

Comparative Studies on Ecological Behavior and Sound Signal of *Sterna vittata* and *Larus dominicanus*, Fildes Peninsula, Antarctica

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This paper deals with the preliminary result of our studies on the Ecology and sound signal of sea birds around the Chinese Antarctic Great Wall station on the Fildes Peninsula, Antarctic. *Sterna vittata* and *Larus dominicanus* are common species of sea birds in the Fildes Peninsula, Antarctic. When *S. vittata* flies freely in the sky, it sings away "Jee..." sound signals. This sound signals are mainly composed a series of pulses and a continuous sound wave. Occasionally, single pulse also appears. A series of pulse which consists of regular single pulse. But the number of single pulse is irregular and there are different variation in width and interval of a series of pulse. Single pulse lasts relative regular time, about 0.7ms. Its frequency is 468-4350 Hz and its spectrum energy in this frequency range mainly concentrates on 2.7 and 4.2 kHz. Sometime, the spectrum crest in the frequency also concentrates on 1.4, 2.4 or 2.5 kHz but the spectrum crest is lower. The sound signal of *L. dominicanus* is continuous series of pulse. The series of pulse lasts 13ms. Single pulse lasts 0.5-0.7 ms. The interval is 0.5ms. The frequency range is 1360-4153 Hz. The spectrum crest is relative dispersion and usually appears at 1.3, 2 and 2.9 kHz.

Key words: ecological behavior, sound signal, single pulse, a series of pulse, interval, spectrum crest

INTRODUCTION

It is reported that Antarctic birds (including penguins) consists of more than 100 species. About 30 species of them may breed themselves in the southern areas from Antarctic Convergence. There are only seven species of birds can breed in Antarctic Continent and adjacent coastal areas.

It is case that Antarctic birds have been free from human stimulate and encroach except that penguins are greatly caught for the use of their oil and full resources. So that Antarctic is the biggest bird natural protected area at present. This provides our researches on birds ecology and sound behavior with a good natural environment and resource.

Antarctic birds belong to migratory birds. It has a migration every year. On each October they land on Antarctic Continent to breed and lift in a flock in the following March to find a warmer place to live through the winter.

When Antarctic birds multiplicity and migration

are frequently accompanied by ecological behavior and mean while, they are keeping in touch by giving complex and quick-changing sound signals.

Sound signal is the birds important physiological function for their survival. So that, through a careful investigation and study. A better understanding of the structure and characteristic of the sound signals of birds will be get. This might help us to explore and use Antarctic resources properly and it might be promising to get help from the birds wits. And also this will contribute a lot to the studies of ecology and biology by giving relevant theoretic prof.

This paper is accomplished on the basic of my research (from Nov. 1988 to Mar. 1989) material which was copied in Antarctic during that period. Through careful examine of *Sterna vittata* and *Larus dominicanus*'s sound signals which are given as they are performing their various ecological behaviors.

I've got some ideas about the structure and phys-

ical characters of the signals and the relation between sound signal and acoustic behaviors. May it be some help to the courses of bird research work and as well as teaching.

MATERIALS AND METHODS

Field Investigation

I affirmed every of the *Sterna vittata* and *Larus dominicanus*'s ecological behaviors repeatedly mean while, record the sound signals in a place which is 2-4 metres away from the *S. vittata* and *L. dominicanus* with the SANYO-M1012 recorder its frequency is 250-6300 Hz. Notice and recording are carried at the same time.

In the Laboratory

The rough materials are carefully selected. Thus the best recorded material which contains the lowest noise was singled out. Then TYP HP 601 high-pass filter's is used. At last, sampled by 7T08 signal processor.

During this process, the sound signals can be regarded as a stationary ergodic stochastic process in a limited time. The total average characteristic of the sound signal of *S. vittata* and *L. dominicanus* may be indicated by a sample function which is got according to the average of time. Suppose $X(t)$ is a sample. With $(0, T)$ as interval, then the approximate value of the power's spectral density function $G(f)$ is:

$$G(f) = \frac{1}{n} \left[\int_0^T X(t) \cdot e^{-j2\pi ft} dt \right]^2$$

with f is frequency, in the above discrete calculation, the discrete time is selected under the sample theorem.

$$f \geq 2, f_n: \Delta T = \frac{1}{f_s}$$

pointed number $N = 1024$, the sample time interval $T = N \cdot \Delta T$.

By this discrete calculation, we get the acoustic frequency including to the *Sterna vittata* and *Larus dominicanus*'s total acoustic frequency bird.

RESULTS

Ecological Behavior

Ecological behavior of two Antarctic sea bird, *Sterna vittata* and *Larus dominicanus*, investigated are presented in Table 1.

Sound Signal

***Sterna vittata*:** *Sterna vittata* is one of singing sea birds. When it flies freely in the sky, it sings away "Jee..." this signal contains series of pulse which consists of regular single pulse. Single pulse lasts a relative regular time, about 0.7 ms. But the number of single pulse is irregular. Sometime, there are ten; while another time, there are twenty and there are thirty-five occasionally. Some single pulse make up a series of pulses. So the time for them are quite different from each other. The different variations in width of the some of the series pulses are within the range of 6.5-12.5 ms; the interval is 0.6 ms; and there are other series of pulses lasts a longer period 25 ms or so with the interval of 24-100 ms. Occasional, the interval ever may be 172 ms. Thus, it can be found that both of the time it lasts and the interval change are irregular. This is mainly because of the number of the single pulse. The frequency range is 468-4350 Hz and its spectrum energy in this frequency range mainly concentrates on 2.7-4.2 kHz. Sometimes, the spectrum crest in the frequency mainly concentrates on 1.4, 2.4 or 2.5 kHz, but the spectrum crest is lower.

Usually, the *Sterna vittata* will sound "Ah..." as the following sound of "Jee...". But sometimes, when the *S. vittata* sound "Jee..." before sounding "Ah...". Usually, it will give an almost equal width pulse signal which lasts 6.5 ms. The signal frequency range is 810-3829.5 Hz. The energy of the frequency concentrates on a lower part and the spectrum crest usually appears at 1.9 kHz.

As soon as, it founds the "invader" enter or approach its breeding area, it will defend its "home" bravely. It hovers in the sky and attacks the "invader" by sounding "Ah..." as a sound signal and mean while, defects on the "invader". At last, it leaves elegantly.

This behavior is an attack against human's instruction as well as index of an instinctive defense. By analysis, this sound signal is a continuous sound wave. Its frequency range is 292-4709 Hz.

Table 1. Ecological behavior of two Antarctic sea birds

	<i>Sterna vittata</i>	<i>Larus dominicanus</i>
Appear	November - October	The second ten days of September - October
Breeding season	The last ten days of October - The first ten days of January next year	The first ten days of November - The last ten days of December
Egg number	one - three	two - three
Egg size	long diameter: 48 mm short diameter: 33 mm	long diameter: 71mm short diameter: 49mm
Egg weight	26.3 g	80 g
Egg colour	light blue or olive green there are some irregular brown or brown spot on the surface	green or brown there are black or brown black spot on the surface
Hatching period	the last ten days of November - January next year (about thirty days)	about twenty-seven days
Nest	a gentle area of sea shore or farther from sea shore. The nest is very concealment There are some small stone and shall at the nest around.	lower area of sea shore The nest is concealment There are mosses, seaweed, feather, shall and remains bone at the nest around.
Feeding	shall, fish, crustacea	shall(limpet), crustacea, fish, egg of bird, juvenile bird, dead body of seals.
Distribution	Antarctic, Sub-Antarctic. Breeding area: forward south to Antarctic Peninsula 68°S, forward north to South Africa and New Zealand.	The ability for temperature to Antarctic from Antarctic to South Sub-Antarctic. Breeding period forward south to the Antarctic Peninsula 68°S.

The spectrum crest mainly concentrates on 3 kHz. In some occasions, the *Sterna vittata*'s nest is quite near to the *Catharaita lonnbergi*'s nest. Once finding a *C. lonnbergi* is flying above the *Sterna vittata*'s nest, the *S. vittata* will lay siege to the "invader" desperately and at the sometime sending out the rapid signals "Jee..."

By analysis of the signals, we found this sound signal is also a series of pulse. But the interval of "Jee..." signal is very short. Several signals pile up so the signal "Jee..." sounds like continuous partials. Its acoustic frequency range is 341-4953 Hz. The spectrum crest is at 2.9-3.3 kHz. While at 2.3 kHz and 4.9 kHz. There appears weaker spectrum crest.

When the *Sterna vittata* are flying in flock, besides the sound signal "Jee..." we can also found another aspect: when two *S. vittata* fly in the sky, they reach each other with the sounding "Jee..." and then departed with "Der..."

By analysis, we found the "Der..." signal is a series of pulses composed of 6-9 continuous single

pulse. The single pulse only lasts 1.3-2.1 ms and mainly concentrates on 1.8 ms. Because of the number and width of the single pulse, the time of series of pulses is varying in the range of 10.8-16.5 ms, and the interval varies in the range of 6.6-10.8 ms. In spite of its difference of pulse width and interval, the frequency range of the some signal are in the range of 1533-3733 Hz with 4 frequency concentration areas. The spectrum crest is higher at 2.1 and 2.6 kHz and it is lower at 3.2 and 3.7 kHz. By analysis on the frontal of the signal wave, it is clearly discovered that the front part of some series of pulses change more regularly while the back part are on the contrary. Over all there isn't a low that controls the change of the front and back part.

***Larus dominicanus*:** Occasionally, *Larus dominicanus* sings away "Ge...". This signal contains series of pulse. It lasts 13 ms single pulse lasts 0.5-0.7 ms. The interval is 0.5 ms. The frequency range is 1360-4153 Hz. The spectrum crest is relative dispersion. The spectrum crest usually appears at 1.3, 2 and 2.9 kHz.

Juveniles *Larus dominicanus* isn't like to singing in general, but when it finds the "invader" enter or approach its breeding area, it sings away transient and faint weak "Zhi..." sound signals. It contains series of pulse, which consists of 44 single pulse. Single pulse lasts about 0.4-0.6 ms. The repeating frequency of pulse is about 2-3.3 kHz. The series of pulse lasts 20 ms and mainly concentrates on 8-15 ms. The frequency range is 1618-3516 Hz. The spectrum crest appears at 1.7, 2.5 and 2.9 kHz mean while. The adult *L. dominicanus* hovers in the sky and attacks the "invader" by sounding "E..." its frequency range is 1171-4343 Hz. The spectrum crest appears at 1.5 and 2.9 kHz.

When the juveniles *Larus dominicanus* is free, the adult *L. dominicanus* sings away "Ea..." sound signal, it is continuous wave which was formed by several sound signals pile up. The frequency range is 1072-3932 Hz. The spectrum crest is relative dispersion, the spectrum crest usually appears at 1.2, 1.7 and 3 kHz.

DISCUSSION

1. All sound signals of sea birds are accompanying definite acoustic behavior.

2. When *Sterna vittata* and *Larus dominicanus* flies in the sky:

The striking characteristic of *Sterna vittata* sound signals is the repeating of its sound.

The number of the signal "Jee..." sending out during its flight may be even more to six times in one second.

The single pulse of the higher repeat signal "Jee..." sending out by a individual *Sterna vittata* lasts about 0.7 ms with a interval of about 0.6 ms. While the series of pulse of the fewer repeat sound signal "Jee..." of the *S. vittata* is longer and the single pulse still lasts about 0.7 ms. What's different is that the single pulse is obviously increasing in number. This signal is usually composed of series pulse which are made up of 30 signals pulse and lasts 25 ms. The interval is varying in the range of 24-100 ms (ever be long to 100 ms). But under both of the two conditions, "Jee..." signals frequency range is relatively steady. It usually varies within the range 468-4350 Hz. The spectrum crest usually concentrates on 2.7 and 4.2 kHz. Sometimes, on

the other regions, there may appears weaker spectrum crest. When the *S. vittata* is menaced or them it drives the "invader" or gives warnings it will send out a highly repeat signal "Jee...". Which has narrow pulse width and short interval. But the frequency is obviously higher than that of usual occasions.

Larus dominicanus's sound signal "Ge..." contains series of pulse. It lasts 13 ms. Single pulse lasts 0.5-0.7 ms. The interval is 0.5 ms. *L. dominicanus* also sings away "Ea..." sound signal. It is continuous wave which was formed by several sound signals pile up.

The frequency range is 1072-3932 Hz. The spectrum crest is relatively dispersion and usually appears at 1.2, 1.7 and 3 kHz.

3. As soon as, they finds the "invader" enter or approach their breeding area:

(1) *Sterna vittata* hovers in the sky and attacks the "invader" by sounding "Ah..." as a sound signal and mean while defects on the "invader". This sound signal is a continuous sound wave. Its frequency range is 292-4709 Hz. The spectrum crest mainly concentrates on 3 kHz.

(2) *Larus dominicanus* hovers in the sky and attacks the "invader" by sounding "E...". Its frequency range is 1171-4343 Hz. The spectrum crest appears at 1.5 and 2.0 kHz.

4. The "Der..." signal given by two *Sterna vittata* playing in the sky might belong to the chips. So this sound in more pleasant.

This paper had been reviewed by acoustician Prof. Qi Menge and Zhang Sizhao.

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