

## Song repertoire size of the Pied Bushchat *Saxicola caprata*

Among songbirds, male song is a vocal display involved in securing the two requisites, an area (territory) and a partner, for breeding. Although a single species-specific song is sufficient for this purpose, many birds produce songs with complexity and diversity. Song repertoire size varies greatly among species. Some species have only one song per individual whereas others have several hundreds or thousands of songs per individual<sup>1</sup>. Due to this great variation in size, song repertoires have been a wonderful topic for attacking a wide variety of questions in animal behaviour. The structure and use of song repertoires are believed to be traits to understand proximate and functional issues in animal communication. Additionally, studies on song repertoires can provide insights into the circumstances under which the repertoire was acquired and possibly provide information on a male's quality<sup>1</sup>.

To understand the role and evolution of repertoire sizes in species, it becomes a pre-requisite that one should know the accurate repertoire size of the species to be studied. The great majority of information available about bird song repertoires indeed comes from the temperate regions of the world. In fact, tropics have been relatively neglected from a research point of view<sup>2</sup>. For example, the Indian sub-continent has rich avian biodiversity including songbirds, yet systematic studies on bird song behaviour are almost negligible in this sub-continent<sup>3,4</sup>. Furthermore, we do not have any information on the repertoire size of any songbird of the Indian sub-continent to date. Thus, to fill this gap of knowledge, the present study attempts to estimate the song repertoire size of an acoustically complex tropical song bird, the Pied Bushchat *Saxicola caprata*.

The Pied Bushchat (order Passeriformes, family Muscicapidae), a sexually dichromatic species, occurs discontinuously from Transcaucasia and the Indian sub-continent to the Southeast Asia, Philippines, Indonesia (except Borneo), New Guinea and New Britain<sup>5</sup>. The male is black except for a white rump, wing patch and lower belly along with dark brown iris (Figure 1). The female is drab brown and slightly streaked. The species is found in open habitats including scrub, grassland and cultivated areas. Males are

territorial and actively resist intrusion into their feeding and breeding areas by conspecifics or other chats. During the breeding period, males deliver songs from prominent perches<sup>5</sup>.

This study was carried out from February–July 2008 in open/scrub lands within a 10 km radius at Haridwar (29°55'N, 78°08'E), Uttarakhand, India. Nine males were captured in mist nets and ringed with unique combination of plastic colour rings. The territories of these males were mapped by noting locations of singing and boundary encounters. Dawn songs of males were recorded with a Sennheiser ME 67 directional microphone attached to a Marantz PMD 670 digital sound recorder and saved in a computer as wav files with input sampling frequency of 24,000 Hz and sample format of 16 bit. Spectrograms were prepared with Avisoft SASLab Pro 4.1 software with the following set of parameters: FFT-length = 512, frame (%) = 75, window = flat top and temporal overlap = 87.5%. This gave a 235 Hz bandwidth with 46 Hz frequency and 2.6 ms time resolution. Spectrograms were visually grouped into song types to enable

counting of the total number of types. To estimate the size of an individual's song repertoire, we plotted the cumulative number of new song types against the total number of songs in the subject's repertoire. Results are reported as means  $\pm$  SD.

The song of the male Pied Bushchat was composed of a number of different song types. Each song type consisted of a series of similar or dissimilar units referred to as elements (Figure 2). The average minimum and maximum frequencies of song types were found to be  $1.9 \pm 0.1$  and  $6.0 \pm 0.5$  kHz respectively. Song type length ranged from 0.7 to 2.2 s with a mean value of  $1.4 \pm 0.2$  s. Mean length of pauses between song types was found to be  $2.2 \pm 0.7$  s. The average number and types of elements in a song type were  $8.1 \pm 1.5$  and  $7.9 \pm 1.4$  respectively.

Based on visual inspection of the spectrograms, Pied Bushchat males had a mean repertoire of  $22.2 \pm 6.6$  song types (range = 13–29;  $N = 9$  males). It has been suggested that some song types are sung less frequently by males and thus, there are possibilities that these may not be



Figure 1. Male Pied Bushchat *Saxicola caprata* in the study area.

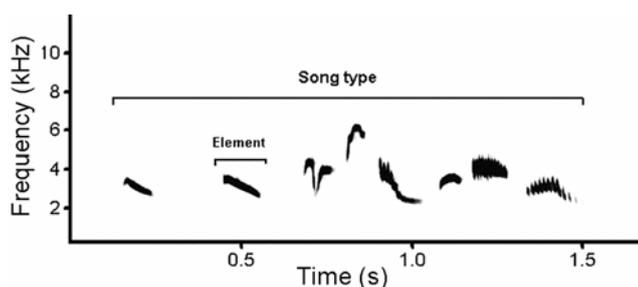
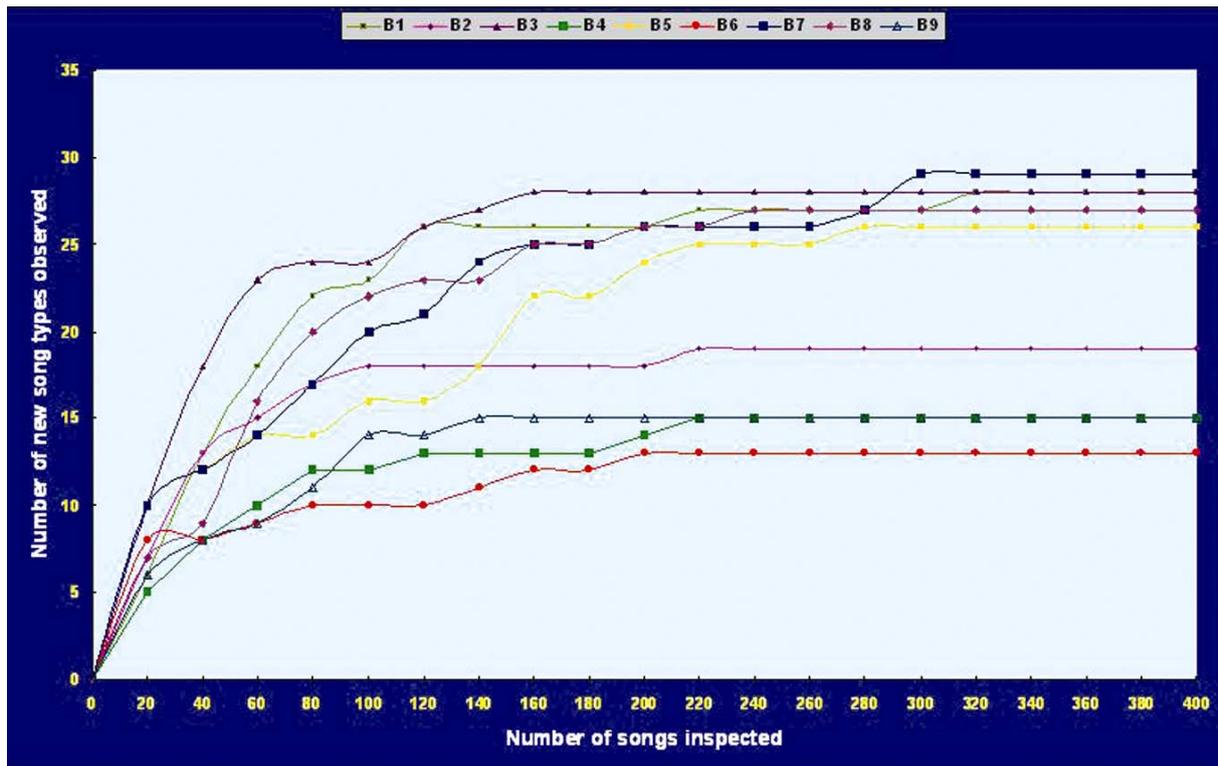


Figure 2. Spectrogram of a song type of male Pied Bushchat *Saxicola caprata*.



**Figure 3.** Plots of the exhaustion curves of new song types against total song types inspected for nine male Pied Bushchats *Saxicola caprata* (B1–B9).

noticed and counted in repertoire estimation<sup>6</sup>. To eliminate this possibility, we inspected at least 2500 song types recorded during different breeding stages for each male. However, inspection of a few hundred song types was sufficient to generate repertoire size with 100% confidence for all males in this study. For example, for some individuals (bird B3, B6 and B9), analysis of up to 200 songs was enough to reveal the complete repertoires of males. However, for bird B1 and B7, we had to analyse more than 300 song types and then the curves approached an asymptote. Overall, we did not find any new song types in the repertoire of any male after inspecting 320 song types (Figure 3). Because plots of the number of newer song types versus the total number of songs uttered approached an asymptote for all the males, we were able to generate accurate song repertoire sizes of the Pied Bushchat.

The songs of Pied Bushchat were found to be highly varied and complex. Five out of nine males had more than 20 song types in their repertoires, thus qualifying the Pied Bushchat to be a species with large song repertoire<sup>7</sup>. However, song repertoires for the remaining

four males ranged between 13 and 19 song types. Like Pied Bushchat, intra-species variation in song repertoires occurs in many bird species and has been correlated with the age of males. That is, older males have larger song repertoires and perform better in intrasexual contests to monopolize resources<sup>8,9</sup>. However, the present study is based on the males of unknown age. Thus, further studies with Pied Bushchat should include experiments that test whether females are sensitive to song repertoires.

Pied Bushchat sang with immediate variety because more than 80% successive song types were different from one another in a song bout. One interesting aspect we found about song repertoire presentation in Pied Bushchat is that males shared their song repertoires. Such sharing permitted matched countersinging, with one male singing a particular song type and another male responding with the same song type or with a different 'shared' song type. Repertoire sharing is an interesting feature in animal communication because shared songs are used in male vocal interactions and can be used to address a particular rival and to signal more specific information such

as arousal or the readiness to escalate a contest<sup>10</sup>. Thus, the characteristic of sharing song repertoires with neighbours makes the Pied Bushchat an ideal model to understand the role of repertoire sharing in territory acquisition and maintenance because males may be more successful in establishing a territory when they share songs with their rivals<sup>11</sup>.

In the present study, males recorded on multiple dates used the same small regions, often near an edge of a territory, for dawn singing. Also, males observed trespassing into adjacent territories were immediately chased from neighbouring territories by the resident male and, shortly thereafter, both males began to sing with variety. Furthermore, dawn singing with complex song repertoire presentation remained apparently constant throughout the breeding period in the Pied Bushchat. Thus, it may be argued that male Pied Bushchats could use song repertoires to communicate with their close neighbours, to announce and assess their strength or willingness to defend the territory, or to challenge neighbours on a daily basis throughout the breeding season (i.e. social dynamic hypothesis)<sup>12</sup>. As Pied Bushchats are

multi-brooded (i.e. a pair may raise up to three broods within a breeding season), then it seems appropriate that vigilance of territories boundaries has to be maintained throughout the breeding season and complex dawn singing probably plays a role in it. However, this does not rule out that song repertoires have evolved under sexual selection. Song repertoires of male Pied Bushchat also could be directed to females. Some studies have suggested that neighbouring females may benefit by eaves-dropping on the intense dawn chorus (as an honest signal) to choose a better quality male for extra pair fertilization particularly during a female's fertile period<sup>13</sup>. Thus, males, with large song repertoires, may be competing with neighbours for opportunities to mate with receptive females, either their own mates or those of neighbouring males through complex dawn singing<sup>14</sup>.

The present study reveals that the Pied Bushchat has large song repertoires where males sing with immediate variety. These characteristics make this species an ideal subject to further understand the process and patterns involved in the evolution of song repertoires through experiments on some important aspects such as the abilities for individual recognition/neighbour-stranger discrimination, year-to-year variations in song repertoire sizes and the correlation between repertoire size and age/territory quality/male quality. This species may be used as a suit-

able model for studying the development of song repertoires.

1. Catchpole, C. K. and Slater, P. J. B., *Bird Song: Biological Themes and Variations*, Cambridge University Press, Cambridge, 1995.
2. Slater, P. J. B. and Mann, N. I., *J. Avian Biol.*, 2004, **35**, 1–6.
3. Bhatt, D., Kumar, A., Singh, Y. and Payne, R. B., *Curr. Sci.*, 2000, **78**, 722–728.
4. Sethi, V. K. and Bhatt, D., *Curr. Sci.*, 2008, **94**, 1173–1179.
5. Ali, S. and Ripley, S. D., *Handbook of the Birds of India and Pakistan, Vol. 9: Robins to Wagtails*, Oxford University Press, New Delhi, India, 1998.
6. Reid, J. M. *et al.*, *Anim. Behav.*, 2004, **68**, 1055–1063.
7. Stoddard, P. K., Beecher, M. D., Horning, C. L. and Willis, M., *Condor*, 1990, **92**, 1051–1056.
8. Mountjoy, D. J. and Lemon, R. E., *Anim. Behav.*, 1995, **49**, 357–366.
9. Birkhead, T. R., Buchanan, K. L., Devoogd, T. J., Pellatt, E. J., Szekely, T. and Catchpole, C. K., *Anim. Behav.*, 1997, **53**, 965–971.
10. Todt, D. and Naguib, M., *Adv. Study Behav.*, 2000, **29**, 247–296.
11. Beecher, M. D., Campbell, S. E. and Nordby, J. C., *Anim. Behav.*, 2000, **59**, 29–37.
12. Staicer, C. A., Spector, D. A. and Horn, A. G., In *Ecology and Evolution of Acoustic Communication in Birds* (eds Kroodsma, D. E. and Miller, E. H.), Cor-

nell University Press, Ithaca, New York, 1996, pp. 426–453.

13. Otter, K., McGregor, P. K., Terry, A. M. R., Burford, F. R. L., Peake, T. M. and Dabelsteen, T., *Proc. R. Soc. London, Ser. B*, 1999, **266**, 1305–1309.
14. Slagsvold, T., Dale, S. and Saetre, G. P., *Behavior*, 1994, **131**, 115–138.

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