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Definition and Function of Two Song Types of the Bush Warbler (*Cettia diphone borealis*)

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It has been suggested that the bush warbler *(Cettia diphone borealis)* uses different song types in various situations. We analyzed song features and conducted playback experiments in order to reveal the function of songs of the bush warbler. Two song types were identified. The short song type has a shorter song duration than that of normal song types and consists of only one or two syllables. Due to its short syllable and low amplitude of the whistle portion, we were able to discriminate the short song type (S song type) from the normal song type (N song type). In the playback experiments, bush warblers sang high rates of short song type for the first three minutes after playback. After 6 minutes of playback, males changed to singing normal songs. These results suggest that the short song of the bush warbler may function to threaten or drive off intruding males.

The number of studies of birds showing that different songs serve different purposes has grown considerably in the last few years (Catchpole and Leisler, 1989; Jarvi et al., 1980; Smith and Smith, 1996). Among birds with a small repertoire, North American and European warblers, and sparrows have been found to have songs of two different types. These types are distinguished by different endings (chestnut-sided warbler *Dendroica pensylvanica*; Lein, 1978), the length of the song (great reed warbler *Acrocephalus arundinaceus*; Catchpole, 1983), and the occurrence of distinctive phrases (blue-winged warbler *Vermivora pinus*; Kroodsma, 1984). It has also been suggested that these different song types differed in function.

Bush warblers (*Cettia diphone*) are classified into two subspecies, *C. d. borealis* and *C. d. cantans* (Park and Yang, 1988). The song of the bush warbler is composed of two parts, a whistle portion and a syllable portion. The whistle portion has one to sixteen notes, while the syllable portion is composed of two to five syllables. Yoon et al. (1995a) established that there are two geographic song variation groups, an Inland (*C. d. borealis*) and a Southern coastal island (*C. d. cantans*) group. The Southern coastal island (*C. d. cantans*) groups' songs were classified into two song types, alpha and beta (Yoon et al., 1995b). The beta song type contains more than three notes in the whistle portion and the alpha song type has less than two notes. Park and Park's playback experiments (unpublished data, 1998) showed that the beta song type was used for intra-sexual competition and also functioned to threaten and drive off other male intruding males. All of the Inland group's (*C. d. borealis*) songs have more than three notes in the whistle portion. From previous experiments, inland birds used unique song types during playback experiments or while there was an intruder in their territory.

In this paper, we defined the song type as a short song type of the inland group and studied the function of the short song type on an intra-sexual competition through the playback experiments.

Materials and Methods

The study area is located in Cheongwon, Chungbuk, Korea (127°.40′ N, 36°.35′ E). The area is composed of small hills. Dominant trees are the *Robinia pseudo-acacia,* the *Quercus denrata* and the *Pinus densiflora.* The stimulus song was recorded at 10 km apart sites from the study area. Recordings of the stimulus song were made by an Uher 4000 Report IC tape recorder with a tape speed of 19 cm/s, and a TELINGA PRO 4 parabolic microphone. We did not manipulate song intervals and sequences of stimulus songs. The stimulus songs lasted for 3 min.

We carried out playback experiments with 10 bush warbler males between 06:30 and 10:00 a.m. from the 10th to the 17th of May, 1997. Each male's territory was determined by advanced observations. The stimulus song was presented using a three-headed cassette-recorder (Sony TCM-5000EV) placed approximately at the center of the subject bird's territory. The volume level of the playback songs was adjusted to about 90 dB at a distance of 1 m from the speaker using a

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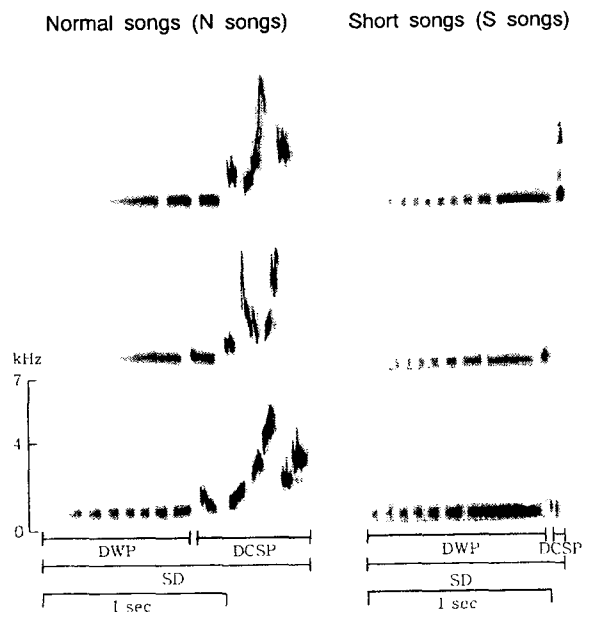

Fig. 1. Typical normal (N) songs and short (S) songs of bush warbler consist of introductory whistle portion and complex ending syllable portion. NNWP, number of note in whistle portion; DFWP, dominant frequency in whistle portion; DWP, duration of complex syllable portion; DCSP, duration of complex syllable portion; SD, duration of song.

precision integrating sound level meter (Larson Davis Laboratories, Model 800B). The playback songs were commenced only when the bird was singing. The playback experiment was performed only once for each male. The songs of each subject were recorded for 3 min before- and during-playback and for 6 min after-playback.

We analyzed the recorded songs by using a Kay Electric Co. sonagraph (Model 5500) with the following settings. Frequency range: DC-8kHz; input shaping: Hi-Shape; buffer size: 4.0 sec; dynamic range: 43 dB; analysis atten.: 20 dB. In order to define the short song type, we selected some song parameters such as the dominant frequency of the whistle portion, number of notes within the whistle portion, and song duration (Fig. 1). To compare characteristics between normal and short song type, we used a *t-test*. During the analyses of playback data, we recorded the change of song types and measured the count data of songs before-, during- and after-playback. Paired *t-test* was used for the different use of two song types while conducting the experiments.

Results

Bush warbler (*C. diphone borealis*) males sang normal songs (N song type) during spontaneous singing (Fig. 1). N song consisted of an introductory whistle portion and a syllable portion. Its duration was 1.15±0.25 (n=338) sec (Table 1). The whistle portions are composed of 5.71±2.60 (n=338) notes (Table 1) and its dominant frequency was 953.13± 256.62 (n=338) Hz (Table 1). The syllable portions consisted of 4.3±1.86 (n=338) syllables (Table 1).

During playback experiments, bush warbler males stopped their N songs and sang different songs. We defined the songs as a short song (S song type) (Fig. 1). The short song type had a shorter duration than that of normal song with a value of 0.82±0.23 (n=231) sec (Table 1). The syllables of short song consist of 1.70±0.48 syllables (n=231) (Table 1). Because of the low amplitude of the whistle portion, the short song was barely heard. The dominant frequency of the short song has a mean of 621.30±52.62 (n=231) Hz (Table 1).

Fig. 2 shows results of the playback experiment conducted to confirm the function of the short song type. Before-playback, 10 subject males only used the N song type. When the playback started, 8 of 10 males stopped their normal song and then approached towards the playback speaker. During the playback, all males switched from the normal song into the short song (paired *t-test*, t=-2.607, $p<0.05$) During the first three minutes after playback, most bush warbler males (8 of 10 males) sang more short songs than normal songs (paired *t-test*, t=-2.583, $p<0.05$). During the second 3 minutes after playback, the number of normal and short songs were not significantly different (paired *t-test*, t=0.100, $p>0.05$). After 6 min of playback, males returned to singing normal songs without short songs.

Discussion

Song types are generally considered to be functional

Table 1. A comparison of parameters ($\bar{x}$ ±SD) of normal songs and short songs of the inland bush warbler

Song type	NNWP[a]	DFWP[b] (Hz)	DWP[c] (sec)	DCSP[d] (sec)	NS[e]	SD[f] (sec)
Normal song	5.71 ±2.60	953.13 ±256.62	0.74 ±0.23	0.37 ±0.05	4.31 1.86	1.15 ±0.25
Short song	7.05 ±3.56	621.30 ±52.62	0.74 ±0.24	0.05 ±0.01	1.70 ±0.48	0.82 ±0.23
P	***	***	*ns*	***	***	***

[a]Number of note in whistle portion, [b]Dominant frequency in whistle portion, [c]Duration of complex syllable portion, [d]Duration of complex syllable portion, [e]Number of syllables, [f]Duration of song. *** $P<0.001$.

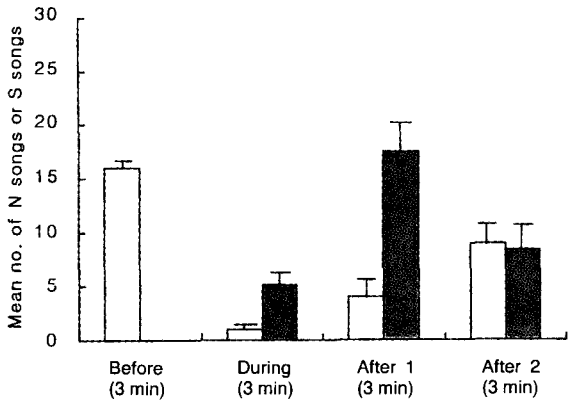

Fig. 2. The mean number (±SE) of N song (□) and S song (■) produced by male bush warblers before, during, and after playback of songs.

units in bird songs (Podos et al., 1992). Our results confirm that there are two different song types in the bush warbler (*C. diphone borealis*), which can be classified by ear and by a sonagraph (Fig. 1). In *C. d. borealis*, N and S songs have different features. First, S songs either have none or one syllable within the complex syllable portion, unlike the that of the N song which has 3-8 syllables. Second, the frequency and amplitude of S songs are lower than those of N songs. Third, the song duration of the short song type is shorter than that of N songs. It is still unclear how those song parameters function. However, we can compare our results to those in several other warbler species.

Short songs of the great reed warbler (*Acrocephalus arundinaceus*) play a role in intra-sexual competition at a distance (Catchpole, 1983). Short songs of the willow warbler (*Phylloscopus trochilus*) (Jarvi et al., 1980) and the aquatic warbler (*Acrocephalus paludicola*) (Catchpole and Leisler, 1989) are lower in amplitude and also were used to defend their territories or to drive off intruders. Such results indicate that songs with low frequency and amplitude are probably produced in response to threats from the male opponent (Chatchpole, 1983; Chatchpole et al., 1984). The short song of *C. d. borealis* have similar characteristics. During spontaneous singing, bush warbler males only sang N songs. As soon as the playback was started, the male stopped the N song, and approached the playback speaker. Once the male was within 2 m of the speaker, he flew up and down changing sites from one branch of a small tree to another, probably to find the intruder. Most birds then started the S song. Our results showed that for the first 3 min after-playback, the subject birds sang mostly S songs. After 6 min of playback, the birds returned to singing N songs again. These results indicate that S songs play a role in intra-sexual interactions.

It is interesting to compare the results for inland subspecies's use of N-S songs and the results of the island group's use of alpha-beta song types. The comparison between two subspecies can give insight into the evolution of song types. The island group (*C. diphone cantans*) commonly produced alpha and beta song types during spontaneous singing. Although the function of the alpha song type is not clear, the beta song type plays a role in intra-sexual competition. We suggests that because of their adjoined territories, *C. d. cantans* can always hear a neighboring male's song. Thus, island males sang not only an alpha song, which probably attracts females, but also a beta song which functions to drive off intruders. *C. diphone borealis* territories are spaced at an interval of 200 m or more. In this situation, males of *C. d. borealis* may face little threat from intruders. It means that in the natural environment, the bird uses little or none of the S song drive off other males. Therefore, *C. d. borealis* generally sings only the N song. However, when another male invades his territory, he switches to the S song.

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References

Catchpole CK (1983) Variation in the song of the great reed warbler *Acrocephalus arundinaceus* in relation to mate attraction and territorial defence. *Anim Behav* 31: 1217-1225.

Catchpole CK and Leisler B (1989) Variation in the song of the aquatic warbler, *Acrocephalus paludicola* in response to playback of different song structures. *Behaviour* 108: 125-138.

Catchpole CK, Dittami J, and Leisler B (1984) Differential responses to male song repertoires in female song birds implanted with oestradiol. *Nature* 312: 563-564.

Jarvi T, Radesater T, and Jakobsson S (1980) The song of the willow warbler *Phylloscopus trochilus* with special reference to singing behaviour in agonistic situation. *Ornis Scand* 11: 236-242.

Kroodsma DE (1984) Blue-winged warbler (*Vermivora pinus*) recognize dialects in type II but not type songs. *Behav Ecol Sociobiol* 15: 127-131.

Lein MR (1978) Song variation in a population of chestnut-sided warblers (*Dendroica pensylvanica*): is nature and suggested significance. *Can J Zool* 56: 1266-1283.

Park BS and Yang SY (1988) Song variation on two subspecies of *Cettia diphone* in Korea. *Bull Inst Basic Sci Inha Univ, Inchon* 9: 112-124.

Podos J, Peters S, Rudnicky T, Marler P, and Nowicki S (1992) The organization of song repertoires in song sparrows: themes and variations. *Ethology* 90: 89-106.

Smith WJ and Smith AM (1996) Information about behaviour provided by Louisiana waterthrush, *Seiurus motacilla* (Parulinae), songs. *Anim Behav* 51: 785-799.

Yoon MB, Park DS, and Park SR (1995a) The characteristic of α and β song modes and comparison among α, β mode, and inland geographic variation groups' songs of the bush warbler (*Cettia diphone*). *Korean J Behav Biol* 4: 31-42.

Yoon MB, Park DS, and Park SR (1995b) Geographic variation of bush warbler (*Cettia diphone*) songs. *Korean J Behav Biol* 4: 115-130.

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