

## Territorial song in the Oriental Magpie-Robin *Copsychus saularis* in suburban areas of Kota Samarahan, Sarawak

ZAHARAN MANSOR AND DENCY FLENNY AUGUSTINE GAWIN\*

Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia. \* Corresponding author: [agdfleppy@unimas.my](mailto:agdfleppy@unimas.my)

**Summary.** Despite its reputation for unique and melodious vocalisations, the Oriental Magpie-Robin *Copsychus saularis* remains remarkably under-studied in Borneo. We undertook an examination of the territorial song of this species at the Universiti Malaysia Sarawak campus and Kota Samarahan, Sarawak, to learn more about its structure, repertoire size and physical characteristics. Throughout the breeding season, males started to sing intensely usually half an hour before sunrise until 09:00 or 10:00 hrs. Fifty minutes of song were collected from each of five colour-ringed breeding males. From the total of 2,198 phrases, 112 different phrase types were identified. Spectrograms revealed that most singing episodes consist of a repeated phrase, many of which vary by including dissimilar syllables. We confirmed that the purpose of males singing was to secure and maintain their territories, as males aggressively responded to playback near their nesting sites by increasing their singing rates. The female's song seems to initiate male territorial singing during the entire breeding season.

**Ringkasan.** Meskipun dikenal karena suaranya yang unik dan merdu, namun mengejutkan ternyata suara Oriental Magpie-Robin *Copsychus saularis* ternyata masih kurang diteliti di Kalimantan (Borneo). Maka, kami melaksanakan sebuah penelitian suara teritorial spesies ini di kampus Universiti Malaysia Sarawak dan di Kota Samarahan, Sarawak, untuk mempelajari mengenai struktur, ukuran repertoar, dan karakter-karakter fisiknya. Sepanjang musim berbiak, burung-burung jantan mulai bernyanyi secara intens biasanya setengah jam sebelum matahari terbit sampai jam 09.00 atau 10.00 dipagi hari. Akumulasi 50 menit nyanyian dikumpulkan dari lima jantan. Dari total 2.198 frase, 112 tipe frase berbeda teridentifikasi. Spektogram menunjukkan bahwa bagian-bagian (episode) yang paling banyak nyanyian terdiri dari satu frase yang diulang, banyak dari pengulangan ini bervariasi dengan memasukkan suku suku kata berbeda. Kami mengonfirmasikan bahwa tujuan nyanyian burung-burung jantan adalah untuk menjamin dan mempertahankan teritori-teritori mereka, karena burung-burung jantan secara agresif merespon kepada suara rekaman yang diputar dekat lokasi-lokasi sarang mereka dengan cara menaikkan tingkat suara nyanyian mereka. Suara burung betina nampak dimaksudkan untuk memulai nyanyian teritorial burung jantan selama musim berbiak.

### Introduction

Avian vocalisations are generally classified as calls or songs (Catchpole & Slater 2008). In many species, calls are associated with enhancement of daily activity performance: food acquisition, predation alarms and social contact (Kumar & Bhatt 2001). Songs last longer and are more complex than calls. They are usually associated with male individuals, territoriality and breeding (Weary *et al.* 1992; Lambrechts & Dhondt 1995; Catchpole & Slater 2008).

The production of songs in the breeding season and particularly at dawn is influenced by many factors, including hormone cycles, environmental cues and social interaction (Staicer *et*

*al.* 1996). Males sing especially throughout breeding season to establish and defend their breeding territories (Bhatt *et al.* 2000; Dunmak & Sitasuwan 2007; Catchpole & Slater 2008). In Red-winged Blackbirds *Agelaius phoeniceus* and Seaside Sparrows *Ammospiza maritima*, when males are experimentally muted they experience a reduction in the size of their breeding territory as well as an increase in intrusion and dispute events by mating competitors (Yasukawa 1981; McDonald 1989). In Winter Wren *Troglodytes hiemalis*, Oriental Magpie-Robin *Copsychus saularis*, Indian Robin *Saxicoloides fulicatus*, Pied Bush Chat *Saxicola caprata* and White-rumped Shama *Copsychus malabaricus*, males on territories increase their singing rate when exposed to playback of their songs, generally confirming that song is intended to deter intruders and secure breeding territories (Amrhein & Erne 2006; Bhatt *et al.* 2000 2014; Bhattacharya *et al.* 2007; Kumar 2011; Sethi *et al.* 2011; Wikramasinghe & Dilhari 2013; Wanniarachchi & Wijesundra 2016).

Territorial song species may differ among species in phonation, duration, repertoire size and complexity. Some species have relatively small repertoire sizes, including Ovenbird *Seiurus aurocapillus* (Falls 1988) and Redwing *Turdus iliacus* (Bjerke & Bjerke 1981), while other species possesses large or even unrestricted repertoire sizes, as in the Northern Mockingbird *Mimus polyglottos* (Howard 1974) and Sedge Warbler *Acrocephalus schoenobaemus* (Kroodsma & Parker 1977). In respect to singing modes, two general types occur: 'eventual variety', in which a particular song type is uttered repeatedly before being switched to another song type; and 'immediate variety', in which the singer utters a series of dissimilar song types (Molles & Vehrencamp 1999).

The Oriental Magpie-Robin *Copsychus saularis* (Linnaeus) 1758 is a medium-sized passerine (family Turdidae) that lives in open areas of tropical and sub-tropical South and Southeast Asia, including sea coast, mangroves, forest edge, gardens, plantations and cultivated areas (Wells 2007; Mann 2008). This sexually dichromatic species is regarded as one of the best passerine singers within its native range, leading to its over-exploitation by cage-bird traders (Eaton *et al.* 2015), but its vocalisations in Borneo are not well-studied. Information on magpie-robin song, particularly on its physical characteristics and functional significance during the breeding season, is scarce. To help fill this knowledge gap, this paper explores the acoustical properties and functional significance of territorial song in Oriental Magpie-Robins of the widespread race *C. s. musicus* in Sarawak, Borneo. Such studies in the wild are particularly timely, as natural populations of the species are rapidly declining due to over-exploitation.

## Methods and materials

### *Study sites and sound recordings*

This study was conducted on the Universiti Malaysia Sarawak (UNIMAS) campus and at Tanjung Bundong village (27 m asl), both in Kota Samarahan, Sarawak, from March 2015 to February 2017. The campus habitat consists of buildings, roads, open grassland and gardens of ornamental trees surrounded by secondary and mixed peat swamp forest (Voon *et al.* 2014). Song samples were collected from five colour-ringed breeding males (A, B, C, E and G). All call and song recording sessions were conducted during their respective breeding bouts (mostly during incubation and nestling stages) (Table 1).

Audio samples were collected by recording vocalizations produced by ringed males on their territories. These activities were recorded from a distance of 5-15 m without influencing the singing behaviour of the birds. Recording sessions commenced soon after the targeted males were observed at their singing posts and ended after the birds ceased their singing or flew out of recording range. Moving males were followed and sound recording commenced

again if they were found singing on a new perch. All sounds were recorded using a directional microphone (Sennheiser MKH 20 P48) and a solid-state recorder (Marantz Pro solid state recorder PDM67).

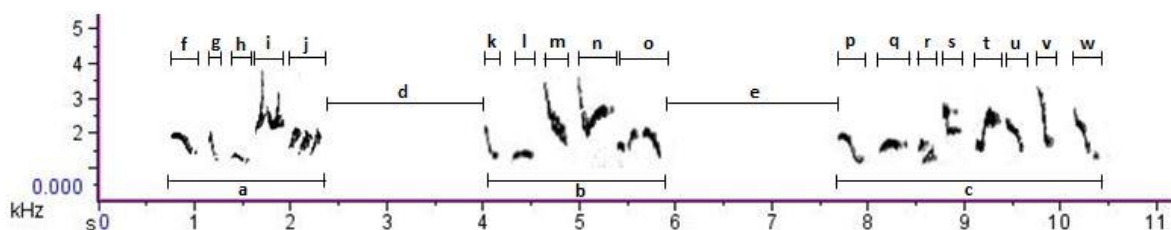
**Table 1:** All song and call recording sessions from the five males.

Male	Song and call sampling durations
A	April to May 2015
B	February to March 2016; April to May 2016; July to August 2016; August to September 2016
C	February to March 2016; April to May 2016
E	April to May 2016
G	January to Feb 2017

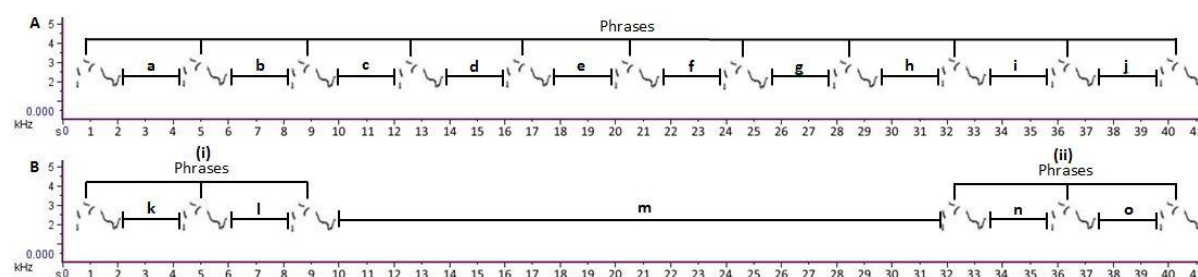
### Song characterisation

Vocalizations were categorized following Bhattacharya *et al.* (2007) and Catchpole & Slater (2008). Bird vocalizations are made up of elements (Catchpole & Slater 2008). An element can be simply represented as a continuous line on a spectrogram (a graphic representation of sound), preceding and segregated from others by a gap of silence of  $<0.5$  seconds (Bhattacharya *et al.* 2007). A phrase is defined as any vocal signal made up of a series of units called syllables, occurring in a particular arrangement with a duration of  $<10$  seconds (Fig. 1). Syllables can be either simple or complex in structure. A simple syllable is made up of a single element while a complex syllable is made up of several elements (Fig. 1).

An episode of singing is defined as a series of phrases that are segregated from each other by a silent interval  $\geq 0.5$  seconds (Bhattacharya *et al.* 2007). If the duration of the interval is  $>20$  seconds, it is a different episode occurs by definition (Bhattacharya *et al.* 2007) (Fig. 2).



**Figure 1:** Characterisation of structural features of song phrases of the Oriental Magpie-Robin, in which (a), (b), and (c) are different phrase types; (d) and (e) are intervals between phrases; (f), (g), (h), (k), (l), (m), (n), (p), (q), (s), (t), (u), (v) and (w) are syllables that comprising single elements; and (i), (j), (o) and (r) are syllables comprising two or three elements.



**Figure 2:** Sample spectrograms demonstrating phrases in the episodes song, modified from Bhattacharya *et al.* (2007)., (A) is an episode of song because none of the intervals between phrases is longer than 20 s. (B) consists of two episodes of song, (i) and (ii), because the interval between phrases (m) is  $> 20$  seconds. Intervals (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), (l), (m), (n) and (o) separate phrases.

## ***Song analysis***

All recorded song samples were saved as WAV files, viewed and analysed using Raven Pro: Interactive Sound Analysis Software (Version 1.4). Ithaca, NY: The Cornell Lab of Ornithology. All spectrograms were generated using the following settings; Hamming window (733 points, 16.6 ms), 16-bit resolution, frequency grid spacing of 43.1 Hz, and DFT size of 1024 samples.

The acoustical features and characteristics of recorded sounds were defined by measuring the physical characteristics of the sound: 1) minimum frequency (in kHz), the lowest frequency of a particular phrase; 2) maximum frequency (kHz), the highest frequency of a particular phrase; 3) range of frequency (kHz), the total frequency between the lowest and highest frequencies; 4) duration of a phrase, the length time in seconds of a phrase; and 5) length of an interval between phrase, the length of time from the last element of a phrase to the first element in the subsequent phrase.

The physical characteristics of phrases in the recording-spectrograms were visually assessed, counted, and measured for each male. Syllables were identified by their shape, structure and number of elements. Phrases were differentiated by the composition and arrangement of syllables. Song complexity was determined by the types of syllables uttered per minute, and repertoire size was measured by determining the total number of phrase types occurring over the total duration of song recordings. One-way ANOVA was used to determine differences in the duration of song (phrase types) between the five breeding males (A, B, C, E and G). All tests were performed using Microsoft Excel 2010 (Version 14) and IBM Statistical Package for the Social Sciences (SPSS) software (Version 21).

## **Results**

### ***Singing behaviour and song repertoire size***

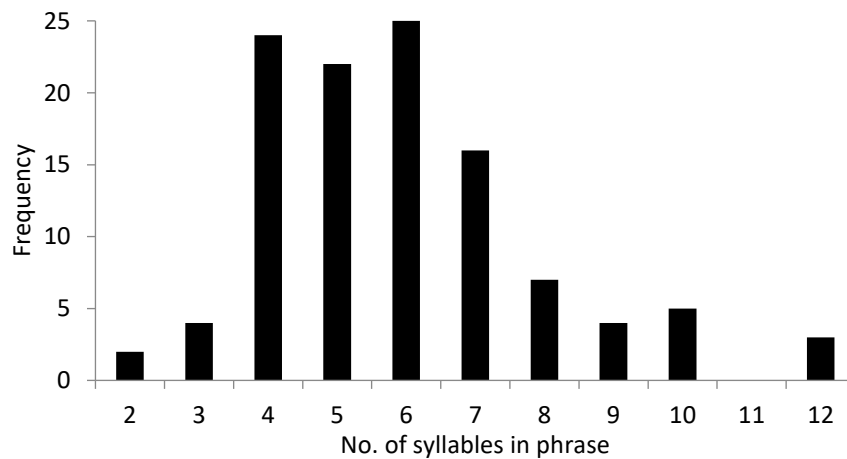
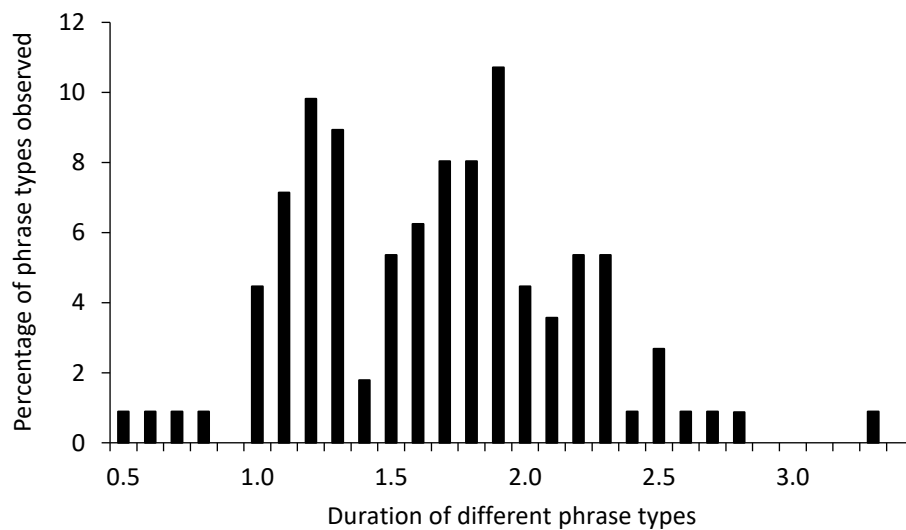
Throughout the breeding season, males delivered territorial song, mostly in the early morning. They started usually half an hour before sunrise and sang continuously until 09:00 or 10:00 hrs in the morning. They also sang occasionally after that, but the intensity of their singing was reduced and the utterance rate unpredictable. When singing, males perched on the edge of buildings, electric poles, electric wires, the tops of buildings, and the tops of trees for 1 to 16 minutes (mean  $2.69 \pm 0.34$  minutes) before leaving for another perch. Females sang occasionally throughout the study period.

For each singing male, we obtained 50 minutes of song recordings during breeding bouts (Table 1). A total of 2,198 phrases interrupted by periods of silence were gathered in total from the five males (A, B, C, E and G). Male A's song consisted of 490 phrases (of 26 different types), male B's song sequence 237 (of 28 different types), male C's song sequence 488 (of 17 different types), male E's song sequence 530 (of 18 different types) and male G's song sequence 453 (of 23 different types) (Table 2). Some phrases were repeated numerous times, while others occurred only singly in an episode. Out of 2,198 phrases produced by the five males, 112 different phrase types were identified (Table 2). The number of syllables in the 112 different phrase types ranged from 2 to 12. Each syllable consisted of one to five elements. Of the 112 phrase types, the most frequent phrase type consisted of 6 syllables (Fig. 3).

The duration of the 112 phrase types ranged from 0.5 to 3.3 seconds (mean  $1.72 \pm 0.05$ ). Most of the phrase types (92.86%) were between 1.0 to 2.5 seconds in length, while the remaining phrases were between 0.5 to 0.9 second (3.56%) and between 2.6 to 3.3 s (3.56%) (Fig. 4). Among the five males, the duration of phrase types did not differ significantly ( $F = 0.638$ ,  $df = 4,140$ ,  $P = 0.636$ ).

**Table 2.** Physical characteristics of territorial song in five males (A, B, C, E and G) of Oriental Magpie-Robin

Male	Sample duration (min.)	Total phrase (s)	No. phrase types	No. phrase types per min.	Types of syllables per min.	Phrases duration (s)	Interval between two phrases (s)	Minimum frequency (kHz)	Maximum frequency (kHz)
A	50	490	26	3.50 ± 0.16	17.04 ± 0.62	2.18 ± 0.05	4.03 ± 0.13	1.89 ± 0.12	4.84 ± 0.29
B	50	237	28	2.52 ± 0.25	12.52 ± 1.40	2.05 ± 0.07	7.23 ± 0.07	1.89 ± 0.04	4.24 ± 0.10
C	50	488	17	1.94 ± 0.15	9.40 ± 0.82	2.06 ± 0.04	3.93 ± 0.10	1.68 ± 0.06	4.36 ± 0.16
E	50	530	18	2.58 ± 0.13	10.18 ± 0.55	2.11 ± 0.04	3.38 ± 0.08	1.67 ± 0.06	4.24 ± 0.14
G	50	453	23	2.62 ± 0.19	13.14 ± 0.65	2.39 ± 0.03	4.19 ± 0.08	1.85 ± 0.03	4.26 ± 0.13
<b>Total</b>		<b>2198</b>	<b>112</b>	<b>2.64 ± 0.08</b>	<b>12.45 ± 0.38</b>	<b>2.17 ± 0.02</b>	<b>4.23 ± 0.05</b>	<b>1.81 ± 0.03</b>	<b>4.40 ± 0.09</b>

**Figure 3.** Frequency of phrase types (N = 112), based on the variation in syllable number, produced by five singing Oriental Magpie-Robin males**Figure 4.** Distribution of phrase-type duration (N = 112) in five males of Magpie-Robin.

### ***Physical characteristics and structure of phrases***

Based on the analysis of 2,198 phrases, the territorial songs of the five male Oriental Magpie-Robins lasted between 0.5 to 5 seconds (mean  $2.17 \pm 0.02$ ), and intervals between songs ranged from 0.6 to 19 seconds (mean  $4.23 \pm 0.05$ ) (Table 2). The minimum and maximum frequencies of phrases were  $1.81 \pm 0.03$  and  $4.40 \pm 0.09$  kHz, respectively, with a frequency-range of  $2.59 \pm 0.08$  kHz (Table 2). The birds delivered  $2.64 \pm 0.08$  phrases and  $12.45 \pm 0.38$  syllables per minute (Table 2).

The spectrograms revealed that syllable types in phrases differed among the five males. Similar types of syllable were found to occur in several types of phrases. However, the arrangement and position of the syllables differed. In many cases, singing episodes were composed of a single type of phrase repeated over and over (Fig. 5). In other cases, identical phrases were uttered repeatedly several times before switching to another type. Occasionally, different types of phrase were alternated with one another in a single episode of song (Fig. 6).

Spectrograms also revealed that some phrases occurred with minor variations in a single syllable, or syllables were added to or removed from phrases (Fig. 7). Several different types of phrases (usually 2 to 3 distinct phrases) were often combined in a single episode (Fig. 7). Sometimes, a syllable or several types of syllables, or incomplete phrases, were interposed between combined phrases (Fig. 6). This kind of variation and recombination of phrase types occurred in all of the males.

### **Discussion**

This study indicates that maximum singing by male Oriental Magpie-Robins during breeding season occurs daily from dawn through the morning, as opposed to other times of the day. Dawn singing is a common feature of many passerines species and has always been associated with territorial behaviour (Bhatt *et al.* 2000, 2014; Catchpole & Slater 2008; Sethi *et al.* 2012). Dawn appears to be the best time for birds to sing because there is little wind or air turbulence to interfere with sound transmission (Staicer *et al.*, 1996; Brown & Handford, 2003). In addition, low light intensity at dawn precludes the birds from foraging effectively, and lower temperatures reduced the activity of prey, especially orthopteran and lepidopteran prey (Kacelnik & Krebs, 1983).

We have shown that male Oriental Magpie-Robins sing in order to define and secure their territories from other magpie-robins throughout the breeding season. Males respond immediately and aggressively by increasing their singing rate, when magpie-robin song is broadcast near their nesting sites. We also observed that male morning territorial songs were uttered in response to territorial intrusion by non-conspecific species such as Asian Glossy Starling *Aplonis panayensis* and Common Myna *Acridotheres tristis*.

In contrast to males, the biological significance of song in the female magpie-robins differs substantially from males. Females are non-responsive to playback of magpie-robin songs, thus suggesting that the production of their song has no association with the advertisement and maintenance of breeding territories. As noted by Kumar & Bhatt (2002), the function of female's song seems to be to initiate male singing, as males typically start to sing in response to female song. Female song initiation occurs at dawn and throughout the morning. The singing activity in females is common in many tropical passerines, including Tropical Boubou *Laniarius aethiopicus*, Red-vented Bulbul *Pycnonotus cafer* and Warbling Antbird *Hypocnemis cantator* (Grafe & Bitz, 2004; Kumar, 2004; Seddon & Tobias, 2005). However, the functions of song vary across species (Cooney & Cockburn, 1995; Eens & Pinxten, 1998; Gillbert & Carroll, 1999; Hall, 2004; Slater & Mann, 2004; Riebel *et al.*, 2005; Catchpole & Slater, 2008).

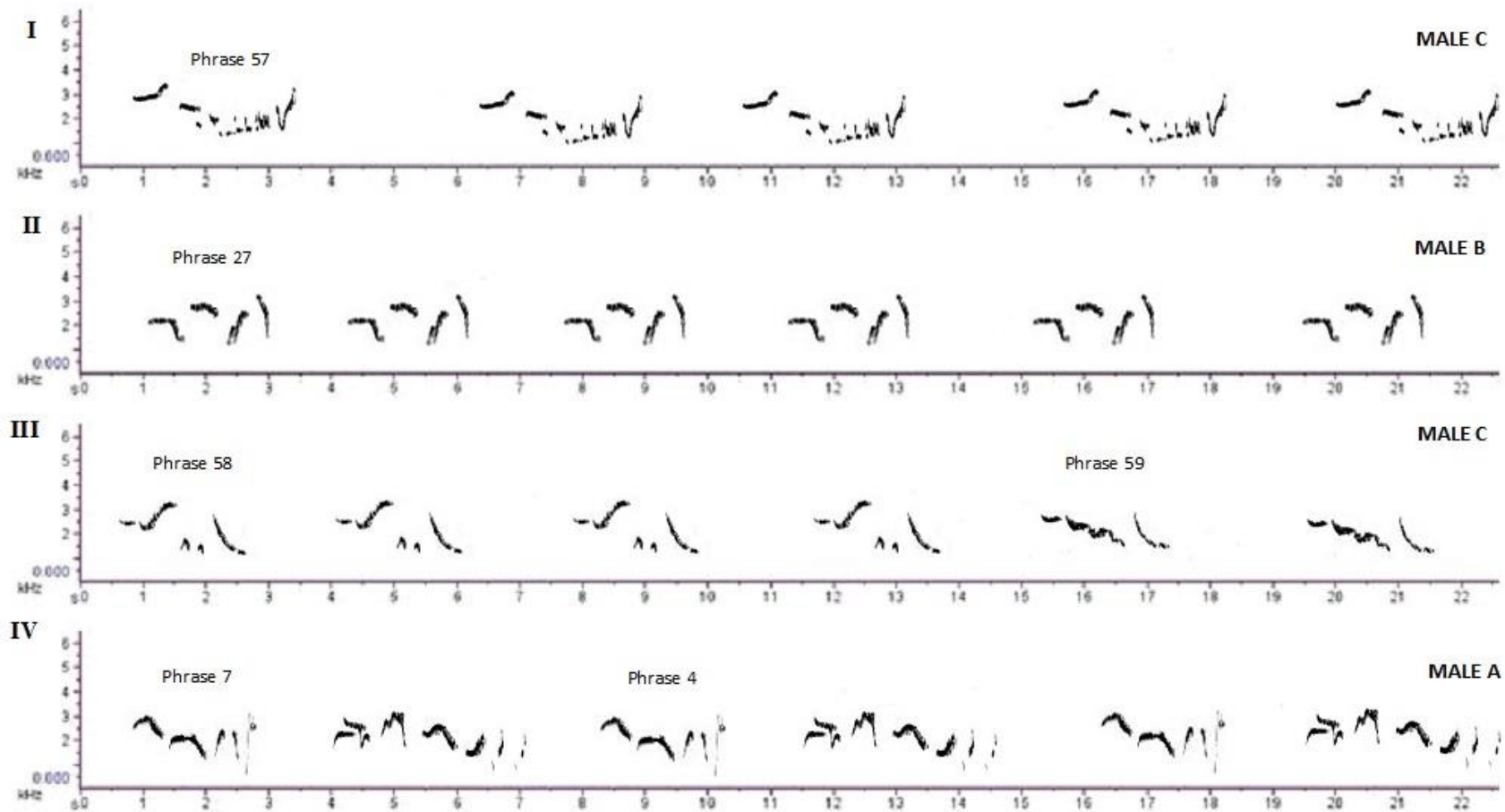


Figure 5. Graphic representation of phrase structure in male Oriental Magpie-Robin song. In (I) and (II) a single type of phrase in an episode is repeated. In (III) a single type of phrase is repeated several times before it is switched for another type of phrase in a single episode. In (IV) two distinct types of phrases (phrase 7 and 4) are repeated alternately with one another in a single episode of singing.

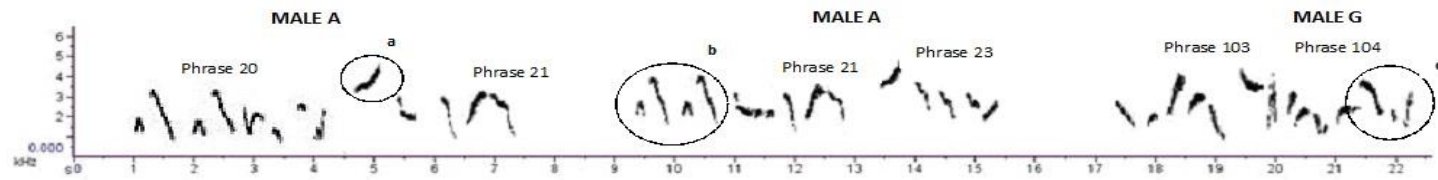


Figure 6. Graphic representation of variation in phrase structure in two individuals of Oriental Magpie-Robin. To the left, a single syllable (a) is interposed between two phrases (20 and 21) of the male A. In the middle, an incomplete version of phrase 20 (b) occurs together with phrases 21 and 23 in male A. To the right, syllable c occurs after the combined phrases 106 and 107 in the male G.

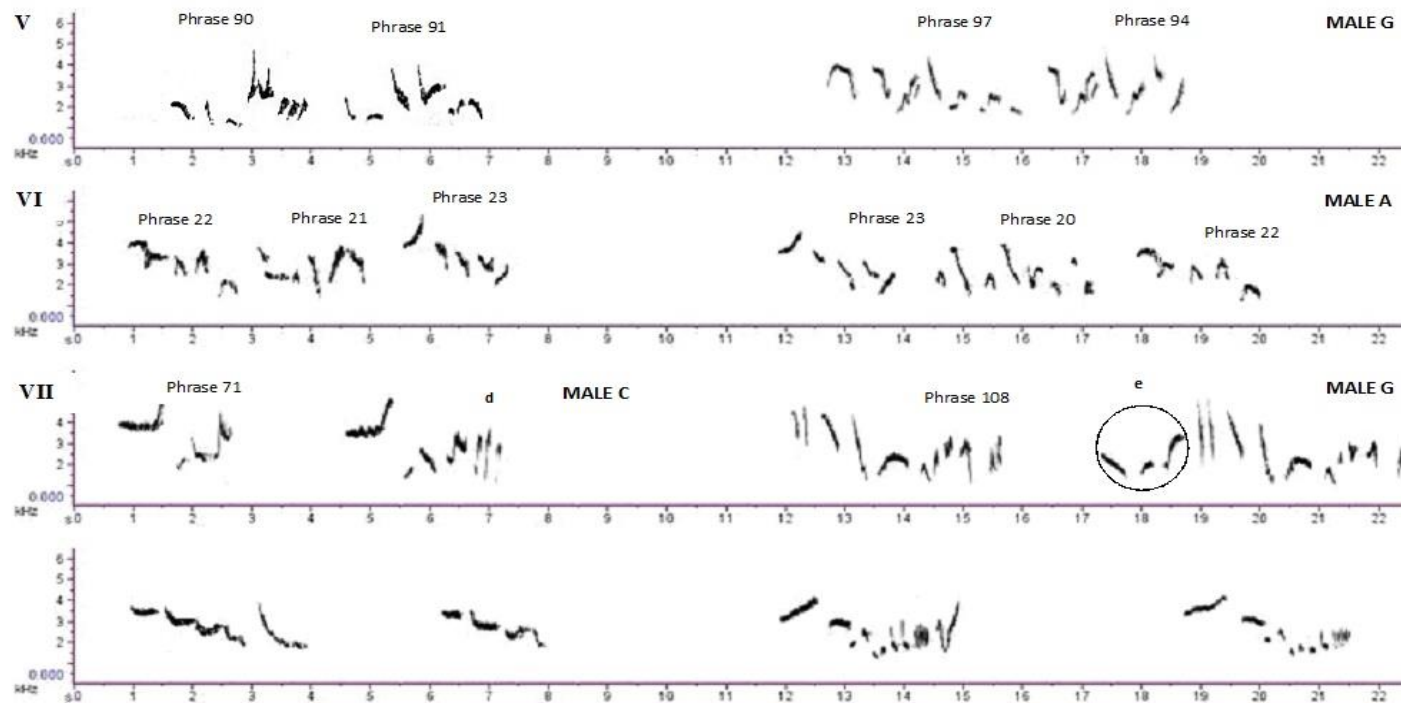


Figure 7. Graphic representation of variation in phrase structure in male Oriental Magpie-Robins. In (V) and (VI), two (V) or three (VI) different types of phrases occur in a single episode of song. In (VII), different types of syllables (d) and (e) are added to each phrase. In (VIII), syllables f and g are deleted in each phrase



The physical characteristics of male magpie-robin territorial songs are similar to those found by Bhatt *et al.* (2000) and Bhattacharya *et al.* (2007). Most songs last for 2 seconds, with an interval between songs of more than 0.5 seconds. The five males we examined did not share song repertoires but sang in three different ways. Most of the time, the birds uttered a single type of phrase repeated over and over until the end of an episode of singing (e.g. A-A-A-A-..). This is consistent with the findings of Bhattacharya *et al.* (2007), which revealed many songs of the studied male individuals are repetitions of the same one phrase. Sometimes, males sang according to 'eventual variety' (Molles & Vehrencamp, 1999), in which a single type of song was repeated several times before a different type of song type was introduced (e.g. A-A-A-B-..), which is consistent with the findings of Bhatt *et al.* (2000). Eventual variety has been reported in several tropical species, including Indian Robin (Kumar, 2011) and Pied Bush Chat (Sethi *et al.*, 2012). Male magpie-robins also were observed to vary song types (e.g. A-B-A-B-..), but this occurred infrequently. Interestingly, in many cases magpie-robin song contained phrases that did not appear to have finite structure. Variation in phrases were common, with some elements deleted or added, while in other cases elements of phrases were combined. Such variation was also observed in Indian and Nepalese populations of magpie-robins (Bhatt *et al.* 2000; Bhattacharya *et al.* 2007) and also in many other passerines, including Red-vented Bulbul (Kumar 2004) and Indian Robin (Kumar 2011).

## Conclusions

The physical characteristics, acoustical properties and functional significance of territorial song in Oriental Magpie-Robin have been described. The peak of singing activity in males is in the early morning and is associated with the establishment and maintenance of breeding territories. Most male song consists of a single phrase type, but males differ from one another in phrase structure and overall repertoires. Both sexes sing during breeding activities, but the biological significance and function of their songs differ. Males sing to define and defend territories, while females sing to communicate with their mate.

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