# NOTES

## Vocalizations of the Chinstrap Penguin *Pygoscelis antarctica*

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**Abstract.**—The vocalizations of the Chinstrap Penguin (*Pygoscelis antarctica*) are described including information on calling behavior. For each call type, characteristic audiospectrograms and oscillograms are presented. Numerical information about the spectral and temporal features of the calls is provided as well. The results are compared with descriptions of repertoires of other species of penguins. *Received 31 March 1995, accepted 19 November 1995.*

**Resumen.**—Se describen las vocalizaciones del Pingüino Barbijo (*Pygoscelis antarctica*) incluyendo información sobre el contexto en el que se emiten. Para cada tipo de llamada se presenta un audioespectrograma y un oscilograma típico. Los resultados son comparados con las descripciones del repertorio vocal de otras especies de pingüinos.

**Key words.**—Antarctica, South Shetland Islands, Chinstrap Penguin, *Pygoscelis antarctica*, vocalizations.

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Penguins are garrulous when on their breeding colonies. Individuals rely almost exclusively on vocalizations to recognize their partners during the breeding period. Also, parent and offspring seem to learn each other's voice and are able to recognize each other at the time chicks join crêches (Penney 1968, Bustamante *et al.* 1992).

While the acoustic repertoire of some species e.g., Adélie Penguin (*Pygoscelis adelia*; Penney 1968, Spurr 1975, Jouventin 1982), the crested penguins (*Eudyptes* spp.; Warham 1975), King Penguin (*Aptenodytes patagonicus*; Jouventin 1982) or Emperor Penguin (*A. forsteri*; Jouventin 1982, Bremond *et al.* 1990, Robisson 1991, Robisson *et al.* 1993) has been extensively described and studied, recordings of penguins in the genus *Spheniscus*, or the Chinstrap Penguin (*Pygoscelis antarctica*) are scarce (Jouventin 1982).

Bagshawe (1938) published the first written descriptions of the songs and calling behavior of the Chinstrap Penguin, describing a crowing sound corresponding to the Ecstatic display and Mutual display, and a "queer buzzing sound" associated with the bowing display. Haftorn (1986), describing the breeding behavior of this species, indicates that vocalizations are probably individually distinctive, although he provides no detailed data. Jouventin (1982) provides brief descriptions of the Ecstatic song (N = 10), Bowing call (N = 4) and Mutual display song (N = 20), based on recordings made by B. Despin in South Georgia and includes some numerical data on maximum frequency and duration, as well as an audiospectrogram for each call type.

Our study complements the limited information available on the vocal repertoire of the Chinstrap Penguin, presenting a larger sample of recordings from a different area, and more detailed numerical analyses. We also provide data on chick calls, for which there is no published information.

## STUDY AREA AND METHODS

Vocalizations were recorded in Vapour Col rookery, Deception Island (63°00'S, 60°40'W), South Shetland Islands, by the first author from 10 December 1992 to 4 January 1993. We recorded three types of vocalizations from the acoustic repertoire of adult Chinstrap Penguins corresponding to the Ecstatic display, Mutual display and Bowing display. We also recorded the calls of chicks when 5-10 days old. Recording equipment included a Sony WM D6C tape recorder and a Sennheiser Me 80 directional microphone. A representative audiospectrogram and oscillogram was selected for a 2.5 s recording segment of each type of call. A longer recording (20-60 s) was analyzed to generate numerical information on the spectral and temporal characteristics of each call type.

Recordings were processed with an Apple Macintosh-based digital signal analysis system. Digitalization and editing were completed at a sampling frequency of 44.1 KHz and 16 bit resolution with Sound Tools® hardware and software. Signalyze® software was used to filter sounds, and to obtain numerical information as well as to generate audiospectrograms and oscillograms. Frequency information was obtained through fast Fourier transform (FFT) (33ms/30Hz band).

We followed Jouventin's terminology for both behavioral attitudes (1982, Table 5) and for the description of vocalizations (1982, p. 42). To estimate which call parameter was most individually distinctive, we also followed Jouventin (1982). We calculated the average individual coefficient of variation (as the mean coefficient of variation among calls of the same individual) and the population coefficient of variation (as the coefficient of variation among one randomly selected call of different individuals) for all parameters measured for each syllable or phrase. The ratio of the population coefficient of variation to the individual coefficient of variation provides an index of the individual distinctiveness of a given parameter.

## RESULTS

Numerical data for the different call types are provided in Table 1.

### Ecstatic Song

Ecstatic songs were emitted by penguins while incubating or brooding the chicks as part of the Ecstatic display. The singer stretched out, raising its head and bill vertically; the bird opened and closed its bill repeatedly, while vibrating its chest and synchronously flapping its flippers perpendicular to the body. Neighbors frequently joined the singer in a noisy chorus.

This call is typically composed of two phrases with two syllables each (Figs. 1a and 1e), although the third syllable (first syllable of the second phrase) was sometimes omitted (Fig. 1b), or fused with the second syllable (Fig. 1c). In general, these calls show a great inter- and intra-individual variability in call pattern (syllable structure and sequence). Only at the zenith of the calling bout (not reached in many instances) is the maximum complexity of the Ecstatic call reached with a prolonged third syllable (Fig. 1c). Up to 17 phrase groups may be emitted in succession, first increasing in intensity and complexity, and then decreasing in both. Figure 1d provides an example where the first phrase (A) initially is repeated only, then both phrases (A and B) are produced with increasing intensity and complexity, and finally the song decreases in complexity and intensity again repeating only the first phrase (A).

All syllables have emphasized frequencies in the third, fourth and fifth harmonics, although the first and sixth harmonics show substantial power as well. The first syllable (1) is short (mean duration, 70.83 ms) and typically has an upwards frequency shift (220-294 Hz in the fundamental; see Table 1). The second syllable (2) is longer (mean duration, 132.90 ms) and has an overall decrease in frequency (265-208 Hz in the fundamental), often with some underlying frequency modulation. The third syllable (3) is the longest (mean duration, 297.85 ms)

**Table 1. Characteristics of Chinstrap Penguin vocalizations. Means (SDs in parentheses) are presented for duration and various frequency characteristics.**

| | Number of Individuals | Number of Calls | Mean Duration (ms) | Dominant Frequency (Hz) | Minimum Fundamental Frequency (Hz) | Maximum Fundamental Frequency (Hz) | Characteristic Frequency Modulation |
|---|---|---|---|---|---|---|---|
| Ecstatic Song | | | | | | | |
| First phrase (A) | | | | | | | |
| Syllable 1 | 7 | 45 | 70.83 (14.72) | 968.55 (390.36) | 221.34 (42.85) | 294.13 (41.30) | up |
| Syllable 2 | 7 | 45 | 132.90 (28.69) | 1235.32 (388.69) | 208.43 (35.11) | 265.86 (25.27) | down |
| Second phrase (B) | | | | | | | |
| Syllable 3 | 7 | 29 | 297.85 (45.03) | 1256.27 (363.45) | 232.56 (43.59) | 333.35 (33.43) | up |
| Syllable 4 | 7 | 28 | 127.08 (17.35) | 1296.99 (356.17) | 207.71 (43.27) | 286.10 (27.31) | down |
| Mutual Display Song | | | | | | | |
| First phrase (A) | 6 | 13 | 233.92 (39.96) | 1615.76 (236.97) | 255.46 (16.77) | 339.92 (25.16) | up-down |
| Second phrase (B) | 6 | 21 | 187.42 (40.41) | 1580.38 (223.87) | 270.00 (27.70) | 325.42 (34.43) | up-down |
| Bowing Call | 2 | 5 | 1458.33 (674.93) | 894.38 (233.41) | 434.12 (46.91) | 477.88 (47.19) | up-down (some more complex) |
| Chick's Call | 4 | 14 | 169.13 (40.77) | 3178.84 (514.97) | 3088.07 (351.84) | 3392.31 (432.94) | up-down |

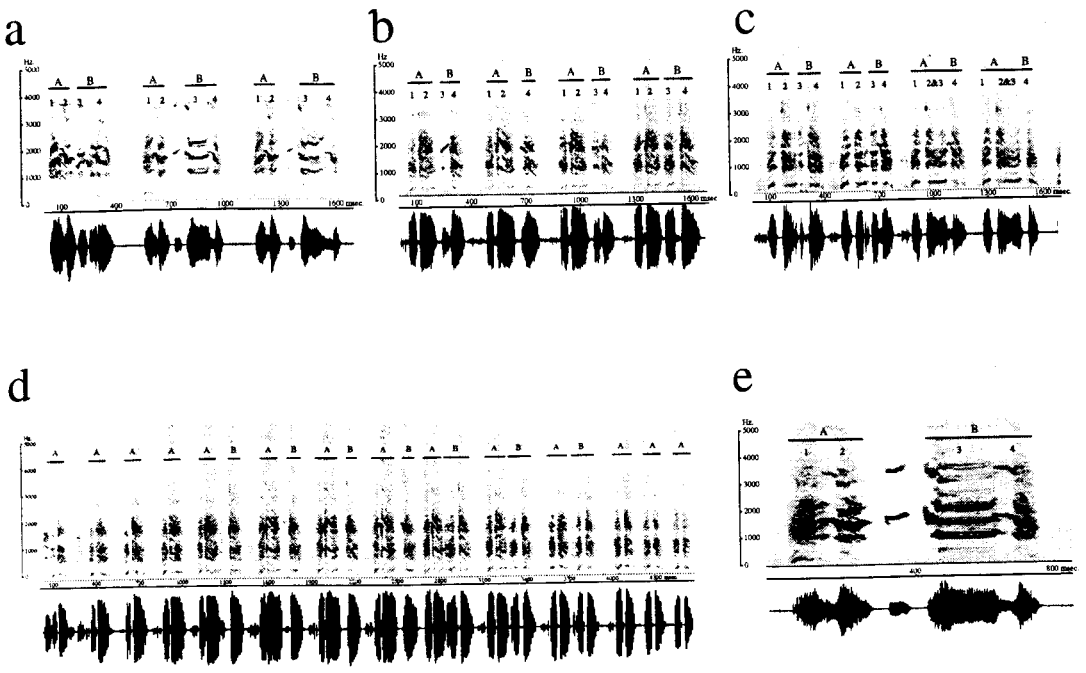


**Figure 1. Audiospectrogram (upper portion with frequency displayed against time in ms) and oscillogram (lower portion with amplitude displayed against time) of a characteristic Ecstatic song with two phrases (A,B) and four syllables (1,2,3,4). a) Characteristic sequence of three phrase groups near the zenith of a song. b) Sequence of four phrase groups; in the second one, syllable 3 is omitted. c) Sequence of four phrase groups; the latter two showing fused syllables 2 and 3. d) Complete Ecstatic song showing increase and decrease of phrase complexity. e) Expanded detail of the middle two phrases of Fig. 1a.**

and has an upwards frequency shift (232-333 Hz in the fundamental). The fourth and final syllable (4) is slightly shorter (mean duration, 127.08 ms), with an overall downwards sweep (286-207 Hz in the fundamental).

Ecstatic songs are more variable among than within individuals. The ratio of the population coefficient of variation to the mean individual coefficient of variation ranged from 0.64 to 3.72 for different parameters measured at the syllable level, and these ratios were significantly greater than one (One-tailed Wilcoxon Signed Ranks Test, Z = 2.811, N = 16, P = 0.002; Table 2). The individual distinctiveness seems greater in syllable duration than in frequency, but the differences are not significant (Two-tailed Wilcoxon Test, Z = 1.881, N = 16, P = 0.06). Differences in individual distinctiveness between the first and the second phrases are not statistically significant (Two-tailed Wilcoxon Test, Z = 1.577, N = 16, P = 0.115).

## Mutual Display Song

Mutual Display songs were emitted before nest relief when a member of a pair returned to a mate tending eggs or chicks. This song is probably important in partner recognition. The initial phrase, A, composed of a single syllable, appears as a wide inverted U shape in the audiospectrogram, with a fast rise in frequency, a more prolonged frequency fall, and an average duration of 234 ms (Fig. 2 and Table 1). The following phrase, B, can be repeated 1-3 times consecutively after phrase A (Fig. 2), and is composed of two syllables, each approximately 90 ms in duration, the first one having ascending frequency modulation (300-350 Hz) and the second syllable having overall descending frequency. Phrase B can also be a single longer syllable, corresponding to a fusion of the abovementioned syllables, with a mean duration of 187 ms. As the syllables were generally not clearly delimited, due to an overlap of the

**Table 2. Ratios of the population coefficient of variation to the mean individual coefficient of variation for the Ecstatic song and Mutual Display song of the Chinstrap Penguin.**

| | Mean Duration | Dominant Frequency | Minimum Fundamental Frequency | Maximum Fundamental Frequency | Mean Ratio | Number of Individuals | Number of Individuals with More than Two Calls | Mean Number of Calls per Individual |
|---|---|---|---|---|---|---|---|---|
| Ecstatic Song | | | | | | | | |
| First phrase (A) | | | | | | | | |
| Syllable 1 | 1.09 | 1.63 | 0.64 | 0.97 | 1.05 | 7 | 5 | 8.6 |
| Syllable 2 | 1.65 | 1.46 | 0.84 | 1.07 | 1.20 | 7 | 5 | 8.6 |
| Second phrase (B) | | | | | | | | |
| Syllable 3 | 3.20 | 1.44 | 1.38 | 2.01 | 1.81 | 7 | 6 | 4.7 |
| Syllable 4 | 3.72 | 1.21 | 1.07 | 1.40 | 1.69 | 7 | 6 | 4.5 |
| Mutual Display Song | | | | | | | | |
| First phrase (A) | 8.37 | 3.40 | 2.03 | 2.94 | 4.19 | 6 | 3 | 3.3 |
| Second phrase (B) | 1.65 | 1.98 | 2.70 | 2.22 | 2.14 | 6 | 5 | 4.0 |

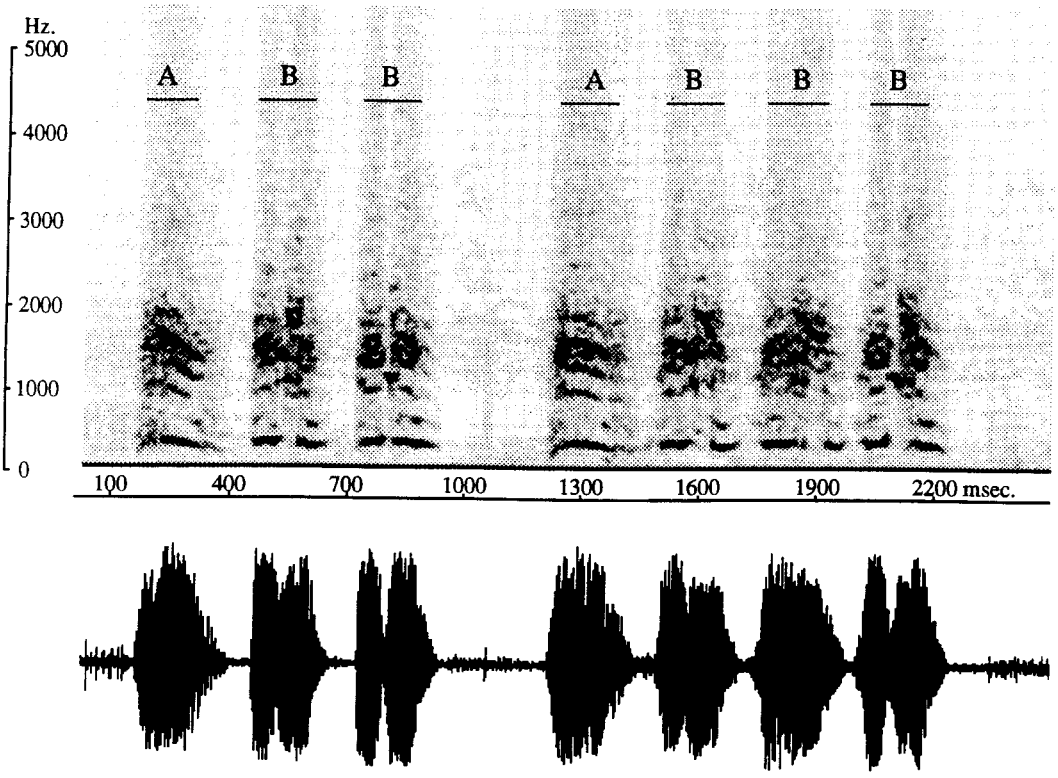


**Figure 2. Audiospectrogram and oscillogram of the Mutual Display song by a single individual. The recording was obtained at the initiation of a calling bout and the responding individual had not started its reply.**

higher frequency components of the call, all measurements were taken at the phrase level (Table 1). Both members of a pair may emit this call concurrently, forming a rather cacophonic duet. The dominant frequency of both syllable types is usually the fifth harmonic, typically involving frequencies 1,500-1,850 Hz. Substantial power is also found in the sixth, fourth and the first harmonic (i.e., the fundamental frequency 300-370 Hz).

Mutual Display songs are also more variable among than within individuals. The ratio of the population coefficient of variation to the mean individual coefficient of variation ranges from 1.65 to 8.37 at the phrase level, and is significantly greater than one (One-tailed Wilcoxon Signed Rank Test, Z = 2.591, N = 8, P = 0.005; Table 2). Differences in individual distinctiveness between the first and the second phrases of the song are not statistically significant (Two-tailed Wilcoxon Test, Z = 1.278, N = 8, n.s.).

Table 2 also indicates that Mutual Display songs are more consistent within individuals than the Ecstatic songs (Two-tailed Wilcoxon Test, Z = 2.941, N = 24, P = 0.003). Although ratios are greater for duration than for frequency parameters, the differences are not significant. To asses this, we compared, for each syllable of the Ecstatic and phrase of the Mutual Display songs, the duration ratio to the mean ratio of frequency parameters (Two-tailed Wilcoxon Signed Ranks Test, Z = 1.467, N = 6 pairs, n.s.).

## Bowing Call

Bowing calls were raucous sounds emitted as part of the Bowing Display, when both members of the pair bowed towards each other. This display was usually repeated one or several times after the Mutual Display song, both before and after nest relief. A similar bowing display could be performed to-

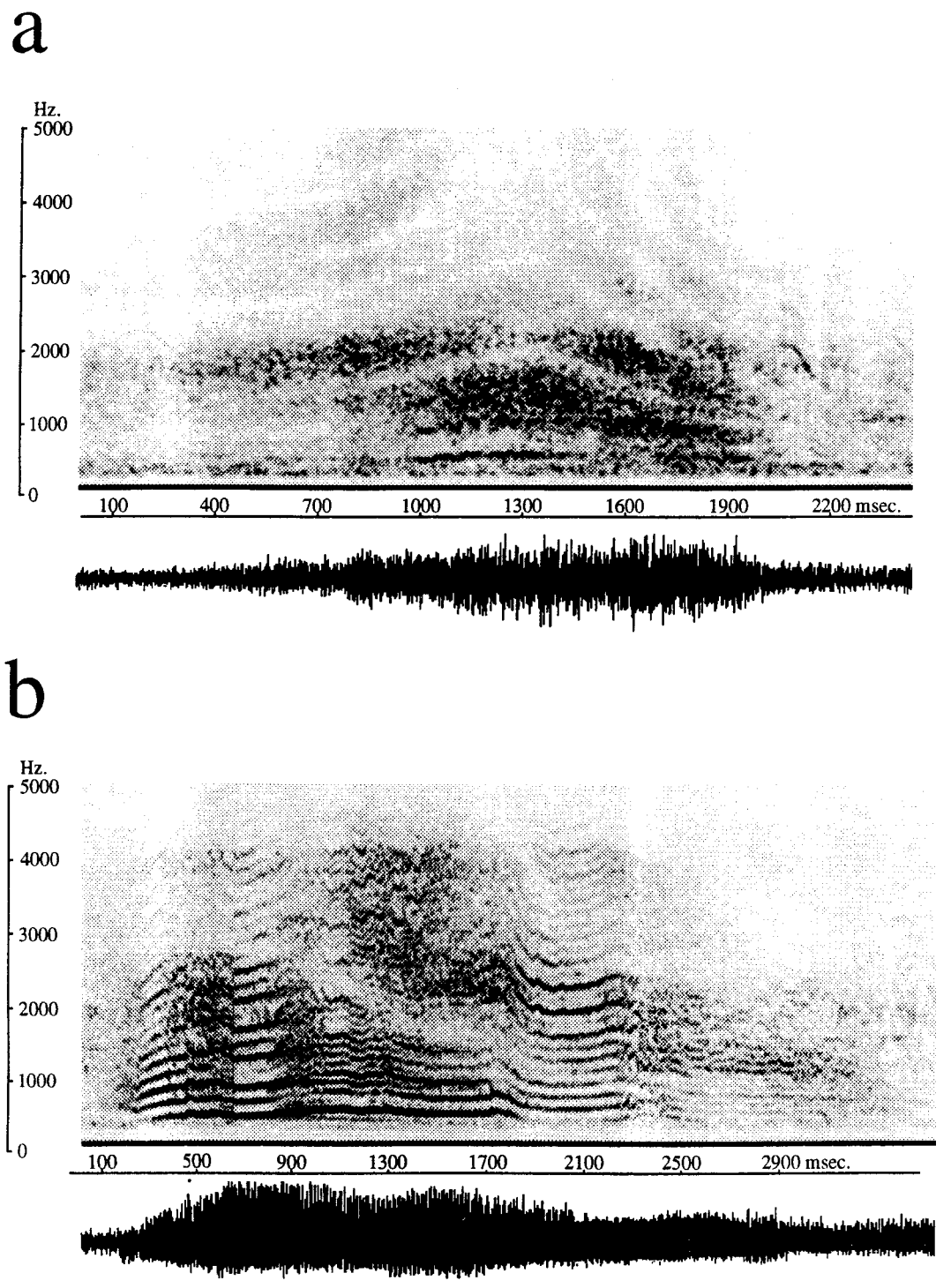


Figure 3. a) Audiospectrogram and oscillogram of a characteristic bowing call showing up-down frequency modulation. b) Audiospectrogram and oscillogram of a longer bowing call showing more complex frequency modulation.

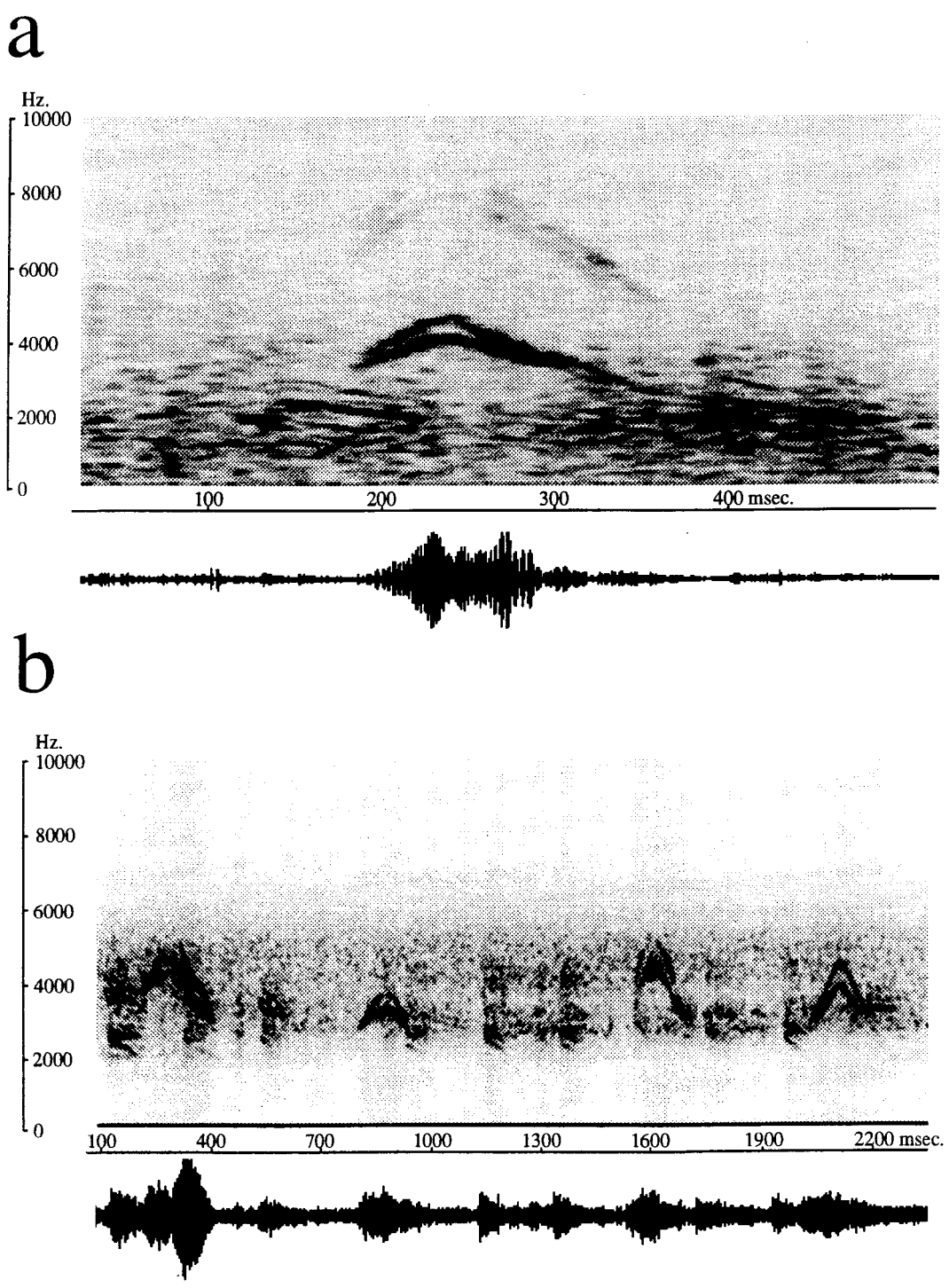


Figure 4. a) Audiospectrogram and oscillogram of a chick's call. The background noise (below 3,500 Hz) is the sound of the adult calls in the rookery. b) Vocalizations of two chicks showing great variability in frequency range. The background noise of the rookery was filtered out (pass band 2,200-5,500 Hz).

ward a chick by a parent alone at the nest. A similar hissing sound was emitted as part of a threat display in response to a disturbance (e.g., a human approaching the nest). Bowing calls were of variable length (0.7-2.3 s), extremely rich in the 250-2,500 Hz frequency band, but with an underlying harmonic structure which was typically modulated in an up-down pattern (Fig 3a). More complex frequency modulation patterns also were observed in longer calls (Fig. 3b).

### Chick's Call

Chicks usually called after the nest relief and before being fed by the adult. Audiospectrograms of the chick vocalizations (Fig. 4) showed an inverted V shape with a short (ca. 50 ms) initial upwards dominant frequency sweep (3,500-4,800 Hz) followed by a marked longer (120 ms) downwards sweep (4,800-2,500). The call is composed of a characteristic double frequency band separated by 300-500 Hz in the dominant frequencies. It is interesting to note that the dominant frequencies of the begging calls are well above the frequencies used by the vocalizations of the adults, being clearly distinguishable from the background noise of the rookery (Fig. 4a). Chick calls can show a marked variability in frequency although they always keep the characteristic up-down frequency modulation. Figure 4b illustrates the combined vocalizations of two chicks.

## DISCUSSION

The Ecstatic song, Mutual Display song, and Bowing call recorded by us also correspond to the repertoire of vocalizations recorded for the other two species of the genus *Pygoscelis*, the Adélie Penguin and the Gentoo Penguin (*P. papua*). Jouventin (1982) reported that the Ecstatic song and Mutual Display song are almost identical in the Adélie Penguin and are very closely related in the Gentoo Penguin. In contrast, our analyses for the Chinstrap Penguin indicate that these two songs have clear differences in syllable length and phrase structure. Unfortunately, as we did not record both songs in the same individual, we cannot determine how much of this difference can be attributed to the individual and how much to the song type. The Ecstatic song of the Chinstrap Penguin is more similar to that of the Adélie Penguin than to that of the Gentoo Penguin. The individual syllables of the first two species show some rather complex frequency modulation patterns which are not shown in the apparently more truncated Ecstatic song of the Gentoo Penguin.

Haftorn (1986) had suggested that the Ecstatic song was individually distinctive. The greater variability between individuals compared to the variability within individuals in the songs we recorded supports this view. The ratio of population variability to individual variability in song parameters are close to those observed by Jouventin (1982) in the closely related Adélie Penguin, but are much smaller than those of the Emperor Penguin that does not have a nest and relies exclusively on vocalizations for individual recognition. We found the Mutual Display song more individually distinctive than the Ecstatic song. The Mutual Display song is more important for individual recognition between partners during nest relief, and it could be the song that chicks learn during the guarding stage which then allows them to recognize their parents during the crêche stage.

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