

Playback Experiments on Bush Warblers (*Cettia diphone*): Their Song Recognition of Intra- and Inter-Population

Shi-Ryong Park*, Dae-Sik Park, Soo-Il Kim, and Moo-Boo Yoon¹

Department of Biology Education, Korea National University of Education, Cheongwon, Chungbuk 363-791;

¹Department of Biology, Kyeong-Hee University, Seoul 130-701, Korea

Playback experiments were performed to clarify the degree of song recognition using inter- and intra-population songs of Bush Warbler at Cheongwon, Chungbuk area. Six territorial males were strongly responded to inter- as well as intra-population songs. Their responses to the inter- and intra-population songs were not differed significantly in all measures of latency time, staying time, and closest distance. This result imply that Bush Warblers in the region did not discriminate the difference between intra- and inter-population songs. It may be the reason that the regional males have little interactions in song exchange with neighbors by keeping a long individual distance. In order to investigate the signal value as species recognition releaser, playback of partial songs, prepared from tow distinct regional populations of the species were presented to males of the study area. The partial songs presented were made of two portions for each presentation, a whistle portion only, and a complex syllable portion only. Territorial males responded stronger to the complex syllable portion than the whistle portion of the song. This result indicate that the complex syllable portion conveys more information on the species recognition. As 'releaser' hypothesis suggested formerly, a function of the complex syllable portion in Bush Warbler song is understood in which conveys most species-identifying information. Thus, the result of this playback experiments supports the releaser hypothesis.

KEY WORDS: Bush Warbler, Whistle Portion, Complex Syllable Portion, Songmatching

In birds, songs have been known that they have functions for survival and successful mating (Smith, 1977). By the songs, birds can identify the mate, relative, and neighbor or stranger individuals, and individual not having reciprocal information in songs through the process of individual recognition (Wiley and Wiely, 1977; Falls, 1982; Colgan, 1983; Sung and Park, 1995). Some studies (Falls, 1982; Hwang, 1994) indicated that such functions were executed by the

characteristics of repertoire size, song duration, frequency, song interval, and songtypes.

Some hypotheses of how species-identifying information is conveyed in bird song were presented (Date *et al.*, 1991), 'additive' (Shiovitz and Lemon, 1980), 'syntactical' (Ratcliffe and Weisman, 1987), and 'releaser' hypothesis (Becher, 1982). The 'releaser' hypothesis is that species identification in a song is localized and information elsewhere in the song are irrelevant to this function, but presumably serves others (Becher, 1982). Various tests, such as playback

*To whom correspondence should be addressed.

experiments, are necessary for application of these hypotheses, because it has been known that each hypothesis could be applied differently according to the species of birds tested (Cheon and Park, 1995).

Bush Warbler (*Cettia diphone*) is a summer visitor in Korea, and it has been classified into two subspecies, *C. d. borealis* and *C. d. cantans*. A Bush Warbler song generally consist of a whistle portion which induces the song, and a complex syllable portion that is enclosed in the song. Park and Yang (1986) suggested that two Korean subspecies commonly have a distinct song variation in the composition and the features of syllables. Yoon (1994) identified that there are two geographic song variation groups, an inland, and a south coastal group ranged south of latitude 35° 35' N approximately. But there was no study relating to the song recognition between these two geographic populations and to the functional factors of their population specific song recognitions.

In this paper, we studied whether subject males at Cheongwon can discriminate intra- and inter-population songs, and what are the main parts conveying con-specific information.

Materials and Methods

Firstly, we analysed numerical characteristics of songs recorded from Cheongwon and Jeju populations, and then carried out playback experiments I and II. Playback Experiments I was purposed to clarify the degree of song recognitions in males of Cheongwon inland group as an intra-population, in males of Jeju south coastal group as an inter population. Also, playback experiments II were executed to verify whether a particular portion of a song, either the whistle portion or complex syllable portion include more information of the species recognition.

Song recording and analyses

During April-July, in 1993 and in 1994, songs of six individual Bush Warblers in Cheongwon, and 12 individuals in Jeju populations were tape-recorded for analyses of the numerical

characteristics. Recordings were made at a tape speed of 19 cm/sec using a Uher 4000 Report IC tape recorder and AKG c1000s microphone mounted on a 54-cm parabolic reflector. Recordings were made during 6:00 to 10:00 a.m. and 16:00 to 19:00 p.m. mostly. Recorded songs were analyzed by using a sonograph Model 5500 of Kay Electric Co. which was set for a wide band spectrum. Seven song parameters categorized for numerical analyses were as following: NNWP (the number of notes in whistle portion), DFWP (the dominance frequency of whistle portion), DWP (the duration of whistle portion), MACSP (the maximum frequency of complex syllable portion), MICSP (the minimum frequency of complex syllable portion), SD (the duration of song), and DCSP (the duration of complex syllable portion) (Fig. 1).

Stimulus tape preparation for playback experiments

Playback Experiments I: to avoid stimulus song

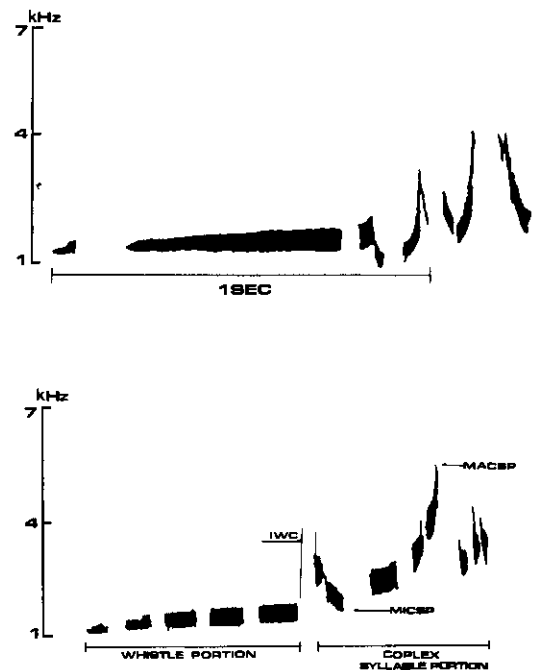


Fig. 1. Parameters of Bush Warbler song for multiple qualitative analysis and the songs for playback experiment originated from inter-(above) and intra (below)-population songs.

presentations that have different song intervals, each stimulus song from Cheongwon and Jeju population was modified as to be equal in song intervals 10s, by using computer interface on a basis of the mean interval of over twenty songs. Because, stimulus song from Cheongwon had five notes, and the song from Jeju population had two notes in whistle portion (Fig. 1).

Playback Experiments II: stimulus song intervals were manipulated by the same method as in experiments I. The duration of complex syllable portion of each stimulus song was given as a silence for the playback of whistle portion only, and vice versa. Stimulus song from Naju has ten notes, and the song from Jeju population has two notes in whistle portion. To compensate this location specific difference, for the playback of each complex syllable portion (Fig. 2), the rest parts of songs that have been used for the playback of whistle portion only were presented.

Playback experiments

Each three territorial male in 1994 and 1995 was tested with the two experiment sets.

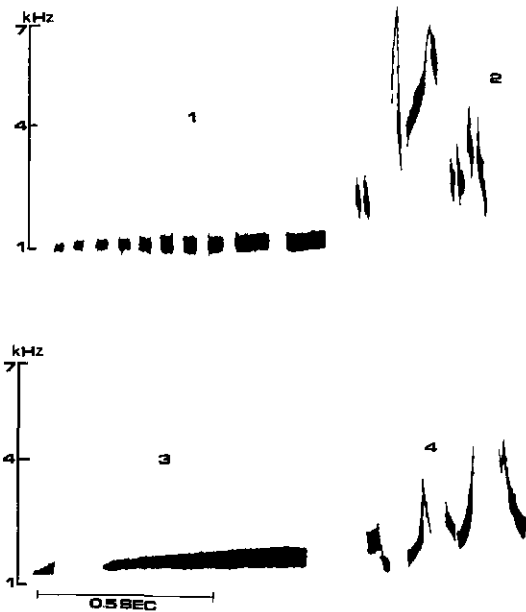


Fig. 2. The songs used for partial song playback experiment. 1; whistle portion, 2; complex syllable portion from Naju population, 3; whistle portion, 4; complex syllable portion from Jeju population.

Territorial boundary of each male was determined by observation made prior to the field tests. Each stimulus song pre-recorded on a cassette tape was played for 3min by the use of three headed cassette-corder (Sony TCM-5000EV) and a speaker (JBL-ProIII) mostly in a bird's regular boundary (Falls and Brooks, 1975). The speaker was placed on a tree 1.5 m high above the ground. The volume level of the playback sound was adjusted to 90 dB, is similar to the natural songs, using a precision integrating sound level meter (LARSON · DAVIS LABORATORIES Model 800B) at 1 m distance from the speaker. Each territorial male was tested with a standard set of stimulus songs randomly selected. Experiments were carried out mostly during 6:30-11:00 a.m., 17 May to 13 June at Cheongwon, to minimize variations associated with the birds' seasonal vocalization and daily activities. In case of the bird's absence at the study area, extra stimulus song recorded from Gapyeong population was given. If subjected bird responds, the experiments were performed according to the designed procedure. When the bird was not present for a long time, another trial of the experiments were given in the next day.

Categories of response and statistical analyses

Each subject males strongly responded to stimulus songs of the experiments I, but weakly responded to both the whistle only and the complex syllable only portions in preliminary playback experiments. Three response categories for experiments I have been established accordingly. The response categories are as following: latency time (sec.), time of approach within 10 m radius circle around speaker; staying time (sec.), staying time within 10 m radius circle around speaker; and closest approach (cm), nearest distance to the speaker. However, for the experiments II, only the number of jumping flight and songmatching after the presentation of stimulus songs have been established as categories of responses.

For the numerical characteristics of songs, Mean test, One-way-ANOVA test and Correlation analysis were used, and also, Wilcoxon matched-

Table 1. Characteristics of Bush Warbler songs in Cheongwon and Jeju populations.

Parameters	NNWP	DFWP	DWP	MACSP
Cheongwon (N=72)	5.34±1.75	926.02±141.47	0.63±0.16	5468.33±464.24
Jeju (N=107)	1.95±1.07	1516.01±338.81	0.69±0.20	4544.00±601.85
One-way ANOVA	*	*	NS	*

Parameters	MICSP	DCSP	SD
Cheongwon (N=72)	916.11±62.09	0.38±0.01	1.07±0.01
Jeju (N=107)	1084.70±123.71	0.39±0.10	1.24±0.25
One-way ANOVA	*	NS	NS

*, Significant, $p < 0.05$ NS; No significant

pairs signed-ranks test (Siegel, 1956) was used for heterogeneity in difference scores for each playback song stimulus and at four response categories.

Results

Numerical characteristics of songs at Cheongwon and Jeju populations

Table 1 shows the results of Mean test and One-way ANOVA test on seven song parameters from the intra- and inter-populations, Cheongwon and Jeju. In comparison to the results of analyses, the number of notes, dominance frequency in whistle portion, and maximum and minimum frequency of complex syllable portion were differed significantly between the two populations, whereas the differences in the rest parameters were not significant.

Playback experiments on responses to the intra- and inter-population songs

All Six subject males strongly responded to both stimulus songs prepared from Cheongwon (intra-) and Jeju (inter-) populations. There was no significant difference in comparisons of the responses in latency time ($z = -1.3522$ 2-tailed $p = 0.1763$), staying time ($z = -1.0142$ 2-tailed $p = 0.3105$), and closest distance ($z = -1.1832$ 2-tailed $p = 0.2367$).

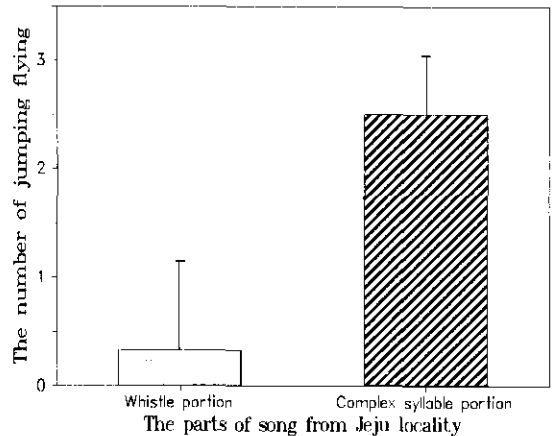


Fig. 3. The difference in responses to whistle portion and complex syllable portion, used as stimulus song originated from Jeju population.

Playback experiments on responses to partial songs, whistle portion and complex syllable portion

The birds' responses to whistle and complex syllable portions, prepared from Jeju population, were significant ($z = -2.0226$, 2-tailed $P = 0.0431$) (Fig. 3). But the responses to those two partial stimulus songs prepared from Naju population were not significant ($z = -1.5724$, 2-tailed $p = 0.1159$).

In the degree of songmatching to each stimulus song, by the Six subject males, during the six times playback experiments showed six times

songmatching to the complex syllable portion of Naju and Jeju populations, and five times to the whistle portion of Naju, and two times to the whistle portion of Jeju population.

Discussion

The original design of playback experiments were established on a basis of the kin selection model (Treisman, 1980), an understanding that birds respond stronger to familiar songs than to stranger songs. Although all subject males responded strongly to stimulus songs, the difference in responses to intra- and inter-population songs was not significant. This may be resulted from territoriality of birds in the region. The Bush Warbler population at Chungwon shows relatively little interactions with neighbors, because males maintain an individual distance up to 1.5-2 km. This could mean that males of the study area may not be discriminant of the stimulus songs originated from two regionally separated populations. It could be the reason that they mostly have no chance of song exchanges with other neighboring males.

In comparison of numerical characteristics for songs from the two populations, there were significant differences in the number of notes in whistle portion, the dominance frequency of whistle portion, and the maximum and minimum frequency of complex syllable portion. Despite these differences, there was no significant difference in responses to those partial stimulus songs. These conflicting results indicate that individual song recognition does not necessarily related to the numerical characteristics of the songs. Rather, the combinations and features of syllables that were presented but could not be counted for a numerical analysis may have played an important role for the tested individuals' song recognitions.

The results of playback experiments II indicate that in Bush Warbler, the complex syllable portion of a song include more information of individual recognition than the whistle portion. Also the results show that the whistle portion of Bush warbler songs normally have a function of

evocation (Falls, 1969), rather than a conveyance of information. In an exposure of lower stimulus, a bird can sing only a whistle portion without syllable portion (Falls, 1969). Conclusively, these results support 'releaser' hypothesis which suggests species identification is localized in a song repertoire and information elsewhere in the song is irrelevant to this function (Date *et al.*, 1991).

The difference in degrees of songmatching to the whistle portion stimuli, originated from Naju and Jeju populations, may be resulted by the differences in number of notes and dominance frequency in whistle portion, which were compared through numerical analysis for songs of the both populations. Although there was no significance found, generally more notes and lower dominance frequency in whistle portion induced stronger responses during the playback experiments. However, a question that which does induce stronger responses, the number of notes or the dominance frequency in whistle portion can only be clarified by comparative playback experiments with an appropriate manipulation of those two factors.

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휘파람새의 Intra- and Inter-Population Songs 인식에 관한 Playback실험
박시룡 · 박대식 · 김수일 · 윤무부¹ (한국교원대학교 생물교육과, ¹경희대학교 생물학과)

충북 청원군 일대에서 휘파람새 6 개체에 대하여 군집내 인 청원군집의 song과 군집외 인 제주개체의 song을 이용하여 playback실험을 실시하였다. 실험의 대상개체는 모두 두 군집의 song에 대하여 강한 반응을 보였으나 군집 사이에 대하여 통계적으로 의미 있는 차이를 나타내지는 않았다. 이러한 결과는 청원군집내의 개체가 두 군집 내외의 song을 구별하지 못함을 의미하며, 청원군집내의 개체간의 먼 간격으로 인하여 이웃개체간의 적은 상호작용에서 기인되어지는 것으로 판단된다. Song의 부분들이 song의 인식에 기여하는 정도를 파악하기 위하여, 휘파람새 song의 whistle 부분과 complex syllable 부분을 이용하여 playback실험을 실시하였다. Complex syllable 부분에 대한 반응의 정도가 whistle 부분에 비하여 의미 있게 높았으며, 이러한 것은 song의 특정한 부분이, complex syllable, 개체의 song인식에 필요한 주된 정보를 담고 있다는 'releaser' 가설을 지지하는 결과로 나타났다.