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ACOUSTIC FEATURES OF RED DEER (*CERVUS ELAPHUS*) STAGS VOCALIZATIONS IN THE CANSIGLIO FOREST (NE ITALY, 2001-2002)

AKUSTIČNE ZNAČILNOSTI OGLAŠANJA JELENJIH SAMCEV (*CERVUS ELAPHUS*) V GOZDU CANSIGLIO (SV ITALIJA, 2001-2001)

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ABSTRACT

Acoustic features of Red Deer (*Cervus elaphus*) stags vocalizations in the Cansiglio Forest (NE Italy, 2001-2002)

During the rut in the years 2001-2002 in the Cansiglio Forest (NE Italy), more then 1300 vocalizations of red deer stags were recorded and analyzed. The acoustic analysis showed an evident spectrographic and temporal heterogeneity, so that we could classify them in 11 different classes. In particular, for the analyzed population, we found a clear distinction between three principal temporal classes, so we described the acoustic repertoire of the stags population during the considered rutting seasons.

Keywords: Red deer, free-ranging population, grunt roars and coughs.

IZVLEČEK

Akustične značilnosti oglašanja jelenjih samcev (*Cervus elaphus*) v gozdu Cansiglio (SV Italija, 2001-2001)

Med jelenjim rukom v letih 2001-2002 je bilo v gozdu Cansiglio (SV Italija) posnetih in analiziranih več kot 1300 oglašanj samcev. Zvočna analiza je pokazala značilno spektrografsko in časovno heterogenost, tako da smo oglašanja lahko razporedili v 11 skupin. Še posebej jasno so se na osnovi časovnih parametrov razlikovale tri skupine, zato smo lahko opisali zvočni nabor populacije samcev med obravnavno sezono ruka.

Ključne besede: jelen, prosto živeča populacija, rukanje in kašljanje.

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INTRODUCTION

This work deals with the Red Deer (*Cervus elaphus*) stag rutting calls in the Cansiglio Forest (North-East Italy, Veneto region).

Although some researches on the acoustic behaviour of Fallow Deer (*Dama dama*) and Red Deer have been done in captivity or in a semi-domesticated condition (FITCH & REBY 2001, LONG et al. 1998, PÉPIN et al. 2001, REBY et al. 1998), the studies on free-ranging populations (REBY & MCCOMB 2003, MCCOMB 2001) are scarce.

The goal of this work was to study and characterize the acoustical features of the roaring stags in the Cansiglio population (VAZZOLA et al. 2005). The question to answer was whether it were possible to develop an analysis procedure to identify general and individual acoustic features and separate those features that are related to the dimensions of the anatomical structures involved in the sound emission (source-filter theory) from those probably related to the personality and motivational status of each individual. In this work we describe the acoustic repertoire of the Cansiglio stags population during the 2001-2002 rutting calls seasons and identify the acoustic parameters that allow individual classification (FAVARETTO et al. 2005).

MATERIALS AND METHODS

More than 60 hours of red deer stags vocalizations were recorded in the Cansiglio Forest (Alps, North Italy, altitude 1000 m a.s.l.) during the 2001 and 2002 rutting seasons (September-October), by using a Beyerdynamic MC-737 shotgun microphone connected to an Apple iBook G3 laptop. The acoustic signals were recorded on the laptop by using a USB Roland UA-30 external audio interface and the Bias Peak 2.6 TDM software, in monophonic mode with 44.1 kHz sampling rate and 16 bit resolution.

The recordings were browsed, selected, divided into categories and, whenever possible, classified according to recognized individual emitters. Analyses were made with Praat (V. 4.0.12, P. Boersma and D. Weenink, University of Amsterdam, The Netherlands, www.praat.org), a software originally developed for speech analysis. We discarded from the analyses all the sounds showing: acoustic overlap of different roars, bad spectrographic display (acoustic signal level too low), environmental noise (caused by rain, wind, airplanes, cars, etc.).

More than 1300 sound units, commonly called roars, belonging to 7 different stags, were analyzed, measured and categorized (Tab. 1). Then we analyzed how these sound units were sequenced (organized temporally) to possibly identify and classify higher level structures, the bouts.

Temporal variables (sound units duration, total duration, number of units, pause between two consecutive units) and spectrographic variables (Fundamental frequency, F0, and Formants, F1, F2..F8) were measured by using the software PRAAT. Temporal variables were measured by selecting every sound unit in the PRAAT spectrographic window. F0 was measured every 20 ms time step in the frequency range between 50 to 250

Hz. Then we measured three values to characterize F0: the highest value (F0max), the lowest (F0min) and the average value (F0med). The first eight formants were measured by processing spectra with the "cepstral smoothing" command (bandwidth: 100 Hz). F0 was measured in all the sounds showing at least one harmonic segment; instead, the formants were measured in those sounds showing at least an harsh "plateau" of stable and no-modulated frequencies, corresponding to maximum elongation of the vocal tract length (Reby & McComb 2003b, Fitch et al. 2001, Wilden et al. 1998).

RESULTS

By analysing the spectrograms, we identified four basic different acoustic types: sounds which contain both harmonic and chaotic structures (Reby & McComb 2003), sounds exclusively harmonic, sounds exclusively harsh and sounds we aren't able to distinguish any clear acoustic structure in.

Considering their temporal aggregation, the sounds are emitted in bouts: every bout is composed by a variable number of sound units, typically ranging from one to 10 and more.

The analysis of the duration showed a clear distinction of all the sounds in three principal categories (Fig. 1 & 2): the "common roar", the "grunt roar" and the "cough". The average duration of the common roar was 0.89 s (SD=0.3) with a repetition rate within a bout = 0.91/s. The grunt roars are shorter than the common roars; they are emitted in fast bout, usually consisting of 3 to 9 units, with a strong harsh characterization. The average duration of the grunt roar was 0.18 s (SD=0.08) with a repetition rate within a bout = 1.82/s.

The cough is shorter than the grunt; it lacks a clear tonal structure, and it seems to be like an human cough (Fig. 10). It has average duration 0.076 s (SD = 0.032) and it is emitted in fast series, typically when the stag runs after another stag or hind. It is normally repeated 3 to 5 times with a repetition rate = 4.13/s. We called "cough" this kind of vocalization that was never described before.

Based on the duration measures we identify the following bout categories:

1. common roar bout (Fig. 5):
   bout composed only by common roars (average duration of 2.88 s, average number of roars=2.6, min number of roars=1, max =12; SD =1.93).
2. grunt roar bout (Fig. 11):
   bout composed by grunt roars emitted in series, harsh in most cases (average duration of bouts= 4.64 s; SD=1.7; average number of roars= 6.22); in this bout often do appear also some common roars especially in the final position, but sometimes also in the initial one.
3. cough bout (Fig. 10):
   bout composed by coughs. In rare cases this bout can end with a common roar.

The grunt roars bouts are emitted more frequently when the rutting season raises the climax; so, the common roar bouts are more numerous all along the season, in the ratio of circa 10:1 (FAVARETTO 2004).

The three categories of bout seen above may show variable roars composition. Combining the duration measures and the spectrographic analyses, we divided all the sounds in 8 subcategories, obtaining the following possibilities of bout composition:

Common roar bout composition

1. harmonic common roar: sound completely harmonic (Fig. 3, 5).
2. harsh common roar: sound completely harsh (Fig. 4).
3. mixed common roar.

3.1. harmonic part followed by an harsh one (Fig. 5, 8).
3.2. two or more harsh segments (Fig. 6).
3.3. first harsh, then harmonic (Fig. 9).
3.4. first harmonic, then harsh, then harmonic again (Fig. 7).

4. "vague" common roar: sometimes emitted as last sound in a bout. The acoustic structure is not clear, the average duration 0.6 s (Fig. 5).

Grunt roar bout composition

5. *incipit:* the sound that sometimes begin a grunt roar bout: it is a common roar longer then a grunt, normally with harsh structure (Fig. 11).
6. grunt roar.
7. closing roar: it is the roar that closes a grunt roar bout, normally with harsh structure. The duration is quite long. It's a sound that shows formant's stability (Fig. 11).

Coughs bout composition

8. cough (Fig. 10), rarely ending with a common roar.

During the two years field experience we measured 1346 sounds, organized into ca. 500 bouts. Table 2 shows the average values of time-related variables. Once we classified the different sounds and bouts, we were able to analyze the pool of vocalizations with advanced statistical procedures to test our individual identification data.

By applying Discriminant analysis (SPSS 11.0) to the three categories of bouts we found that the grunt roar bouts exhibited the highest degree of separation into identifiable clusters that match our field observation on individually recognized individuals. By using the grunt roar bouts it was possible to correctly classify all the 7 different individuals with a high confidence degree (94.8%) (Fig. 12).

CONCLUSIONS

From the data gathered has emerged that the acoustic features of *C. elaphus* is more complex then expected; on the other hand, we described the repertoire of the Cansiglio

population that is based on acoustic units variably combined to generate different bouts. In particular, we found that grunt roar bouts convey individual features that may play an important role in the communication system of this species.

This study may lead to important applications in applied zoology, with the aim of widening the knowledge about the considered species and with the perspective of a concrete use in the demo-ecology field, in the wildlife management and in the monitoring of free-ranging animals.

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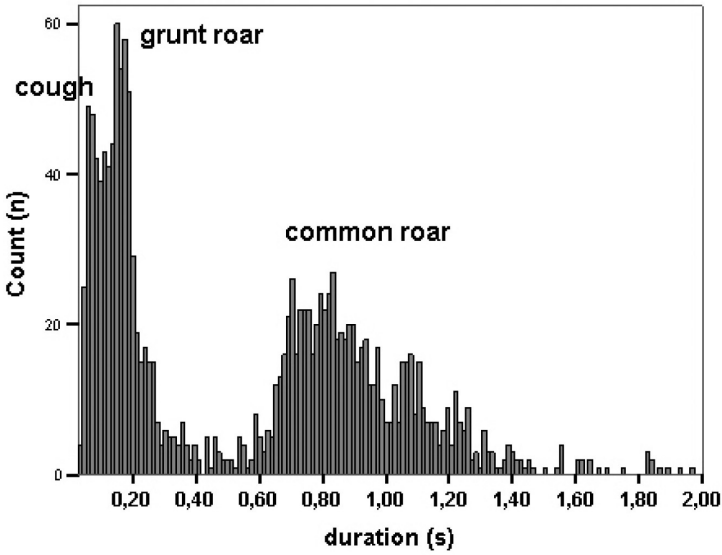

Figure 1: Duration of roars.

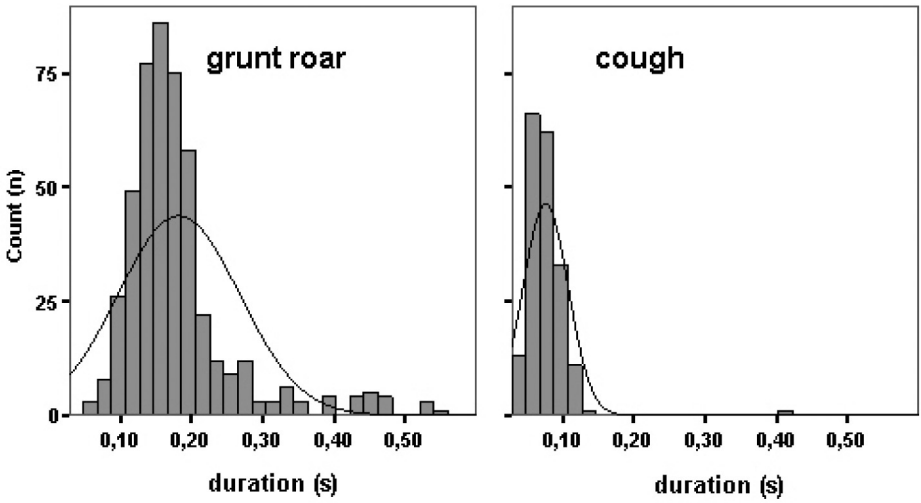

Figure 2: Duration of coughs and grunt roars.

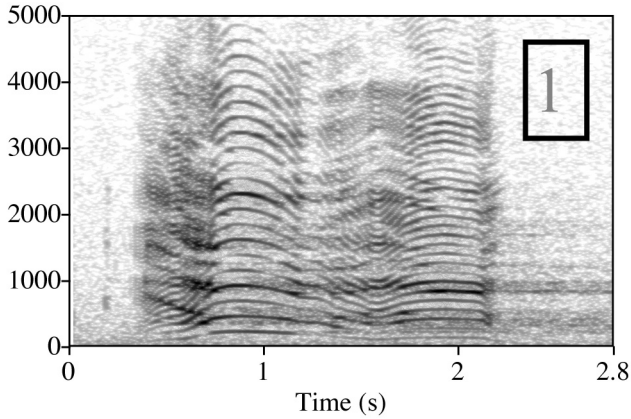

Figure 3: Vocalic common roar.

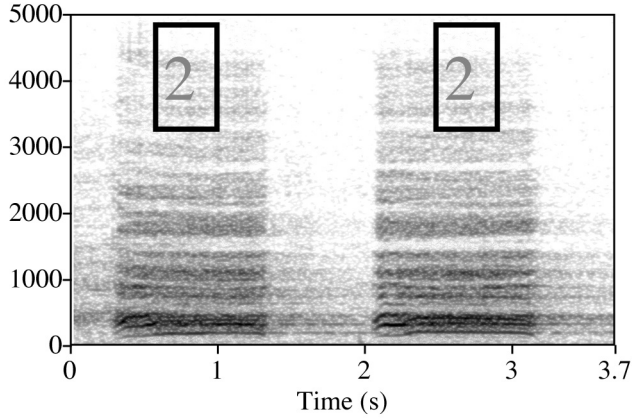

Figure 4: Harsh common roars.

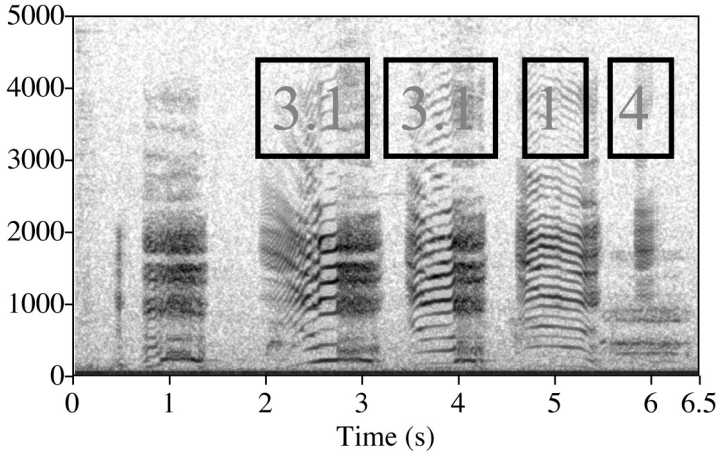

Figure 5: Common roar bout.

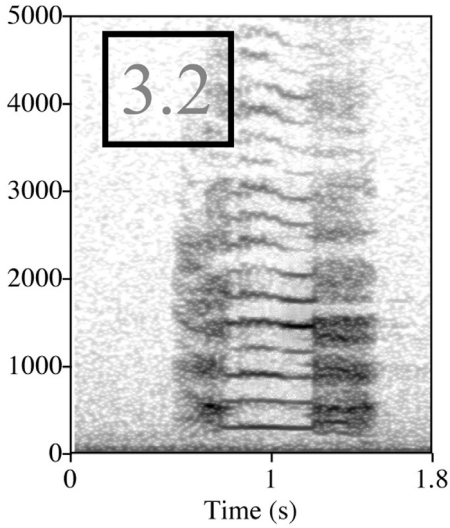

Figure 6: Common roar with two chaotic events.

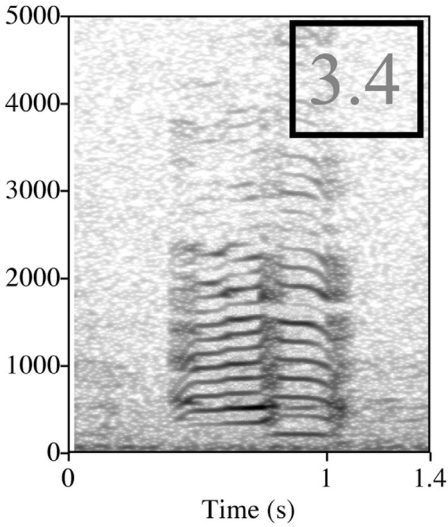

Figure 7: Common mixed twice vocalic.

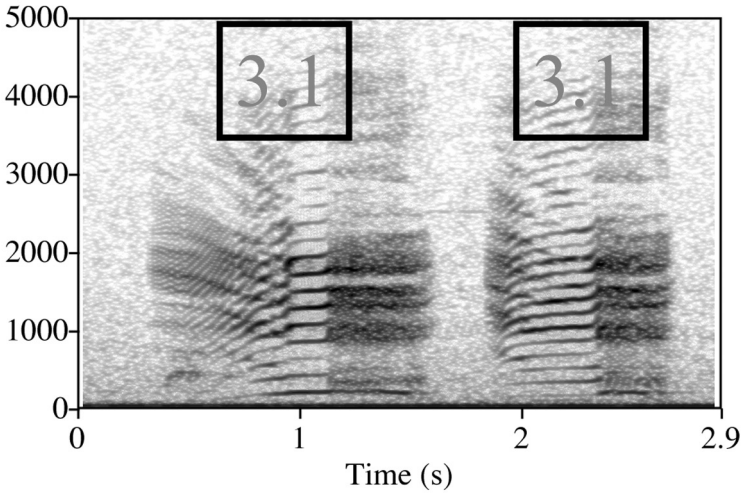

Figure 8: Normal common roar.

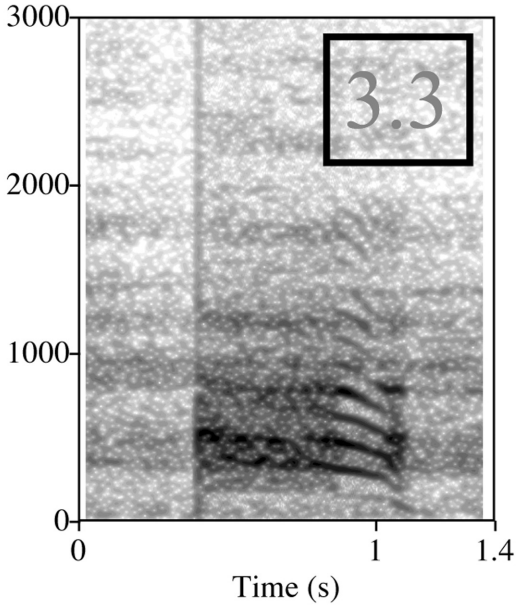

Figure 9: Common roar first harsh, then harmonic.

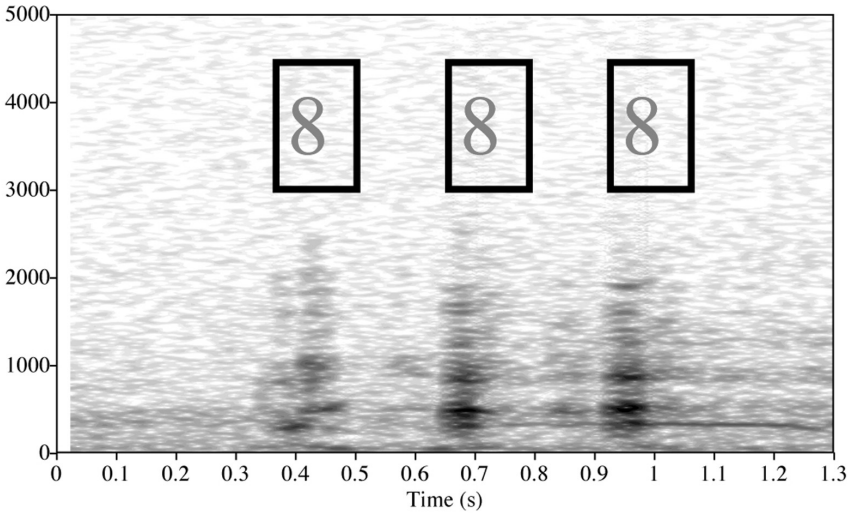

Figure 10: Cough's bout.

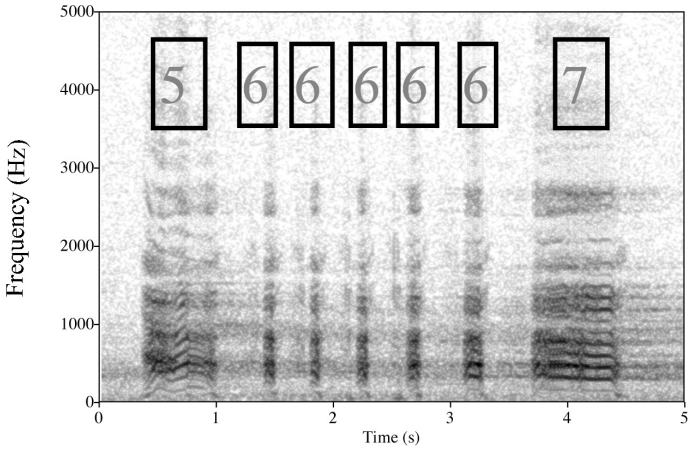

Figure 11: Grunt roar bout with incipit and closing roar.

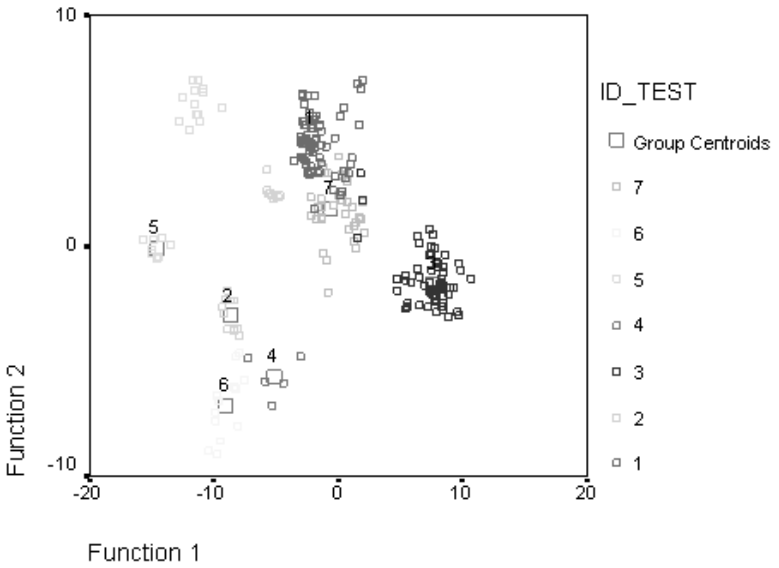

Figure 12: Cannonical discriminant function

Table 1: Average values of time-related variables

			Predicted Group Membership							Total
	ID_TEST		1.00	2.00	3.00	4.00	5.00	6.00	7.00	
Original	Count	1.00	72	0	0	0	0	0	0	72
		2.00	1	11	0	0	0	0	7	19
		3.00	0	0	62	0	0	0	3	65
		4.00	0	0	0	5	0	0	0	5
		5.00	1	0	0	0	20	0	0	21
		6.00	0	0	0	0	0	13	0	13
		7.00	0	0	0	0	0	0	37	37
	%	1.00	100	0	0	0	0	0	0	100
		2.00	5.3	57.9	0	0	0	0	36.8	100
		3.00	0	0	95.4	0	0	0	4.6	100
		4.00	0	0	0	100	0	0	0	100
		5.00	4.8	0	0	0	95.2	0	0	100
		6.00	0	0	0	0	0	100	0	100
		7.00	0	0	0	0	0	0	100	100
A 94.8 % of original grouped cases correctly classified										