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Some notes on the distribution and songs of two Oriental Cuckoo taxa, *Cuculus* (*saturatus*) *saturatus* and *Cuculus* (*saturatus*) *optatus*

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The Oriental Cuckoo *Cuculus saturatus* (*sensu lato*) is a widespread Palearctic non-passerine, which has recently been shown to have distinct songs in different areas. We analyse this variation further, and also show that it is more complex than earlier described. Song recordings of the taxa *C.* (*saturatus*) *optatus* and *C.* (*s.*) *saturatus* originating from Russia, Eastern China (Hebei province), Southern China (Sichuan province), Taiwan and the northern Indian subcontinent were studied using sound spectrogram analysis. The Southern China and Indian subcontinent samples were similar to each other, but all the other samples were distinctive.

INTRODUCTION

In recent publications (e.g. Payne 1997, 2005, King 2005) the two widely distributed subspecies of Oriental Cuckoo *Cuculus saturatus* have been regarded as two separate species. King (2005) designated *C.* (*s.*) *optatus* Oriental Cuckoo and *C.* (*s.*) *saturatus* Himalayan Cuckoo, but in this article we use the scientific names *optatus* and *saturatus*, without expressing any opinion on their taxonomic status. The most important argument for treating them as two separate species is said to be their different courtship vocalisations, here referred to as song.

The geographical distribution of *optatus* covers a broad zone from Eastern Europe through the Siberian boreal forests to the Pacific shores. It also continues to Sakhalin Island, the Kuril Islands, Japan and China southwards to the region of the river Yangzi (=Yangtze) (Cramp 1985). According to Payne (2005), *saturatus* breeds from Pakistan east through the Himalayas to South China and Taiwan.

The song of *optatus* has been described in detail in several sources, e.g. Thiede and Wallschläger (2000), Lindholm and Lindén (2003), King (2005) and Payne (2005). In brief, it is a sequence of two low and soft similar notes preceded by a series of faster and even softer similar notes. No geographical variation has been found in this song. The song of *saturatus* has been described by Wells and Becking (1975), King (2005) and Payne (2005). It has been described as consisting of 4–5 notes (King 2005) or 3–5 notes (Payne 2005), where the first note is weaker, higher and shorter. The remaining notes are similar to each other.

In this article we present some additional findings about the songs and distributions of these two taxa. The third taxon of 'Oriental Cuckoo', Sunda Lesser Cuckoo *C.* (*s.*) *lepidus*, also has a distinctive song, and it is nowadays most often recognised as a distinct species (Wells and Becking 1975, Payne 2005). It occurs as a resident on the Malayan Peninsula and several Indonesian islands.

METHODS

The recordings used for the analyses presented here are mainly from Taiwan and from Hebei, Shanxi and Sichuan provinces of China. In addition, some are from the northern Indian subcontinent: one from Sikkim, two from Meghalaya, three from Nepal, and two from Bhutan. For details about the recordings see Table 1. All these recordings were analysed in the same way, and were compared with 58 individuals from Russia's northern taiga belt: from Komi, European Russia to Primorskiy, Far Eastern Russia (largely the same material referred to in Lindholm and Lindén 2003). If the Yangzi River is regarded as an approximate border between *optatus* and *saturatus*, the material from Hebei and Shanxi provinces of Eastern China should clearly be of the northern (*optatus*) type, Sichuan is close to the border and the Indian subcontinent is south of it.

We use here mostly the same terms as in Lindholm and Lindén (2003): sequence, soft phrase (the initial part of the sequence), phrase (*BU-BU*), note (the syllables of song, *BU*), period length (time interval between subsequent beginnings of phrases, sometimes called 'interphase interval'), basic rhythm (other parts of the sequence than the soft phrase), introductory note (initial note of a phrase, called 'weak note' by Lindholm and Lindén 2003) and main notes (other notes) (Fig. 1a). By the number of notes in a phrase we mean the total number of notes, including the introductory note when present. In this material, all phrases with three or more notes included the introductory note, and none with two had it. For methods of measuring song parameters, see Lindholm and Lindén (2003). In brief, the timing of the notes was measured from three successive phrases, randomly selected from a continuous and regular part of the song. The averages of these measurements were selected to represent the individual. The frequencies of the notes were measured from one randomly selected phrase. Different spectrogram bandwidths were used to optimise resolution when measuring frequency and timing, respectively. Sound spectrogram software programs used were Sound Ruler by Marcos Gridi-Papp, and Raven Lite 1.0 by the Cornell Laboratory of Ornithology.

Univariate descriptive statistics for each variable are presented for each area. Estimated arithmetic means, standard deviations and 95% confidence intervals for the means are reported. Assuming normality of samples, the confidence intervals for means were calculated as $\overline{X} \pm t_{crit} \frac{SD}{\sqrt{N}}$, where N is sample size (number of different individuals) and t_{crit} is the 0.975th quantile of a t-distribution with N-1 degrees of freedom. Non-normality of samples may give rise to inaccurate confidence intervals, even if the method is quite robust for some types of non-

Table 1. Oriental Cuckoo recordings analysed. Reference numbers, where available, are from the British Library National Sound Archive (BLNSA). Recordings with missing reference numbers have not yet been submitted to the BLNSA. Where latitude and longitude were not included in the recording documentation (marked by an asterisk) they were taken from a map or other sources.

Ref. No.	Date	Recordist	Country / Province	Place	Coordinates
13859	May 1979	John G. Corbett	Sikkim	Ranjit River	27°N 88°E *
11792	25 April 1984	John G. Corbett	Nepal	East Nepal	27°N 87°E *
13944	16 April 1973	Ben Coffey	Nepal	Shivapuri	28°N 85°E *
80247	March 1990	Sebastian T. Buckton	Nepal	Phulchowki	28°N 85°E *
65026	14 April 1996	Paul Holt	Bhutan	Central, near Nobding	27°N 91°E *
65027	18 April 1996	Paul Holt	Bhutan	East Bhutan, Kori La	27°N 92°E *
65028	17 April 1996	Paul Holt	Bhutan	Central. Limithang road	27°N 91°E *
100576	2000	Craig Robson	Meghalaya	Shillong Ridge	25°N 92°E *
100599	2000	Craig Robson	Meghalaya	Shillong Ridge	25°N 92°E *
43861	2 May 1994	Nick Gardner	Sichuan	Emei Shan	29°31′N 103°20′E
43890	5 May 1994	Nick Gardner	Sichuan	Emei Shan	29°31′N 103°20′E
43897	6 May 1994	Nick Gardner	Sichuan	Emei Shan	29°31′N 103°20′E
46485	4 May 1994	Alan Greensmith	Sichuan	Emei Shan	29°31′N 103°20′E *
46317	6 May 1994	Alan Greensmith	Sichuan	Emei Shan	29°31′N 103°20′E *
46319	7 May 1994	Alan Greensmith	Sichuan	Emei Shan	29°31′N 103°20′E *
	1 May 1995	Hannu Jännes	Sichuan	Emei Shan	29°31′N 103°20′E
	19 April 2006	Antero Lindholm	Taiwan	Guguan	24°11′N 121°05′E
	21 April 2006	Antero Lindholm	Taiwan	Huben	23°43′N 120°37′E
	22 April 2006	Antero Lindholm	Taiwan	Huben	23°43′N 120°37′E
	22 April 2006	Antero Lindholm	Taiwan	Huben	23°43′N 120°37′E
	22 April 2006	Antero Lindholm	Taiwan	Huben	23°43′N 120°37′E
	23 April 2006	Antero Lindholm	Taiwan	Huben	23°43′N 120°37′E
	25 April 2006	Antero Lindholm	Taiwan	Dayuling	24°11′N 121°19′E
	25 April 2006	Antero Lindholm	Taiwan	Dayuling	24°11′N 121°19′E
51073	18 May 1995	Paul Holt	Hebei	Lao Ling	41°N 120°E *
51074	18 May 1995	Paul Holt	Hebei	Lao Ling	41°N 120°E *
45890	18 May 1994	Paul Holt	Hebei	Lao Ling	41°N 120°E *
	21 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
	22 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
	22 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
	22 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
	22 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
	22 May 2002	Antero Lindholm	Hebei	Lao Ling	41°N 120°E
51072	1 June 1995	Paul Holt	Shanxi	Pangquangou, west of Taiyuan	38°N 112°E *

normality. The null hypothesis of normality was tested using Lilliefors's test (Lilliefors 1967). Possibly inaccurate confidence intervals are pointed out in the results.

A cautionary note about our analyses is needed because cuckoo songs may vary according to social context. For example, a series of recordings of a male from Huben, Taiwan, on 22 April 2006, includes several female calls, and a female was observed interacting with the male by, for example, flying together. Every time the male heard the female call, it stopped singing at once, but started again very soon, with or without a soft phrase. There were several soft phrases following each other, as well as guttural calls, which were quite similar to the corresponding call of Eurasian Cuckoo *Cuculus canorus*. There were some irregularities in the rhythm of the normal call, especially several one-note phrases. But there was no change in pitch or speed in the normal basic rhythm. It is also possible that the song varies according to the time of year relative to breeding, but our samples are too few for detailed analysis of this factor. Eurasian Cuckoos apparently may sing songs out of tune during the late breeding period (Payne 2005). We have not seen or heard evidence for this kind of variation in *saturatus* or *optatus*, nor seen it mentioned in the literature. Such variation should, however, be easy to notice and we doubt that our analyses are affected by it.

RESULTS

Our major results are presented in Table 2 and Figs. 1 and 2. Two raw variables (frequency of the first main note and period length) separated the groups almost equally well as a canonical discriminant analysis, and were for simplicity used here as such. In the following paragraphs the main results are described.

Song on the Indian subcontinent

The normal type of the song has four notes: it starts with an introductory note, which is shorter, higher-pitched and weaker than the others and it is followed by three very similar main notes. The song of one individual in our sample mainly consisted of five-note phrases, but one phrase was of four notes. Another normally used four notes, but had five in one phrase, and a third individual had four notes apart from one phrase with three. The remaining six individuals used four notes for the whole of the recorded time. The average period length of these

Table 2. Univariate results of the sound analysis. Numbers represent mean±SD, with 95% confidence limits on the mean in curly brackets. In samples for which the null hypothesis of normality was rejected, the confidence intervals may be inaccurate and these are marked with an asterisk.

	Number of notes[1]	Period (seconds)	Frequency of first main note (Hz)	Frequency of second main note (Hz)	Frequency difference of the notes (Hz)
Russia (N=58)	2	1.06±0.184 {1.012, 1.108}*	401.4±16.9 {397.0, 405.8}*	399.5±15.7 {395.4, 403.6}	-1.85±4.10 {-2.93, -0.77}
Indian Subcont. (N=9)	(3–) 4–5	2.09±0.201 {2.036, 2.144}	426.2±14.5 {414.1, 438.3}	424.2±11.6 {414.5, 433.9}	-2.00±4.80 {-6.02, 2.02}
Sichuan (N=8)	4 (–5)	2.02±0.097 {1.994, 2.046}	426.1±14.2 {414.3, 438.0}	424.6±18.9 {408.8, 440.4}*	-1.50±6.88 {-7.26, 4.26}*
Taiwan (N=8)	2	1.16±0.087 {1.137, 1.183}	475.0±27.3 {452.2, 497.8}	470.5±27.7 {447.4, 493.6}	-4.50±1.95 {-6.13, -2.87}
Hebei (N=9)	3 (–4)	1.61±0.165 {1.566, 1.654}	433.2±19.6 {418.1, 448.3}	435.4±17.3 {422.1, 448.7}	2.30±4.90 {-1.47, 6.07}
Shanxi (N=1)	4	1.62	447	447	

[1] Numbers (of notes) in parentheses were found in the recordings, but not in the analysed sections of the recordings.

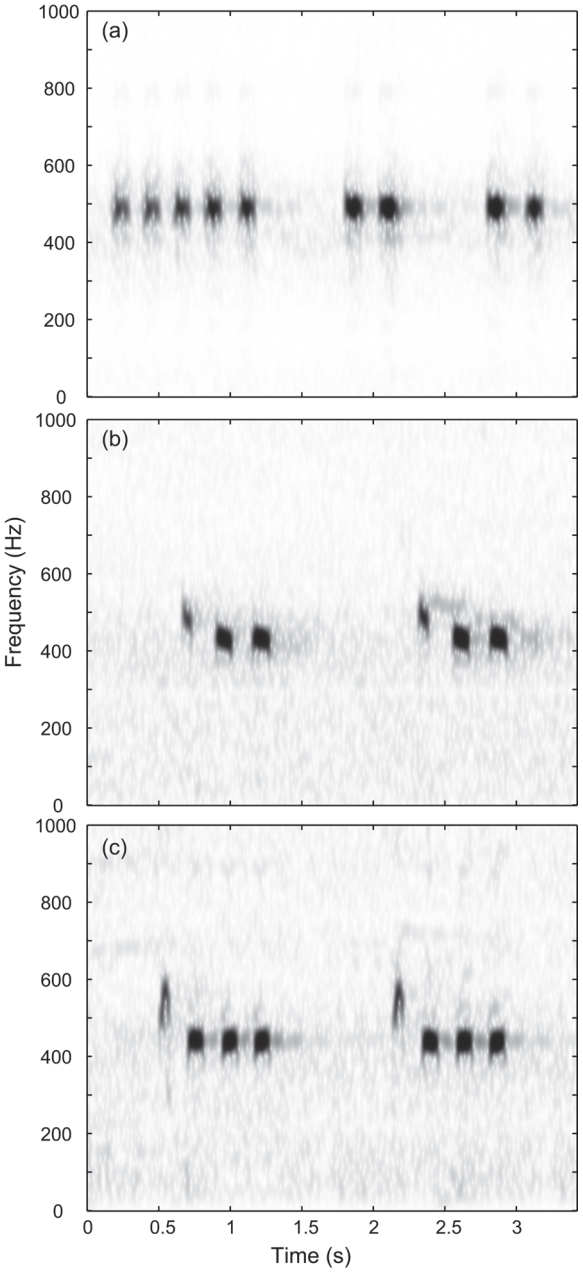

Figure 1 (left). Sound spectrograms of Oriental Cuckoos made using the following specifications: sample rate 8000, FFT-size 4096, Blackmann-Harris window with width 600 smpl, overlap 584 smpl. This equals a frequency resolution of about 2 Hz and a time resolution of 0.002 s. (a) A bird recorded at Huben, Taiwan, on 23 April 2006. A soft phrase followed by two basic rhythm phrases with two notes each. The time difference between the first notes of two successive basic rhythm phrases is the period length of the song. (b) A bird recorded at Lao Ling, Hebei, China, on 21 May 2002. Two phrases, both with three notes, of which the first is the introductory note. (c) A bird recorded at Shanxi, China, on 1 June 1995.

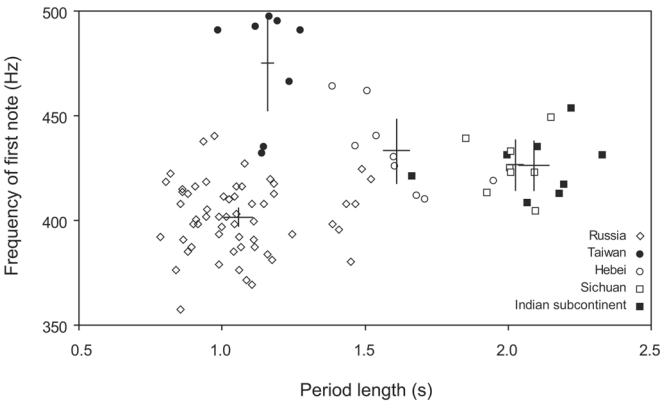

Figure 2. Scatterplot of period length versus frequency of the first note in the sound samples. The Shanxi sample is not plotted. Perpendicular lines denote means and 95% confidence intervals of the mean for the different areas: reading from the left, Russia, Taiwan, Hebei, Sichuan, and the Indian subcontinent.

southern recordings is over two seconds, which is due to the large number of notes. The frequency difference between the main notes is small in this sample too.

Song in Sichuan
With the exception of one, all seven recordings have four notes, the first of which is the introductory note. The last three notes are very similar to each other, and the frequency difference is again negligible. The exception also has a four-noted basic rhythm, but in part of the recording the bird seems to be very excited, with many irregularities in the song, including some five-note and three-note phrases. The period length in Sichuan is about two seconds. In practice the songs are very similar to those of the Indian subcontinent.

Song in Russia
Our song material from Eastern Europe and Siberia is as described in the literature for *optatus*. The two notes of the phrase are very similar to each other, but the first is very slightly higher-pitched on average. The song is fast, period length is only slightly more than one second, and the pitch is quite low, averaging 400 Hz.

Song in Taiwan
Although the Oriental Cuckoos in Taiwan were described as nominate *saturatus* in earlier publications (e.g. Payne 2005), King (2005) included one recording from that island which was of *optatus* type, and Anderson (2005) mentioned that the four individuals he heard there were of this type and not like *saturatus*.

Between 17 and 28 April 2006, Antero Lindholm and Annika Forsten heard 18 calling male Oriental Cuckoos in Taiwan, of which eight were sound-recorded, and our sample of Taiwan songs consists of these recordings. All birds were heard at an altitude of 180–1,700 m except one, which was heard on an intensively farmed lowland plain almost at sea level (this individual was not sound-recorded, or included in the analysis). The mountain birds were considered to be local breeding birds and not passage migrants because they were observed at several sites in the Central Mountains, where all other obvious passage migrants were absent (in contrast to the lowlands and coast). We even observed interactions between males and females, and also sound-recorded female calls. All these birds had song structure of *optatus* type: they had no introductory notes and just two main notes. Soft phrases were heard as in our material from Russia (see Lindholm and Lindén 2003).

The recorded eight individuals have a mean period of 1.16 seconds, and the time interval between notes is 0.23 seconds. Both these time measurements are similar to Russian *optatus* (Lindholm and Lindén 2003), but there is a small but statistically significant difference from Russian *optatus* in period length. Average frequencies are 475 Hz and 470 Hz, for the first and second note respectively, and these are clearly higher than in normal Siberian and Eastern European Oriental Cuckoos. This means that in Taiwan the song is similar to that heard in Siberia, but higher-pitched. Fig. 1a shows a typical section of a song from Taiwan.

Song in Hebei and Shanxi
The Hebei province lies far north of the described distribution area of *saturatus*. However, from our material, it is clear that the song is different from that of Siberian and Eastern European *optatus* and closer to *saturatus*.

The Hebei recordings are all from Lao Ling, near the town Qinghuangdao. In all nine analysed samples, and in every single phrase recorded, there is a introductory note. This makes Oriental Cuckoos from this area easily separable from the Siberian ones. In every sample analysed, there are three notes and the two main notes are of very similar pitch in comparison to each other. In other parts of the recordings, which were not included in the sample analysed, (presumably) the same individuals uttered a four-note phrase on many occasions, with the introductory note followed by three similar notes. In one recording, the individual clearly switches from a four-note phrase to a three-note. In that same recording, a call, similar to the soft phrase of the Siberian type, is heard; it is harsher and more barking than in Siberia.

The song in Lao Ling is slightly higher-pitched than in Siberia. The period is longer, which is due to the phrases including more notes. Fig. 1b shows a typical section of song from Lao Ling.

The only recording available from Shanxi province consisted of four notes, as in the recordings from Sichuan and the Indian subcontinent. The song was quite fast and high-pitched, but fell within the range of the Hebei samples. A spectrogram of this song is shown in Fig. 1c. However, as this is a single recording, any conclusions must remain tentative.

Visual characters
The taxa *saturatus* and *optatus* are normally separable using measurements of the flattened and straightened wing. In male *saturatus* the wing length is usually shorter than 198 mm, and in male *optatus* most are longer than 204 mm. These crude limits are based on our own measurements from skins collected within the breeding area and housed at the Natural History Museum, Tring (NHM): male *optatus* from Japan and Russia 202–216 mm (N=5), male *saturatus* from Himalayas and Southern China, excluding Taiwan 183–198 mm (N=10). The samples are small and in the migration and wintering areas it is easy to find birds that fall between these two limits. For example, in Australia, it was easy to identify all males as *optatus* using measurements but among females there were several small birds that were difficult to classify (Higgins 1999). Kennerley (1998) describes two individuals that he identified as *saturatus* because of measurements (wing lengths 188 and 186 mm). King (2005) and Payne (2005) show similar results for differences in wing length between the two taxa.

There are no known differences in the plumage or bare parts between *saturatus* and *optatus* (King 2005, Payne 2005). However, it seems that the amount of yellow on the lower mandible may be more extensive and the yellow area more clear-cut in *saturatus* than in *optatus*. This character warrants closer investigation. The bill of *saturatus* is of roughly the same size as in *optatus*, which means it is proportionally bigger, but it seems unlikely to be a useful field character. The barring of the underparts and the underwing patterns appear to overlap completely. The average number of primary bars and the extreme values in our material were similar for the two taxa (see Lindholm and Lindén 2003 regarding counting primary bars).

DISCUSSION

The distribution of the *optatus*-like, two-note song continues south to Taiwan, but it seems that the birds there are not *optatus* in size. There are three cuckoo skins from Taiwan in the NHM collection, two of which are labelled as males and the third is also male-coloured. They were collected in May (precise date unknown), 28 June and 7 April, and their wing lengths are 195, 184 and 195 mm respectively. Therefore, *saturatus* is clearly a better match in size. Payne (2005) also includes some Taiwan skins in his *saturatus* material. The situation on the island clearly needs more study. The higher frequency of song compared to that of Siberia *optatus* might reflect the smaller body size of the birds.

In the mountains of Hebei province there are birds with song similar to *saturatus* from the northern Indian subcontinent and southern China, containing similar introductory notes, but on average fewer main notes. Further morphological and bioacoustical studies covering larger areas are required for a better understanding of the specific and subspecific status of the birds in the Hebei province and elsewhere in north-east China. Further molecular analysis may also be beneficial, although resolving relationships of *saturatus*, *optatus* and Eurasian Cuckoo *C. canorus* has not succeeded so far (Payne 2005).

There seems to be some geographical variation in the song of *saturatus*. The previously published specific border between *saturatus* and *optatus* is ambiguous: the Hebei birds can be classified as *saturatus* and the Taiwan birds as *optatus* but this would only leave the presence or absence of the introductory note as a character that separates the two. Alternatively, our material can be interpreted as showing that at least four distinct song types of Oriental Cuckoo are found in East Asia. These can be identified with high certainty, but differences are small (in the presence or absence of the introductory note and number and pitch of the main notes). Intermediate populations, not covered by our material, may bridge these types. Cuckoos, like most other non-passerines, normally lack geographical variation in their vocalisations (Baptista and Kroodsma 2001, Payne 2005). Because no morphological differences among breeding-season *saturatus* were apparent in an examination of museum specimens (Payne 2005), geographical variation among *saturatus* seems to be confined to vocalisation.

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