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Aspects concerning the song of *Acrocephalus arundinaceus* (Great Reed Warbler), during reproduction

Constantin ION* and Ştefan Remus ZAMFIRESCU

University "Al. I. Cuza" Iasi, Faculty of Biology, University "Al. I. Cuza", str. Carol 11A, Iasi, 700506, Romania.
Corresponding author: C. Ion, E-mail: costin_zoo@yahoo.com

Abstract: The observations concerning the acoustic behaviour and the recordings of the songs of the Great Reed Warbler (*Acrocephalus arundinaceus*) were made during the reproduction periods, from April to July, in 2003 and 2004. During the reproduction period, while singing, the Great Reed Warbler shows a characteristic posture: he cleans his plumage with the peak; the plumage is slightly ruffled; the tail is spread; the head is orientated towards the lake or reed beds where it intends to establish a territory. Every time when the Great Reed Warbler sings, it chooses a high place for revealing his vocal repertoire. The Great Reed Warbler's song shows a considerable varied structure. In the studied area, the songs comprise six different types of units. The average song duration is 3.57± 0.10 s. The average number of units per song is 12.29± 0.96, whereas the average number of distinct units per song is 3.75± 0.81. There is a positive correlation between the song duration and the number of units per song. The highest amplitudes of the songs of the Great Reed Warbler from the studied area correspond to frequencies smaller than 3 kHz.

Key words: Great Reed Warbler, song duration, song units, spectrogram, relative amplitude spectrum.

Introduction

The ornithologists say that warblers, both males and females, are monomorphic, the colour of the plumage being gloomy, without any kind of ornaments (Cramp 1992). The male characteristics that attract the females to reproduce are the song, and especially the posture (Hasselquist 1998).

The song of the Great Reed Warbler is very complex. It comprises successive units that alternate in various ways, and consequently represents one of the most important behavioural characteristics. The male is the only one who sings. Great Warblers are able to modulate the volume, tonality, harmonic structure and the succession of the vocal units, which results in a great variety of signals for their potential parteners. However, the warblers could be easily missidentified if the species identification involves only morphological traits (Paspaleva 1977). In our opinion, a detailed analysis of the song would allow the recognition of its role and the species identification.

Some authors said that are possible to exist some differences between populations (Catchpole & Slater 1995) concerning songs structure. The principal aim of our study was to verify if there are some differences between western and eastern populations of the Great Reed Warbler knowing that the populations of these birds within the habitats are more numerous in the East of Europe than the West and in the East doesn't exist such analyses. In our opnion a hiher density of the Great Reed Warblers density could cause a more complex songs.

Material and Methods

The observations concerning the acoustic behaviour and the recordings of the songs were made during the reproduction periods of Great Reed Warbler, from April to July, in 2003 and 2004. The field investigations were carried out in two wet zones: Larga Jijia - Vladeni (21 km North from Iasi, 47º26'N, 27º15'E) and Botanical Garden (near Iasi, 47º11'N, 27º33'E).

For the behavioural observations, we performed 1 km long visual transect surveys and visual fixed point surveys, with the help of binoculars (10x50) and fieldscope (40x60).

We recorded the songs (as long as short songs described by Hasselquist & Bensch 1991) using a taperecorder Sony with an omnidirectional microphone (Sony). Then, 79 selected song recordings were transformed into digital sound files (.wav), which were processed in order to obtain spectograms and average amplitude spectra (sampling rate=44,100 Hz, sampling precision= 16 bit or 96 dB, Fast Fourier Transformation- 512 points, spectral line resolution= 86,133 Hz, time line resolution= 11.61ms, smoothing window function- Hanning). These representations allowed the investigation of song units (unit is similar with the syllable described by Cramp 1992), duration, frequencies and relative amplitudes. Consequently, the resulted data were statistically processed and interpreted (Fowler et al. 2000, Gerhardt 1998, Varvara & Zamfirescu 2001).

Results

Through the analysis of song repetitive structure we identified six types of units, noted A, B, B', C, D and D' (Fig. 1). The units types were analyzed separately. We also observed the postures and the behavioural movements of the warblers while they were singing, which are described at the discussion.

The unit A type is a strong sound with an approximate duration of 200ms (Fig. 2). This is the longest type. The relative amplitude peak corresponds to a frequency of 2 kHz (Fig. 3). The unit B type (Fig. 4) is the shortest (40-60ms). The energy of this unit is distributed to four distinct frequencies (1.8 kHz, 3 kHz, 4.7 kHz and 6.3 kHz); therefore the graphic shows 4 peaks (Fig. 5). The unit B' type is rather similar to the B type (Fig. 6) except it is longer (100ms). The spectrum reveals four better-outlined amplitude peaks (Fig. 7) that correspond to slightly higher frequencies. The unit type C (Fig. 8) is relatively similar to the A type, except it is shorter (100ms) and the maximum relative amplitude has a corresponding frequency of 3 kHz (Fig. 9), which is higher compared to the A type. The unit type D is structurally similar to the type B. The approximate duration is 130ms (Fig. 10). The maximum relative amplitude is distributed to several corresponding frequencies. The highest relative ampli-tude peak corresponds to 4 kHz (Fig. 11). The unit D' type is not very different from the D type. Its approximate duration is 130 ms (Fig. 12). There are several amplitude peaks, among which the highest corresponds to 3 kHz (Fig. 13).

We also made a statistic description of 79 analysed Reed Warbler songs (Table 1). During the reproduction period, the average duration of the song was 3.57± 0.10s (Table 1). The longest song duration of all was 13.04s, while the shortest was 0.8s. The average number of units per song in *Acrocephalus arundinaceus* was 12.29±0.96 (p=0.95). The maximum value of this characteristic was 40, while the minimum one was 3. (Table 1). The average number of types of units per song was 3.75±0.81 (p=0.95). The maximum value of this variable was 5, whereas the minimum one was 2.

The song duration and the number of units per song are correlated (R^2= 0.748). The determination coefficient (R^2) shows that approximately 74% of the values of these two variables are correlated (Fig. 14). The repertoire siye can be correlated with some measures of habitat quality, such as the amount of high quality reed within the territory as is shown in: Catchpole & Slater 1995.

The correlation between unit types and song duration is faible (36). It means that if the songs are longer is not necesarely to be more distinct units.

In order to outline the characteristics of the 79 analysed songs, we produced average amplitude relative spectra (Fig. 15). This analyse could represent a base for future researches concerning intraspecific differences in songs structure. Each song gave 252 frequencies and the corresponding amplitude values. For each frequency we computed the average of the 79 corresponding amplitudes and the 95 confidence interval (Fig. 15).

The amplitude peak corresponds to the 3 kHz frequency, and decreases at frequencies higher than 4 kHz.

Discussion

Immediately after the spring migration, the singing warblers are sporadic. After the warblers recover their

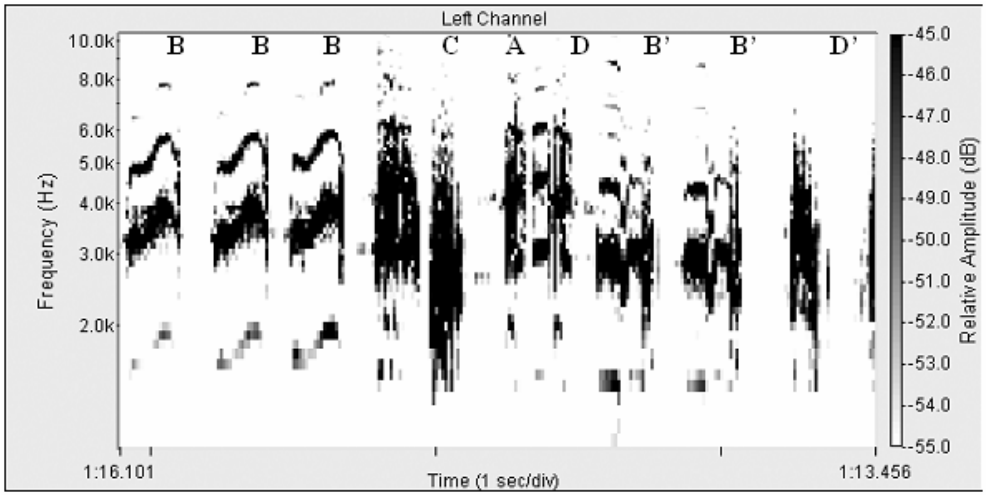

Figure 1. Spectrogram of a song of *Acrocephalus arundinaceus*- unit types

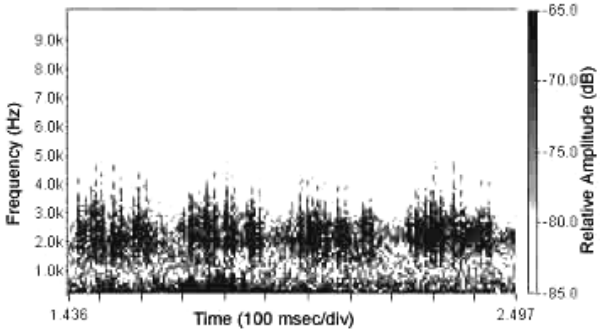

Figure 2. Spectrogram of four units type A

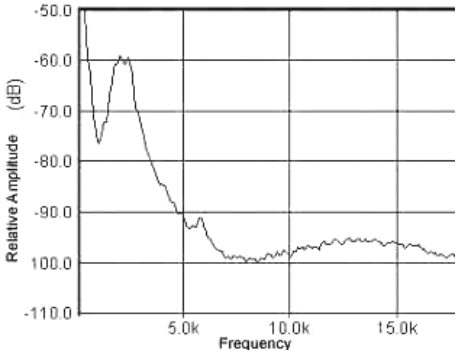

Figure 3. Relative amplitude spectrum of unit type A

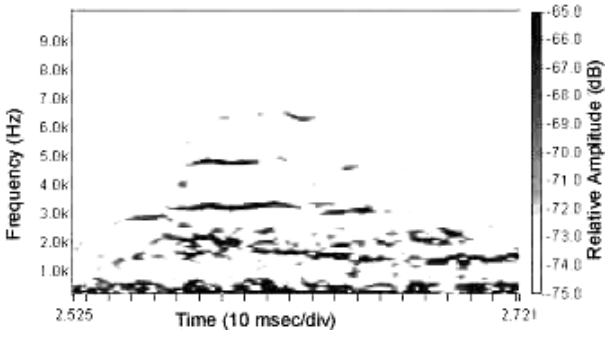

Figure 4. Spectrogram of unit type B at

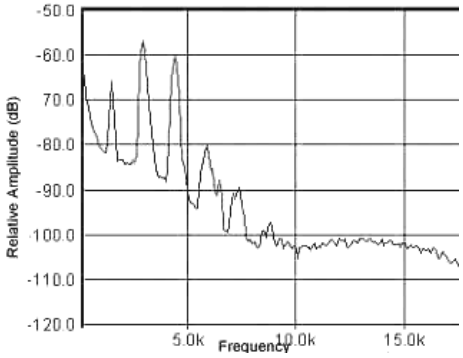

Figure 5. Relative amplitude spectrum of unit type B

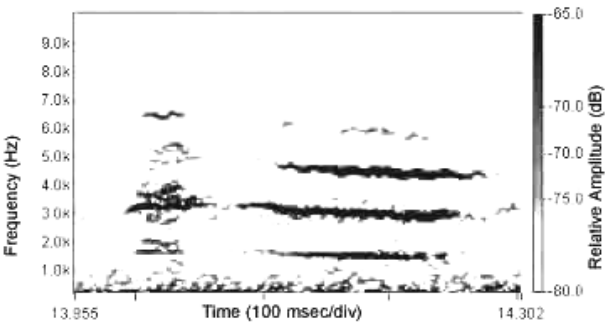

Figure 6. Spectrogram of unit type B (left) and B′ (right)

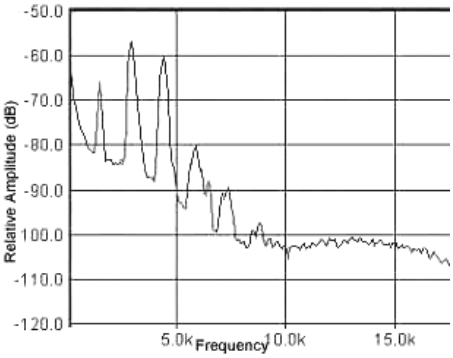

Figure 7. Relative amplitude spectrum of unit type B′

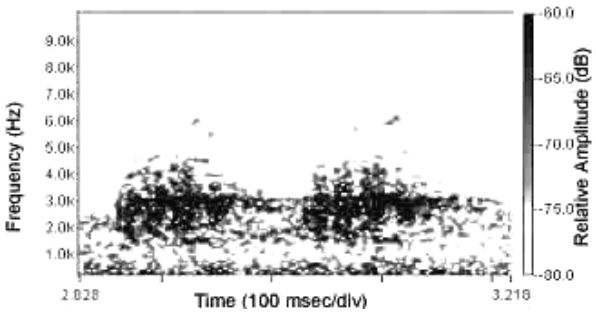

Figure 8. Spectrogram of two units type C

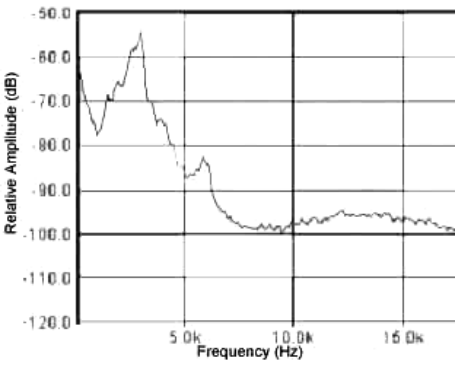

Figure 9. Relative amplitude spectrum of unit type C

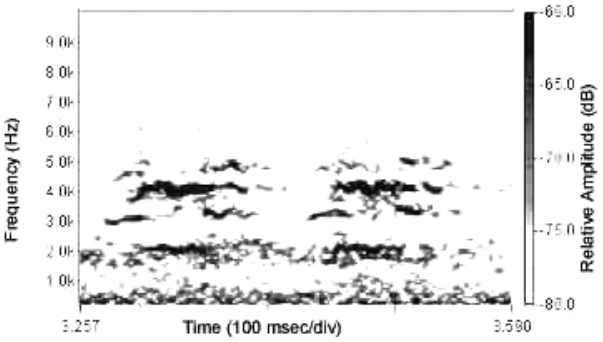

Figure 10. Spectrogram of two units type D

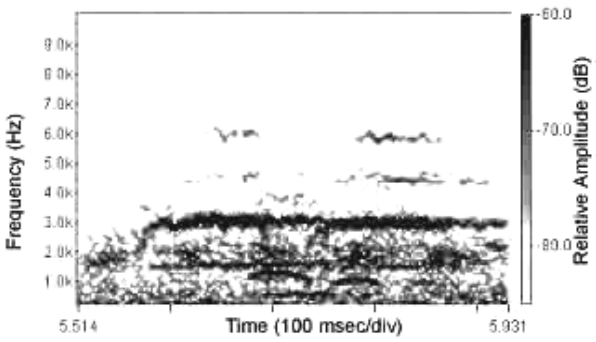

Figure 12. Spectrogram of two units type D′

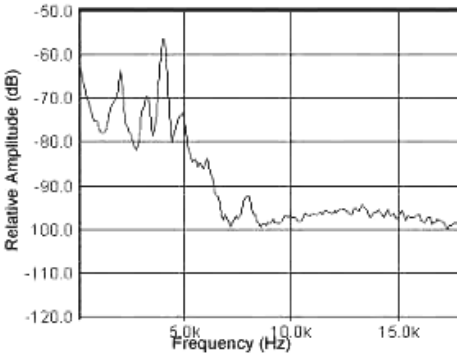

Figure 11. Relative amplitude spectrum of unit type D

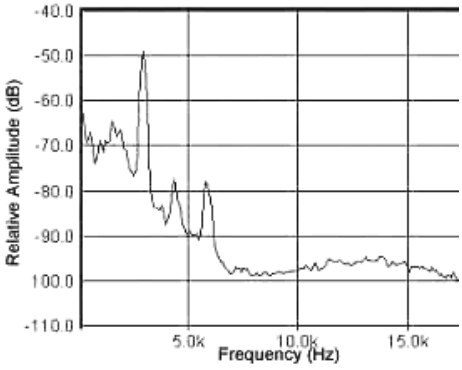

Figure 13. Relative amplitude spectrum of unit type D′

Table 1. Statistic description of song duration, number of units per song and number of types of units per song at *Acrocephalus arundinaceus*

	Time	No. of units	No. of type of units
Count	79	79	79
Mean	3.572658228	12.29114	3.759494
Standard Error	0.228991177	0.695689	0.108418
Median	3.18	12	4
Mode	3.41	12	4
Standard Deviation	2.0353181	6.183418	0.963636
Range	12.24	37	4
Minimum	0.8	3	2
Maximum	13.04	40	6
Standrad error x $t_{(0,05, 78)}$	0.455886517	1.385011	0.215843
Inferior Limit (Mean- Standrad error x $t_{(0,05, 78)}$)	3.116771711	11.3276	2.948034
Superior Limit (Mean+ Standrad error x $t_{(0,05, 78)}$)	4.028544745	13.67615	4.570953

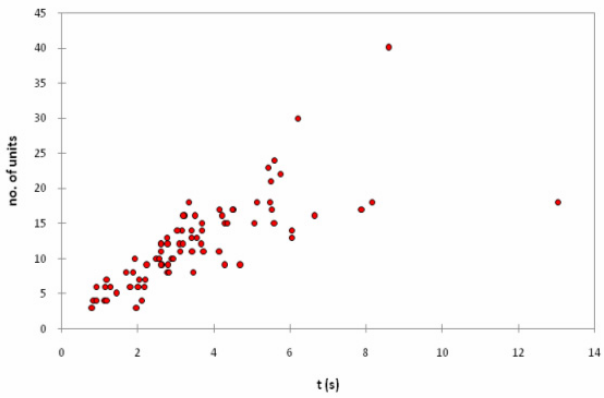

Figure 14. Corelation chart between song duration and number of units per song at *Acrocephalus arundinaceus*

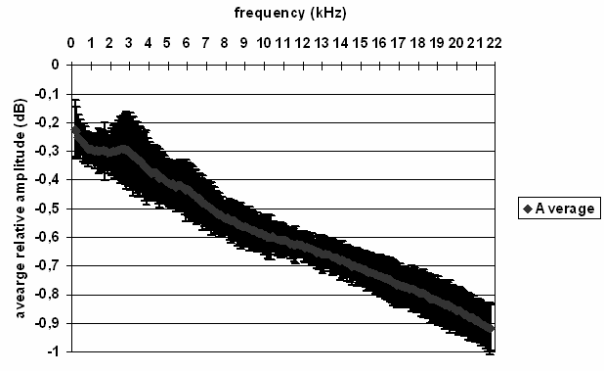

Figure 15. The medium spectrum of songs at *Acrocephalus arundinaceus*

energetic reserve, the songs become complex and they are sung all day long until the paring period. While a Great Reed Warbler sings, it adopts a characteristic posture: it cleans its plumage with the peak; the plumage is slightly ruffled; the tail is easily spread; the head is orientated towards the water surface or the inner reeds beds. Sometimes the Great Reed Warblers make short pauses for cleaning the head or throat plumage with the help of one claw. The females of the Great Reed Warblers come later than males in the breeding territories. They are feeding inner the reeds beds and fly over the water searching for males with which they will mate.

The songs are well heard during the morning. The singing warblers form a true chorus during spring days. The echo from around contributes to the sonority of the songs. At dawn, the warblers sing more intensily because during this period of the day they do not forage. It is too cold for insects to fly and too dark for them to be observed by warblers. Other observations (Capek & Kloubec 2002) show that during the day, only humidity evidently influences the song of the Great Reed Warbler.

The rising sun may warm the air before it reaches the land, so that a layer of cold air may form between the ground and the warming sky above. One of the characteristics of sound waves is that, rather than cross the boundary between cold and warm air, they tend to be deflected by it. Sound waves, instead of escaping upwards into the sky, are bent downwards, funnelled along the invisible aerial conduit (Attenborough 1998).

We noticed that the Great Reed Warbler males use reed tips for singing. Each time the Great Reed Warbler sings, it chooses a high place to reveal its vocal repertoire. Singing their territorial songs from a high place, like reed tips, assure, acording some specialists (Jilka & Leisler 1974, in: Cramp 1992) an "optimal sonorous penetration".

Although, the literature (Panov 1973, in: Cramp 1992) mentions that the Great Reed Warbler sings in flight during the breeding period, we observed this behaviour, only in the morning, and never in the afternoon or in the evening.

The Great Reed Warbler's song shows a considerable varied structure (Ion, 2007). In the studied area, the songs comprised six different types of units. The number of units is close to the values given by the literature (Cramp 1992). The number of units per song is a little greater than the one given by other researchers (Cramp 1992, Hasselquist 1998, Nowicki et. al. 2000). We consider that this difference is due to the recordings which were made in the most active period of warblers, in the reproduction phase. It is possible also to exist differences between populations of the Great Reed Warbler from Eastern Europe and Westearn or Central Europe. In literature is mentioned (Catchpole & Slater 1995) that differences concerning songs between populations are most obvious in species where each bird sings only one or a few songs type, and where neighbour sharing is high, in other words where there is little variation within an area. In these category of birds is subscribed the great Reed Warbler.

The warblers emit two types of songs: complex and signal songs. The complex songs are a succession of units that make up phrases delimited by short pauses and are emitted only by males. The signal songs are for advertisment or for defending, and both partners can emit them. Bensch (1992) mentions that the male of the Great Reed Warbler emits two types of song: long and short. The long song is used for attracting the females towards the territory, while the short one is for defending the fertile females.

We observed a positive correlation between the song duration and the number of units per song. Indiferent to

the length of the songs, the units are emited with the same cadence, explains the correlation between the song duration and the number of units per song. The average duration of the song determined by us is almost similar to that described in literature (Cramp 1992, Hasselquist 1998).

Generally, as it is mentioned in literature (Cramp 1992), a song comprises up to three or four phrases. The vocal timbre of the Great Reed Warbler is varied. Principally, the song is divided into two segments (Cramp 1992). Our observations emphasized that the first phrase has a longer duration, with higher relative amplitude. The second phrase is shorter, with relatively lower amplitudes. The duration of a phrase is very important because females tend to choose males whose songs compris the longer units (O`Loghlen & Bucher 1999). The complex studies (Forstmeier and Leisler, 2004) concerning the song analysis show that the duration and the complexity of the vocal repertoire are positively correlated with juvenile viability, reproduction success and male longevity.

The highest amplitudes of the songs of the Great Reed Warbler from the studied area correspond to frequencies smaller than 3 kHz, which is different form other warblers species (Cramp 1992).

Thus, considering the structural variation of songs relative to posture and behavioural movements, one will be able to interpret the significance of the Great Reed Warbler's song and behaviour.

Aknowlwdgements. We declare that our experiments comply with the current laws of the Romania and European Committee.

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