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Intraindividual and Interindividual Variations of Stereotyped Songs in Gray-headed Bunting (*Emberiza fucata*)

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From a population in Kang-Nae, Cheong-won, Chung-Buk, acoustic behaviours of Gray-headed Bunting (*Emberiza fucata*) were observed. The singing of males was classified into two major types, stereotyped song and squeaky song. The stereotyped songs of eight territorial males were recorded individually and individually distinctive features were studied.

Individuals produced their song in distinctive ways in terms of song duration and the number of syllables. Gray-headed Buntings sang various syllable types. We found that a male produced more constant syllables in anterior group than those in posterior group. Males sang distinctive syllables among them. Some syllable types which were frequently appeared in an anterior group.

In these analyses, we suggest that the anterior groups in songs of a Gray-headed Bunting express the constant information and the posterior groups contribute to situational communication.

KEY WORDS: Stereotyped song, syllable, variation, infromation.

Recognition of individuals is important in many of the varied and subtle social interactions found among vertebrates (Wilson, 1975). Individual recognition by acoustic signaling in birds should be widespread. Considerable evidence to this effect has accumulated, much of it since Beer's (1970) excellent review. Past studies on individual recognition concentrated whether birds can recognize one another by play-back experiment (Catchpole, 1978; Thompson, 1969). Little is known about how the birds perform this discrimination (Weary, 1990). Recent works have found out the facts of individual recognition through the influence of sophisticated analyzing equipment (Weary, 1990; Weary, 1989; Falls *et al.*, 1988; Shy *et al.*, 1986). In fact, the study on individual recognition is based on a close analyses of individual songs.

Falls (1982) use the term individual variation where it has been demonstrated that significant variation exists among the sounds of different individuals beyond that found in repeated sounds of the same individual. Individual variation is essential for individual recognition. An ideal signal for individual recognition would be highly stereotyped within each individual, vary noticeably among individuals (Falls, 1982).

This study describes individually distinctive features of stereotyped songs in Gray-headed Bunting that is rare in a world-wide and comes every year in Korea. There are few acoustical studies on Gray-headed Buntings because they have limited breeding area.

Materials and Methods

This study was conducted in 1991 (Apr.-Aug.)

and 1992 (Apr.-Aug.). Several adult males of Gray-headed Bunting were used as subjects in each year in the hillock, Gang-Nae Myeon, Cheong-Won Gun, Chung-Buk. 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+.

Each male was recorded individually in his territory. It was recorded that Gray-headed Bunting sang stereotyped song spontaneously. All data were collected mostly between 06.00 and 09.00 h during the summer (April-August).

Payne *et al.* (1981) and Margoliash *et al.* (1991) analysised the phrase sequences of all songs (i.e. the sequence ignoring repetition of a syllable type). In this paper, syllable analyses were used to assess the different syllables that could be classified as belonging to the correct individual.

Most of the analyses reported here are concentrated on the syllabic material of song. It were first examined exemplars of stereotyped songs to identify all common syllable types and to produce printed copies of all syllable exemplars. For comprehensive analyses, we made the catalogue of syllables. Brooke (1978) said that this method could be used to measure a individuality.

To evaluate syllable variation within songs, we divided songs of each individual into three groups (i.e., anterior, medial, posterior group) that equalize the number of syllables grouped within songs of an individual, that is, the total number of syllables within anterior group of an individual is the same as that within medial group and that within posterior group.

To compare individuality, we obtained the proportion of expression (SR) of each syllable per song as fallows.

$$SR = \frac{N.S}{T.S}$$

N.S: the number of times of a syllable in total recorded song samples of an individual.

T.S: A total of recorded song samples of an individual.

Therefore, SR is a value that represents the number of appearance of specific syllables per song. The appearance frequency of specific syllable in anterial group, medial group and posterial group 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.

Results

Discription of song

The singing of male Gray Headed Buntings was classified into two major types of song: namely stereotyped song, squeaky song (Fig. 1). Territorial adults sing stereotyped song (also meaned the 'avertising song"; Thompson, 1968). These were extracted from Margoliash's paper (1991) on Indigo Bunting.

A stereotyped song is composed of various syllables. A syllable is composed of one or more notes (or element that is a continuous trace on the sonagram). Syllable is synonymous with the term 'figure' used in Bunting catalogue (Thompson, 1970) and has been described as the consensus term (Shiovitz, 1975). A song is any temporal grouping of syllables that is broken by intervals longer than the intersyllable interval (Wiliams,

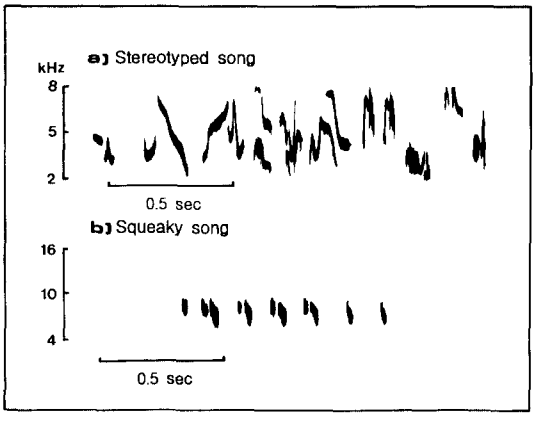


Fig. 1. Song repertoires of male Gray-headed Buntings. The singing of male Gray-headed Bunting was classified into two major types of song. a): Territorial adults sing stereotyped song. b): Gray-headed Bunting also sing high frequency, simple songs with 'squeaky' characteristics during staged territorial encounter.

1977).

Song duration and the number of syllables

We recorded and analysed 513 stereotyped songs of 8 males individually with sonagram. As the results of ANOVA-test, each male produced his songs in distinctive ways in terms of song duration ($F = 19.841$. $df = 7$, $P<.001$) and the number of syllables ($F = 39.383$, $df = 7$, $P<.001$). These differences were very significant for the number of syllables.

Most songs were made up of from 14 to 21 syllables and varied in duration from 1.39 to 1.83 sec. In Fig. 2, we represented the individual extents of song duration and the number of syllables as ellipses.

Analyses of syllables

In our study, each male sang different syllables. Some syllables were produced distinctively among individuals, others were shared by males. Gray-headed Bunting used 158 different syllables. Fig. 3 gives sonagrams of syllables that appeared frequently in 8 males. Syllables were somewhat different in terms of frequency range and syllable duration. Fig. 4 gives partial SR values of syllabless that were represented in Fig. 3. And syllable types had a disposition to express in one of three groups.

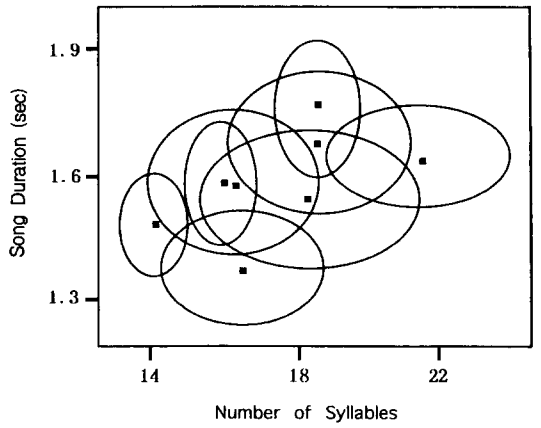


Fig. 2. Each ellipse represents the mean ± SD across the signature songs (i.e., unique to an individual) in Gray-headed Bunting. The extent of the ellipses seperated is a measure of the individual distinctiveness of the songs. n = 536.

Several syllables were repeated consecutively in a song.

In all cases, the mean of SR_A (i.e., the SR of anterior groups) was larger than that of SR_M (the SR of medial group) and SR_P (the SR of posterior group)(Fig. 5). This showed that the syllables in anterior groups are least various and most expressed of the three. In summary, the syllables of anterior groups are constant than those of posterior group.

Some syllables were frequently expressed in anterior groups of an individual in Table 1. These analyses showed that a song belonged to an individual. On the other hand, the syllables expressed in posterior group had a little individually distinctive feature.

In summary, our results showed that Gray-headed Bunting's song had individually distinctive syllables.

Discussion

We believe that Gray-headed Buntings have adequate information to recognize individuals in their songs. This information will be in the form of signature songs and distinctive ways of singing each syllable type among their songs.

Each male Gray-headed Bunting sings a characteristic sequence of syllables to make up a complete song pattern. Also Gray-headed Buntings had syllables in common, but they either contained some different syllables or placed the shared syllables in a different sequence, and so we didn't consider the song types to be the same. Gray-headed Bunting sang very various repertoires. Thompson (1970) had already published 98 syllable types in Indigo buntings. Gray-headed Buntings shared some syllable types with Indigo Bunting and Siberian Meadow Bunting.

The beginning of the song of some species is markedly stereotyped while the ending is more plastic and it shows individual characteristics (e.g. Reed Bunting (*Emberiza schoeniclus*), Willow Warbler (*Phylloscopus trochilus*), Yellowhammer (*Emberiza citrinella*): Schubert (1969); Tree Pipit (*Anthus trivialis*): Bjerke (1971); Whitethroat

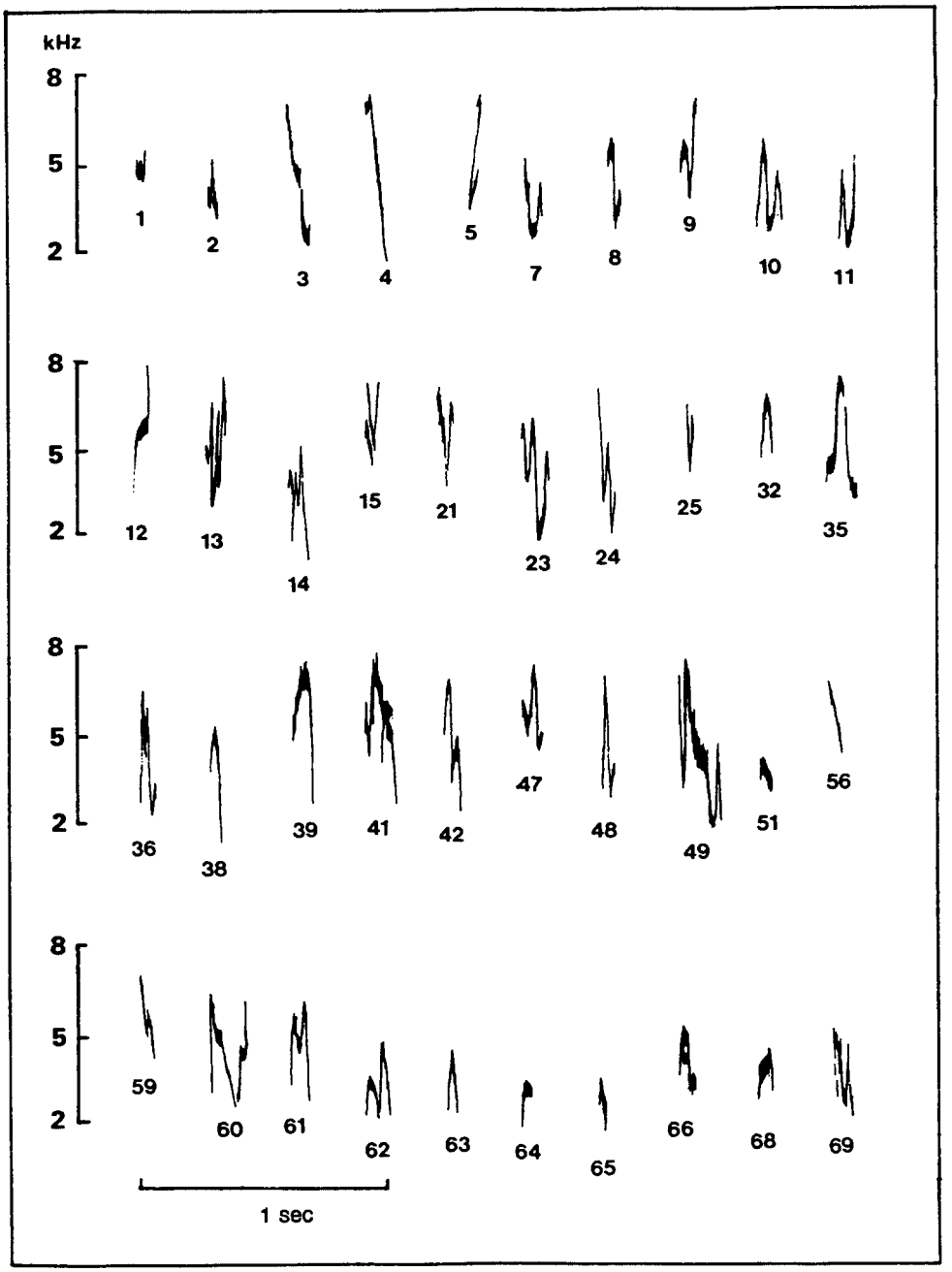


Fig. 3. Syllables used by 8 male Gray-headed Buntings.

(*Sylvia communis*): Bergmann (1973); Hazel Grouse (*Bonasa bonasia*); Bergmann et al. (1975); Indigo Bunting: Emlen (1972); Shiovitz (1975); Goldcrest (*Regulus regulus*): Becker (1974, 1976)). In Golden-winged Warbler, Indigo Bunting and Goldcrest, the beginning of the song functions in gaining the attention of conspecifics (Ficken and Ficken, 1973; Shiovitz, 1975; Becker,

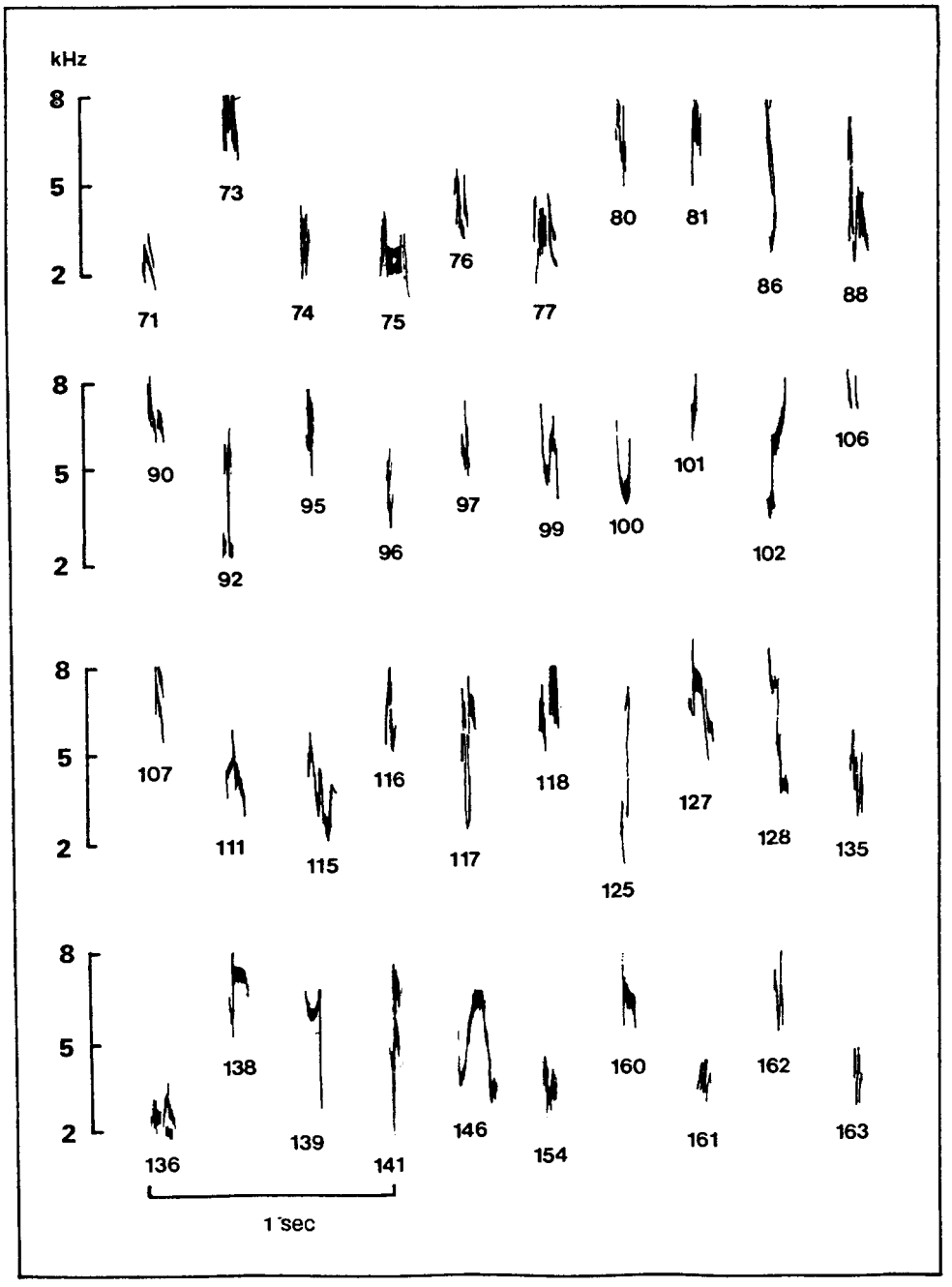


Fig. 3. Syllables used by 8 male Gray-headed Buntings.

1976). In the Goldcrest, the song ending is important in communication within the pair (Becker, 1976; Thaler, 1979). In Indigo Bunting, motivation is encoded in the number of terminal elements in the song.

In comparison to above, in Gray-headed Bunting, discrimination can be made on the basis of only several syllables. In a population,

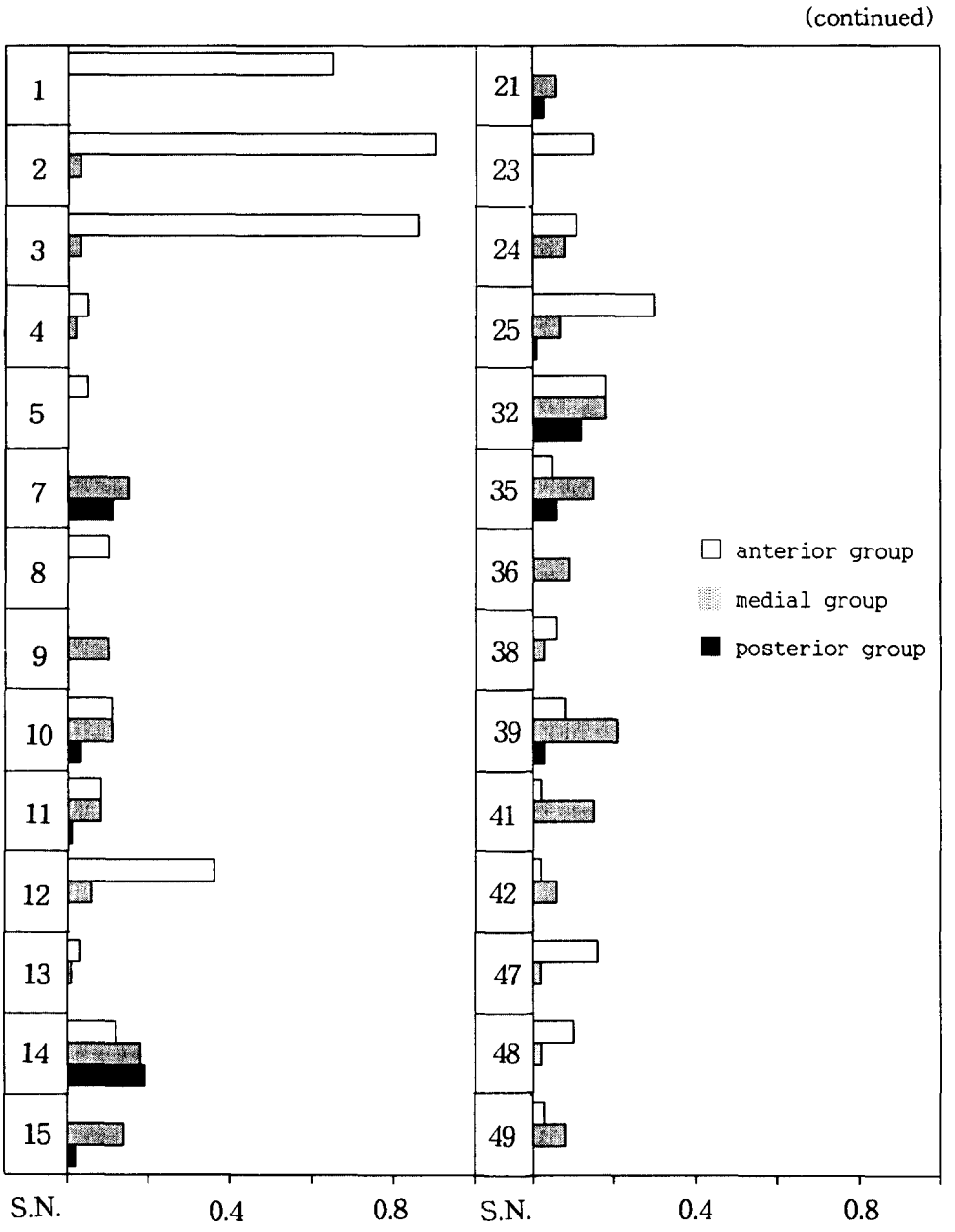
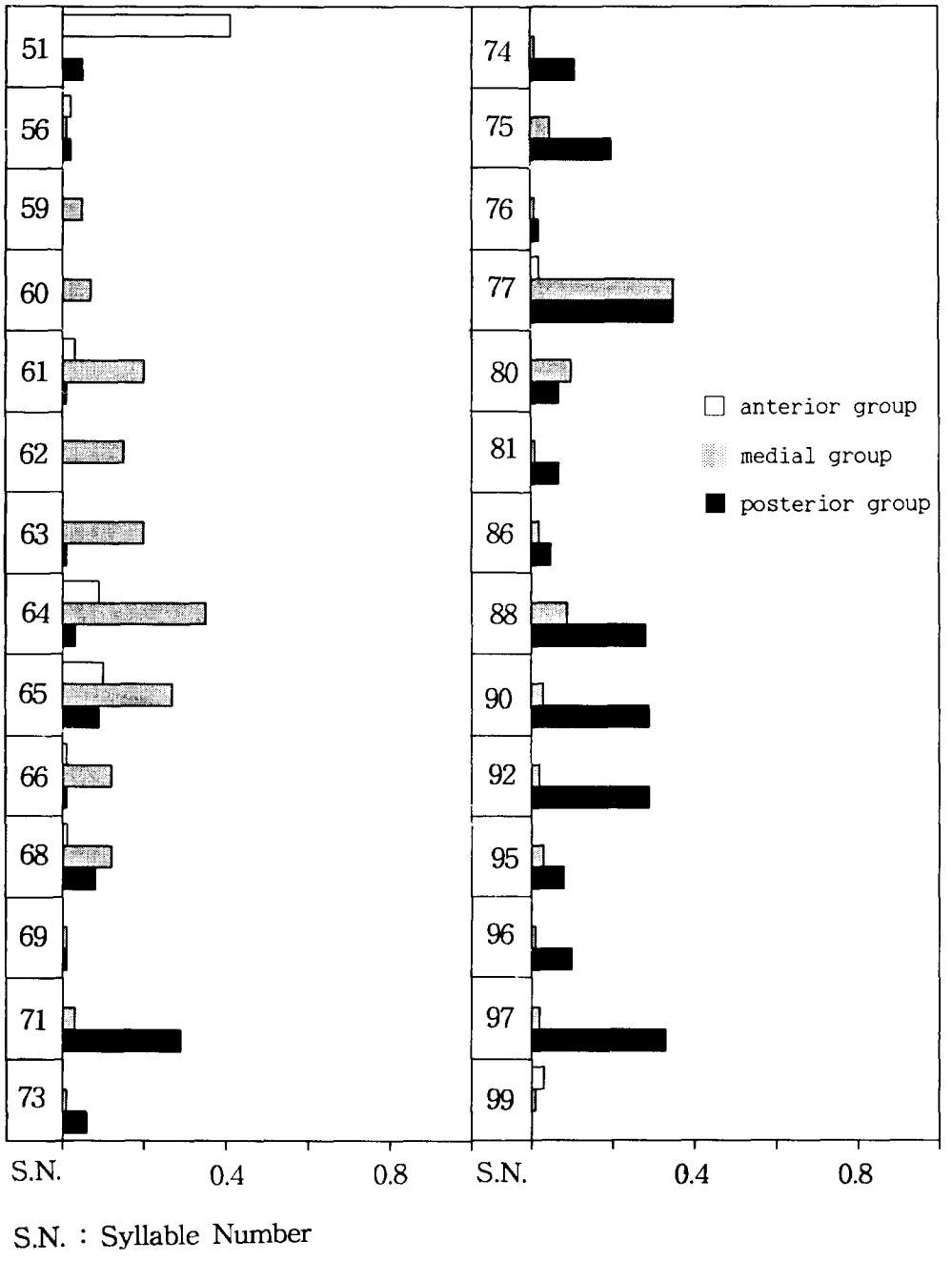


Fig. 4. The SRs of syllables used by 8 male Gray-headed Buntings (represented syllables in Fig. 3). Especially, each syllables were expressed among groups and individuals.

individuals often sang the first part of the pattern of another bird, and those syllables were identical in form and sequence to those of the second individual. But some syllables in the anterior group of Gray-headed Bunting's song may be important for individual recognition.

In a recent study on Indigo Bunting (Margoliash *et al.*, 1991), Buntings isolated during their first

(continued)



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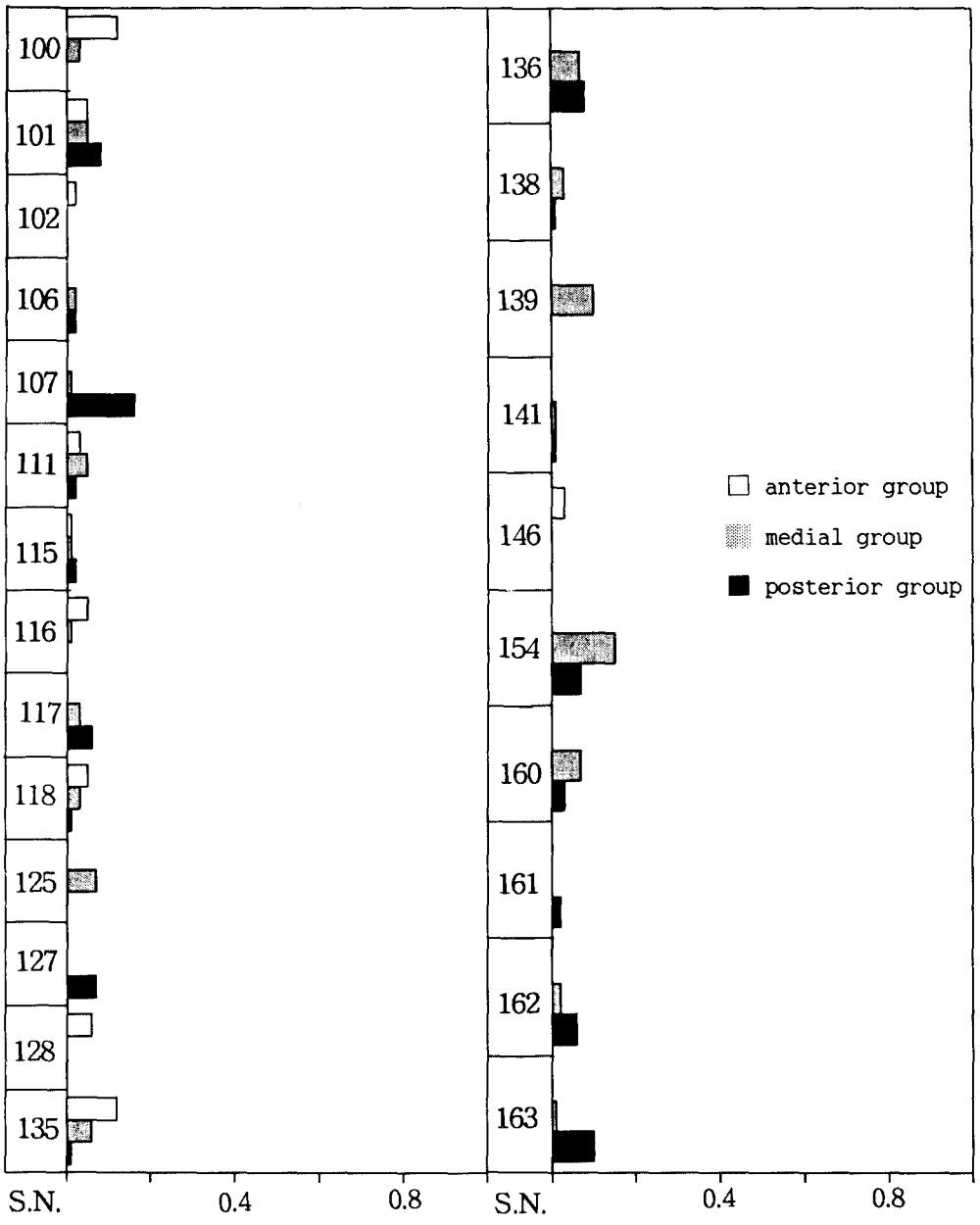

Fig. 4. The SRs of syllables used by 8 male Gray-headed Buntings (represented syllables in Fig. 3). Especially, each syllables were expressed among groups and individuals.

year expressed a high-frequency 'S-note' in the terminal sequence of stereotyped song. We guess that Gray-headed Bunting has a posterior group for situational communication.

The most direct way to assess the potential for individual recognition is to determine the extent to which individuals in a population can be identified accurately by their sounds (Falls, 1982). In the case of Great Tit (*Palus major*), one of birds most largely studied, its individuality was explained in

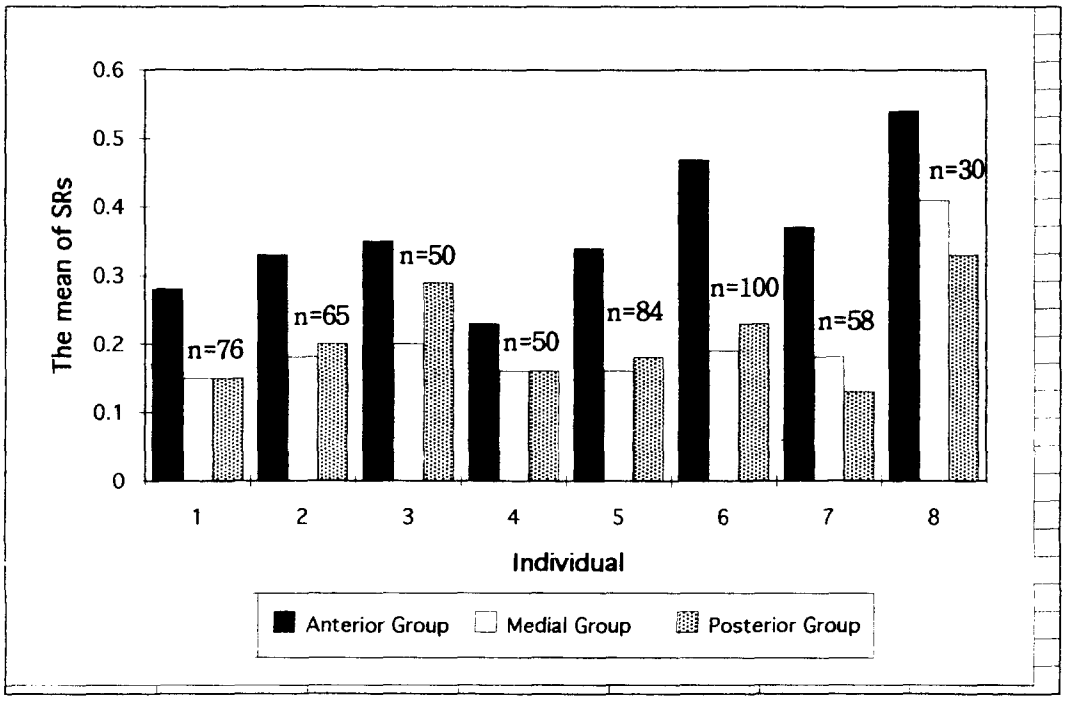

Fig. 5. The mean of SRs per group in Gray-headed Bunting. In all cases, the mean of SR_A (i. e. the SRs of anterior groups) was larger than that of SR_M (the SRs of medial group) and SR_P (the SRs of posterior group). This showed that the syllables of anterior group are less various and more expressed.

Table 1. The comparison of SR between individuals in anterior groups.

Syllable No.	Individual							
	1	2	3	4	5	6	7	8
1	.36	.62	.64	.96	.44	.96	.91	.37
2	.67	1.34	1.00	.96	.55	.97	.93	.77
3	1.03	.66	.58	.12	.86	1.00	.66	1.00
23	–	–	–	–	.39	.73	–	–
28	–	–	–	.40	–	–	–	–
38	–	.49	–	–	–	–	–	–
39	–	–	.06	–	.44	–	–	–
48	–	–	–	–	–	–	–	.77
51	–	–	.58	–	–	.71	.34	.97
100	.87	–	–	.12	–	–	–	–
144	–	–	–	–	–	–	.45	–

Some of syllables in anterior groups were collected. Syllable 1, 2, 3 were shared by individuals. Other syllables were expressed distinctively in each individual. SR value is the proportion of expression of each syllable per song (See Method).

the frequency range (Weary *et al.*, 1990). Individuality of Gray-headed Bunting was found meaningfully in range of number of syllables and song duration, and we point out that syllable types and its sequence give more distinctive ways to explain the individuality. Birds may cue into the distinctive ways in which individuals sing each syllable in their songs, or into the shared features of all the songs within an individual sings. We think that syllables of Gray-headed Bunting can be units of individual recognition and learning.

Also, the great variety of song types and syllables within the population must certainly enhance individual recognition. Experimental studies of the response of territorial birds to familiar and unfamiliar songs, will give that wild birds recognize individual songs.

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붉은뺨멧새(**Emberiza fucata**) Stereotyped song 내 Syllable의 개체내, 개체간 변이 비교

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충북 청원군 강내면에 도래하여 번식하는 붉은뺨멧새(*Emberiza fucata*) 의 음향학적 행동을 관찰하였다. 그 결과, song repertoire는 크게 stereotyped song과 squeaky song으로 나타났으며, 이들의 세력권을 바탕으로 stereotyped song을 개체별로 녹음하여 분석하였다.

각 개체들은 song duration과 song을 구성하는 syllable 갯수에서 개체간에 의미있는 차이를 보였으며, 개체내에서 또 개체간에 syllable 유형의 다양한 변이를 나타냈다. 붉은뺨멧새 8마리 총 513개의 song, 9087개의 syllable에 나타난 syllable 유형은 158 개로 파악된다. Song의 전반부에 syllable 구성은 후반부의 syllable 구성에 비해 한 개체내에서 더 일정하게 표현되었다. 각각의 syllable 유형은 일정 개체에 또 song의 일정 부분에 더 많이 표현되는 특징을 지닌 것으로 분석되었다. Song의 전반부에 몇몇 syllable 유형은 군집 전체에서 빈번한 출현을 보였다.

이러한 분석에서 붉은뺨멧새 stereotyped song의 전반부는 보다 변하지 않는 정보를 표현하는데, 후반부는 상황적인 의사 소통에 기여하리라 추측된다.