-number of *Laughs*, is: 1–2, 2–14, 3–30, 4–11, 5–6, 6–7, 7–3, 8–1, 9–3, 11–2, 12–1, 15–1.

Amplitude generally increased regularly over the course of each *Laugh* element and reached a peak at the end of the main portion (Fig. 4).

Temporal characteristics of *Laugh* elements and the intervals between them varied among individuals but were fairly consistent within birds (Figs. 1, 4, 6). However, despite individual variations, *Laughs* tended to have longest elements and briefest intervals at the beginning. Elements showed a weak trend toward intermediate durations late in a sequence, and briefest in between; intervals between consecutive elements showed a general increase in duration as *Laughs* progressed (Figs. 1, 4, 6; Table 2).

The call described by Dixon (1927, p. 7, 13) as "tee tee teet" was presumably the *Laugh*.

OTHER CALLS

One Surfbird uttered variable calls after a skirmish on the ground and when approached by one of us (Figs. 6D–G). Some calls were uttered singly and others as groups; the former were soft and the latter quite loud. At an extreme, the calls' structure suggested incipient song (Fig. 6G).

DISCUSSION

Surfbirds in display flights beat their wings in a loose flutter with deep amplitude on the wingbeats. This pattern is shared with the Stilt Sandpiper, *Calidris himantopus* (Miller 1983b) and Baird's Sandpiper, *C. bairdii* (Miller, unpubl. data) with one difference: Surfbirds have long gliding phases while calling, whereas the other two species beat the wings almost continuously even while vocalizing. Fluttering and its temporal patterning in Surfbirds are distinctively different from the Least Sandpiper (*C. minutilla*), Dunlin (*C. alpina*), and Semipalmated Sandpiper (*C. pusilla*). In the latter three species the wings are held motionless in brief gliding phases that alternate with rapid bursts of shallow-amplitude fluttering of the wings, a pattern that is not coordinated with calling. Finally, Surfbirds are unique among the species mentioned in traveling slowly but continuously and directly in aerial display. The other species hover, then glide or drift slowly over relatively small distances (sometimes while fluttering) to an area where they resume hovering, and so on.

In the calidridine species mentioned *Song* is accompanied by elaborate wing displays and invariably precedes or accompanies descent from a display flight (Miller 1983a, 1983b). We neither saw nor heard descents of Surfbirds from display flights, so do not know if the species deviates from this pattern.

Surfbirds utter bouts of *RRC*s during display flights. This is the common pattern for the species mentioned. Of the latter, Least Sandpipers are unique in uttering extremely long rhythmical sequences of *RRC*s with very few pauses.

*RRC*s of Surfbirds are most similar to those of Least Sandpipers, of the species mentioned above, in having several brief introductory elements then a long tonal portion. Surfbird *RRC*s have less energy in the fundamental than in the second harmonic, a feature characteristic of many call types in calidridines studied to date (Miller 1983a, 1983b).

Song is the most complex utterance of Surfbirds and other calidridines and is also the most species-distinctive. Certain qualities of *Song* are recognizable in different species but very few homologies at the level of individual elements have been identified. *Song* of the Short- and Long-billed dowitchers (*Limnodromus griseus* and *L. scolopaceus*, respectively) is strikingly similar to that of the Least Sandpiper (Miller et al. 1983, 1984). *Song* of the Surfbird resembles that of the Stilt Sandpiper due to the harsh quality of rapidly repeated broad-band pulses, but neither the organization nor the components of Surfbird *Song* are obviously homologous with those of other calidridines studied to date. In contrast, the *Laugh* of the Surfbird has easily recognized homologues in related species, as judged by the contexts in which they are given, their audile qualities, and their acoustic structure (Cramp 1983; Miller 1983b, unpubl. data). A distinctive call type which has been identified in several other calidridines is the *Rattle*. We did not hear or record a similar sound in the Surfbird, possibly because of our limited observations.

To summarize, three common types of breeding vocalizations of the Surfbird are homologous to those described for other species. The *Laugh* and *RRC* are simplest and most similar to those of related species; *Song* is the most complex and divergent. Several attributes of flight motor patterns used in aerial displays are also shared with related species. The different degrees of evolutionary divergence of these attributes should yield insight into relationships among calidridines at various levels. For example, *RRC*s and *Laughs* seem to be most conservative so should be valuable in revealing relationships among species and species-groups but not among populations; in keeping with this prediction, one detailed quantitative analysis of *RRC*s in the Least Sandpiper revealed remarkably uniform characteristics from Nova Scotia to British Columbia and the Yukon (Miller 1986). We predict that motor patterns in aerial displays will be uniform too, but they are much harder to describe and measure accurately and are more prone to environmental variation (e.g., due to weather). Conversely, *Song* should be a sensitive indicator of infraspecific divergence and of divergence between sister species. This hypothesis can be tested through analyses of *Song* from well-differentiated populations (e.g., subspecies of *Calidris ptilocnemis*) or from species-pairs like the Surfbird and Great Knot.

ACKNOWLEDGMENTS

This study was undertaken with the help and enthusiasm of the late Robert Frisch of Dawson City, whose knowledge of Surfbirds will probably never be surpassed. We thank him and Julie Kehoe for their encouragement, company, and field assistance in the Yukon. Brina Kessel generously provided us with unpublished data and commented on the manuscript. We also thank A. E. Bowles and J. R. Jehl, Jr., for reviewing the paper. Financial support was provided by an Individual Operating Grant from the Natural Sciences and Engineering Research Council of Canada and by a Research Grant from the Friends of the British Columbia Provincial Museum, both to E. H. Miller. We thank Erica Bates for typing many manuscript drafts, Craig Dickson and Roy Snell for encouragement and help with MSL, Ed Longprés for his fine photographs, and Leonard Peyton for providing supplementary recordings from Eagle Summit.

LITERATURE CITED

BAKER, A. J., A. LYNCH, AND C. EDWARDS. 1985. Biochemical genetic studies of shorebirds: methods and applications. Wader Study Group Bull. 44: 34–39.

BAKER, A. J., AND J. G. STRAUCH, JR. In press. Genetic variation and differentiation in shorebirds. *In* G. F. Barrowclough and A. J. Baker [eds.], Genetic structure of avian populations. Proc. XIX Int. Ornithol. Congr. (1986).

BENT, A. C. 1929. Life histories of North American shore birds, part II. U.S. Natl. Mus. Bull. 146.

CRAMP, S. [ED.]. 1983. Handbook of the birds of Europe, the Middle East and North Africa: The birds of the Western Palearctic. Vol. 3. Waders to gulls. Oxford Univ. Press, London.

DIXON, J. 1928. The Surfbird's secret. Condor 29:3–16.

FRISCH, R. 1978. Surfbirds in Ogilvie and Richardson Mountains, Yukon Territory. Can. Field-Nat. 92: 401–403.

FRISCH, R. 1982. Birds by the Dempster Highway. Privately published, Dawson City, Yukon Territory. (See Appendix to the present paper.)

GOCHFELD, M., J. BURGER, AND J. R. JEHL, JR. 1984. The classification of the shorebirds of the world, p. 1–15. *In* J. Burger and B. L. Olla [eds.], Shorebirds: Breeding behavior and populations. Plenum Press, New York.

HAYMAN, P., J. MARCHANT, AND T. PRATER. 1986. Shorebirds. An identification guide to the waders of the world. Croom Helm, London.

JEHL, J. R., JR. 1968. The systematic position of the Surfbird *Aphriza virgata*. Condor 70:206–210.

JOHNSGARD, P. A. 1981. The plovers, sandpipers, and snipes of the world. Univ. Nebraska Press, Lincoln.

KESSEL, B. 1979. Avian habitat classification for Alaska. Murrelet 60:86–94.

KESSEL, B., AND D. D. GIBSON. 1978. Status and distribution of Alaska birds. Stud. in Avian Biology 1:1–100.

MARCHANT, J. H. 1986. Identification, habits and status of Great Knot. Br. Birds 79:123–135.

MILLER, E. H. 1983a. Structure of display flights in the Least Sandpiper. Condor 85:220–242.

MILLER, E. H. 1983b. The structure of aerial displays in three species of Calidridinae (Scolopacidae). Auk 100:440–451.

MILLER, E. H. 1984. Communication in breeding shorebirds, p. 169–241. *In* J. Burger and B. L. Olla [eds.], Shorebirds: Breeding behavior and populations. Plenum Press, New York.

MILLER, E. H. 1986. Components of variation in nuptial calls of the Least Sandpiper (*Calidris minutilla*; Aves, Scolopacidae). Syst. Zool. 35:400–413.

MILLER, E. H., W.W.H. GUNN, AND R. E. HARRIS. 1983. Geographic variation in the aerial song of the Short-billed Dowitcher (Aves, Scolopacidae). Can. J. Zool. 61:2191–2198.

MILLER, E. H., W.W.H. GUNN, J. P. MYERS, AND B. N. VEPRINTSEV. 1984. Species-distinctiveness of Long-billed Dowitcher song (Aves: Scolopacidae). Proc. Biol. Soc. Wash. 97:804–811.

MYERS, J. P., O. HILDÉN, AND P. TOMKOVICH. 1982. Exotic *Calidris* species of the Siberian tundra. Ornis Fenn. 59:175–182.

PRATER, A. J, AND P. J. GRANT. 1982. Waders in Siberia. Br. Birds 75:272–281.

APPENDIX

Frisch's "Birds by the Dempster Highway" (1982) is hard to obtain but contains important original notes on *A. virgata*, so excerpts of these are reproduced here.

". . . highly restrictive in . . . habitat preferences (stony but not excessively barren mountain heath) . . . well established in the Southern Ogilvies . . ." (p. 32).

"In the Richardsons Surfbirds were found in the southern chain but not in the northern ranges . . . suitable habitat [in the latter] seemed present but much more restricted than in the southern part . . ." (p. 33).

"Breeds sparingly in stony alpine heath of Ogilvie and Southern Richardson Mtns. In the Northern Ogilvies it seems to occur only in the high southern ranges . . ." (p. 62).