

## VOCALIZATIONS OF THE GOLDEN-CROWNED KINGLET IN EASTERN NORTH AMERICA

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Abstract.—Songs and calls of the Golden-crowned Kinglet (*Regulus satrapa*) from a number of locations in Eastern North America were examined. Songs were comprised of a variable number of six syllable types. The order of syllable presentation, however, was highly predictable both within and among individuals. Song structure resembled that of the congeneric Firecrest (*R. ignicapillus*) of Europe. Two common calls of the Golden-crowned Kinglet (*ti* and *zeet*) occurred throughout the geographic range examined and strongly resembled calls of the Firecrest and Goldcrest (*R. regulus*), as well as having similar putative functions.

### VOCALIZACIÓN DE *REGULUS SATRAPA* EN EL ESTE DE NORTE AMÉRICA

Sinopsis.—Se examinó el canto y las llamadas de individuos de *Regulus satrapa* en localidades del este de Norte América. Se encontró una serie de cantos variables de seis sílabas. El orden de las sílabas resultó ser predecible tanto en un mismo individuo como entre individuos. La estructura de la canción es parecida a la de congéneres europeos como *R. ignicapillus*. Dos de las llamadas del ave (*ti* y *ziit*) se encontraron a todo lo largo de la extensión geográfica estudiada y se parecen mucho a las producidas por *R. ignicapillus* y *R. regulus*. Las llamadas parecen tener una función similar en las tres especies.

Despite extensive descriptive work over the past several decades, the vocalizations of most species of North American passerines have yet to be adequately described. The Golden-crowned Kinglet (*Regulus satrapa*) is one such species. In contrast, European members of this genus, the Goldcrest (*R. regulus*) and the Firecrest (*R. ignicapillus*) have been studied extensively (Becker 1976, 1977a,b).

An early description gives the song of the Golden-crowned Kinglet as "rising at first with fine, high-pitched, somewhat faltering notes, and then falling away into a short, rapid rather explosive warble" (Forbush 1929: 376). Galati and Galati (1985) recognized two categories of song: simple song, consisting of a series of ascending notes, and complex song, which begins like simple song but ends in a musical warble.

Descriptions of calls of the Golden-crowned Kinglet have recognized from two to five call types (Forbush 1929:376, Galati and Galati 1985), but the absence of sound spectrographs and variation in onomatopoeic descriptions make the work of previous authors difficult to compare. Here I present descriptions and sonagrams of the song and two call types of the Golden-crowned Kinglet.

### METHODS

I obtained tape-recorded Golden-crowned Kinglet vocalizations from three sources. First, I recorded spontaneous songs and/or calls from 12 Golden-crowned Kinglets at intervals from 9 May–15 Oct. 1991 at the

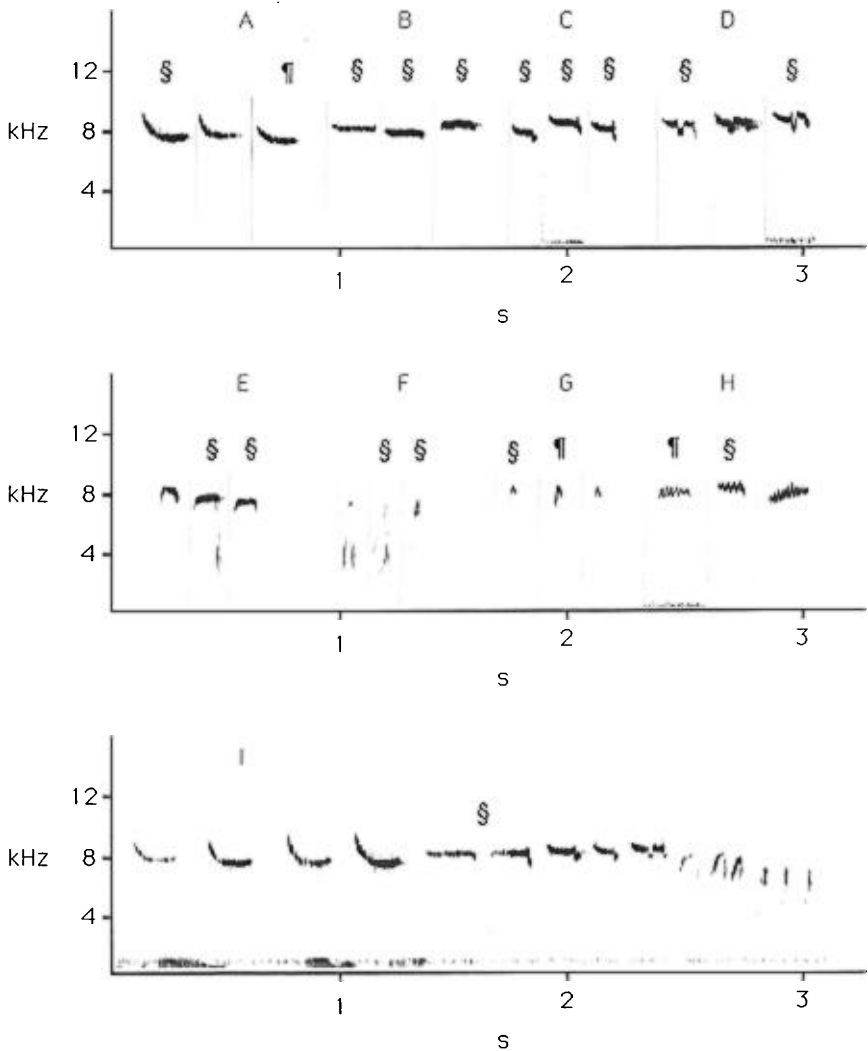
Evelyn and Morrill Richardson Field Station property, Bon Portage Island, Nova Scotia, Canada, and five birds on 3–8 May 1991 near Bridgewater, Nova Scotia. These recordings were made with a Sony WM-D60 cassette recorder and a Sony PC-62 microphone mounted in a 30-cm parabolic reflector. Individuals were not color-marked, but rather single recordings were made from various birds believed to be different individuals because of their locations. Second, I obtained the following recordings from the Library of Natural Sounds, Cornell University, Ithaca, New York: one bird recorded in Michigan 14 Jun. 1956; one bird recorded in New Jersey 29 May 1959; four birds recorded in New York State 28 May 1959 and 13 Aug. 1974; two birds recorded in Maine on 17 Sept. and 8 Oct. 1981; and two birds recorded in North Carolina on 11 May and 13 Jun. 1979. The Maine recordings and two of the New York recordings were of calls only, the others were of songs. The breeding status of singing birds was not definitely known. All recordings of singing birds were made within the usual breeding season, however. Third, the Borror Laboratory of Bioacoustics, Department of Zoology, Ohio State University, Columbus, Ohio, provided me with recordings of songs from two birds recorded in Ohio on 10 Apr. 1955 and 18 Apr. 1971 (likely before breeding had commenced), and one bird from New York State on 2 Jun. 1989. Although female Golden-crowned Kinglets have been reported to sing similar songs to those of the males (Galati and Galati 1985), all songs on which this paper is based were recorded from males.

I spectrographically analyzed 131 songs from 19 individuals using a Kay Elemetrics Corp. 5500 DSP Sona-Graph and a Kay Elemetrics Corp. 5509 Grey Scale Printer. I measured frequency (defined as the frequency at peak amplitude) and duration parameters from song syllables and notes. Note and syllable types were then classified by frequency, duration and note morphology. The small number of individuals from most localities did not permit statistical comparisons among geographic areas.

#### RESULTS

*Songs.*—Golden-crowned Kinglet songs were composed of a series of syllables, most of which were repeated several times. Individual syllables were sorted into six different types with little ambiguity. The most common syllable type was designated by the letter 'A' and subsequent letters were assigned on the basis of the most common heterosyllabic transitions (Fig. 1). Frequency and duration parameters of these syllable types are given in Table 1. All syllable types were present in all of the geographic areas sampled with two exceptions. Syllable type F was not observed in the New York sample, and syllable types A and B were not observed in the New Jersey sample. This, however, may have been a sampling artifact due to the small number of individuals from these areas.

The number of syllable types used and the number of repetitions of each type varied in subsequent songs from the same individual. The simplest songs contained only syllable type A. If more syllable types were present, the order of presentation within a song was highly predictable.



**FIGURE 1.** (A)–(F) syllable types comprising Golden-crowned Kinglet song, three examples for each type, each from a different individual, (G) *ti* call note from three individuals, (H) *zeet* call note from three individuals, (I) typical Golden-crowned Kinglet song. All sonagrams printed with a 234 Hz analyzing filter. Sonagrams marked with (\$) are © 1991 all rights reserved, Library of Natural Sounds, Cornell Laboratory of Ornithology, Ithaca, New York. Sonagrams marked with (I) are © Borrer Laboratory of Bioacoustics, Department of Zoology, Ohio State University, Columbus, Ohio, all rights reserved. Unmarked sonagrams are from birds recorded by the author in Nova Scotia.

**TABLE 1.** Parameters of Golden-crowned Kinglet syllable types. Means were calculated for each individual, and the means of means (grand means) are reported below. Sample size is the number birds.

| Parameter            | Syllable type |      |       |      |      |       |
|----------------------|---------------|------|-------|------|------|-------|
|                      | A             | B    | C     | D    | E    | F     |
| Mean frequency (kHz) | 7195          | 7665 | 7768  | 7900 | 7349 | 4731  |
| SE                   | 19.0          | 33.5 | 127.0 | 53.1 | 56.6 | 488.0 |
| <i>n</i>             | 11            | 6    | 9     | 6    | 6    | 4     |
| Mean duration (s)    | 0.17          | 0.15 | 0.15  | 0.20 | 0.59 | 0.05  |
| SE                   | 3.6           | 6.0  | 21.6  | 7.0  | 3.1  | 1.0   |
| <i>n</i>             | 11            | 6    | 9     | 6    | 6    | 4     |

Table 2 shows the transition probabilities (i.e., the probability that type B follows type A) for the syllable types in the songs I examined. Matrices calculated for individual birds were very similar and so only the pooled matrix is shown here. Most syllables were repeated several times, except syllables B and D, which were more likely to be followed by a different syllable type than repeated (Table 2). This table also shows that Golden-crowned Kinglets would occasionally skip a syllable type within a song but would rarely go back to an earlier type. For example, one bird from Bridgewater, Nova Scotia, gave five successive songs with the syllable patterns AAAAAC, AAABCCCCEFFFF, AACCCCDDE, AAABCCC and AAAABCCC. Birds switched to an earlier syllable type in only four of 1155 transitions examined, and two of these instances are from a single song rendition from the New Jersey bird. This bird is also the only one that did not begin its songs with syllable type A and was the only individual

**TABLE 2.** Transition probabilities for next syllable type in Golden-crowned Kinglet songs, based on 131 songs from 19 individuals from Nova Scotia, New York, New Jersey, North Carolina, Michigan and Ohio. Number in parentheses is number of observed instances. Some rows do not sum to one because of rounding errors.

| Syllable N | Syllable N + 1 |              |               |              |               |               |
|------------|----------------|--------------|---------------|--------------|---------------|---------------|
|            | A              | B            | C             | D            | E             | F             |
| A          | 0.82<br>(427)  | 0.16<br>(82) | 0.02<br>(13)  | 0            | 0             | 0             |
| B          | 0              | 0.31<br>(33) | 0.57<br>(60)  | 0.12<br>(13) | 0             | 0             |
| C          | 0              | 0.01<br>(1)  | 0.66<br>(127) | 0.19<br>(36) | 0.11<br>(21)  | 0.03<br>(6)   |
| D          | 0              | 0            | 0             | 0.35<br>(16) | 0.63<br>(29)  | 0.02<br>(1)   |
| E          | 0              | 0            | 0.01<br>(1)   | 0.01<br>(1)  | 0.75<br>(139) | 0.24<br>(44)  |
| F          | 0              | 0            | 0             | 0            | 0.01<br>(1)   | 0.99<br>(104) |

that incorporated a *zeet* call into its song (see below). The incorporation of calls in songs has been previously reported for this species (Forbush 1929:376).

The mean frequency of syllable types within a song generally increased from syllable types A to B to C to D, and decreased from syllable types D to E to F (Table 1).

The structure of Golden-crowned Kinglet song closely resembles that of the congeneric Firecrest of Europe, described by Becker (1977a). The songs of both species consist of groups of repeated notes, with remarkable similarity in note structure between the two species (compare Fig. 1 and Becker 1977a:Fig. 2). In contrast, Goldcrest song is composed of a series of repeated phrases each consisting of several syllables (Becker 1977a).

*Calls.*—The two most commonly observed calls were the *ti* and *zeet* (Fig. 1). In Nova Scotia, the only location in which field observations were made, both of these calls were given by either sex. The *ti* note is apparently the *tse* call referred to by Galati and Galati (1985). I chose one of these notes at random from eight different individuals to measure frequency and duration. This sample consisted of two birds from Ohio, two from New York, and four from Nova Scotia. The mean frequency was 7992 Hz (SE = 96.1), and the mean duration was 0.04 s (SE = 0.003). This call may function as a contact note, as it was often heard when two or more birds were together. This call has also been reported to function in parent-offspring interactions (Galati 1991:41). The mean frequency of *zeet* calls from 12 individuals from the same locations was 7728 Hz (SE = 62.8), and the mean duration of the same calls was 0.18 s (SE = 0.04). During territorial conflicts or in response to human disturbance, birds often gave *zeet* calls or a series of *ti* calls rapidly repeated. The “close-contact note” and “alarm note” (Becker 1977b) of the Goldcrest and Firecrest strongly resemble the *ti* and *zeet* calls, respectively, of the Golden-crowned Kinglet (Fig. 1), and appear to have similar functions.

#### DISCUSSION

This paper presents the first quantitative analysis of vocalizations of the Golden-crowned Kinglet. The most extensive qualitative analysis to date is that of Galati and Galati (1985) and Galati (1991) on Golden-crowned Kinglets in Michigan. These authors classified song as either simple or complex, depending on duration and the presence of a lower “musical warble” at the end of the song. In the present study, songs containing note types A to D probably correspond to the simple song reported by these authors. Likewise, songs containing all note types probably correspond to complex song. The functional significance of song variation in this species is unclear. It is possible, however, that songs with different numbers of syllable types are used in different behavioral contexts. For example, Galati (1991:41–42) states that simple songs are often used in direct agonistic exchanges with another individual and complex songs are used for “proclaiming territory.” There is often a large amount

of variance, however, in consecutive songs from the same individual while presumably engaged in the same behavior.

My observations support the suggestion of Galati (1991:41) that the *ti* call note is used as a contact call. Galati does not refer to the *zeet* call, however, although I found this vocalization was commonly used.

The similarity in structure of Golden-crowned Kinglet and Firecrest songs may indicate relatedness between these species, although Mayr and Short (1970) suggested that the Golden-crowned Kinglet was actually more closely related to the Goldcrest. With two sympatric species in North America and two in Europe, this genus may prove to be an interesting group in which to examine song evolution if the phylogenetic history can be determined (see also Ingold et al. 1988).

Future research on vocalizations of Golden-crowned Kinglets should include a more detailed analysis of among-individual song variation in specific geographic locations, and should also examine the possible functions of within-individual song variation.

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