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The Inter- and Intra-specific Comparison of Stereotyped Songs in Sympatric Gray-headed Bunting (*Emberiza fucata*) and Siberian-Meadow Bunting (*Emberiza cioides*)

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동소성 붉은뺨멧새(*Emberiza fucata*) 와 멧새(*Emberiza cioides*)의 Stereotyped Song의 비교

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ABSTRACT

Songs of Gray-headed Buntings(*Emberiza fucata*) were compared with those of Siberian Meadow Buntings(*Emberiza cioides*) from a population in Kang-Nae, Cheong-won, Chung-Bug holding almost same ecological niche. Song duration and the number of syllables revealed a significant distinction within and between species. Song variation of intrapopulation and intraindividual was represented higher in Gray-headed Bunting. The number of syllables was estimated to be more advantageous to individual recognition than song duration. Comparing of syllable types, Siberian Meadow Bunting sang much simpler types than Gray-headed Bunting. In consecutive songs, Gray-headed Bunting and Siberian Meadow Bunting changed their syllables in posterior groups. There were some differences in method. For the appearance ratio of repeated syllables, Siberian Meadow Bunting showed remarkably high ratio throughout the song but Gray-headed Bunting showed only in posterior group.

In these analyses, factors for individual recognition and species recognition were suggested.

Key words : Interspecific comparision, Sympatric species, Syllable, Recognition

INTRODUCTION

Interspecific responses only occur under certain conditions of competition in sympatry (Catchpole 1978). These are when a later arriving species overlapped and invaded the habitat already occupied by sympatric species(Becker 1982).

Neighbor recognition has been documented mostly in dispersed territorial species and almost exclusively with respect to song or similar long range signals(Falls 1982). Marler (1960) suggested that song might enable males "to distinguish between new intruders and old rivals" and Thorpe(1961) suggested that a "rival might recognize a given male not merely by the position of his territory but actually by his individual voice independently of his territory. By the time these statements appeared some experimental evidence was already accumulating.(Richards 1979, Catchpole 1978)

This study deals with the comparison of stereotyped song between Siberian Meadow Bunting and Gray-headed Bunting which are sympatric species. Siberian Meadow Bunting and Gray-headed Bunting have a common ecological niche, which may show interspecific response. These analyses and comparisons give basic informations in communication and species recognition.

MATERIALS AND METHODS

This study was conducted in 1991(Apr.-Aug.) and 1992(Apr.-Aug.). Adult males of each year were used as subjects in the hillock, Kang-Nae, Cheong-Won, Chung-Bug. We used 5 males of Siberian Meadow Buntings, sympatric species(territory shared and overlapped), with Gray-headed Bunting.

Recording was made with Uher 4000 tape recorder(tape speed 19cm/s). Songs were analysed on a Kay Electric Company DSP sona-graph Model 5500. Statistical analyses were conducted with SPSS/PC$^+$.

Songs of male were recorded individually in his territory. All data were collected mostly between 6.00h and 9.00h during the summer(April-August).

Analyses were conducted by the method used in Gray-headed Bunting(Kim 1992, Kim and Park 1993, Kim *et al.* 1992). To evaluate a syllable variation within songs, we used SR(syllable ratio) value(Kim 1992, Kim and Park 1993). SR is a value that represents the number of appearence of specific syllables per song. The appearence frequency of specific syllable in anterial group, medial group, posterial group(Kim 1992) in a song can be represented by partial SR values. In analyses of stereotyped song, We obtained the partial SRs of each syllables and compared with SRs in a population.

The Coefficient of Variation(CV = standard deviation /mean) is useful for comparing the extent of variability across individuals in different features where measurements differ in magnitude(Hutchison *et al.* 1968). A feature showing a large CV across individuals is most likely to be useful for individual recognition. Jouventin and Roux(1979) used a ratio of [CV across individuals / CV within individuals] to compare individuality. We compared CV of song duration and the number of syllables in stereotyped song of Gray-headed Bunting and Siberian Meadow Bunting by the method given above.

We then figured out AP(Appearance Percentage) for the purpose of comparing syllables that appeared consecutively and repeatedly:

$$AP = \frac{R\,S}{T\,S} \times 100(\%)$$

TS is a total of syllables that is counted in each group(anterior, medial, posterior group) and RS is the number of syllables that is found repeatedly. Using AP value, we could know how many and where repeated syllables appeared.

RESULTS

Five males(of Siberian Meadow Bunting), total song of 333 with 1,754 syllables were analysed with sonagram. Siberian Meadow Bunting and Gray-headed Bunting contest with each other as seen in Figure 1, because they use the same type of territory and the same food(Fig. 1).

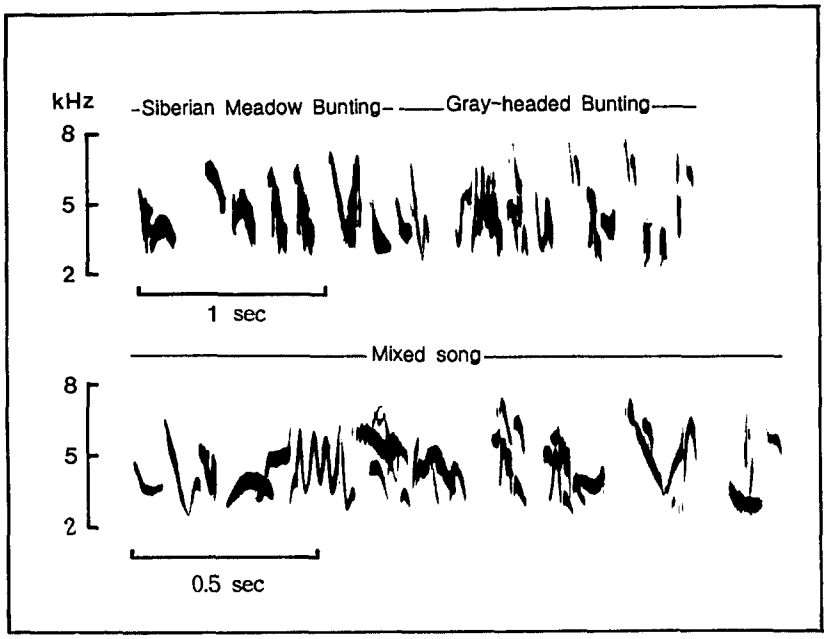

Fig. 1. The competitive singing of Gray-headed Bunting and Siberian Meadow Bunting. Gray-headed Bunting held almost same ecological niche with Siberian Meadow Bunting.

As the results of ANOVA-test, individuals of Siberian Meadow Bunting produced their songs in distinctive ways in terms of song duration($df=4$, $P<0.001$), and the number of syllables($df=4$, $P<0.001$). It is the number of syllables that produce more significant difference between Gray-headed Bunting and Siberian Meadow Bunting(Fig. 2). Song duration and the number of syllables produced meaningful differences individually within species, more meaningful differences between species. These factors have an important function to distinguish between species. Siberian Meadow Bunting had 29 types of

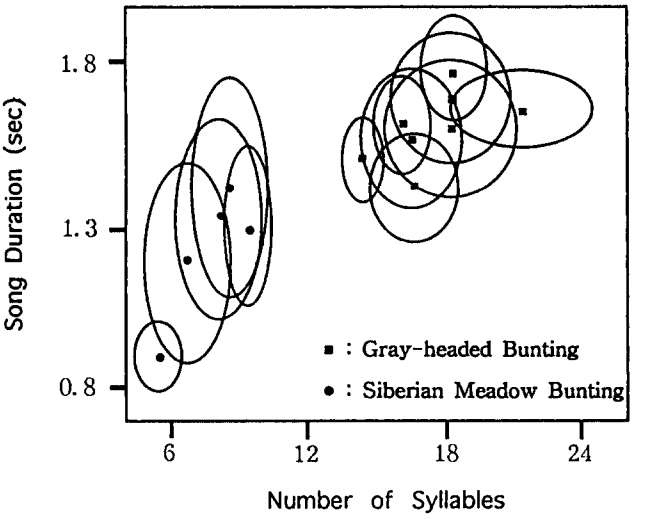

Fig. 2. Each ellipse represents the mean±SD across the signature songs in Gray-headed Bunting and Siberian Meadow Bunting. The extent to which the ellipses are separate is thus a measure of the individual distinctiveness of the songs.

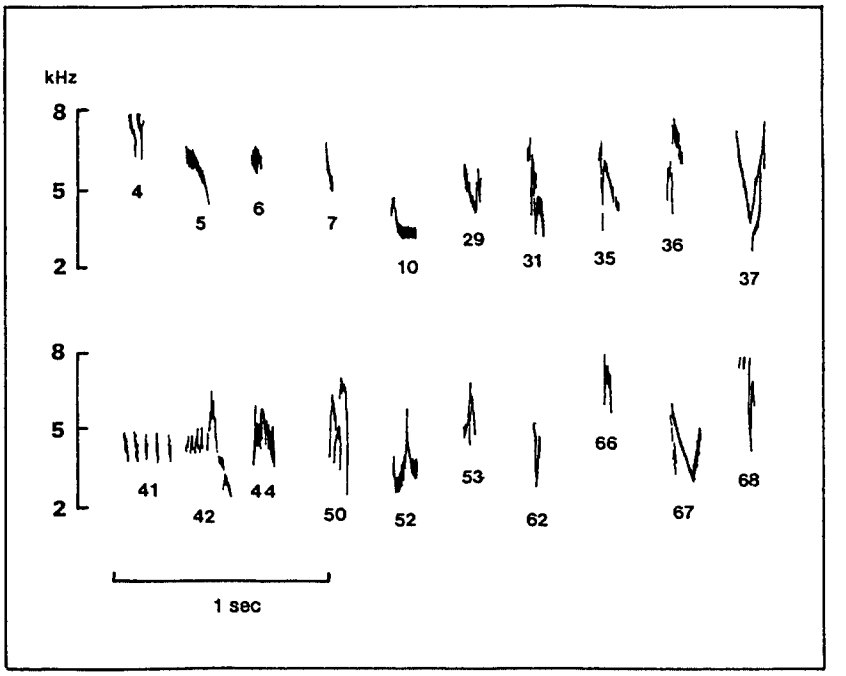

Fig. 3. Syllables used by 5 male Siberian Meadow Buntings.

syllables in 333 songs while Gray-headed Bunting had 158 types of syllables in 513 songs. Gray-headed Bunting used much more syllable types than that of Siberian Meadow Bunting. Figure 3 represents 20 types of syllable which was selected from 29 types of syllable of Siberian Meadow Bunting. Siberian Meadow Bunting had a tendency to use one type of syllable repeatedly and most their phrase durations were longer than those of Gray-headed Bunting. Figure 4 gives SRs of syllables in each group represented in Figure 3. Siberian Meadow Bunting didn't produce syllables of No. 1, No. 2, No. 3 clearly while Gray-headed Bunting produce them in their anterior group (Kim 1992, Kim and Park 1993). Siberian Meadow Bunting's syllables of No. 6, No. 7, No. 35, No. 52 exhibited high frequency in general compared with other syllables. Siberian Meadow Buntings used some individually

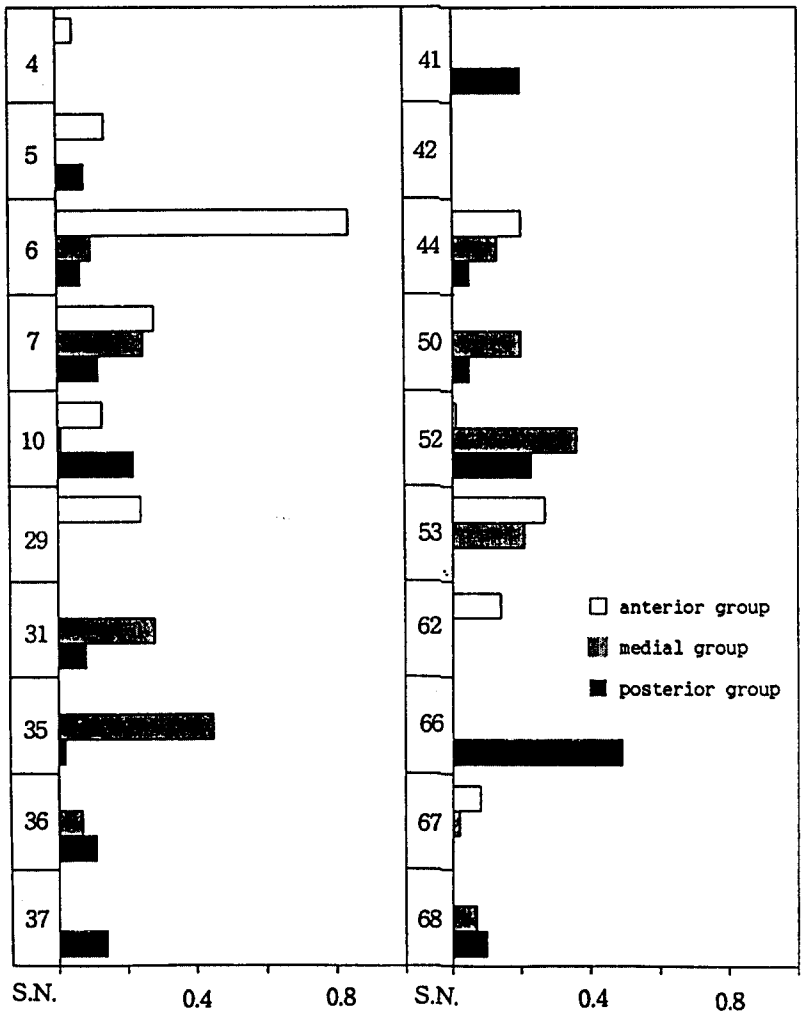

Fig. 4. The SRs of syllables used by 5 male Siberian Meadow Bunting(the syllables shown in Fig. 3). S.N. : Syllable number

distinctive syllables, which were analysed to be meaningful in comparison with Gray-headed Bunting. The tendency that syllables of anterior group appear more constant than those of posterior group, seems to be more or less weak in Gray-headed Bunting (Kim 1992, Kim and Park 1993). It was distinctive that SRs of Siberian Meadow Bunting were high in general in comparison with Gray-headed Bunting. This is due to the regu-

Table 1. Intrapopulation CV(Coefficient of Variation) /Intraindividual CV. The individuality was higher in the number of syllables than in the song duration. The individuality of Gray-headed Bunting was higher in these two factors than that of Siberian Meadow Bunting.

Gray-headed Bunting			Siberian Meadow Bunting		
Ind.	Song duration	The number of syllables	Ind.	Song duration	The number of syllables
A	1.20	1.08	A	1.44	2.17
B	1.72	1.23	B	1.13	1.03
C	1.35	1.35	C	1.67	1.35
D	1.09	1.32	D	1.11	1.23
E	1.14	1.21	E	0.96	1.05
F	1.37	2.14			
G	1.56	2.19			
H	1.63	2.53			
Mean	1.38	1.63	Mean	1.26	1.36

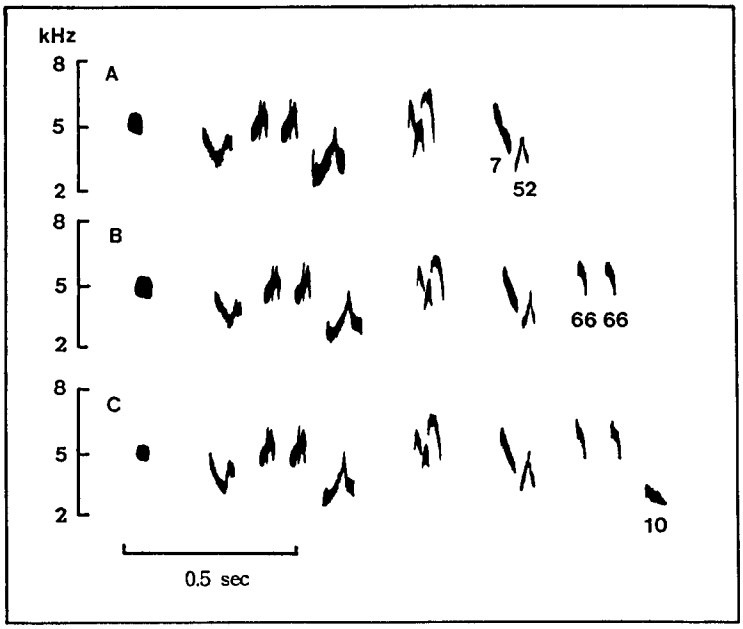

Fig. 5. Consecutive song types used by Siberian Meadow Bunting. Males that were singing continuously stereotyped songs, transformed consecutive songs by adding and subtracting syllables.

larity of song and the majority of repeated syllables in Siberian Meadow Bunting.

Table 1 shows [intrapopulation CV vs intraindividual CV]. These values of above 1.00 represent that intraindividual variation is less than intrapopulation variation. These values remarked higher in the number of syllables and in Gray-headed Bunting. This means that the number of syllables was more characteristic than song duration, and Gray-headed Bunting revealed higher individuality for the two factors. Comparing a series of stereotyped songs of Gray-headed Bunting with the case of Siberian Meadow Bunting, an aspect transforming the posterior group differed somewhat. As an example, B song in Figure 5 added syllables of No. 66 repeatedly, and C song also added syllables of No. 10. In comparison with Figure 6, reversion of the order was not observed. Comparison of repeated syllable in two species was given Table 2. In the case of songs of Gray-headed Bunting, repeated syllables appeared frequently in posterior group, while those of Siberian Meadow Bunting appeared throughout the whole groups. This may be species-specific between Gray-headed Bunting and Siberian Meadow Bunting.

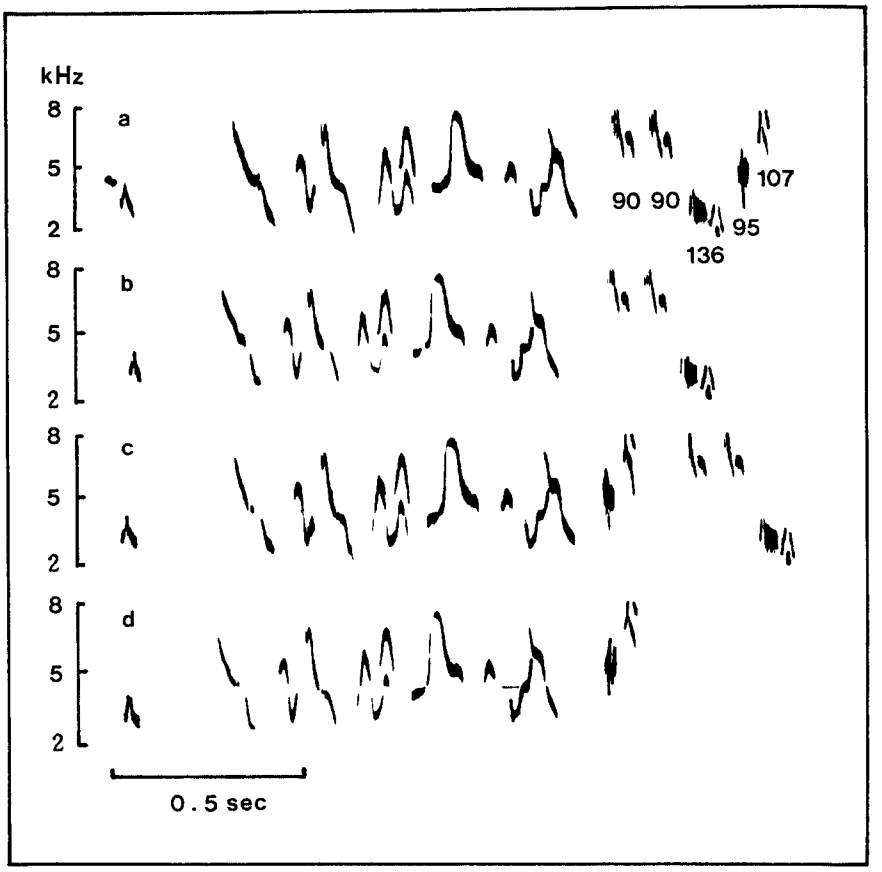

Fig. 6. Consecutive song types used by Gray-headed Bunting. Males that were singing continuously stereotyped songs, transformed consecutive songs by adding, changing and subtracting syllables.

Table 2. The appearance percentage (AP) of repeated syllables.

	The value of AP		
	Anterior group	Medial group	Posterior group
Gray-headed Bunting		9.16%	23.02%
Siberian Meadow Bunting	38.31%	23.10%	42.53%

AP is obtained by RS / TS

RS : the appearance frequency of repeated syllables.

TS : the total number of syllables within each group.

DISCUSSION

Can we predict whether or not a signal will be used for individual recognition ? Experimental approaches used in this study make possible to find out the factors of recognition. Closely related sympatric species often differ markedly in their vocalizations. This seems to support the views that selection can produce strong divergence in the vocalization and the vocalizations may serve in species isolation (Nicolai 1959). Many studies have shown that related species can discriminate one another's vocalizations, so such calls may be isolating mechanism (*Catharus*: Raitt and Hardy 1970, *Certhia*: Thielcke 1962, *Empidonax*: Johnson 1963, Stein 1963, *Zonotrichia*: Peters *et al.* 1980, *Parus*: Ludescher 1973, Romanowski 1979, Martens 1975, *Passerina*: Thompson 1969, Emlen 1972, Emlen *et al.* 1975, *Regulus*: Becker 1977, *Sturnella*: Rohwer 1973, *Toxostoma* and *Dumetella*: Boughey and Thompson 1976, *Vermivora*: Murray and Gill 1976).

Gray-headed Bunting held almost the same ecological niche with Siberian Meadow Bunting. The human ear can easily distinguish each species of them by differences in the rhythmic characteristics of the stereotyped song. The detailed structure of each syllable is not evident to the human ear, but it is very likely to birds. Siberian Meadow Bunting was significantly different from Gray-headed Bunting in song duration and the number of syllables. Also syllable types and syllable sequence were very different each other.

Yet seldom have species-specific parameters and individual-specific cues been studied in the same species. Some exceptions are White-throated Sparrow (Falls 1963, 1969, Brooks and Falls 1975a,b), Indigo Bunting (Emlen 1971, 1972), Ovenbird (Weeden and Falls 1959, Falls 1963), and Golden-winged Warbler (Ficken and Ficken 1973). In all these studies, characteristics that encode individual identity are also parameters in species specificity. For example, in the White-throated Sparrow, the range of frequency is critical for species identity and within that range, individual-typical frequency differences are used in encoding individual identity. Within the range of variation in a species-specific parameter there remains adequate room for the coding of individual characteristics (Becker 1982).

Also in Gray-headed Bunting and Siberian Meadow Bunting, within the range of variation in a species-specific parameter there remains adequate room for the coding of individual distinctive features.

Interspecific discrimination of sounds minimizes unnecessary expenditure of energy, interspecific conflicts and hybridization and in general makes intraspecific acoustical communication more efficient (Becker 1982)

Birds produce a wide variety of songs, but we know little about how they perceive this variation and use it to form categories that are important to them (e.g. own species versus different species, neighbor versus strangers, song type A versus song type B, etc.). On the basis of our study, it would be studied to clear a factor of recognition.

적 요

거의 동일한 생태적 지위를 갖는 동소종인 멧새(*Emberiza cioides*)와 붉은뺨멧새(*Emberiza fucata*)의 stereotyped song이 분석 비교되었다. 붉은뺨멧새와 멧새는 song duration과 syllable 갯수에 있어서 두 종간 뿐만 아니라 종내의 개체들 사이에서도 의미있는 구별을 보였다. 그리고 개체군내의 변이계수 (CV) 와 개체 내의 CV의 비(개체군내 변이계수/개체내 변이계수)는 붉은뺨멧새에서 다소 높게 나타났다. 두 종 모두에서 song duration 보다 syllable 갯수가 개체 인식에 더 유리하게 나타났다. Syllable의 유형별 SR (syllable ratio) 값의 비교에서 전체적으로 멧새의 SR 값이 높게 나타났으며, syllable 유형들의 song 내 배치에서 멧새가 훨씬 단순한 경향을 보였다. 계속되는 song에서 붉은뺨멧새와 멧새는 후반부의 syllable들을 변화시키는데, 그 양상에는 다소 차이가 있었다. 또 멧새에서는 song 전체에 반복 syllable의 표현 비율이 매우 높게 나타나는 반면, 붉은뺨멧새는 후반부에만 반복 syllable이 특징적으로 등장하였다. 이러한 분석에서 음향학적 요소들에 대한 종간, 개체간 인식 가능성을 논의하였다.

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