Preliminary account on Stone Curlew (*Burhinus oedicnemus*) call repertoire.

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Introduction

Only song-birds (passerine birds) have true song, which is a sustained and complex vocal activity seasonally delivered mainly by males, with a sexual and territorial function. In contrast calls are usually simpler, they are normally given by males and females, both adult and young, all year round. Birds have often different calls given in particular contexts, each conveying particular information to listeners . These simple distinctions between songs and calls will suffice for the purposes of this paper, but it is worth saying that distinguishing between songs and calls sometimes it is not so clear-cut (Kroodsma 2005).
Some birds have a quite small call repertoire, others a very large one. Marler (2004) says that " ..relatively few have been intensively studied, and entire repertoire have not often been thoroughly documented. You have to be intimate with the entire behaviour of a species....throughout the life cycle, to give a reliable estimate of call repertoire size; and assembling such a catalogue is by no means straightforward. There are always problems about where boundaries between call categories should be drawn." If these statements are true for most birds, they are even more than true for Stone curlews, whose secretive, cryptic and nocturnal habits make harder the study of their vocal behaviour.
Maybe for this reason, the bioacoustic literature on this topic is very scarce; therefore I have compared my data with only two accounts about Stone curlew voice (Cramp 1983, Vaughan & Jennings 2005), the most complete in the existing literature, as far as I know. I shall often refer to these two works throughout this paper, trying to increase the knowledge of call repertoire of these birds.
Despite the difficulties linked to the behaviour of Stone curlews, I think that a better knowledge of their calls is very interesting from a biological viewpoint, since bird calls serve many functions, which have a great importance in their life, especially in communication about issues that are vital for individual survival (Marler 2004).
Once we better know the categories of calls and we understand how they vary, it will be possible to relate the different calls to different contexts in which they are used, searching for the meaning in each sound. Of course this is a much harder and complex task, given the secretive and nocturnal behaviour of these birds.

Materials and methods

In this paper the Stone curlew calls will be named following the phonetic renderings used by Cramp (1983); in Table 1 the reader will find the correspondence between each verbal rendering and sonogram (when available) found in Cramp (1983), in Vaughan & Jennings (2005) and in the present work. Some data of table 1 are drawn also from Bergman & Helb (1982).

Call types of Stone curlew described in the literature and studied in this paper

Cramp 1983		**Vaughan & Jennings 2004**		**This work**	
Verbal rendering	***Sonogram***	***Verbal rendering***	***Sonogram***	***Verbal rendering***	***Sonogram***
Kurlee	Fig. II	kurlee	Fig.1a/1b	Turli (T)	Fig. 5
gallop-rythm	Fig. IV	tylliwick	Fig.4a/4b	PP	Fig. 3
kluii (call 8)	n.a.	klee	Fig. 3	Bisyllabic Tu-lii	Fig. 8
Kurlee II type	Fig. I	kurlee	Fig 1d	Turlì II type	Fig. 6
whee (call7)	Fig. V	phwee	Fig. 2	Monosyllabic whistle	Fig. 9
chhhwhIK	Fig.III b	shurr-ik	Fig.5a/5b	Strangled call	Fig. 10
Ker-vic(call 3)	n.a.	Kervic	n.a.	Bisyllabic PP	Fig. 4
Quig (call 10)	n.a.	Caw-wik	Fig.6a/6b	Not described	n.a.
Hissing (call 9)	n.a.	Hiss	n.a.	Not described	n.a.
Not described	n.a.	Whit	Fig.7a/7b	Not described	n.a.
Wuii wuii (call 7)	n.a.	Not described	n.a.	Fuii whistle	Fig. 11
Strangled kurlee	Fig.III a	Not described	n.a.	Strangled Turlì	Fig. 7

Table 1*:* Figures cited in column 2-4 are found in Cramp (1983) p. 77 and Vaughan & Jennings (2004) p. 60-68. Figures cited in column 6 are referred to the present work. n.a. = not available

The data shown in Figure 1 and Figure 2 were drawn from the field notes about Stone curlew spontaneous

vocalizations heard by the author and some other ornithologists in the Grosseto province since 2003. These field notes recorded the number of birds, the exact locality, time, date, call type (following the categorization shown in Table 1) and - when possible - the bird behaviour.
In the present study spontaneous vocalization means that it was uttered in the wild by an undisturbed bird and it was not induced by playback of conspecific calls. I made over 100 minutes of recording of spontaneous vocalization uttered by 20 Stone curlews in different locations of Grosseto province. Recordings were performed by night from 7 to 11 pm. and at dawn from 4 to 6 am., during early spring, summer and autumn, using a Marantz PMD 222 cassette recorder with an Audiotechnica AT815B shotgun microphone. Analog to digital conversion of the recorded songs was done using a standard audio chip of a PC. Sampling frequency of the audio files submitted to spectral analysis was 48 kHz with 16 bits accuracy. Sonograms were done by means of *SeaWave v. 1.1* software (Pavan 2001), with the parameters set as following: FFT size = 2048 points, scan step = 256 points, Window type Gaussian, overlap = 87,5% (frequency resolution = 23 Hz, time resolution 5 ms).
The use of playback recordings for studying elusive or secretive species was employed in a variety of studies over the last two decades to elicit behavioural or vocal responses from birds (Marion et all. 1981). Stone curlews have been censused with playback methods (Bibby et all. 2000; Tinarelli et all. 1990). In winter 2004, 2005 and 2006 - during a separate bird monitoring study undertaken to assess the wintering population (Giovacchini et all. 2007) - two different Stone curlew calls (kurlee and gallop rhythm calls - check Table 1) were played back by night in 140 different locations of Grosseto province. Each call was played for 1 minute, followed by about 2 minutes of listening time. Two such 6 minute sessions were performed in each location. The same two calls from the same bird were used as playback stimuli for all the 140 trials, therefore the results of this experiment should be treated only as preliminary suggestions, because pseudoreplication (McGregor 2000) arises from such a protocol. Before beginning this study I had not enough good quality call samples recorded from different birds and therefore I could not avoid this drawback.
The answers to these playback stimuli were recorded (when possible) and digitized with the apparatus described above. If the answering bird was too far or there were too loud background noises for getting an acceptable recording, then the number of answering birds and the call type were noted carefully following the categorization shown in Table 1.

Results

Figure 1 shows the seasonal pattern of Stone Curlew spontaneous vocal activity. Voice is freely used throughout the year, with a minimum in January, a first maximum in early spring and a second peak in summer; a sustained activity was recorded in autumn until November, when there is a noticeable decrease. This picture is quite similar to that recorded for 2004 in a previous work (Dragonetti 2005) performed in a very small area of Grosseto province. Cramp (1983) reports a picture of seasonal activity referred only to the breeding period, while there are no details from winter quarters. Vaughan & Jennings (2005) say that " although stone curlews may be heard at any time of the year, more calling is heard in spring and autumn, than in summer and winter."
Nine call types were recorded and identified. All these call types are described by Cramp (1983) and 8 out of 9 are reported by Vaughan & Jennings (2005) , as shown in Table 1.

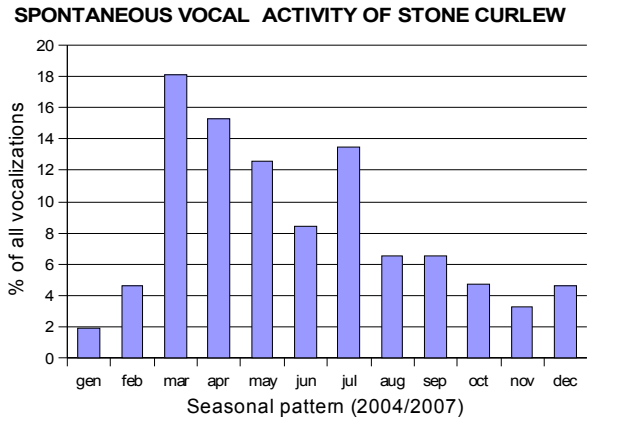

Figure 1 - Seasonal pattern of all call types.

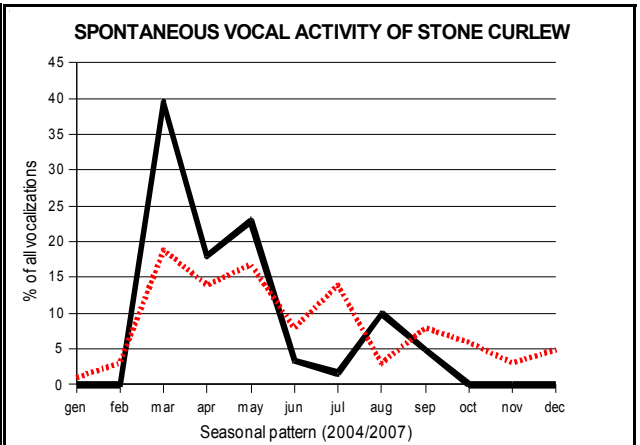

Figure 2 - Solid line: gallop rhythm calls. Dashed line: all other calls

One of the most common vocalization is gallop-rhythm call (Figure 3), which is mainly uttered during breeding season, associated with spring display (Cramp 1983). Vaughan & Jennings (2005) reports that this call is more often heard in spring and summer, less often in autumn roosts. The results shown in Figure 2 are consistent with these views: while all other calls are uttered throughout the year, the gallop-rhythm call

(as spontaneous vocalization) is only heard from March until September, with one peak in early spring and one (far less high) at the end of breeding season. Thus this call seems linked to the reproductive activity, but it is also true that during spring it is often accompanied by nearly all other call types (kurlee, kluii, chhhwhIK, wuii). It must be stressed that, like all other calls, gallop-rhythm is very variable either between or within individuals (see Figure 3); the number of syllables (from 2 to 7 in my recordings), the relative pitch, the length of each bout, the rhythm of repetitions are all variable features. Following Cramp (1983) it is " ..irregular (generally 3-5 syllables), but highly repetitious, in a high rapid series.." .
I have recorded this call in winter too, but only in response to playback stimulation and never as spontaneous vocal activity. Interestingly, this call type seems to be the most powerful playback stimulus, because it elicited 65,1% of total answers while kurlee call was effective only in 33,7% of cases (Chi^2 $P<0.01$). Moreover during playback stimulation Stone curlews matched the gallop-rhythm call type in 39 cases out of 54 (Chi^2 $P<0.01$), while kurlee call was matched only in 15 cases out of 28 (Chi^2 n.s.). The results of these statistic tests should be considered with caution for the reasons specified in the Method section.

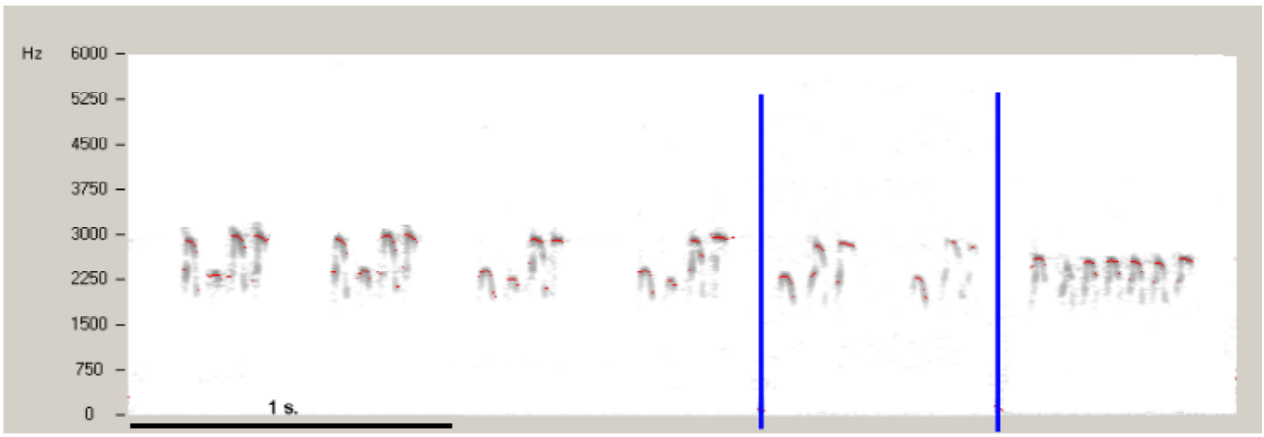

Figure 3: Gallop-rhythm calls recorded from 3 different birds. Note the different number of syllables and the variable pitch pattern.

The ker-vick call is categorized as a separate vocalization by Cramp (1983) and by Vaughan & Jennings (2005), but bearing in mind what stated above about the variability of gallop-rhythm call, it is preferable viewing it as a bisyllabic variant of gallop-rhythm call. This is confirmed by the sonogram (Figure 4), which shows a morphology strongly recalling that of gallop-rhythm vocalization. In my recordings this bisyllabic vocalization is intermingled with polysyllabic gallop-rhythm calls of the same bird. On the other hand Vaughan & Jennings (2005) says about the gallop-rhythm call : "...this rapidly repeated, usually trisyllabic call, ... could be considered a trisyllabic version of the ker-vick call."

Figure4: Kervick call is a bisyllabic variant of gallop-rhythm. Note the first trisyllabic phrase followed by kervick calls.

The kurlee call is probably the most used vocalization (Vaughan & Jennings 2005) and, like the above mentioned gallop-rhythm call, is quite variable. Three main versions can be described: the most typical - in my opinion - is the rolled trisyllabic form (Figure 5), while the bisyllabic non-rolled form (Figure 6) was recorded intermingled to the rolled form and in two cases it was between a rolled kurlee and a bisyllabic kluii call (Figure8). This last finding suggests that it might be an intermediate form between these two calls (kurlee

and kluii).
A third kurlee type is reported by Cramp (1983) as a common strangled version of kurlee call, while Vaughan & Jennings (2005) do not mention this vocalization. I have found such a call type (Figure 7) rhythmically mixed with the bisyllabic kurlee form and uttered before dawn in a spontaneous bout of calls.
These three call types too are highly variables in length, pitch, frequency modulation etc. This variability can be found within and between birds.
The first two kurlee types were commonly recorded in winter as answers to playback stimulation, although they were less frequent than gallop-rhythm call (see above). When used as playback stimulus, the kurlee call seemed less powerful than gallop-rhythm call and it was less matched by answering birds.

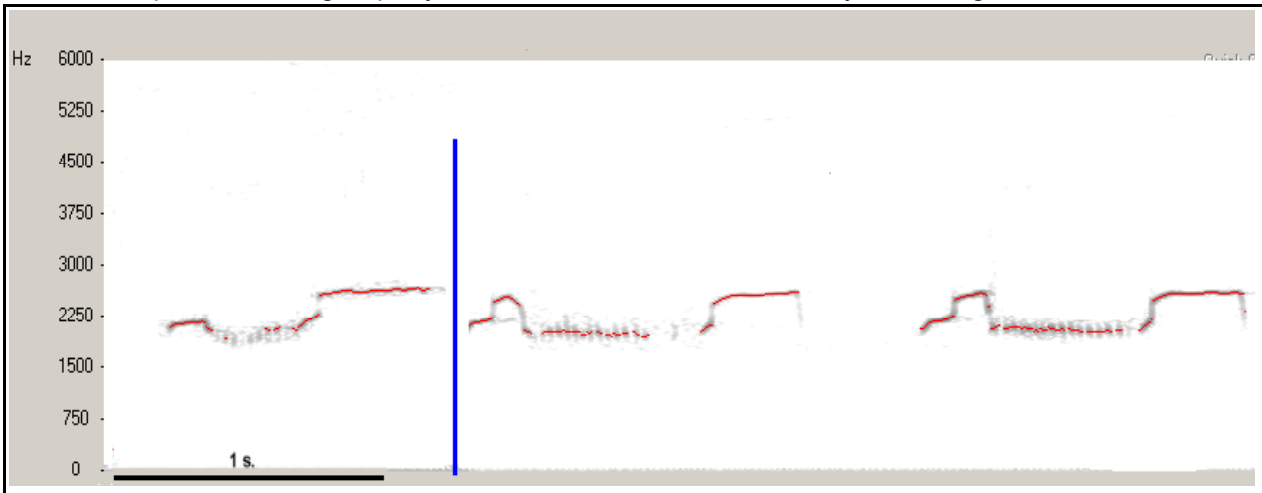

Figure 5: Kurlee calls from 2 different birds. This is the trisyllabic form: note the "rolled" part in the middle of the call.

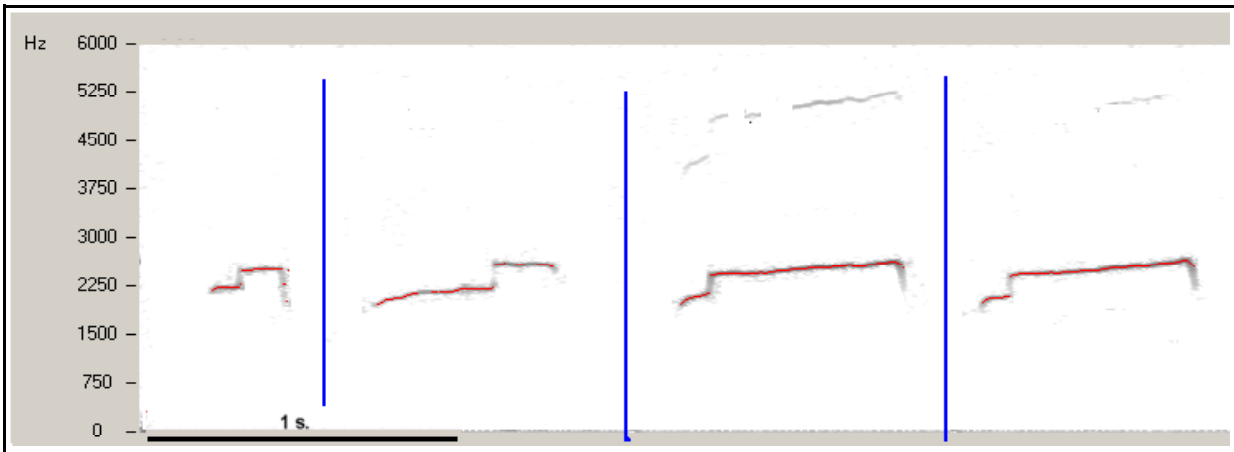

Figure 6: Bisyllabic kurlee call from 3 different birds. The two calls on the right are recorded from the same bird at different times.

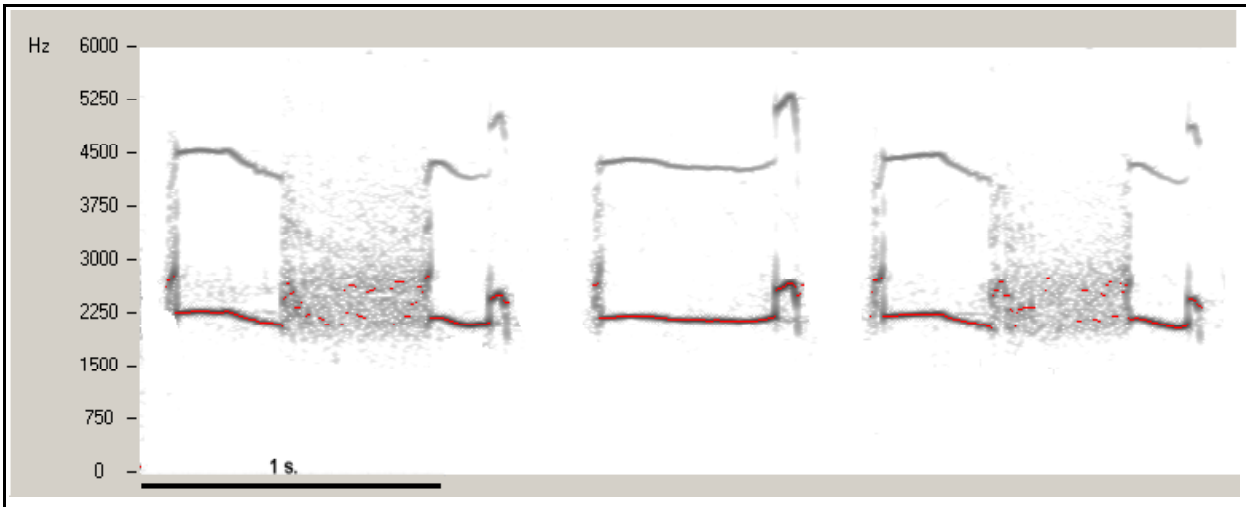

Figure 7: Strangled version of kurlee call, rhythmically alternated to a bisyllabic kurlee call.

The kluii call is a pure bitonal loud whistle (Figure 8) and a fairly common vocalization. I recorded it several times as an answer to playback stimulation in winter and as spontaneous vocalization. The call was uttered in flight or on the ground, in some cases when the birds were aware of my presence and therefore it could be an alarm call. However one bird recorded in March, during spontaneous vocalization on breeding ground, uttered some kluii calls, mixed with gallop-rhythm, kurlee and chhhwhIK calls. The common behavioural situation in both cases was a strong excitation.
Vaughan & Jennings (2005) reports this call when Stone curlews are flushed by humans or threatened by birds of prey, but on the other hand they say that the kluii call is often given at night by a bird in flight when there seems to be no cause for alarm or element of warning. It is apparently used as a contact call too. Cramp (1983) reports that "bird flushed by intruder shows a single quick liquid kluii".

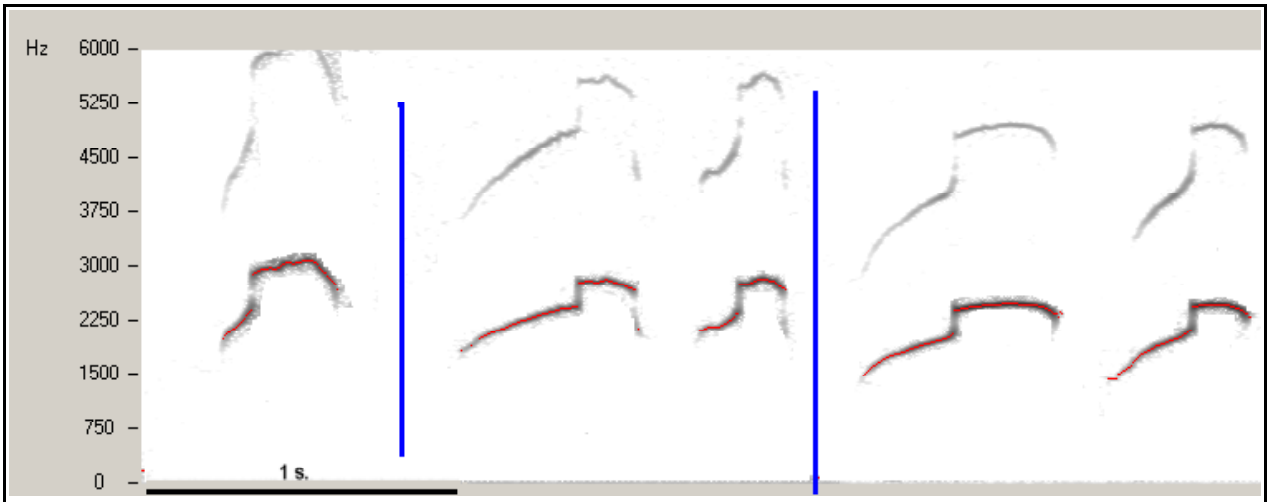

Figure 8: Kluii calls uttered by 3 different birds.

The whee call is a penetrating monosyllabic whistle (Figure9) less commonly heard. I recorded it mainly during early spring, spontaneously uttered on breeding ground, but it was also heard after playback stimulation in winter. It is greatly variable in frequency modulation and duration.
Vaughan & Jennings (2005) describe this call as a territorial vocalization and Cramp (1983) associates it with spring display.

Figure 9: Whee calls recorded from 2 different birds.

The chhhwhIK call is a strangled drawn-out sound lasting with a sharp high pitched note (Figure 10). I recorded it during early spring on breeding ground and in two cases I heard it also in winter after playback stimulation. In most cases this call introduces either the gallop-rhythm or the kurlee calls and it shows a slight difference in morphology in these two different situations (see Figure 10). When introducing a bout of gallop-rhythm calls, the chhhwhIK shows a rhythmic pattern that sounds like the subsequent vocalization, while it is more drawn out, if uttered before a kurlee bout or alone.

Vaughan & Jennings (2005) say that it is associated with sexual and social display both in spring and autumn. The same call was considered an alarm vocalization by Cramp (1983).

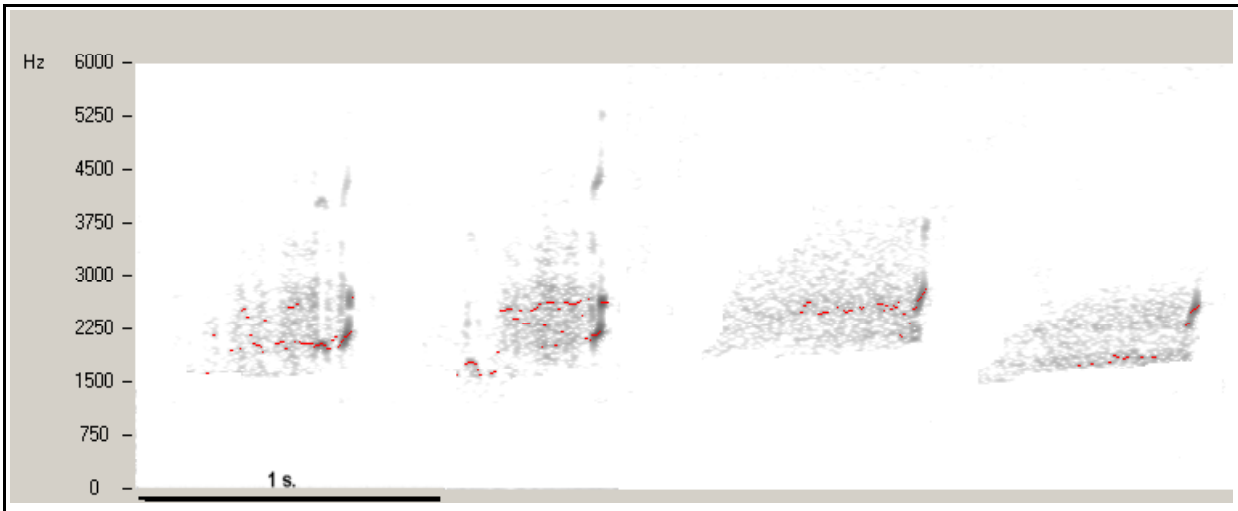

Figure 10: The chhhwhIK call: the first two calls from the left were uttered before a gallop-rhythm bout, the third call was before a kurlee bout and the fourth was alone.

In my recordings I have found an increasingly high pitched whistle (Figure 11) which fits well the description of the wuii call made by Cramp (1983 - check call 7 p.77). Unfortunately Cramp (1983) doesn't report a sonogram to validate my opinion, however in table 1 I considered these two calls the same. Vaughan & Jennings (2005) have not succeeded to identify such a vocalization.
I never recorded this call after playback stimulation; it was uttered at the end of spontaneous bouts of gallop-rhythm / kurlee calls and at the beginning of a bout of chhhwhIK / gallop-rhythm calls. Therefore it seems seldom uttered together with other more common call types. As reported by Cramp (1983) for the wuii call, I heard this vocalization only in early spring on breeding grounds.

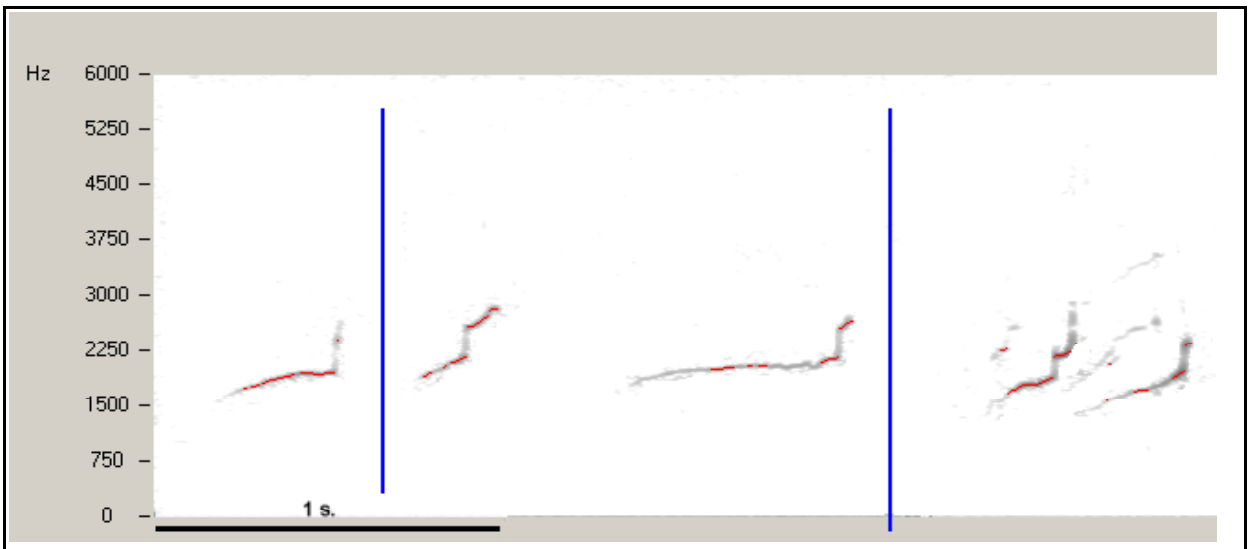

Figure 11: Wuii calls recorded from 3 different birds during early spring.

I was not able to record two calls cited both by Cramp (1983) and by Vaughan & Jennings (2005), probably because these vocalization are uttered only in some particular contexts and they are audible only at close quarters. The quig call (table 1) is uttered by the birds near the nest with eggs, between pairs when nest scraping or between adults and chicks.
The hissing call (table 1) is unlikely to be audible to humans at the distance from which Stone curlews normally have to be watched (Vaughan & Jennings 2005). It is considered a threat call recorded between fighting birds (Cramp 1983) and uttered by a pair in a threat display against a sheep (Vaughan & Jennings 2005). It is also reported during distraction-display (Wadewitz 1955).
I have ignored several other calls cited only by Vaughan & Jennings 2005 (toy-it call and kwaa call) or only by Cramp 1983 (a rasping cu-ick recalling Nightjar, a mournful piping duuu - a monosyllabic whistle? - and a

yelping tuEE like Oystercatcher - maybe a bisyllabic whistle ?). The absence of sonograms make very difficult a comparison with my work and on the other hand these vocalizations appear to be quite rarely heard.

Discussion and conclusion

Stone curlews are relatively noisy birds during spring and summer, but they can be quite easily heard during autumn and winter nights too. Their call repertoire is relatively limited, consisting mainly of two most commonly used call types: the kurlee call and the gallop-rhythm call. The other call types are less frequently used.
I agree with Vaughan & Jennings (2005) who state that "...each of these sounds varies infinitely in itself and often merges with others so that there is a gradation between them.."...and... "....in any bout of calling, the tempo and intensity of the calls may vary considerably. They may be spaced out and subdued at the start of a bout and tail off at the end, particularly in bouts of gallop-rhythm and kurlee." Therefore the categorization I have used is to be viewed mainly as an attempt to isolate and describe the better-known calls; unfortunately the meanings of the vocabulary of Stone curlew are still poorly understood, largely because of its nocturnal and secretive habits.
Most of the Stone curlew calls do not seem to be specialised in function, because a bird may use a variety of different calls in a single circumstance and these same calls may be used in different circumstances. This puzzling feature, found either by Cramp (1983) and by Vaughan & Jennings (2005), is confirmed by the results shown in this paper too: particularly during spring on breeding ground, I could record almost the entire call repertoire. A mix of different calls was the rule observed in many different circumstances.
Only one call (the gallop-rhythm call - check Figure 2) can be related to the reproductive season and therefore might be associated, albeit together with other vocalizations, with heterosexual / territorial behaviours. A similar idea is suggested by Cramp (1983), who states "..it is associated with spring display, when may be accompanied by dancing leaps.....". Vaughan & Jennings (2005) too found that "...it is more often heard in spring and summer; less often at autumn roosts." Moreover the fact that playback stimulation in winter made with this call type is the most effective in eliciting an answer supports the idea that this is a reproductive / territorial vocalization. It is well known that in some passerine species spring song has a strong attractive power towards conspecifics, even if it is broadcasted in autumn or winter. The results shown here suggest that this could be true even for a non passerine species like the Stone curlew.
The results of playback stimulation in winter show that almost every call type is uttered in response to the stimuli, further supporting the view of a non specialised function of most call types. The exception is the gallop-rhythm call, which elicited responses with a significantly higher rate of the same call type: a similar call matching phenomenon was found in a corvid species (*Cyanocitta cristata*) by Kroodsma (2005). This account on Stone curlew vocalizations is of course largely incomplete - maybe all the existing accounts are not completely satisfying - but I hope that my contribution can be useful for a better definition and morphological characterization of this species vocabulary. Further studies are needed about the correspondence between each call and the bird behaviour for better understanding Stone curlew vocal activity. This will need in turn a development of new techniques which will enable the observers to follow and study these birds during their nocturnal activity.

Abstract. Stone curlew calls spontaneously uttered and stimulated by playback were recorded in Grosseto province (Italy) since 2004. These recordings were analysed by means of sonograms for better defining the morphology of each vocalization. The results were compared to the two most complete account in the literature about Stone curlew vocal behaviour (Cramp 1983; Vaughan & Jennings 2005). Nine call types were described and analysed, but only two are the most commonly used. All this repertoire is described by Cramp and eight calls are reported by Vaughan & Jennings. I was not able to document a couple of vocalizations recorded by both these authors, but these last calls are rarely uttered and are audible only at close quarters.
Stone curlew use voice freely throughout the year, with a maximum in early spring and summer. Most of calls do not seem to be specialised in function, except for gallop-rhythm call, which can be associated with reproductive - territorial behaviour. The results of playback show that almost every call type is uttered in response to the stimuli, though gallop-rhythm call - when used as playback stimulus - induces a significantly higher rate of the same call type.
This work, albeit largely incomplete, wants to be a contribution to a better definition and characterization of Stone curlew vocabulary. Further studies are needed for better understanding the significance of each call of this secretive nocturnal bird.

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