

UDC 598.296:591.582.2

**SONG REPERTOIRE OF THE CRIMEAN CHAFFINCH,
FRINGILLA COELEBS (FRINGILLIDAE), AND COMPARATIVE
ANALYSIS OF THE VOCALIZATION FEATURES OF
F. C. SOLOMKOI, *F. C. COELEBS* AND *F. C. CAUCASICA*
SUBSPECIES**

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Received 15 May 2012

Accepted 21 November 2012

Song Repertoire of the Crimean Chaffinch, *Fringilla coelebs* (Fringillidae), and Comparative Analysis of the Vocalization Features of *F. c. solomkoi*, *F. c. coelebs* and *F. c. caucasica* Subspecies. Tsvelykh A. N., Yablonovska-Grishchenko E. D. — Song repertoire of chaffinch *F. c. solomkoi* subspecies from Crimea was analyzed. We discerned 38 song types in Crimean chaffinches' repertoire, 27 of them were more frequent. Comparing Crimean chaffinches' songs with those of nominative subspecies from Eastern Europe showed no common songs. Comparison of individual song elements showed that songs of *F. c. solomkoi* consisted of 108 elements, of which 18 were distinctive to Crimean birds, 18 were specific to Crimean chaffinches and Carpa-thian *F. c. coelebs* population while absent in songs of chaffinches from Eastern Europe plains. Comparison of *F. c. solomkoi* songs with songs of Caucasian subspecies *F. c. caucasica* revealed no common types of songs. There are certain similarities in song structures between some Crimean chaffinches and hybrid popula-tion of *F. c. caucasica* and *F. c. solomkoi* from Northwest Caucasus. Other specifics of vocalization showed drastic differences in rain-call structures of all sub-species and no after-song "kit" element for Caucasian sub-species.

Key words: Chaffinch, song, repertoire, vocalization, Crimea, sonogram, subspecies.

Песенный репертуар зяблика, *Fringilla coelebs* (Aves, Fringillidae), из Крыма и сравнительный анализ особенностей вокализации подвидов *F. c. solomkoi*, *F. c. coelebs* и *F. c. caucasica*. Цвельх А. Н., Яблоновская-Грищенко Е. Д. — Проанализирован песенный репертуар зябликов подвида *F. c. solomkoi*, населяющих Крымские горы. В репертуаре зябликов Крыма выявлено 38 типов песен, из которых наиболее распространены 27. Сравнение песен крымских зябликов с песнями птиц номинативного подвида из Восточной Европы показало полное отсутствие общих для обоих подвидов типов песен. При сравнении отдельных элементов песен из 108 элементов, выявленных в песнях *F. c. solomkoi*, 18 оказались специфичными для крымских птиц, еще 18 элементов — общими с элементами, выявленными исключительно у популяции *F. c. coelebs* Карпат и отсутствующих в песнях зябликов из равнинных районов Восточной Европы. Сравнение песен *F. c. solomkoi* с песнями птиц кавказского подвида *F. c. caucasica* также показало отсутствие общих типов песен. Отмечено определённое сходство в структуре некоторых песен зябликов крымской популяции и птиц из Северо-Западного Кавказа, населённого гибридной популяцией *F. c. caucasica* и *F. c. solomkoi*. Сравнение других особенностей вокализации демонстрирует радикальные отличия в структуре «дождевого сигнала» между всеми исследованными подвидами и отсутствие исполнения послепесенного элемента «kit» птицами кавказского подвида.

Ключевые слова: зяблик, Крым, вокализация, репертуар, сонограмма, подвид.

Introduction

Song of the chaffinch is narrowly determined. It always begins with several phrases, each is a sequence of identical elements. The song ends with specific “end element”. Sometimes there are “inserted elements” between phrases, sometimes also one or more of “pre-end elements” are present. Examination of the song structure enables us to characterize, analyze and compare song repertoires of different chaffinch populations objectively.

Range of *F. c. solomkoi* Menzbier et Sushkin, 1913 subspecies is restricted to the Crimean peninsula, mainly to the mountains. Song repertoire of this geographically isolated population was not studied before. We aim to identify and analyze song repertoire of the chaffinches in Crimean mountains and to compare vocalization specifics of the Crimean subspecies and other geographically contiguous subspecies.

Material and methods

We recorded chaffinch songs in 17 areas of the Crimean mountains: in the western part (to the west from Belbek river — Alupka line), in the eastern part (to the East from Zuya river- Solnechnogorskoe line), and in the central part (between these regions). We collected 1831 songs from 275 specimens during the nesting periods (May–June) in 2007, 2008 and 2011 (88 specimens from central Crimea, 84 from western and 103 from the eastern part).

The songs were recorded with Sony TRV 110 E and Sony TRV 550 E digital cameras with remote microphones. The data obtained were analyzed with Studio DV 1.0 program. For further analysis we converted files to Wave-format without any compression or sound clearing. To process the data and to obtain sonograms we used Sound Forge 5.0 and Syrinx 5.2s software (Burt, 1995–2005).

Song types were identified using semiquantitative analysis of sonograms (Yablonovska-Grishchenko, 2006). To ensure this, the elements of the same frequency-temporal characteristics were coded similarly. Each song was then recorded as a coded formula. Songs described by similar formulas were grouped into types (their sonograms were almost identical). If song formulas differed insignificantly (in 1–2 similar elements), they were considered subtypes of the same type. However, if a new phrase occurred in a song formula, at the complete coincidence of the other elements, a new type was ascribed to the song.

The “*kit*” element, sometimes added after the end of a song of any type, is not a part of it and was not included in typological analysis. The presence (or absence) of “*kit*” element in repertoire of a population was considered in comparative analysis of subspecies.

Song types of *F. c. solomkoi* were compared to song types of other geographically contiguous chaffinch subspecies — nominate *F. c. coelebs* L. 1758 and Caucasian *F. c. caucasica* Serebrowski, 1925. We used partly the already published (Yablonovska-Grishchenko, 2005; Yablonovska-Grishchenko, Grishchenko, 2005, 2007, 2008) and partly the original song sonograms of the chaffinch nominate subspecies from the forest and forest-steppe zones of Ukraine and Carpathians. We also used sonograms of chaffinches from other Eastern Europe regions: Russia (Simkin, 1983; Simkin, Steinbach, 1988; Astahova, Beme, 2010) and Poland (Böhner, Wistel-Wozniak, 1995). We used comprehensive catalog of sonograms of the chaffinch subspecies from Caucasus and Transcaucasia (Sultanov, 1991) and other published chaffinch sonograms from this region (Simkin, 1983; Sultanov, 1984, 1988). Data were statistically processed with STATISTICA 5. 1, *p*-value calculated by Student’s *t*-test.

Results and discussion

The song repertoire of the Crimean chaffinch. Sonogram analysis revealed 38 song types of the Crimean chaffinch. Sixteen song types were most frequent (fig. 1, 1–16), all of them were present in song repertoires of chaffinches from the western, central and eastern Crimean Mountains. Song types N 1–6 were recorded at more than a half of the recording plots. Eleven song types were slightly less common. They were recorded at central and western or both at central and eastern Crimean Mountains, at 2–7 recording plots. Eleven more song types were found locally — at one recording plot only.

Songs of the Crimean chaffinches consisted of 3–7 phrases, sometimes with “inserted elements”. Half of the song types had no inserted elements between phrases, 34 % of song types included one “insert”, 13 % of song types included 2–3 “inserts”, and 3 % (1 type) included three “inserts”. Most song types (74 %) included the end element and one or two pre-end elements; other song types did not have pre-end elements and one song type had no end element either (fig. 1, 17). Therefore, song structure of the Crimean chaffinch is very variable: from short, primitive songs with few strophes and no end element to quite complex songs.

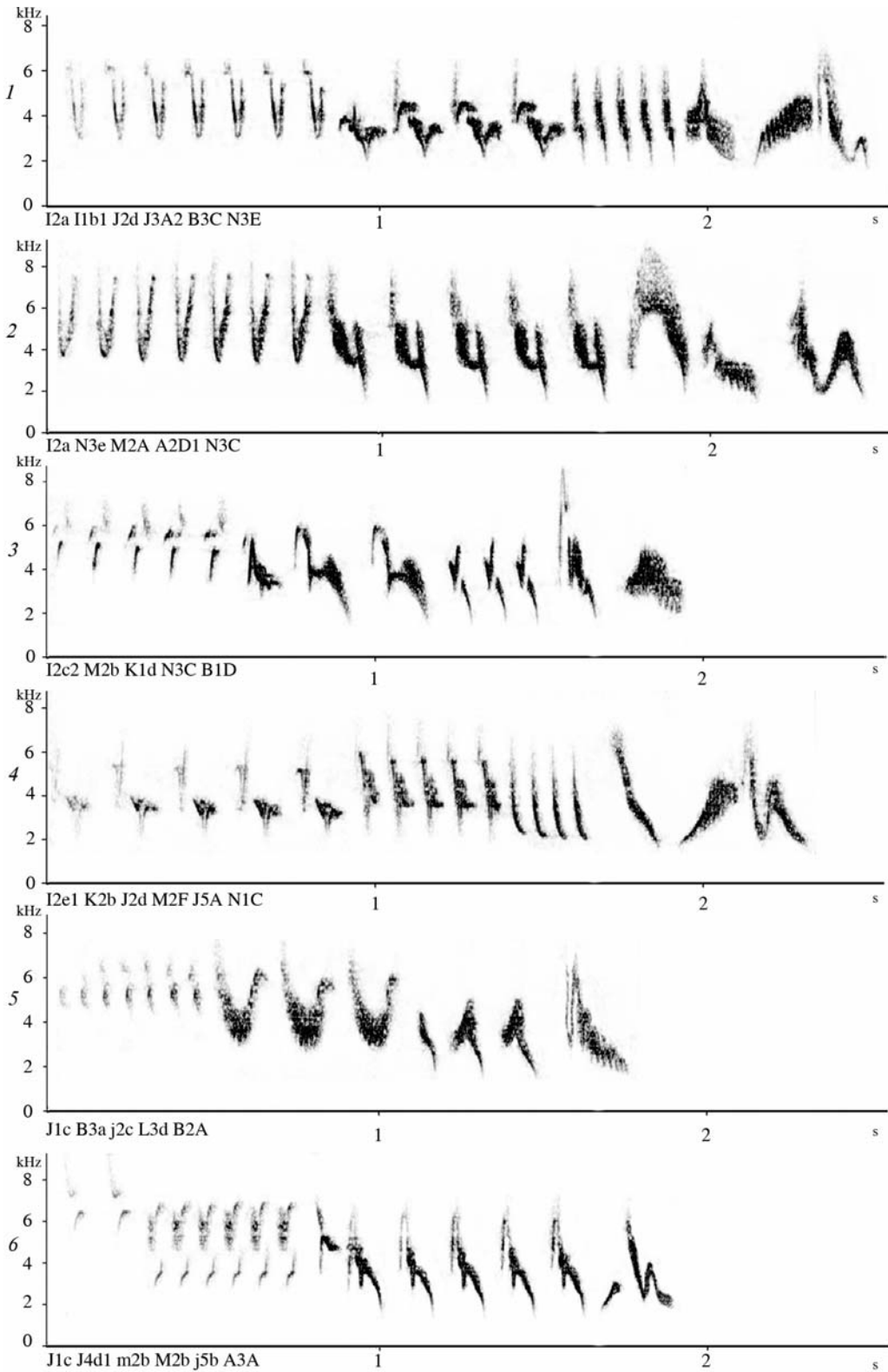


Fig. 1, 1–6. Sonograms and formulas of the most widespread types of the Crimean chaffinch song.

Рис. 1, 1–6. Сонограммы и формулы наиболее распространенных типов песен крымских зябликов.

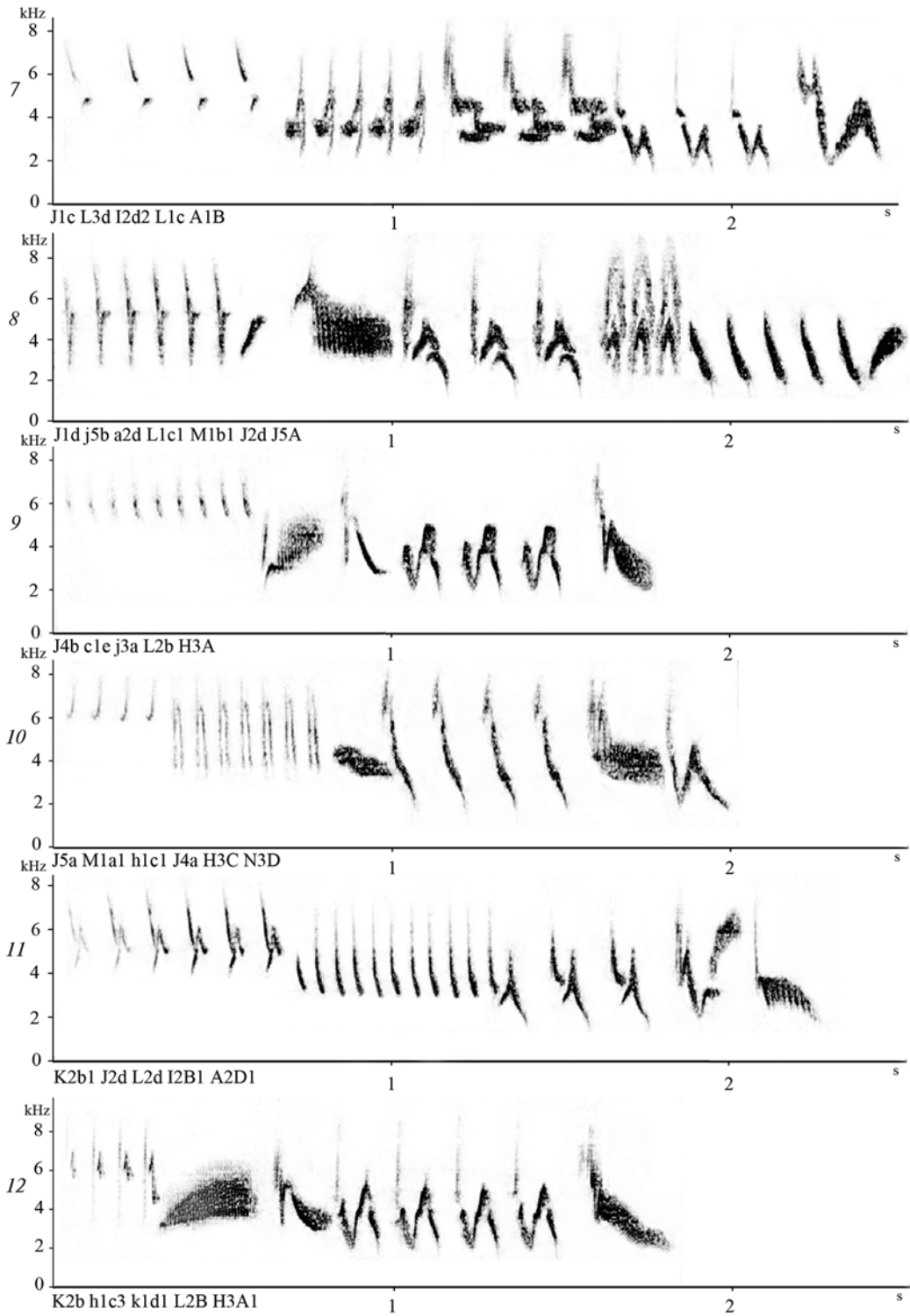


Fig. 1, 7–12. Sonograms and formulas of the most widespread types of the Crimean chaffinch song.
Рис. 1, 7–12. Сонограммы и формулы наиболее распространенных типов песен крымских зябликов.

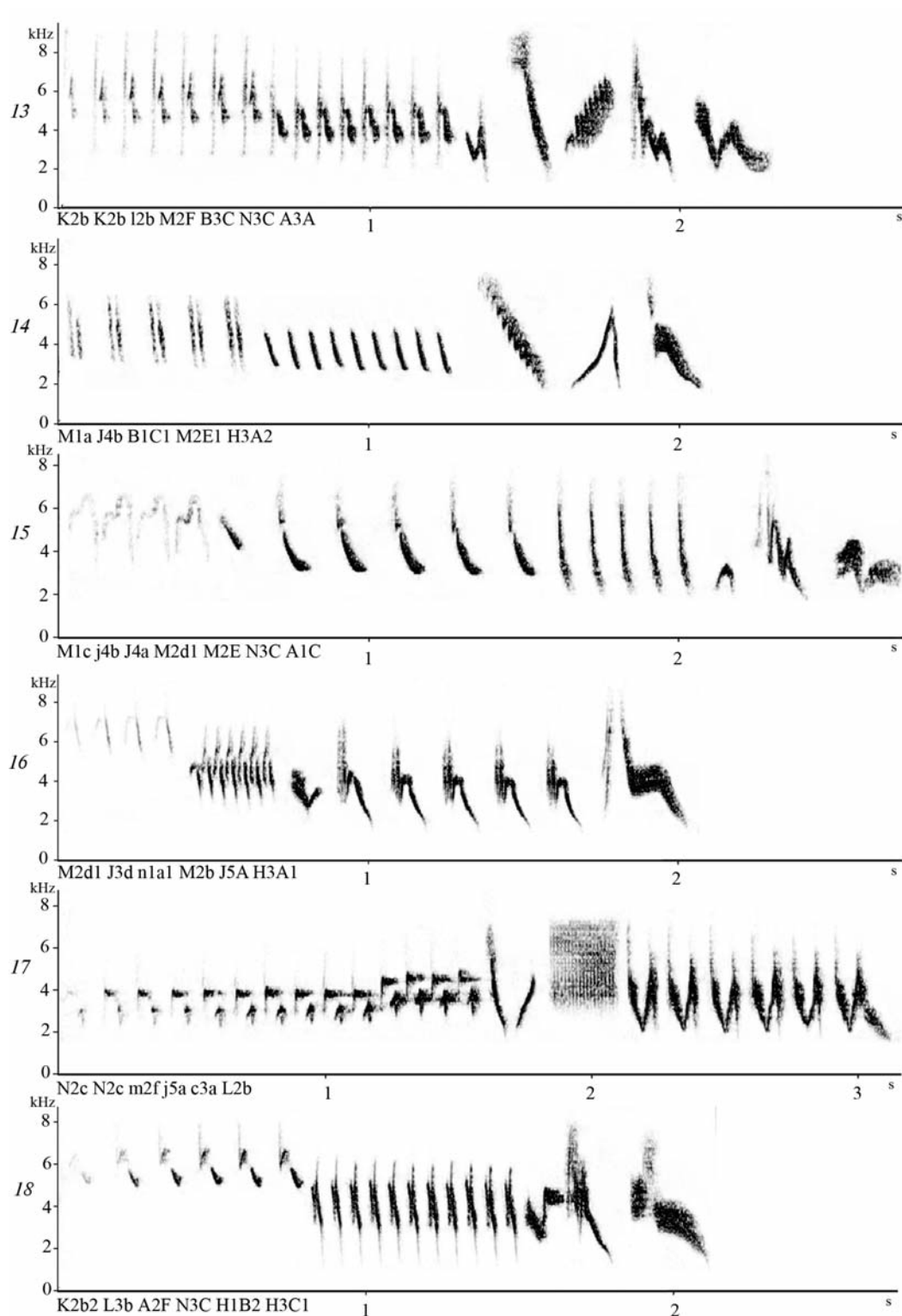


Fig. 1, 13–18. Sonograms and formulas of the most widespread types of the Crimean chaffinch song.

Рис. 1, 13–18. Сонограммы и формулы наиболее распространенных типов песен крымских зябликов.

There were 108 elements in songs of Crimean chaffinches — whistles, harmonics and trills. With one exception, all song types began with whistles. The end element consisted mainly of harmonics (34 %) and whistles (29 %). The elements often changed location in a song; for example, parts of an “end element” were found in the “pre-end” element (8 times), as well as other elements usually found in the middle of a song. Otherwise, parts of the inserted element were found in the “end element”, or at the beginning of a song as a full-scale phrase.

All of the song types of the Crimean chaffinch were concluded with the “kit” element.

Comparative analysis of *F. c. solomkoi* and *F. c. coelebs* vocalization specifics.

Comparison of the songs of the Crimean chaffinches to the songs of chaffinches of the nominate subspecies from forest and forest-steppe plains of Ukraine and to those from Carpathians revealed no identical song types. Crimean chaffinches share no common or at least somewhat similar song types with chaffinches from Russia (Simkin, 1983; Simkin, Steinbach, 1988; Astahova, Beme, 2010) or Poland (Böhner, Wistel-Wozniak, 1995).

Structurally, song types of the Crimean chaffinches were similar to song types of chaffinches from Ukrainian plains (table 1) — almost all parameters showed no significant differences, except for the mean value of inserted elements in songs of chaffinches from Dnieper left-bank Ukraine which was significantly smaller ($t = 2.04$; $p < 0.05$). Songs of the Crimean and Carpathian chaffinches, though, were distinctly different: songs of the Carpathian chaffinches include significantly less phrases ($t = 4.48$; $p < 0.001$) or inserted elements ($t = 2.55$; $p < 0.05$).

Using the massive of data on studied subspecies we compared sequences of elements of their songs. Crimean chaffinch has 108 song elements; 72 of them are found in songs of these subspecies, 18 are specific to *F. c. solomkoi* (fig. 2A). Eighteen other elements (fig. 2B) are absent in songs of chaffinch populations from Ukrainian plains but identical to the elements found in Carpathian populations of *F. c. coelebs* before (Yablonovska-Grishchenko, Grishchenko, 2007, 2008).

Comparative analysis of rain-calls is of particular interest. Rain-call is an anxiety signal used by males during nesting periods. Crimean chaffinches have unique rain-calls noted by H. Kratzig (1943); they consist of short melodic whistles, while nominate subspecies has rhythmic short rattle trills (Tsvelykh, 2011). Rain-call sonograms of these subspecies are quite different (fig. 3).

Comparative analysis of *F. c. solomkoi* and *F. c. caucasica* vocalization specifics.

Chaffinch population of Caucasus and Transcaucasia is heterogenous (Tsvelykh, 2003). Caucasus and Transcaucasia are mostly populated by *F. c. caucasica*. The North-West of Great Caucasus (up to 40°E) is populated by hybrid population of *F. c. caucasica* and *F. c. solomkoi*. South-East of Transcaucasia (Talysh Mountains) is populated by *F. c. alexandrovi* Zarudny et Bilkevitch, 1916. Published chaffinch sonograms (Simkin,

Table 1. Structure of the Chaffinch songs from different regions

Табл. 1. Структура песен зяблика из различных регионов

| Song parts | Crimea <i>n</i> =38 | | Caucasus <i>n</i> =191 | | Carpathians <i>n</i> =58 | | Right-bank Ukraine <i>n</i> =191 | | Left-bank Ukraine <i>n</i> =78 | |
|-------------------|------------------------|------------|---------------------------|------------|-----------------------------|------------|-------------------------------------|------------|-----------------------------------|------------|
| | <i>X</i> ± <i>S.E.</i> | <i>lim</i> | <i>X</i> ± <i>S.E.</i> | <i>lim</i> | <i>X</i> ± <i>S.E.</i> | <i>lim</i> | <i>X</i> ± <i>S.E.</i> | <i>lim</i> | <i>X</i> ± <i>S.E.</i> | <i>lim</i> |
| Phrases | 5,47±0,15 | 3–7 | 4,58±0,07 | 2–7 | 4,55±0,14 | 3–8 | 5,80±0,09 | 3–8 | 5,33±0,11 | 3–8 |
| Inserted elements | 0,71±0,13 | 0–3 | 0,43±0,04 | 0–2 | 0,31±0,08 | 0–2 | 0,66±0,07 | 0–3 | 0,40±0,07 | 0–2 |
| Pre-end elements | 1,32±0,16 | 0–3 | 0,31±0,04 | 0–3 | 0,38±0,07 | 0–2 | 1,04±0,05 | 0–2 | 1,23±0,07 | 0–3 |
| End elements | 0,97±0,03 | 0–1 | 0,98±0,01 | 0–1 | 1 | 1 | 1 | 1 | 1 | 1 |

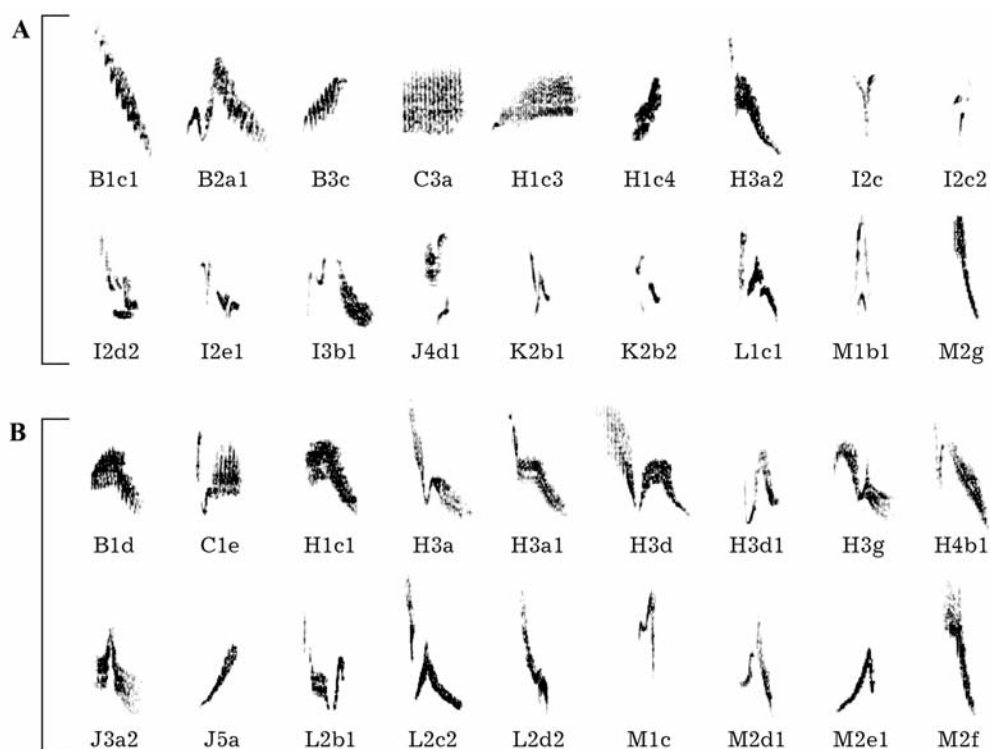


Fig. 2. Specific song elements (A) and elements identical to the Carpathians elements (B) which were found in the songs of the Crimean chaffinches.

Рис. 2. Специфические (A) и общие с карпатскими (B) элементы в песнях крымских зябликов.

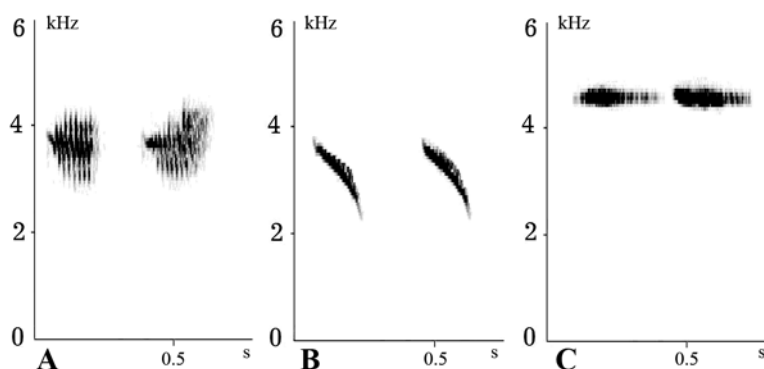


Fig. 3. "Rain-call" sonograms of chaffinch subspecies. A — *F. c. coelebs*, Ukraine; B — *F. c. solomkoi*, Crimea; C — *F. c. caucasica*, Caucasus.

Рис. 3. Сонограммы «дождевого сигнала» у зябликов разных подвидов. А — *F. c. coelebs*, Украина; В — *F. c. solomkoi*, Крым; С — *F. c. caucasica*, Кавказ.

1983; Sultanov, 1984, 1988, 1991) were collected mainly in the range of *F. c. caucasica*, and to a lesser extent at the *F. c. alexandrovi* populated area. There were almost no data from the intergradation zone of *F. c. caucasica* and *F. c. solomkoi* from the North-West of Great Caucasus.

Comparative analysis of *F. c. caucasica* (Simkin, 1983; Sultanov, 1984, 1988, 1991) and *F. c. solomkoi* sonograms revealed no completely similar song types. There was only one song type from Pitsunda region (Caucasian coast of the Black Sea) (Sultanov, 1991), somewhat similar to one of song types relatively abundant in Crimea (fig. 1, 18).

Also, other songs from Pitsunda region are to some extent structurally similar (in some elements and their sequences) to the Crimean chaffinches' songs. Perhaps, this is due to hybridization between *F. c. caucasica* and *F. c. solomkoi* at Pitsunda region (40°E is a border of the subspecies' intergradation zone) (Tsvelykh, 2003).

Structurally, Crimean and Caucasian chaffinch songs are quite different (table 1): Crimean chaffinch songs consist of more phrases ($t = 5.38$; $p < 0.001$) and inserted elements ($t = 1.99$; $p < 0.05$). Other parameters, as in the case of nominate subspecies, show no differences. However, songs without obligatory "end elements" were found only in Crimea and Caucasus.

We were unable to compare our data to sequences of elements of *F. c. caucasica* sonograms as fully as it was done for *F. c. solomkoi* and *F. c. coelebs* because of the lesser quality of published sonograms of Caucasian subspecies. But analysis of available data allowed us to conclude that: 1) most of the song elements of *F. c. caucasica* and *F. c. solomkoi* are similar, as it is for *F. c. solomkoi* and the nominate subspecies; 2) none of 18 elements specific to Crimea and 18 other specific both to Crimea and Carpathians were found in songs of Caucasian birds (that had only 4 specific elements not present in the songs of both *F. c. solomkoi* and *F. c. coelebs*).

As it has been already noted, Crimean chaffinches and birds of nominate subspecies frequently added the "kit" element after the end of their songs. This element is absent in the repertoire of most of the birds from Caucasus and Transcaucasia (including the *F. c. alexandrovi* subspecies from Talysh Mountains) except for a few specimens from western Caucasus (Sultanov, 1991). Considering that the "kit" element was found at the 40°E, it is possibly a sign of hybridization between *F. c. caucasica* and *F. c. solomkoi*. We must conclude that at the area of Caucasian subspecies (i. e. to the east of 40°E) this element is absent from chaffinch repertoire.

Rain-call of Caucasian chaffinches is whistling but it sounds distinctly different from likewise whistling call of Crimean birds (Tsvelykh, 2003; Tsvelykh, 2011). Interestingly, at the western border of intergradation of *F. c. solomkoi* and *F. c. caucasica* (at the Northwest end of Caucasian ridge) a typical Caucasian chaffinch call is rare. Much common is the complete "rain-call"- like call consisting of strict alternation of the Crimean and Caucasian sequences of sounds (Tsvelykh, 2003). "Rain-calls" of *F. c. caucasica* consist of elements of (almost) the same frequency while Crimean chaffinches include elements of rapidly decreasing frequency (fig. 3). Besides, *F. c. caucasica* birds sing in frequency diapason exceedingly higher then 4 kHz while *F. c. solomkoi* sings in frequency less then 4 kHz (Tsvelykh, 2011).

Conclusion

We identified 38 song types in repertoire of *F. c. solomkoi* subspecies, of which 27 song types were more frequent. Typological structures of songs of the Crimean chaffinches and the nominative subspecies from Eastern Europe are distinctly different; there are no common song types. Comparative analysis of individual elements revealed that out of 108 song elements of *F. c. solomkoi* songs, 18 are specific to Crimean birds, 18 are common for *F. c. solomkoi* and Carpathian population of *F. c. coelebs* but not for *F. c. coelebs* from Eastern Europe plains. These shared elements may indicate remote relation of Crimean and Carpathian subspecies or (and) conservation of some relict song elements in these geographically disjunct mountainous populations. G. N. Simkin assumed possible existence of such "archaic" populations in these regions (Simkin, 1983). Comparative analysis of songs of Crimean chaffinches and *F. c. caucasica* subspecies also did not show any common song types. There is a certain similarity in structure of some songs between Crimean chaffinch and hybrid *F. c. solomkoi* and *F. c. caucasica* population from Northwest Caucasus. Other vocalization specifics

include drastic differences in rain-call structure between all subspecies and absence of “kit” element in songs of Caucasian subspecies.

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