



Physical characteristics, categories and functions of song in the Indian Robin *Saxicoloides fulicata* (Aves: Muscicapidae)

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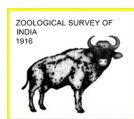
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Author Details: DR. ANIL KUMAR is a scientist in ZSI, Solan. Over the years his research work is focused on communication of birds. So far, he has recorded over 200 avian species mainly from Himalaya and contributed over 30 research papers/ articles. For ZSI, he has worked on some departmental research projects pertaining to mainly faunal studies.

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Abstract: The physical characteristics and biological significance of song in the endemic Indian Robin *Saxicoloides fulicata* are described. Songs are discrete and composed of strophes (structural units) with frequency ranging from 1.03 to 8.00 kHz, preceded and followed by temporal intervals from 0.21 to 21.25 sec. Occasional, monosyllabic whistles are also identified. In a song bout usually the same type of strophe is repeated several times in a stereotyped manner with minor structural variations of elements before switching to another type of strophe. Most strophes are composed of two to five elements, having both simple and complex structure. Two categories of songs have been identified on the basis of their acoustical features and context of production. Type-A songs are simple, stereotyped, spontaneous and common, while type-B songs are rare, female-oriented and more complex than type-A. Song is used in both inter- and intra-sexual contexts. It seems that type-A songs are driven by male-male competition for territory and mates. Males also shorten the length of strophes and reduce gaps between strophes (in type-B songs) on the arrival of females in the vicinity, most probably to increase the song rate, suggesting it to be an indicator of male quality.

Key words: Indian Robin, *Saxicoloides fulicata*, song organisation, song characteristics, song function.

Hindi Abstract: स्थानीय कलचिड़ि में गायन की विशेषताओं तथा उसके जैविक महत्व का उल्लेख किया गया है। गायन छंदों (संरचनात्मक इकाई) से बना, 0.21 से 21.25 सेकंड के कालान्तरों से विभक्त, अनिश्चर प्रकार का था जिसकी ध्वनी आवृत्ति 1.03 से 8.00 किलो हर्ट्ज के मध्य थी। एकल शब्दांशिय, आकस्मिक सिटियों भी पायी गयी। एक गायन अवधि में, एक छंद से दूसरे छंद पर जाने से पहले, अंशों में निहित छोटे-छोटे अंतरों के साथ, साधारणतया एक प्रकार के छंद को बारम्बार प्रयोग किया गया। अधिकांश छंद दो से लेकर पाँच अंशों से बने थे, तथा सरल एवं जटिल दोनों प्रकार की संरचना वाले थे। ध्वनी विशेषताओं तथा उपयोग के संदर्भ में, गायन को दो वर्गों में विभक्त किया गया। वर्ग 'अ' का गायन सरल, रुढ़िबद्ध, स्वतः स्फूर्तित तथा सहज था जबकि वर्ग 'ब' का गायन दुर्लभ, मादा उन्मुख तथा अधिक जटिल था। इस शोध में, कलचिड़ि ने गायन को अन्तर्जातिय तथा सजातिय दोनों संदर्भों में प्रयोग किया। ऐसा प्रतीत होता है कि वर्ग 'क' का गायन क्षेत्र रक्षण तथा मादा प्राप्ति हेतु, नर नर प्रतिद्वन्द्विता के परिणाम स्वरूप उत्पन्न हुआ। नरों ने मादा के निकट आने पर, संभवतया गायन की तीव्रता को बढ़ाने के लिये, गायन में छंदों की लम्बाई को लघु कर दिया तथा उनके मध्य कालान्तर को भी संकुचित कर दिया (वर्ग 'ब' का गायन) जो कि नर उत्कृष्टता का द्योतक हो सकता है।

INTRODUCTION

Mate acquisition and male-male competition are responsible for the evolution of song in passerine birds (Catchpole & Slater 1995). Song characteristics such as acoustical features, mode of production, temporal patterns and structural complexity (variability of elements) are highly diverse among oscine birds (Marler & Slabbekoorn 2004). Many passerine species sing two categories of songs that differ in their patterns of temporal, spatial and contextual use (Spector 1992). The first category songs are often simple and highly stereotyped, sung at relatively low rates. In contrast, second category songs are usually more complex and variable, and sung at higher rates (Highsmith 1989; Kroodsm et al. 1989; Staicer 1989; Bolsinger 2000). Studies on the functions of song (with some exceptions) suggest that type-A songs (more stereotyped) are used as intersexual signals, while type-B (more variable) are used

intraxually (Kroodsma 1981; Spector 1992; Bay 1999). Mode of singing also varies in birds. Mostly oscine birds use two types of singing mode i.e., 'repeat' or 'eventual variety' (singer produces one song type/strophe repeatedly before switching to another type of strophe), and 'serial' or 'immediate variety' mode (singer produces a variety of song strophes/ phrases without any apparent rule) (Molles & Vehrencamp 1999).

In many species song repertoire is organised around a limited number of strophes or song types, such as in the White-crowned Sparrow *Zonotrichia leucophrys*, where each male uses only a single, simple, monotonous song in stereotyped manner (Baptista 1975). Some other species, namely European Redwing *Turdus iliacus* (Bjerke & Bjerke 1981), Splendid Sunbird *Nectarina coccinogastra* (Grimes 1974) and Ovenbird *Seiurus aurocapillus* (Falls 1978) are also known for their small repertoire size. While in others, such as in Mokingbird *Mimus polyglottos* (Howard 1974) and Sedge Warbler *Acrocephalus schoenobaenus* (Kroodsma & Parker 1977; Catchpole 1976), the songs composed of a large number of dissimilar structured song elements with an unrestricted number of combinations (Catchpole & Slater 1995).

Robins belong to old world Chats-Flycatchers (Muscicapidae) with some exceptions; the American Robin *Turdus migratorius* and Mountain Robin *T. plebejus* belong to family Turdidae, the Scarlet Robin *Petroica multicolor* belongs to the family Petroicidae (del Hoyo et al. 2006). Robins use both simple and complex vocalisations for communication (Bhatt et al. 2000; Kumar & Bhatt 2001). For example, European Robin *Erithacus rubecula* use a complex, melodious song (made up of prolonged notes, short warbles and trills) for territory defence, almost throughout the year (Hoelzel 1986, 1989; Scriba & Goymann 2010). African Forest Robins (*Stiphornis*) have been reported to use two types of vocalisations (Beresford & Cracraft 1999). However, functions of these categories remain unclear. Similar patterns of vocalisations were also reported in a recently discovered species of African Robin, the Olive-backed Forest Robin *Stiphornis pyrrholaemus* (Schmidt et al. 2008). Oriental Magpie Robin *Copsychus saularis* also use two distinct categories of songs, which differ in structure and functions (Bhatt et al. 2000; Kumar 2003).

The Indian Robin *Saxicoloides fulicata*



Image 1. Indian Robin *Saxicoloides fulicata*

(Muscicapidae) is an endemic, small-sized (19cm), passerine species, distributed throughout the Indian subcontinent except northeastern, higher Himalaya and Thar Desert, and is divided into a few races. It is a common, resident, territorial and sexually dimorphic bird. Males have glossy black under parts and a white shoulder patch (Image 1), while females have grayish-brown upperparts and grayish under parts and lack white shoulder patch. It prefers dry, stony areas with sparse scrub, arid stony ridges, low rocky hills outcrops, edges of cultivation and deserted buildings, gardens and groves (Ali & Ripley 1983; Grimmett et al. 1998). Information is scanty on the singing behaviour & sociobiology of the species (Nirmala & Vijayan 2003). In this article, I describe and quantify the organisation of song in terms of physical characteristics, categories and context of production in the Indian Robin for the first time.

METHODS

Field recordings

Songs of 23 male Indian Robin were recorded in their natural habitat from four different places in northern India. Recordings on 11 individuals were made in Dehradun (30°26'N & 78°06'E) during May 2002 to February 2005; during the same period, five

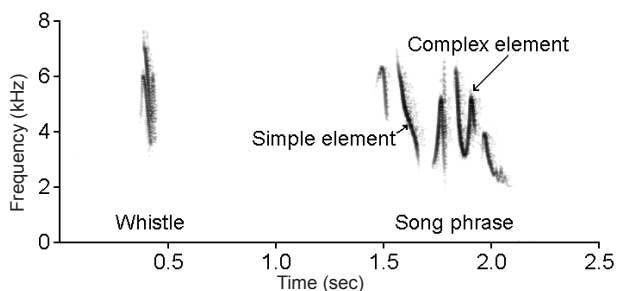


Figure 1. Song components and terminology used in the present study.

birds were recorded at Srinagar, Garhwal (30°21'N & 78°77'E); two at Haridwar (29°55'N & 78°08'E); and five recordings in and around Jodhpur (26°21'N & 73°06'E) during March–April 2001. All birds recorded were unbanded. To avoid recording the same individual twice, each bird was recorded only when it was within view and recordings were made in each area only once. A total of 183 recordings (2–9 per individual) were made ranging 2–14 minutes duration. Signals were recorded using Sony CFS 1030S or Sony PCM-M1 or Marantz PMD 222 sound recorders and JVC MZ-500 or Sennheiser ME-66 microphones. Behavioural correlates were used to infer the possible meaning of the song.

Data analysis

Recordings were digitised using M-Audiophile 2496 (sound card) at the sampling rate 48kHz and 16 bit resolution. After editing, cuts of high quality recordings (excluding recordings of five individuals due to poor quality) were analyzed with the help of windows based sound analysis software, Avisoft SAS Lab Pro (version 4.1). Spectrograms were displayed on a computer monitor and measurements of variables were made using frequency and time cursor. Dominant frequency of given strophe was analysed generating power spectrum. The frequency of highest peak was recorded. For the sequential analysis of strophes, spectrograms were printed using several line mode. In this mode, about 40sec long recording was printed in seven lines on A4 size paper in landscape page setup. All spectrograms were calculated using following setting of SAS Lab: 512 FFT-length, 75% Frame, Hanning window and 87.5% time window overlap. In the present study, minimum and maximum frequency, frequency bandwidth, dominant frequency (frequency of maximal amplitude), duration and

intervals in song strophes were measured. Number and types of elements per strophe, song rate (strophes per minute) and complexity level (types of elements per min.) were calculated to define the acoustical features of songs. Results were expressed as mean±SE. Non-parametric statistics was used to measure the level of significance in differences, since most data were not normally distributed. Windows based software SPSS was used for the analysis.

Song terminology

Study of literature reveals that there is no standardization of terminology for the songs of different species. Indeed, different authors used different terms for the same songs features (Spector 1992). I labeled structural units of song on the basis of morphological features, using terminology partly adopted from literature (Staicer 1989; Bay 1999). The song in Indian Robin consists of a number of distinct sections, called strophes or phrases and each strophe consists of several smaller units known as elements (Fig. 1). An element is a short tracing on the spectrogram. On the basis of frequency modulations the elements can further be classified into simple (constant pitch, un-modulated or slightly modulated frequency) and complex (varied pitch, rapidly modulated or multi harmonic frequency) elements. In a song bout, in different phrases, often bird use a combination of one to three elements together and is named as a syllable (Catchpole & Slater 1995).

RESULTS

Physical characteristics

Males sang during the breeding season mostly in the morning (0500–0900 hrs) and evening (1700–1730 hrs). Individuals were observed singing from exposed branches of trees, rocks, walls, electric wires and on the ground. The song of Indian Robin was composed of strophes with occasional whistles (Fig. 2). The strophes were made up of one to nine elements, with dissimilar structure and occasional repetition of elements. The frequency of song ranged from 1.03 to 8.00 kHz. Dominant frequency of most songs was 4.2 kHz (2.3–6.5 kHz). Average duration of strophes was 0.68±0.03 to 0.21±0.02 sec. preceded and followed by temporal intervals ranging 6.34±0.46 to 0.61±0.03

Table 1. Physical characteristics and temporal variations in two categories of songs in the Indian Robin.

Variables	Song type-A (Mean±SE)	Song type-B (Mean±SE)	Mann-Whitney U-test	Z-Score	Probability P
Minimum frequency (kHz)	2.48±0.05 (1.87-3.53, N=18, n=64)	2.19±0.11 (1.03-4.34, N=8, n=48)	1169.00	-2.16	0.031
Maximum frequency (kHz)	6.96±0.07 (5.43-8.00, N=18, n=64)	6.22±0.14 (4.31-7.65, N=8, n=48)	900.00	-3.74	0.001
Frequency Bandwidth (kHz)	4.48±0.08 (2.87-6.00, N=18, n=64)	4.03±0.09 (2.88-5.87, N=8, n=48)	955.50	-3.41	0.001
Dominant frequency (kHz)	4.21±0.08 (3.44-6.50, N=18, n=64)	4.20±0.15 (2.30-6.35, N=8, n=48)	1502.50	-0.20	0.844*
Strophe duration (sec)	0.68±0.03 (0.24-2.16, N=18, n=64)	0.21±0.02 (0.05-0.64, N=8, n=48)	125	-8.30	0.001
Inter-strophe interval (sec)	6.34±0.46 (2.17-21.25, N=18, n=64)	0.61±0.03 (0.21-1.29, N=8, n=48)	0.00	-9.00	0.001
Song Rate (Strophes per min)	9.33±0.67 (6.00-14.00, N=12, n=15)	70.56±3.71 (54.00-84.00, N=6, n=9)	0.00	-4.04	0.001
No. of elements per strophe	5.81±0.22 (1.00-9.00, N=18, n=64)	2.17±0.11 (1.00-4.00, N=8, n=48)	67.00	-8.75	0.001
Types of elements per strophe	4.73±0.18 (1.00-9.00, N=18, n=64)	1.47±0.11 (1.00-3.00, N=8, n=48)	93.00	-8.66	0.001
Song complexity (Types of elements per min)	9.18±1.22 (4.00-24.00, N=9 n=16)	21.36±1.31 (16.00-29.00, N=5, n=11)	8.50	-3.93	0.001

* Not significant; Ranges are given in parenthesis with number of individuals (N) and number of song/strophe samples (n).

Table 2. Some examples of sequence of phrases in song bouts in the Indian Robin. For example, bird D1 used two types of phrases i.e. a and b, alternatively in 5 minutes long bout, and bird J1 used six types of phrases almost randomly.

Locations of the recordings	Bird ID	Sequence of phrases in 5 min. song duration					Types of phrases
		1	2	3	4	5	
Dehradun (30°26'N & 78°06'E)	D1	aabababbbbabaaaaabbbbbaaaaaababababaaaaabbbb▶..bbbbbb▶aaaaa					2
	D1*	abccdefcgcghaaeddiddaaeddiddaaeddiaaedejdaakddekdialadedmlddm					13
	D2	aaaaaaaaaaaaaaaaaaa...aaaaaaaaaaa...aaaa▶▶bbbbbbbbbb▶▶aaaabbbb					2
Srinagar, Garhwal (30°21'N & 78°77'E)	S1	aa ▶▶▶ b ▶▶▶ bbbbbb...▶▶▶...▶▶▶...aaaacaaa...bbb ▶▶▶ aaaaa...bbbc					3
	S2	aaaaaaaaaaaaaaaaaaaaaaaaaaa...aaaaaa...bbbbbbb...aaaaa..bbaabbbbaaaaa					2
Jodhpur (26°21'N & 73°06'E)	J1	aabac...bbb...abbbbbb...acadacacacacacacacef ▶ caacacbbb ▶▶▶▶▶					6
	J2	aaaaaaa ▶ aaaa▶aaaabbbbbbbbbbb▶▶▶▶▶ aaaaaaaaaaaaa ▶▶▶bbb					2

▶ Whistle; ... Longer intervals; * Song type-B (given time duration is not actual)

sec. Songs were produced at variable rate; 9.33±0.67 strophes per minute in song type-A and 70.56±3.71 strophes per minute in song type-B (Table 1).

Indian Robin sang in moderate sized song bouts ranging one to six minutes duration (sometimes <1 or >6 min). Different types of temporal patterns were identified. On the basis of sequence of strophes, three categories were observed. However, distinction is purely temporary and individuals do not follow strict rule in sequencing. Two to nine types of phrases with modulated frequency were identified in song bouts. However in most cases (74%) males used two

to three types of phrases. Occasional whistles were also observed. These were monosyllabic in structure and uttered 1–5 times between any two consequent phrases of a song bout.

Stereotyped mode

In many cases (58%), the bird repeated a particular strophe in stereotyped order with minor structural variations of elements (Fig. 2A, element g in P1 is replaced by f in P2 and elements c, d & e showed variations in their minimum and maximum frequencies, respectively, and adding or deleting of an

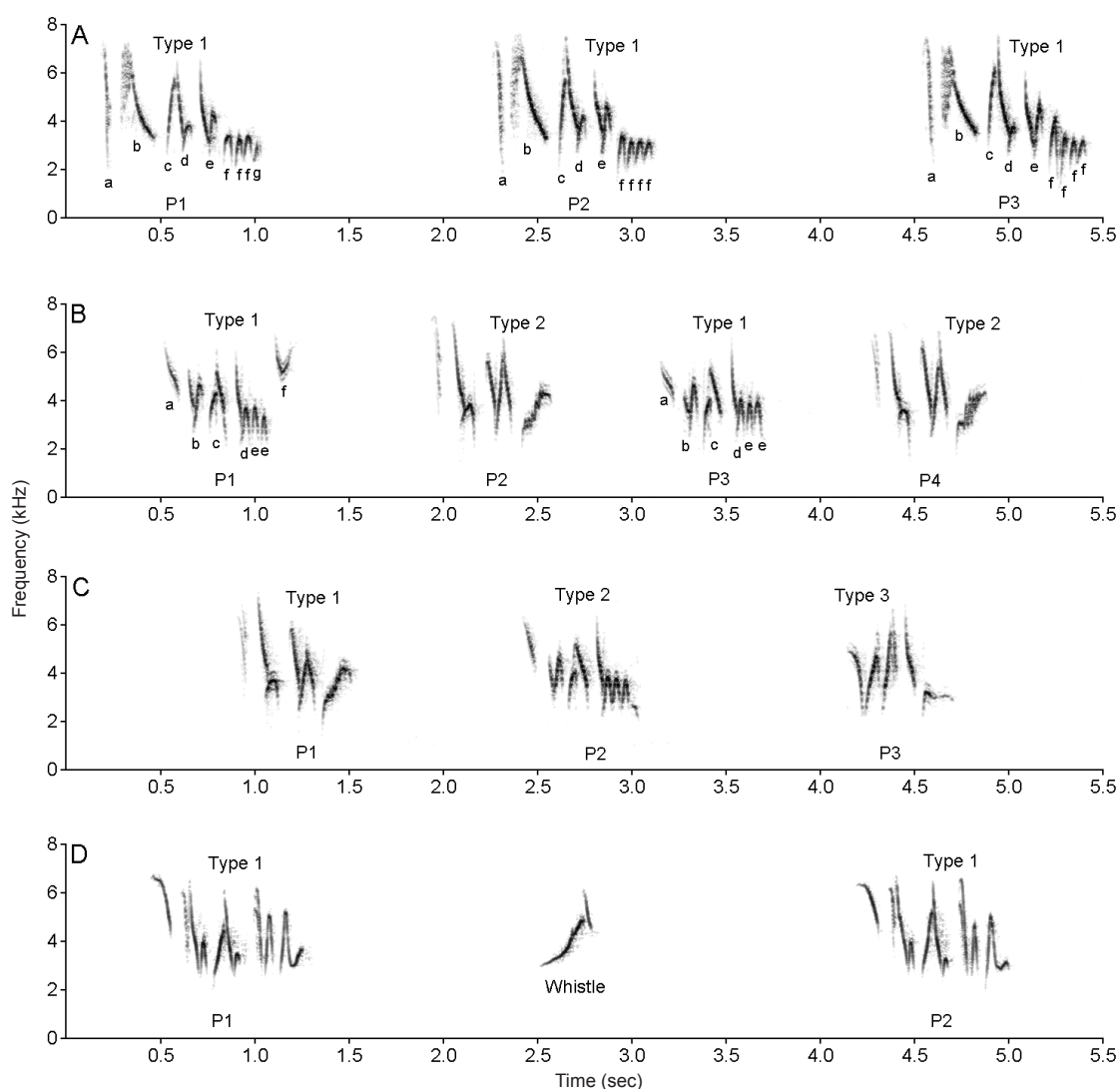


Figure 2. Temporal variations in the song of Indian Robin.

A - Stereotyped mode with minor structural variations in elements; B - Alternative mode with adding/ deleting of elements, such as element f of P1 is omitted in P3 phrase; C - Use of three different types of phrases in a given song bout; D - Use of whistles between phrases.

element, such as in Fig. 2B, element f of P1 is omitted in P3). This mode was observed mainly in isolated birds (N=9) with no conspecific neighbor.

Alternative mode

In this mode individuals produced two or three types of phrases in alternative manner (Fig. 2C). For instance, bird D1 (Table 2) produced a and b phrases alternatively and bird J1 produced a, b, c and d phrases alternatively without fixed number and sequence and new phrases such as e and f, in a recording. In some recordings occasional whistles were also used between phrases (Fig. 2D). This mode of singing was observed

only in birds (N=3) having conspecific neighbours.

Complex mode

Contrary to type-A songs in stereotyped mode (Fig. 3A), in some cases (16 %) such as type-B songs, birds produced large number of phrases randomly with out any strict order in sequence (Fig. 3B, C). However, repetition of phrases (such as in Fig. 3B and C, Type 1 repeated as P1, P5 and P7) and re-assortment of elements/ phrases (such as Type 2 as P2, P8 and P12 in Fig. 3B and C) were identified, for example type-B (Table 2) songs of bird D1.

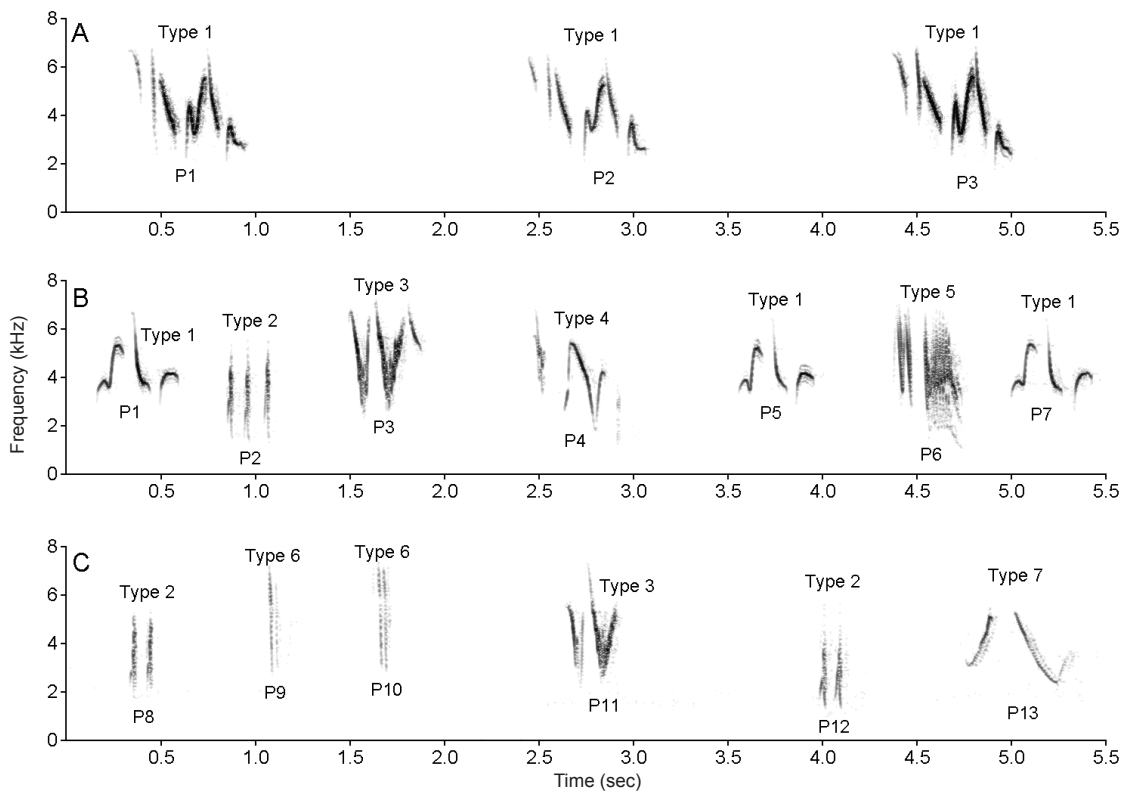


Figure 3. Song categories in the Indian Robin.

A - Type-A song in stereotyped mode; B & C - Type-B song with 7 types of phrases with repetition of some phrases, such as type-1.

Song categories and functions

Syntactically two categories of songs were identified (Fig. 3). Type-A songs were common (84% of total songs recorded) in breeding season and consisted repeated strophes having 0.68 ± 0.03 sec duration and followed by 6.34 ± 0.46 sec gap. Usually, the bird repeated a particular strophe several times before switching to another strophe. These songs usually uttered during territory advertisement and to maintain pair-bond. However, territorial conflicts were not obvious ($n=5$). This could be the result of low population densities of this species in northern India (pers. obs.; unpub. data). Mostly solitary pairs were observed in a particular area.

Type-B songs were more complex (Mann-Whitney U-test; $U=8.5$, $p<0.001$) and rare (only 16% of songs recorded) as compared to type-A songs. Most acoustical characteristics significantly differ (Table 1) from type-A songs except dominant frequency ($P=0.844$). Type-B songs were consisted of short strophes having 1–4 elements. The duration and gap of strophes were significantly lower ($p<0.001$) than type-A songs. The

males produced 70.56 ± 3.71 strophes per minute. These songs were observed only in the presence of females and during courtship. Courtship displays were also associated with these songs. During these displays male birds were observed running on the ground or on a wall 0.65 to 2.15 m towards a female with splayed and erected tail, forwarded beak and lowered head while emitting a complex song. Within a few seconds the male mounted the female for insemination.

DISCUSSION

Physical characteristics

In the present study, the Indian Robin used stereotyped songs, organised around a limited number of strophes (except type-B songs). Studies on temperate song birds provide some insights on how song output is organised. Like the Indian Robin, Chaffinch *Fringilla coelebs* use three or four song types (phrases) in its song, with a sequence of each in turn before returning to the first (Slater 1983). Sequence of song types is not

always the same and the phrases are not necessarily sung with equal frequency. It is quite common in many species for one song to comprise a much larger part of the bird's output than another (Catchpole & Slater 1995). Degree of song variability is highly diverse in birds and song characteristics may also vary temporally and spatially (Catchpole & Slater 1995). Tawny Pipit *Anthus campestris* use short and simple songs (Osiejuk et al. 2007) and males are known to have single song type repertoire (Neuschultz 1986). In contrast, Chaffinch *Fringilla coelebs*, Great Tit *Parus major*, Ring Ousel *Turdus torquatus* and Dark-eyed Junco *Junco hyemalis* use several song types (Krebs et al. 1978; Slater 1981; Ince & Slater 1985; Williams & MacRoberts 1977), while others, like Red-eyed Vireo *Vireo olivaceus* and Marsh Wren *Cistothorus palustris* use 12 to >100 song types in their repertoire (Borror 1981; Kroodsma & Verner 1987). Common Nightingale *Luscinia megarhynchos* have a large repertoire (up to 260 different song types) divided into whistle songs and nonwhistle songs (Kipper et al. 2004; Kunc et al. 2005).

In most oscine birds, song complexity serves as an honest signal of male quality (Hesler et al. 2011), and selection may also favour song parameters such as song rate and song length (Garamszegi & Møller 2004; Kunc et al. 2005). In species with large repertoire, sexual selection might favour the evolution of structural song traits such as whistle songs in nightingales (Kunc et al. 2005), thought to be evolved to attract migrating females at night (as structurally simple whistles suffer less from spectral degradation during propagation over long distance; Slabbekoorn et al. 2002). While, in species with a small repertoire, it may favour song length and song rate, as reported in some species such as Willow Tit *Parus montanus* (Welling et al. 1997) and Hoopoe *Upupa epops* (Martiu-Vivaldi et al. 2002). In the present study, Indian Robin used song in both inter- and intra-sexual contexts. When inferred with the behavioral observations, type-A songs were driven by male-male competition for territory and mate acquisition. Males also shortened the length of strophes and reduced gap between strophes (in type-B songs) on the arrival of females in close vicinity, most probably to increase song rate, which could also be an indicator of male quality as suggested for other species.

The songs of Indian Robin range from 2.19 to 6.96

kHz frequencies. The dominant frequency (i.e. 4.2 kHz) of songs was considerably higher than expected for its body weight. Wallschläger's regression function (Wallschläger 1980) of 'central frequency' on body weight predicts a frequency of 3.6 kHz for birds having body weight (i.e. 18–19 g) like Indian Robin (Ali & Ripley 1983). Similar trends have also been reported in some South American passerines (Ryan & Brenowitz 1985). Lambrechts (1996) suggested that birds should have greater performance at about one-fourth of their frequency range.

Indian Robin produced its song in three different modes. In stereotyped mode, in a song bout bird produced same phrase again and again (like ...AAAAA...), while, in alternative mode bird used two or three types of phrases (likeAAA...BBBB...AAAA...BB....CCCC...). Third mode of production was complex and observed only in type-B songs. In the literature, singing mode refers to the sequential pattern of song type (strophes/ phrases) production (Molles & Vehrencamp 1999). It is classified as 'repeat/ eventual variety' such as 'stereotyped/ alternative mode' of singing in Indian Robin, and 'serial/ immediate variety' analogue to 'complex mode' of singing in present study. Previous studies showed that in some species singers increase their switching rate among song types during agonistic conflicts and on the arrival of female (Kramer et al. 1985; Langmore 1997). In the present study it seems that Indian Robin used the stereotyped mode of singing in low territorial pressure situations (where conspecific territorial neighbors were absent) and the alternative mode in relatively high territorial pressure situations (when the singing male had a conspecific neighbour). Although not substantiated conclusively in the present study, it opens scope to test this hypothesis in future studies.

In the present study, it was observed that the Indian Robin mostly sing in morning and evening hours, like many other passerines (Catchpole & Slater 1995). Catchpole (1973) studied the diurnal rhythms of song production in two European *Acrocephalus* species, the Reed (*A. scirpaceus*) and Sedge (*A. schoenobaenus*) warblers. He observed a marked peak of singing activity around dawn and dusk in these species. The acoustic transmission hypothesis (ATH) predicts that birds sing their full songs most intensively at dawn because this is the time of the day when these songs propagate most effectively and hence should be most

effective for long-range communication (Henwood & Fabrik 1979). However, experiments made by Dabelsteen & Mathevan (2002) on Blackcap *Sylvia atricapilla* in temperate deciduous forests, indicate that the dawn singing can't be understood only by ATH, some other factors such as feeding and social conditions may also be responsible for dawn singing. I am unable to contribute to these ideas but the Indian Robin can be a suitable model to test the ATH in tropical habitats in future studies.

Song categories and functions

On the basis of acoustical features and context of production, two categories of songs were emerged in Indian Robin. Type-A songs were simple, stereotyped, spontaneous and common, while type-B songs were rare, female oriented and more complex (Mann-Whitney U-test; $U=8.5$, $p<0.001$) than type-A. In such a manner, two or more acoustically distinct song classes have been reported for some passerine birds (namely Dark-eyed Juncos, Titus 1998; Field Sparrow *Spizella pusilla*, Nelson & Croner 1991; Yellow-throated Vireo *Vireo flavifrons*, Smith et al. 1978; Yellow-rumped Caciques *Cacicus cela*, Trainer 1987; Red-vented Bulbul *Pycnonotus cafer*, Kumar 2004; Oriental Magpie Robin, Kumar 2003). In some species, such as European Blackbird *Turdus merula* (Dabelsteen & Pedersen 1990), European Robin (Dabelsteen et al. 1997), Lesser Whitethroat *Sylvia communis* (Balsby 2000) and Song Sparrow *Melospiza melodia* (Anderson et al. 2008), songs are described as 'broadcast songs' (type-A songs of Indian Robin) and 'soft songs' (type-B songs of Indian Robin) also termed as 'quiet song', 'twitter song' or 'whisper song' in previous studies (Anderson et al. 2008). Like the Indian Robin, the first category songs of these species were loud and conspicuous and second category songs were soft, low amplitude and rare, used in different contexts such as female courtship, male-male aggression or both (Dabelsteen et al. 1998; Titus 1998; Anderson et al. 2008). However, in Indian Robin, type-B songs were used only for mating/ courtship purpose but the scope of present study limits us from discounting this feature for other functions in other seasons. Some species of North American wood-warblers (Parulidae) also sing two categories of songs. The first category songs of these species were often simple and highly stereotyped, sung at relatively low rates and near

females. While, second category songs were usually more complex and variable, sung at higher rates and in male-male interactions (Spector 1992; Bolsinger 2000). In contrast with wood-warblers song system, in the present study, Indian Robin used simple and stereotyped songs for territory/pair-bond maintenance and, complex and varied songs for mating.

Some hypotheses have been proposed to explain the proliferation of song categories in birds (Nelson & Croner 1991). It is hypothesized that all song types (phrases) within the vocal repertoire of a species may have the same purpose. Evolution of large numbers of song types in a species may be favored by both inter- and intra-sexual selection. Large repertoires may effectively repel the rival males by appearing to represent the presence of several singing males. Large repertoires might also be favored by females during mate selection (Catchpole 1980). Another hypothesis assumes that different song categories/ song types within a repertoire contain different information (Smith et al. 1978; Trainer 1987). Different song types are sung in different behavioural contexts, and thus appear to provide different information to listeners. In the present study, the Indian Robin used two categories of songs in different behavioural contexts; it seems that second class hypothesis may fit to understand the evolution of song in this species.

CONCLUSION

Studies carried out during the last five decades on the quantification of complexity and variability in bird song provides deep insights in understanding the evolution of song and sexual selection in temperate birds. It is now well-understood that the complexity of songs in passerines play an important conceptual, theoretical and empirical role. Studies on the singing behaviour of Indian birds are restricted to comparatively few species. It is believed that most tropical birds exhibit quite different social systems than temperate species. Communication systems of most Indian birds cannot be properly understood based only on the information available from temperate birds. So, extensive long-term investigations are needed for the characterisation and documentation of the vocal repertoire of Indian birds to understand the evolution of song in these species. The present study is a base-

line effort in this direction and may possibly enable more detailed studies to be carried out in the future, especially on repertoire size, individual variations, regional dialects, and ecological and behavioural constraints on the evolution of song in Indian birds.

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Justification for delayed publication:

During 2005, I was selected as a scientist in the ZSI and posted at Itanagar, Arunachal Pradesh for about five years. The lack of bio-acoustic facilities and relevant literature in the early phase of my posting, and prolonged illness of two family members led to the delay in publication -- Anil Kumar (author).

The song characteristics and functions of the species do not change in ten years. There are no new studies on this topic and therefore the findings are informative and provide a base line for the song features of the species -- Aziz Aslan (subject editor).