STUDY OF SOME IMPORTANT ASPECTS OF BREEDING ECOLOGY AND VOCALIZATION OF JUNGLE PRINIA IN SISWAN COMMUNITY RESERVE, PUNJAB, INDIA

Dissertation submitted to the

Saurashtra University Rajkot, Gujarat

In partial fulfillment of

Master's Degree in Wildlife Science

By

Vignesh Chandran M

Under the Supervison of

Dr. Dhananjai Mohan

Dr. Pratap Singh

July, 2021

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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DECLARATION

I, **Vignesh Chandran M**, hereby declare that the research work titled **"Study of some important aspects of breeding ecology and vocalisation of Jungle Prinia (*Prinia sylvatica gangetica*) in Siswan Community Reserve, Punjab, India"**, carried out in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot is an original piece of research work. This research work was carried out under the supervision of **Dr. Dhananjai Mohan,** Wildlife Institute of India, Dehradun and **Dr Pratap Singh,** IFS (Retd.) from January 2021 to June 2021. I hereby declare that this work has not been submitted for any other degree of any university.

Date: July 31, 2021

Place: Dehra Dun

Mr. Vignesh Chandran M

(XVII M.Sc. Course)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248 001, उत्तराखण्ड, भारत
Post Box No. 18, Chandrabani, Dehradun - 248 001, Uttarakhand, INDIA
ई.पी.ए.बी.एक्स : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
EPABX : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
ई-मेल/E-mail : wii@wii.gov.in, वेब/Website : www.wii.gov.in

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

This is to certify that **Mr. Vignesh Chandran M** has carried out an original piece of research in partial fulfilment of Master's Degree in Wildlife Science of the Saurashtra University, Rajkot, Gujarat. The topic of his dissertation is **"Study of some important aspects of breeding ecology and vocalization of Jungle Prinia (*Prinia sylvatica gangetica*) in Siswan Community Reserve, Punjab, India".** The study was carried out under our supervision from January 2021 to June 2021. We hereby certify that this work has not been submitted for any degree to any university.

Dr. Dhananjai Mohan
Director, Wildlife Institute of India
Supervisor

Dr. Pratap Singh
IFS (Retd.)
Co- Supervisor

Date: July 31, 2021
Place: Dehradun

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248 001, उत्तराखण्ड, भारत
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ई.पी.ए.बी.एक्स : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
EPABX : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
ई-मेल/E-mail : wii@wii.gov.in, वेब/Website : www.wii.gov.in

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Wildlife Institute of India, D.Dun

Supervisor

(Dr. Dhananjai Mohan)

पत्रपेटी सं. 18, चन्द्रबनी, देहरादून-248 001, उत्तराखण्ड, भारत
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ई.पी.ए.बी.एक्स : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
EPABX : +91-135-2640100, 2640114, 2640115, फैक्स : 0135-2640117
ई-मेल/E-mail : wii@wii.gov.in, वेब/Website : www.wii.gov.in

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SUMMARY

Several groups of songbirds including North-American wood warblers belonging to the genus *Vermivora, Parula, Dendroica,* and *Setophaga* have developed two singing modes or categories of songs which are having different functions. Among Indian breeding birds Jungle Prinia along with three *Phylloscopus* warblers (*humei, pulcher, and chloronotus*) are known to have two singing modes. To find out function of two singing modes by the bird during different stages of breeding in Jungle Prinia, I studied the use of two singing modes of Jungle Prinia and its relation with its habitat or vegetation. My study suggests that the singing mode A is related to aggressive mal-male interactions and singing mode B is linger distance signal and has role in male and female interactions. Bird density was found to be positively related to the differential singing mode B use.

INTRODUCTION

Sound is one among the several communication channels used by the birds as the olfactory system is poorly developed in birds unlike mammals. Like human beings birds mostly depend upon visual and acoustic signaling. The Acoustic communication has the advantage over other communication channels that it can transmit a large amount of information rapidly and efficiently(Catchpole & Slater 2008). The birds moving through dense thickets or higher canopies cannot really rely upon visual displays and attractive colouration or plumage for communication always and instead they use acoustic signaling or vocalizations like songs or calls

which are much more effective in communication. Even if the bird is not visible, vocalizations would indicate their presence and helps in efficient and effective transfer of information.

Generally, vocalization can be broadly classified into ‘Calls’ and ‘Songs’. But, most of the time we fail to give a clear-cut definition to these terms. When compared with calls, songs are longer in duration, spontaneous and structurally complex whereas calls are vocalizations with short-duration, having a very simple structure. Calls are usually having more different social functions than songs and are sometimes very shorter that it consists of a single element in a Song. A Song or call is produced by birds only in certain instances and these vocal signals can transmit a large amount of information rapidly and efficiently through sound channel. Calls are produced by both male and female birds, especially in the presence of predators, or while showing some aggression(Thielcke 1976, Catchpole & Slater 2008).

Birds produce the vocalizations by the help of the vocal organ called syrinx which is located at the junction where the trachea divides into two bronchial tubes. The bird order Passeriformes is divided into two sub-orders that are Oscines and Sub-oscines. Among these two sub-orders the Oscines are referred to as the ‘True Song birds’ as they are equipped with a number of specialized syringeal muscles and highly developed vocal centres in the brain which helps them to produce more complex and difficult vocalizations. The Oscines are having 7-9 pairs of syringeal muscles on the other hand Sub-oscines are having around 2-3 pairs usually. These specialized muscles are connected to the trachea and to the typaniform membranes(Baker 1997). The repertoire of calls produced by True song birds or Oscines is very large and

varies from species to species. They were originally belonging to the order Passeriformes and later got separated from the rest because of the unique ability to produce complex vocal signals especially songs. Among these group of birds, songs are produced only by breeding males. In birds, vocalization is usually used for intra-specific and inter-specific communication. The bird song plays an important role in the breeding cycle of a bird. Territory defense, mate attraction and mate stimulation are the main functions of bird song(Pierce & Greenough 1970). Most of the time a single song serves the two functions of attracting mate and defending feeding or breeding territories but there are many species which are having different songs for different purposes. Usually, the Passerine songs are interpreted as if it simultaneously fulfills both mate attraction and territoriality. This idea has been largely responsible for the development of the 'Dual function' theory, which suggests that male song functions both to attract females and repel rival males(Pierce & Greenough 1970, Collins 2004, Catchpole & Slater 2008). But the main question which still most of the studies related to the avian communication struggles to answer is what message the sender wants to convey to the recipient.

Most of the oscines are having more than one version of their typical species song and these different versions are called song types which constitutes the basic units of song called elements or notes(Singh 2014). The song repertoire size is the number of song types in a bird's whole song and the whole song of a bird is referred to as a complete song with repeated song-units that is song-types(catchpole & slater 2008, singh 2014).

Moreover, an interesting aspect of bird vocalization is that several song birds around the globe have developed two category of songs or singing modes that differ in motivation and function. The birds sub-divide their repertoire songs into different Singing modes which can be repertoire of song-types that are used in different ways or in different contexts. The singing modes are also referred to as the sequential pattern of presenting the song-types(Molles & Vehrencamp 1999). The two category of songs or Singing modes differ in their presentation patterns and in the contexts in which they are performed(Wiley 1994, Beebee 2004a, 2016, Price 2013, Price *et al.* 2020). The warblers belonging to the genera *Vermivora, Parula, Dendroica, Setophaga* and *Mniotilla* are the better studied groups of birds with distinct modes of singing. In Indian context four warbler species (for example: *Phylloscopus humei, Phylloscopus pulcher, Phylloscopus chloronotus*) along with Jungle prinia are the birds which have distinct singing modes. In case of Jungle prinia the singing modes absolutely distinct as both of the singing modes have entirely different structure and consists of elements.

Jungle Prinia is a small passerine bird which inhabits the low bush jungle with coarse grass in open, stony country in plains and hills up to 2000 m. The distribution extends from Himachal Pradesh and Punjab to Northern Bengal and North-western Bangladesh. Jungle prinias are found usually singly or in pairs and also has the tendency of forming small groups in non-breeding periods. They usually forage in the ground vegetation that is they skulks through the low vegetation(Baker 1997). This specific species is one of the least studied Prinias in India. Prinias are very poorly studied species belonging to the Cisticolidae family even though they are very

common in any scrub forest and open grassland patches in peninsular India. The Jungle prinia looks bit similar to Plain prinia but the size, unique stout bill and pale supercilium makes it different from Plain prinia(Grimmett *et al.* 2011). Both the species are having very different vocalizations which is the main character that separately keeps both the species different. The Jungle prinia is a more sort of jungle species but Plain prinia is present and found in fields and human dominated landscapes also. The population of Cisticolids is ecologically important within the Thorn forest, scrub jungle and Dry deciduous ecosystems, as they are pests, pollinators and seed dispersers in that given ecosystem. In India, most of these scrub jungles are considered as wastelands which are providing the suitable habitat for many species native to this habitat. The breeding season of Jungle prinia extends from March to October having two breeding peaks that is in the months of June and October(Ali & Ripley 1972). There are five sub-species of Jungle prinia throughout the country that are as follows, *Prinia sylvatica insignis, Prinia sylvatica gangetica, Prinia sylvatica mahendrae, Prinia sylvatica sylvatica , Prinia sylvatica valida*(Ali & Ripley 1972, Baker 1997). The sub-species on which my study was carried out was *Prinia sylvatica gangetica* which is spread across from Kangra district of Himachal Pradesh to Northern Bengal through Punjab, Uttar Pradesh, Northern Madhya pradesh and Nepal. The courtship display by Jungle Prinia is very interesting that the male sings by sitting on a higher perch and does aggressive, repeated nose dives and frequent wing snappings along with singing. While nose diving and singing the male spreads its tail feathers to display its white tail feathers on the sides and tips. Compared to Northern sub-species the Southern sub-species starts breeding early due to the influence of varied climatic conditions and rainy

season. The breeding of the birds also depends upon the abundance of food resources especially insects in the case of members of Cisticolidae family(Ali & Ripley 1972).

Usually the two singing-modes in birds are related to the dual song theory Two singing-modes may serve communication with females and males and also may represent the specialization for long-range and short-range communications (Catchpole & Slater 2008).

Jungle prinia vocalizations consists of songs and calls. Songs play main role in breeding and only these were considered in the present study. Jungle prinia is the only species known to have two singing-modes among all fourteen species of prinias present in India(C.Rasmussen & C.Anderton 2005). Most Prinias in India prefer same habitat and are sympatric but only Jungle prinia has developed two songs. Due to lack of research on this species, the exact functions of the two singing modes are still unclear in this species. Therefore, Understanding the ecological significance of each song is very crucial in breeding biology of species.

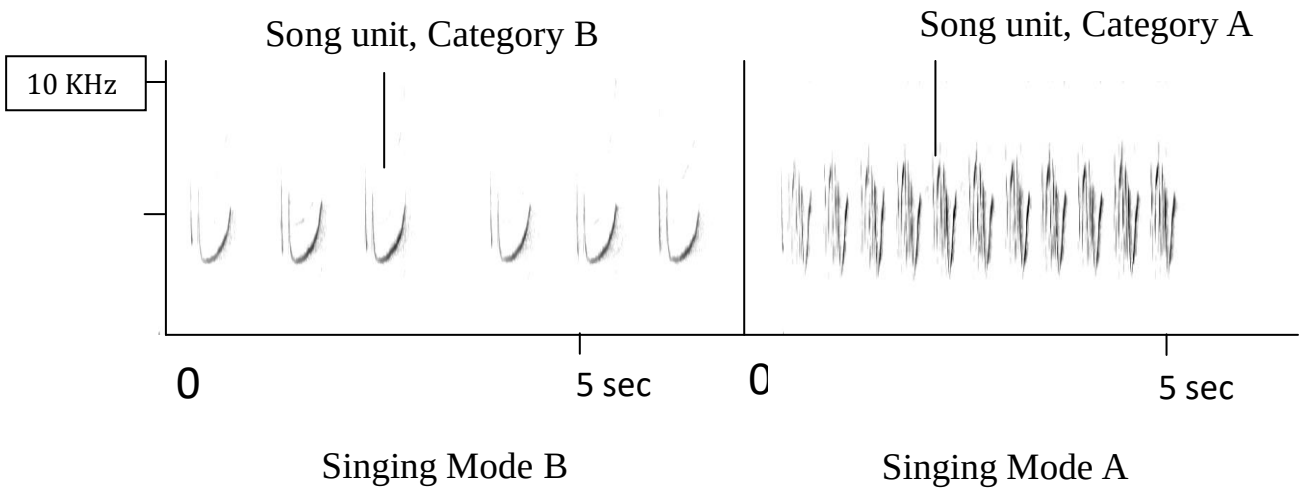


Figure 1 Two singing modes or song categories in jungle prinia. singing mode B consists of repetition of one element of longer duration, sometimes preceded by short-duration element.

Singing-mode A consists of units of multiple elements rendered at shorter intervals and have broader frequency bandwidth.

In this study I predicted that the distinct singing modes of Jungle prinia might have sex-specific functions and the proportional use of singing modes changes during the day. I also predicted that the two singing modes might be influenced by the habitat and vegetation. Other expectation was that there might be a difference in the use of distinct singing modes across the different stages of pre-nesting phase.

LITERATURE REVIEW

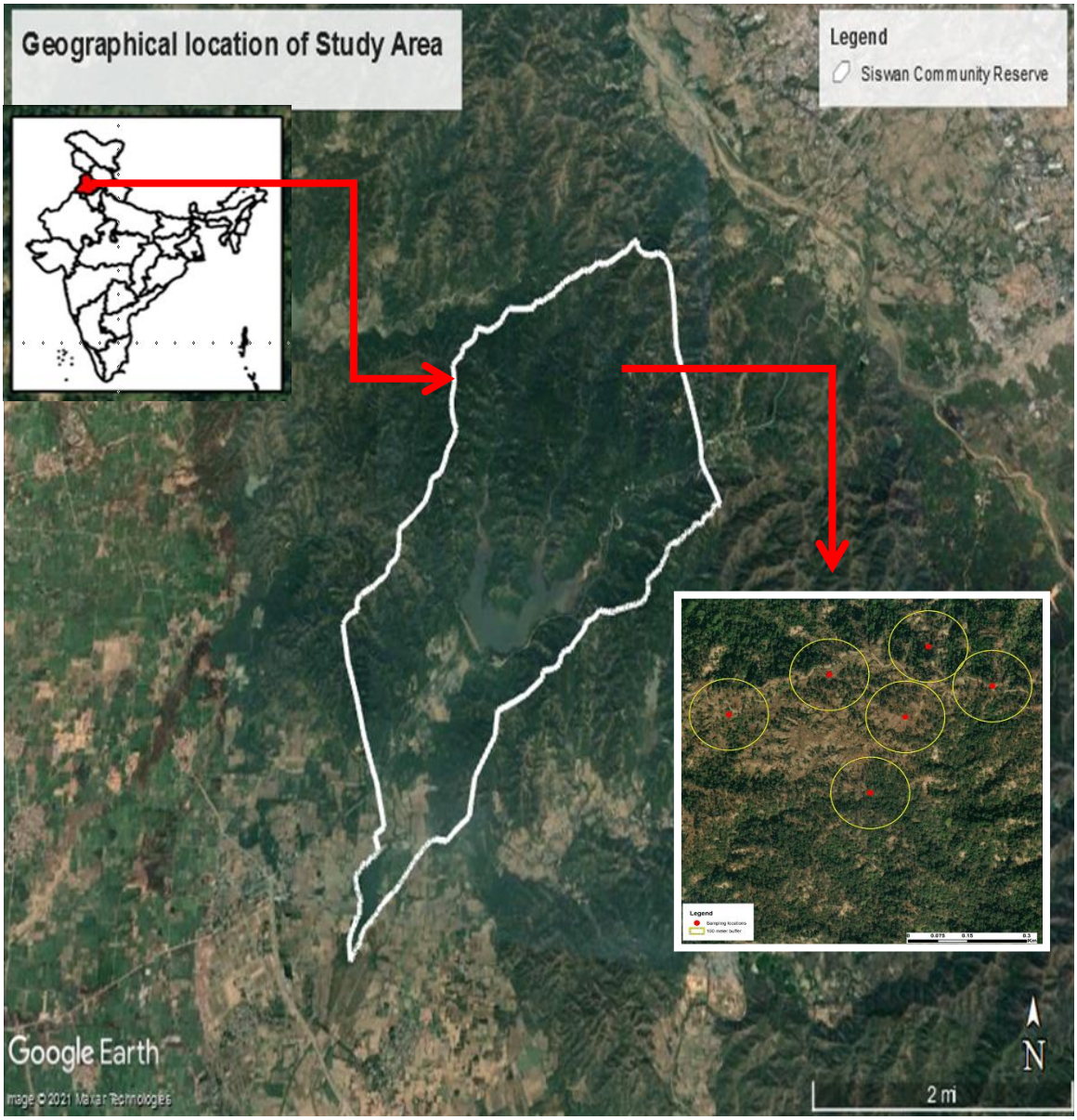
There are a few studies done related to the singing modes in North American Wood warblers which belong to the genus *Setophaga*(Beebee 2004a, Price *et al.* 2020). In most of the studies, the production of two different songs is linked with sex-specific functions during breeding. Some studies of wood warblers in America suggest that the two singing modes in this group are each specialized for interacting with one of the two sexes that is one singing mode for interacting with females and the other one for interacting with other males(Beebee 2004b). But other studies found that that songs differ before pairing and after pairing and another finding was that the male bird produces two different songs, Type 1 song in pre-breeding and Type 2 in post-breeding seasons. In India, the breeding ecology of Ashy prinia has been investigated(Jayvardhan *et al.* 2017, Sarwar & Hussain 2018); however, no full-fledged research has been conducted on the breeding ecology of Jungle prinia. The acoustic signal partitioning in four different species of prinias has been done (Chitnis *et al.* 2019). There is only one study from Maharashtra which mainly focuses on the vocalizations of a Jungle prinia during breeding season(Apte 2005). In this study the author has given us a broad idea about the vocalizations of male birds and. The study says that the singing mode A progresses with time and singing mode B has the function of alarm call. So far, no research has been conducted on the two separate singing modes of Jungle prinia, nor has any research been conducted on the singing modes in relation to vegetation or habitat.

MATERIALS METHODS

STUDY AREA

The study area was selected on the basis of e bird data and consultation with bird experts. From the e bird data, it was evident that Siswan region in Punjab had a fairly good presence of Jungle prinia and by refering to the Management plan of Siswan community Reserve (SCR) (prepared by Wildlife Institute of India) I could understand that SCR was a less disturbed area, away from human inhabitation which could serve as a potential study area.

The intensive study area inside Siswan community reserve was selected after preliminary survey on the basis of presence of Jungle prinia. The intensive study area selected had large grassy areas where undergrowth patches dominated with the grass species *Neyraudia arundinaceae.* The Jungle prinia species was found to be restricted to these large grassy patches.


Geographical location of Study Area
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Siswan Community Reserve
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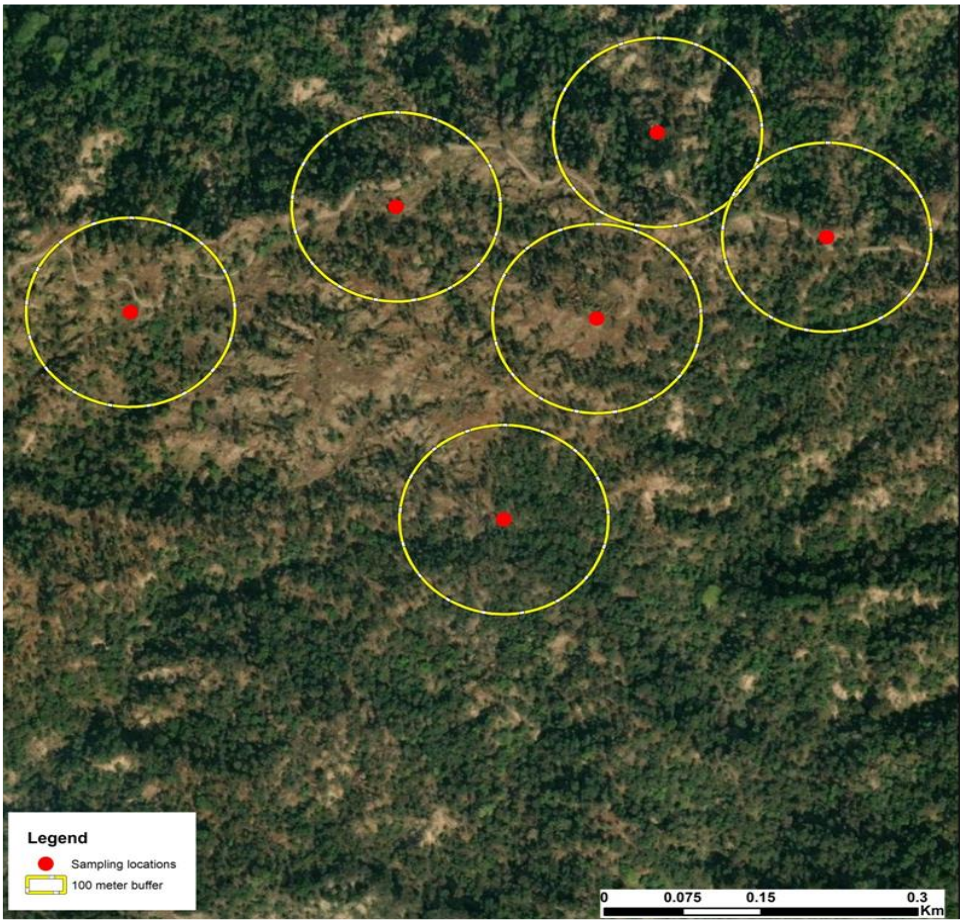


Figure 2 Intensive study area map

LOCATION

The SCR is named after Siswan village, which is located towards the south-western part of the reserve. The Community Reserve is located in the Shivalik Hills adjacent to state boundaries of Punjab, Haryana and Himachal Pradesh. Siswan Community Reserve is located in Majri Tehsil of Sahibzada Ajit Singh Nagar, Mohali district of Punjab. It is spread over an area of around 13 Sq. km. Of the four community reserves of Punjab, two of which were the first ever notified in India, SCR is the latest and declared so in December 2017(Mohan *et al.* 2020). Area is characterized

by tropical dry deciduous forest and abundance of thorny species. Agriculture continues to be practiced in the surrounding landscapes.

FLORA

The Siswan Community Reserve consists of about 160 species of vascular plants, out of which 45.6% was herbs, 21.3% trees, 12.5% shrubs, 10% grasses, 8.8 % climbers and 1.9 % sedges. Fabaceae is the most dominant family with 29 species followed by Poaceae family with 29 species. The forest is mainly dominated by Acaia species (*Acacia catechu, A.nilotica and A.modest)* and the mid-seral stage consists of *Butea monsperma, Diospyros cordifolia, Leucanea leucocephala, Lannea coromandelica*. The SCR is dominated with dry deciduous forest type.

FAUNA

There are 15 species of mammals, 116 species of birds, five species of reptiles, nine species of amphibians were present in SCR. Mammals included *Panthera pardus fusca, Rusa unicolor, Sus scrofa cristatus, Muntiacus muntjac* etc. Birds included mainly Jungle prinia, Indian peafowl, Rufous treepie, Black drongo, Indian pitta, Short-toed snake eagle, White-eyed buzzard etc.(Mohan *et al.* 2020).

TEMPERATURE

The temperature varies from 4 degrees Celsius in the cold to 45 degrees Celsius in the summer. May and June are mostly the hottest months, while January and February are the coldest. During the monsoon, relative humidity is high, averaging around 70%. The study was carried out in the hottest months that is April to June.

RAINFALL

The south-west monsoon arrives in late June and continues up to about middle of September. The average rainfall observed is about 617 mm. The normal annual rainfall of SAS Nagar district is 1061 mm, which gets distributed unevenly over the area during a period of about 49 days. The period from mid-September to the middle of November constitutes the post monsoon or transition season. The district also receives occasional rainfall in winter from the west.

The villagers and local people near to the Siswan community reserve are dependent on the community reserve in several ways. Most of the areas and land inside the SCR are community land and also owned by people and they have access to NTFP collection, cattle-grazing, fire-wood collection from the reserve. The Siswan Dam is an important source of water for irrigation for the downstream farmers with small landholdings and could help the farmers facing difficulty due to fast depleting ground water in the region. Most of the people in the surrounding villages follow animal husbandry, agriculture etc, and there are fairly good cattle grazing inside the community reserve. Apart from all these, SCR is having a lot of recreational and educational value.

FIELD METHODS

The study was conducted from early April to early June during the pre-nesting season of Jungle prinia. The pre-nesting phase was chosen for the study since this is when the majority of the singing activity occurs. The vocalization plays a very

crucial role in the pre-nesting phase of any songbird and once the bird starts nesting the singing activity becomes less in many bird species and vocalizations are very prevalent in pre-nesting phase. The pre-nesting phase was divided into three stages that is early pre-nesting phase, mid-pre-nesting phase and late pre-nesting phase(Cynthia A. Staicer 1989, Wiley 1994). I did sampling spread over approximately three weeks in each stage from early April to early June.

The selection of sampling sites was done after preliminary survey throughout the SCR, the Jungle prinia species was found to be present in the areas which were dominated by grass especially *Neyraudia arundinaceae*. We selected a large patch of the reserve with considerable presence of this species of grass as it harboured a number of individuals of Jungle prinia as the intensive study area. This patch extended to an area of approximately 2.3sq.km and had varying levels of grass cover and habitat physiognomy. In this area six sampling sites were selected on the basis of observational visibility and presence of Jungle prinia. Out of six, three sampling sites were selected almost 300 m away from the walking trail and the other three were selected near to the walking trail.

SINGING BEHAVIOUR SAMPLING

Sampling was done at each sampling point for three hour continuously from approximately morning 6 am to 9 am and during this time period we observed the Jungle prinia individuals in approximately 100 m radius and noted down the movement, usage of different singing modes, interaction with other conspecific

individuals and recorded it on data sheets designed for the sampling and using the following equipment : HAWKE range finder, Garmin eTrex10 GPS and Nikon Aculon A211 Binoculars were used for distance estimation, recording geo-coordinates and for observing Jungle prinia individuals; Zoom H1 Recorder with Sennheiser ME 66 microphone was used to record the vocalizations during sampling.

For sampling, I sat at point above the shrub level to ensure the visibility throughout the point transect. At a particular sampling point I recorded the vocalizing individuals approximate distance from the sitting point using range finder. Around each point, more than one birds were singing and I noted down all the singing bouts of different modes heard. The interaction of individuals with vocalizations and movement of these individuals within 100 m radius were recorded in the datasheet.

The singing modes of multiple individuals were clubbed together to enumerate the frequency of singing bouts. The behaviour of birds was also observed to ascertain the stage of breeding.

POINT TRANSECT

I also conducted point transects at the sampling locations for estimation of density of singing males. Three point counts were done each day with an interval of 1 hour between approximately 6 am to 9 am. As we have already mentioned each sampling sites were minimum 200m apart from each other. A total of 166 point counts were conducted at six sampling sites.

PLAYBACK-EXPERIMENT

In order to find out the function of the two singing modes in Jungle prinia song, we designed and conducted playback experiments of two singing modes. The Playback experiments were done using a Boat stone 350 speaker and mobile phone. We selected around fifteen good quality recordings of both singing modes each from different individuals which were present in and around the study area and these recordings were used to carry out the playback experiment. On locating a bird on the basis of vocalizations/visual sighting, the playback speaker was kept on a tree or inside bushes or thickets nearby without disturbing the bird. Then the initial distance of the bird from the speaker was estimated using a HAWKE range finder. After setting the speaker we sat concealed inside or in between some bushes or trees nearby. The speaker which was connected to the mobile through Bluetooth was used to play the recordings for five minutes. During playing the behaviour of the focused bird was recorded during each minute. We avoided doing playback experiments within short distances or nearby sites, we always ensured that the distance from one playback experiment site to another site was beyond 200m.

I randomized the presentation order of Singing modes and also tested each individual with contrasting pair of different Singing mode recordings. In order to minimize pseudo-replication each individual was tested with different recordings from different parts of the study area. In between each playback we used to wait for at least 2 minutes to play the recording of the other singing mode. During each minute behaviour of the bird was measured, and scoring was made as per the following observations.

Category	Response	Score
Strong	Aggressive response including wing snapping and nose dives as response to the playback, Direct approach/movement towards the speaker within 1-5 m, fly overs, Vocalization from the very first minute.	3
Moderate	Direct approach to the speaker within 6-10 m, Vocalizations after 2 minutes.	2
Mild	Directional approach within 10 m, no vocalizations, no wing snapping or movements	1
No response	No directional movement/approach, no aggressive movements/displays, no vocalizations	0

Table 1 Responses of males (jungle prinia) to the playback and the respective scores

VEGETATION SAMPLING

The vegetation sampling was carried out in six sampling sites which we have described earlier and was conducted in mid-May after the first pre-monsoon rains. In

each site four circular plots were laid using measuring tape and rope. At each site, vegetation plots of 10m radius were laid on all four cardinal directions 10 m away from the point where we used to sit for Singing behavior sampling.

10 m radius circular plot

Circular vegetation plots of radius 10m were laid in four cardinal directions in which the number of trees, Girth at breast height (GBH) and height of the trees were noted down. The number of trees were counted manually and the girth at breast height was measured using inch-tape. Ocular estimation was used to determine the height of the trees.

5 m radius circular plot

Ocular estimation was carried out to determine the percentage of shrub cover, number of shrubs, and average height of shrubs from concentric circular plots inside a 10 m plot. The dominant grass of the area, *Neyraudia arundinacea*, was included with the shrubs owing to its large size and dense tussocks.

1 m radius circular plot

In 1m concentric circular plot inside 10m plot ground cover was assessed by estimating ocularly percentage cover of grass (short-grass covering the ground), leaf litter and bare earth.

TRANSMISSION EXPERIMENT

In order to compare the transmission of singing mode A and singing mode B through the habitat, I conducted transmission experiments for relative accumulation of amplitudes of song A and song B. We used same amplitude syllables of singing mode A and singing mode B for transmitting. The transmitted song where was recorded at 50m with the same settings of the microphone and recorder and the wave form of the resultant of the recorded sound was visually compared on spectrogram to find out relative amplitudes. I conducted two transmission experiments.

ANALYTICAL METHOD

SINGING BEHAVIOUR SAMPLING

The singing behaviour sampling data which was divided into three stages of pre-nesting phase, approximately 3 weeks in each stage, to determine the change in the use of Vocalization across the three stages. As the behavioural changes were not very distinct and varied from site to site, the transition from one stage to another stage in the pre-nesting phase cannot be defined in a clear cut manner. Based on my observations in the 'Early' stage the male-male interaction was more and females were not seen often and in the 'mid-stage' I could observe the females also coming in and both the male-male and male female interaction were happening. Finally in the 'Late' stage I could see birds in pairs and the singing activity declined and territories were established. The raw frequency data was normalized and represented in bar diagrams to understand the changes.

Later, the differential use of songs were calculated for both the singing modes separately that is the ratio of usage of song A to the combined use of song A and song B and ratio of usage of song B to the combined use of song A and song B.

$$Differential\ use\ of\ a\ particular\ singing\ mode = \frac{Number\ of\ bouts\ of\ the\ singing\ mode}{Sum\ of\ bouts\ of\ all\ singing\ modes}$$

VEGETATION SAMPLING

The data collected from vegetation sampling was averaged and linear regression was used to determine the relation between the different vegetation parameters and differential song use. The tree density recorded from four plots at a single sampling site was added up and divided by the number of plots to get average tree density value at a single sampling site.

In 5m circular plots the percentage shrub cover was occularly estimated inside 1m circular plots. The percentage grass cover, leaf litter and bare earth were estimated in 1m circular plots. Percentage shrub cover, grass cover, leaf litter and bare earth from the four vegetation plots at each site were averaged. For example Average percentage shrub cover was calculated using following equation

$$\frac{\sum_{i=1}^{n} \%S}{n}$$

where ‘S’ indicates shrub cover, ‘n’ indicates total number of plots

Likewise rest of the parameters were also averaged and regressed with differential song use of both songs to find out the relation between both.

DENSITY

The ‘Distance 7.3’ software was used to analyze the point transect data collected to find out the density of male birds at each sampling sites. The 166 point count data were ran in the distance software and found out the overall density of the region. Then, using post-stratification function the densities of male birds at each sampling sites were determined. The post-stratification function was used because there were not sufficient point transects performed in certain sampling sites. The densities were correlated with the vegetation parameters and differential song usage to find out the relation.

RESULTS

VOCALIZATIONS OF JUNGLE PRINIA

During the study I found five kinds of vocalizations of Jungle Prinia. These comprised of two singing modes and three call types. As per my objectives I studied the two singing modes out of all these vocalizations.

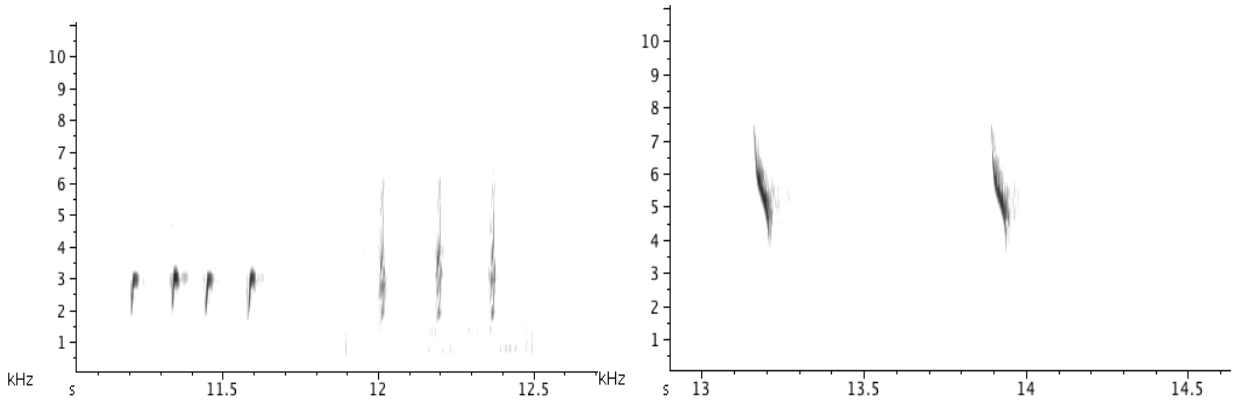
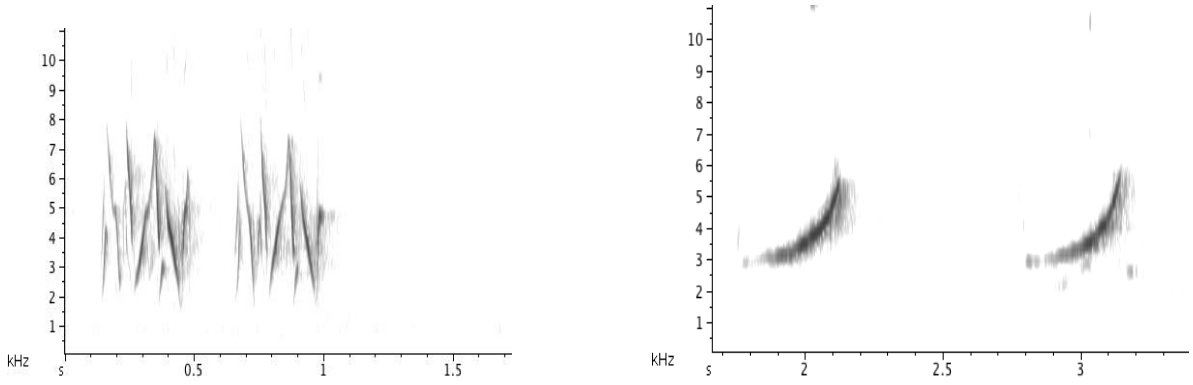


Figure 3 Three calls produced by females recorded from SCR



Song A

Song B

Figure 4 Two singing modes of Jungle prinia recorded from Siswan Community Rreserve

SINGING BEHAVIOUR SAMPLING

The singing behaviour sampling done at the six sampling sites selected in the study area mainly focused on recording the vocalizations and movement of Jungle prinia individuals in the sampling sites within 100 m radius.

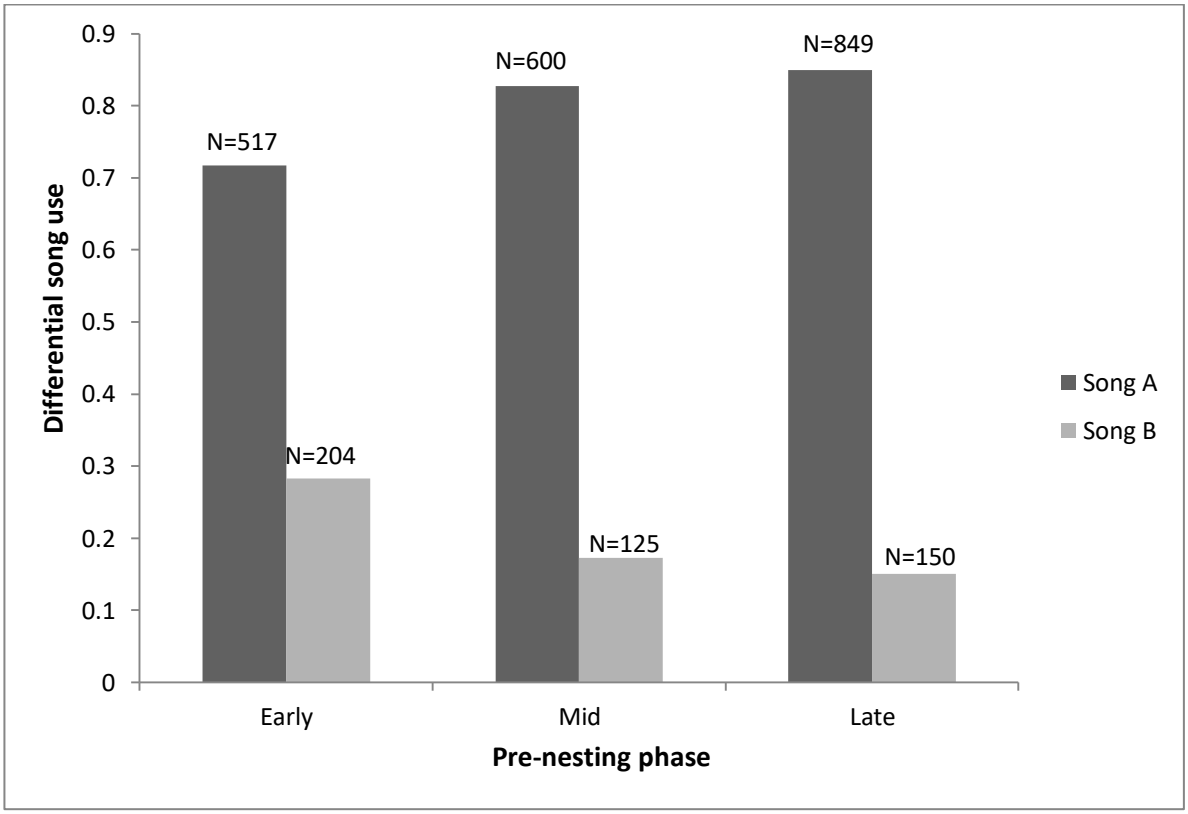


Figure 5 Differential use of song a and song b across the three stages of pre-nesting phase

- The differential use of Song A was more in Hill point(0.864864865) and least in Yellow flower point (0.761061947)
- The differential use of Song B was more in Yellow flower point(0.238938053) and least in Hill point(0.135135135).

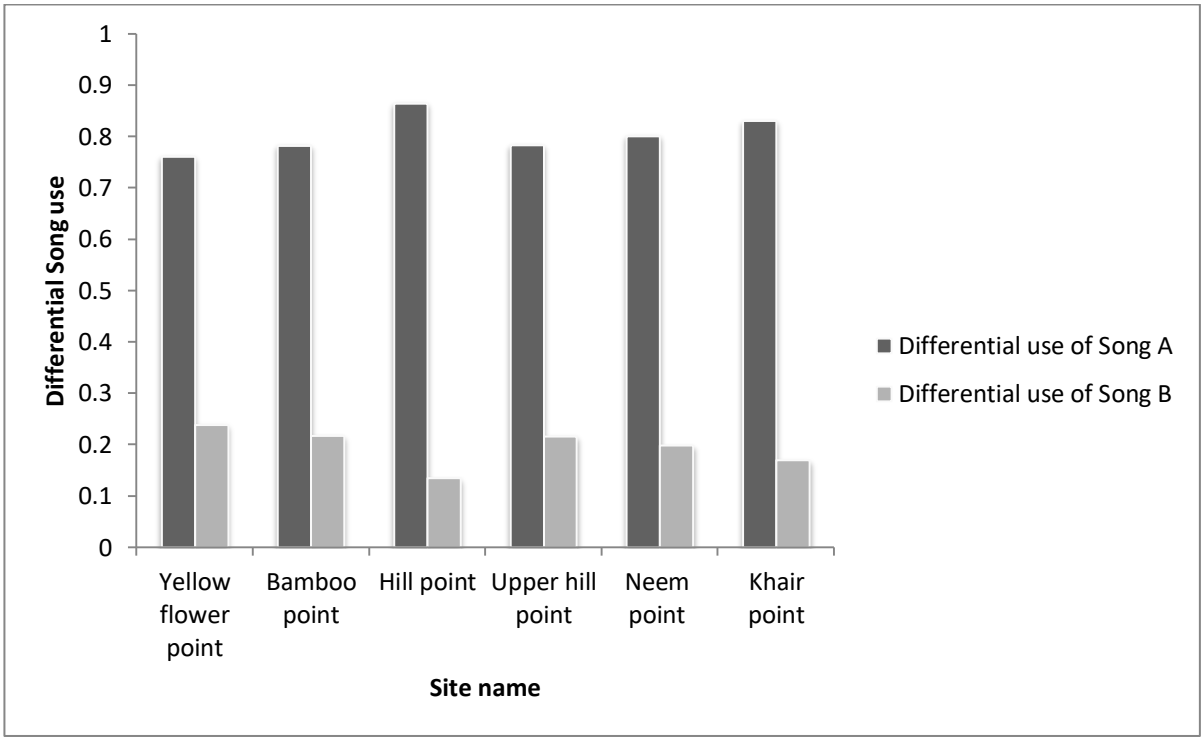


Figure 6 Differential use of song A and song B at different sampling points

The total number of song A and song B for Yellow flower point; $NA_{=}$ 344, $N_{B,}$ Bamboo point; N_A = 205, N_B =57, Hill point; N_A=416, N_B = 65, Upper hill point; N_A =398, N_B= 110, Neem point; $N_{A=}$ 339, N_B = 84, and Khair point; $N_{A=}$ 264, N_B=54

VEGETATION SAMPLING

The vegetation sampling was carried out in the month of May and collected Tree density, Girth at breast height and height of each tree in 10 m circular plots. Shrub cover, Shrub height and abundance of shrub was collected from 5 m. In 1 m Grass cover, Leaf litter and Bare earth were recorded.

Site name	Tree density (per ha)	Shrub cover (%)	Grass cover (%)	Leaf Litter (%)	Bare earth (%)
Yellow flower point	87.5	47.5	3.75	38.75	57.5
Bamboo point	190.9	40	6.25	30	63.75
Hill point	87.5	30	5	40	55
Upper hill point	87.5	40	41.25	30	28.75
Neem point	167.04	45	17.5	67.5	15
Khair point	206.81	33.75	25	42.5	32.5

Table 2 Vegetation parameters collected in different sampling sites

The maximum Tree density was recorded in the Khair point (0.020681818), maximum grass cover in Upper hill point (41.25), Leaf litter in Neem point (67.5), bare earth in Bamboo point (63.75) and Shrub cover in Yellow-flower point (47.5). The average of Tree density, Grass cover, Leaf litter, Bare earth and Shrub cover in the four circular plots were taken and correlated with Differential song use .The differential song use was correlated with various vegetation parameters and only significant relationship obtained is between differential use of song B and percentage shrub cover.

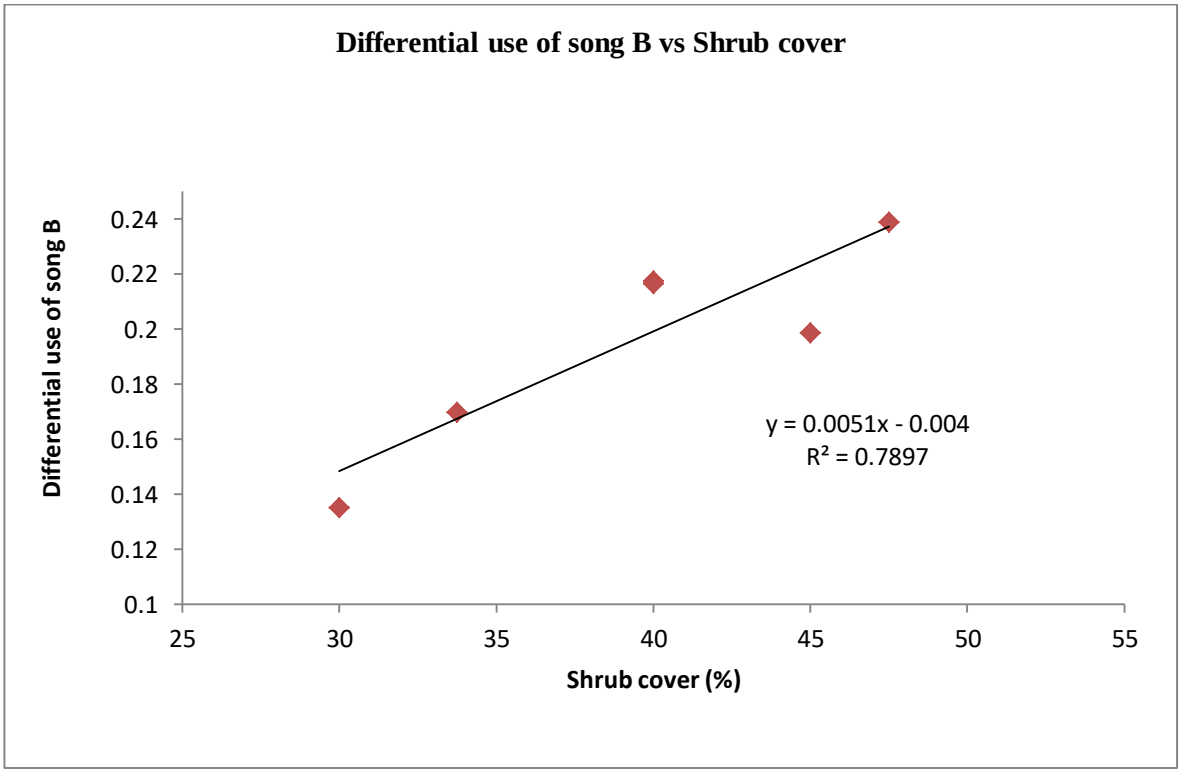


Figure 7 Relation between differential use of song B and shrub cover across the different sampling points

P-value	Sum of squares value(R^2)
0.0179	0.7897

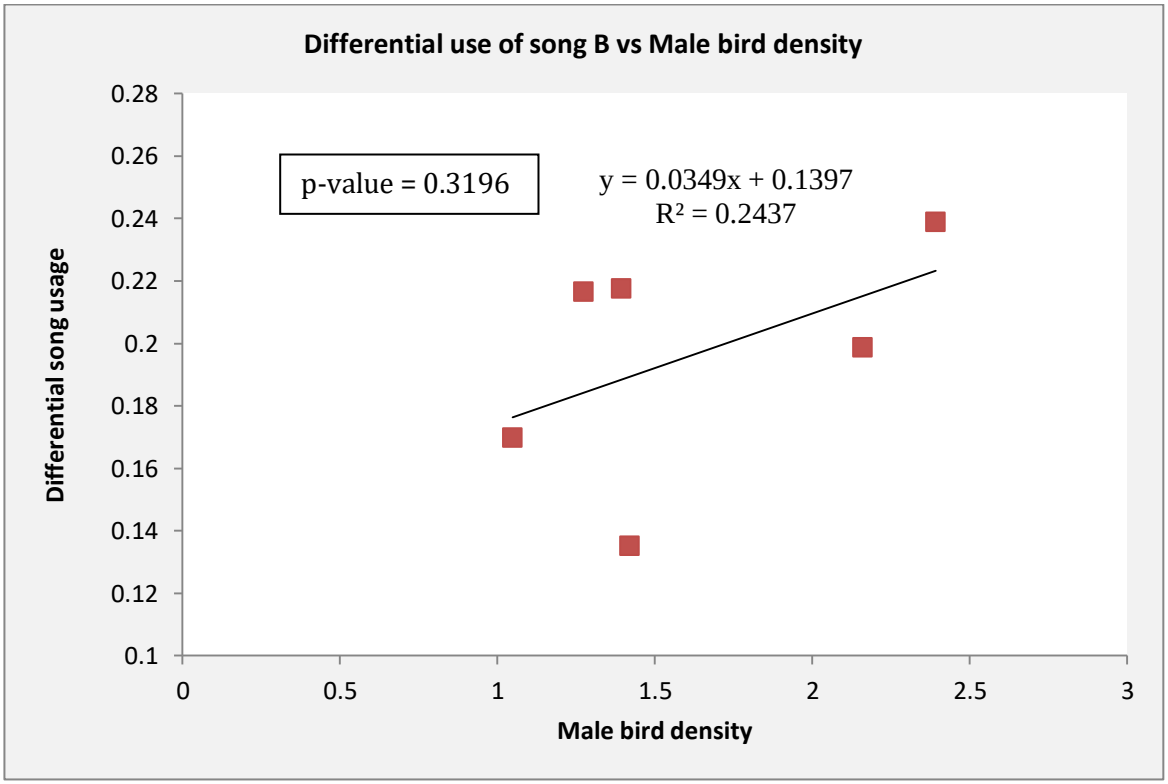
DENSITY

During my sampling period from April to June point transect data of Jungle prinia was collected and the Density of Jungle prinia(males) in six sampling sites were calculated with the help of 'Distance 7.3' software.

Site name	Male Density(per ha)	CV
Yellow-flower point	2.3929	21.68
Bamboo point	1.3950	35.13
Hill point	1.4198	13.25
Upper Hill point	1.2736	15.91
Neem point	2.1598	25.73
Khair point	1.0486	16.04

Table 3 The Jungle prinia density and CV values at different sampling points

Using Distance 7.3 software the densities at each sampling sites were found out. The density of the male birds was highest in Yellow flower point (2.3929) followed by Neem point (2.1598), Hill point (1.4198), Bamboo point (1.3950), Upper hill point (1.2736) and Khair point (1.0486).



Sum of squares (R^2) value	P-value
0.2437	0.3196

Figure 8 Relation between differential use of song B and male bird density (Jungle Prinia) across the different sampling points.

PLAYBACK EXPERIMENT

During my sampling period, from April to June I did total 48 playback experiments of both Song A and Song B, out of which the Song A and Song B playbacks were done and 26 times respectively and the male birds responded to the Song A and Song B playbacks in Song A only. The responses of male birds showed 'Very strong' response to the Song A playbacks for 12 times out of 22 Song A playbacks and there

was no single playback experiment in which the male bird didn't respond. The male bird showed 'Moderate' and 'Mild' response for Song A playbacks 6 and 4 times respectively. The response of male birds for Song B playbacks were not as strong in Song A. There were only 7 times 'Very strong' response observed and 7 times there were no response at all out of 26 Song B playbacks. The 'Moderate' and 'Mild' response was observed 5 and 7 times respectively.

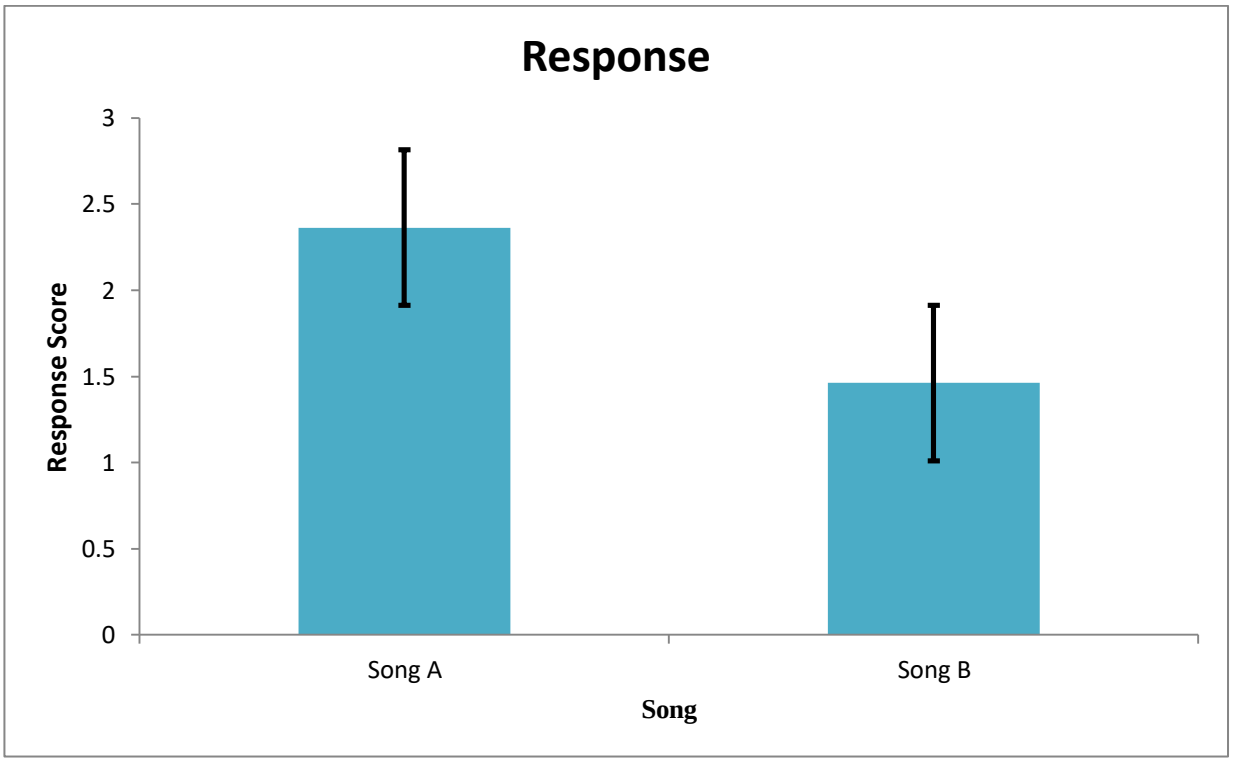


Figure 9 Mean song playback responses for singing mode A and singing mode B with standard error

15 locally recorded vocalizations of singing mode A and singing mode B were used.

The response of Male birds was very strong towards Song A playback experiments when compared with Song B playback experiments. t-Test was done to compare the means of two groups of responses and was found to be significant (p-value = 0.001829).

DISCUSSION

FUNCTION OF SINGING MODES

Differential singing mode use of the birds during different breeding stages, response of the birds to the playbacks of singing mode A and B and transmission of song A and B through the habitat indicate different functions of singing mode A and singing mode B as found. As there was more use of Song A as the breeding season progressed, and also playback responses were always with birds vocalizing song A irrespective of singing mode played. We suggest that singing mode A is for aggressive male-male interaction. As there was decrease in singing mode B with the season, there was less response to playbacks of singing mode B and it was always with singing mode A, and also song B attenuates less with distance. We suggest that the song B is a long-distance signal and used more for male-female interaction. Our field work started on Ist april 2021 that we didn't rule out the possibility that we couldn't capture the earlier stage of breeding where the song B might be more in use, singing mode B is for long range communication and possibly male-female interaction. Some studies on birds with multiple singing modes have found that one singing mode is for mate attraction. But other studies couldn't establish different functions of singing modes(Beebee 2004b). In the case of Jungle Prinia the difference in the song units is substantial in terms of frequency band width, duration of unit, and frequency and amplitude modulation which reinforces our suggestion that Jungle Prinia singing modes are for different functions. This is also supported by the transmission experiment.

The study done in European Redwing found that longer and more varied songs attract and stimulates female and the longer song, the longer song was more in the initial stages and declined later(Lampe & Espmark 1987); similar trend was seen in singing mode B in case of Jungle prinia. In all the three stages the song A was found to be much more frequent than Song B(Apte 2005). There was an increase in overall vocalizations (includes both song A and song B) as the time progressed(Apte 2005). The usage of Song A increased gradually as the pairing started, and towards nesting period it increased.

In the Paruline warblers(Spector 1992) and hooded warblers(Wiley *et al.* 1994), the functions of two singing modes were found to be for long range and short range communication. From the sound transmission experiments, we could find that the singing mode B of Jungle Prinia has more amplitude than singing mode A and had lower attenuation with distance. Thus, it is likely that also the male birds may be using song B for long range communication, as evident from other studies(Lampe & Espmark 1987). and might be also used for male–female interaction(Temrin 1986, Espmark & Lampe 1993).

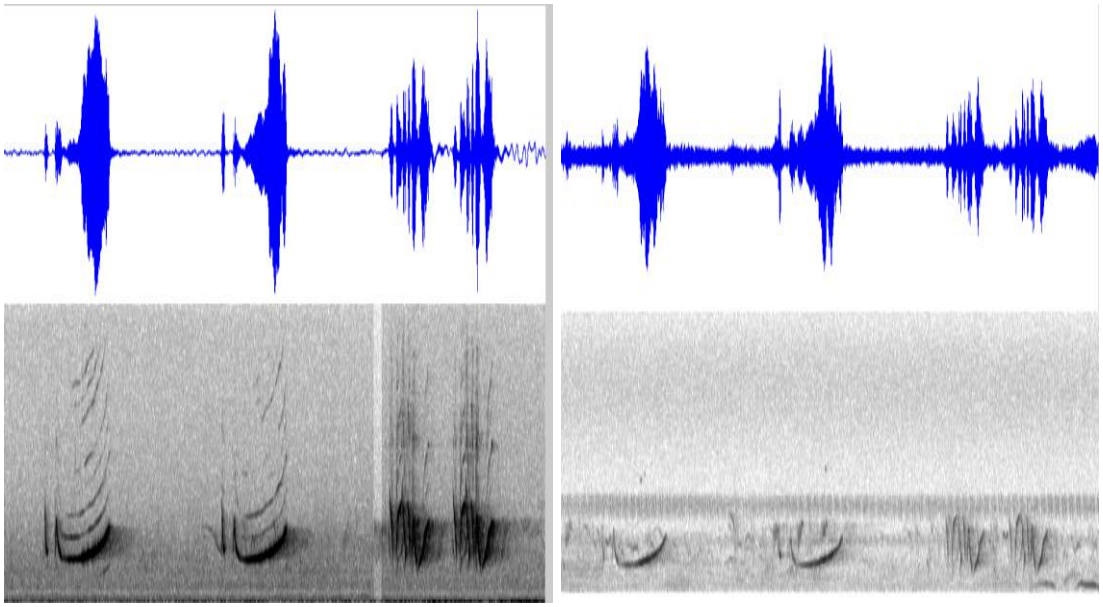


Figure 10 (a)Original recording (b) Recording at 20 m

From the two and half months of field work and observation, I found that both the song A and Song B were produced by males only. From the results of playback experiment, we conclude that the song A may be used for maintaining territory or for male-male interaction as males responded to both Song A and Song B playbacks through Song A. As the birds didn't prefer song B over song A in playback experiments to compete or deal with an intruder, then the function of Song A could be for territoriality. Interestingly, I observed that the response of male birds for song A and Song B playbacks were in Song A possibly because any unfamiliar males in the territory vocalizing in any of the singing mode is considered to be a potential threat and in most of the playback experiments the males showed very strong response towards Song A playbacks. The strong response that males were showing to the Song A playbacks also gives us an indication about the function of Song A as male-male interaction(Pierce & Greenough 1970).

As expected, my results supported that one singing mode is used for interacting with males; however, another one was not observed for interacting with females through continuous observations and playback experiments. On the contrary, most of the studies of two song systems or two singing modes the authors have found out the different functions of two singing modes. Among them the most discussed explanation is that the two songs are having sex-specific functions(Highsmith 1989, Wiley *et al.* 1994, Bolsinger 2000, Beebee 2004b, Demko *et al.* 2013). In several previous studies the song A or the song which is used when interacting with other males and near the boundaries and in some studies it was the singing mode A was used as response over song B(Spector 1992, Wiley *et al.* 1994).There are few studies in which birds didn't show any behavioural change for both songs playbacks(Beebee 2004b)

INFLUENCE OF HABITAT ON SINGING MODE

The habitat parameters in the present study were regressed with differential song use, and it was found that only the percentage shrub cover (which was largely contributed by the large grass clumps of the dominant *Neyraudia arundinaceae*) was having a positive influence on differential use of song B. It is likely that increased use of song B was triggered by denser habitat conditions to ensure greater penetrability thereby ensuring effective communication. As stated earlier, it was experimentally found that song B had a greater transmission than song A. Since densities are correlated with percentage shrub cover, we could find it to be related positively with differential use of song B. The differential use of song B was more in the sampling sites with more male bird density which also indicate a more suitable habitat.

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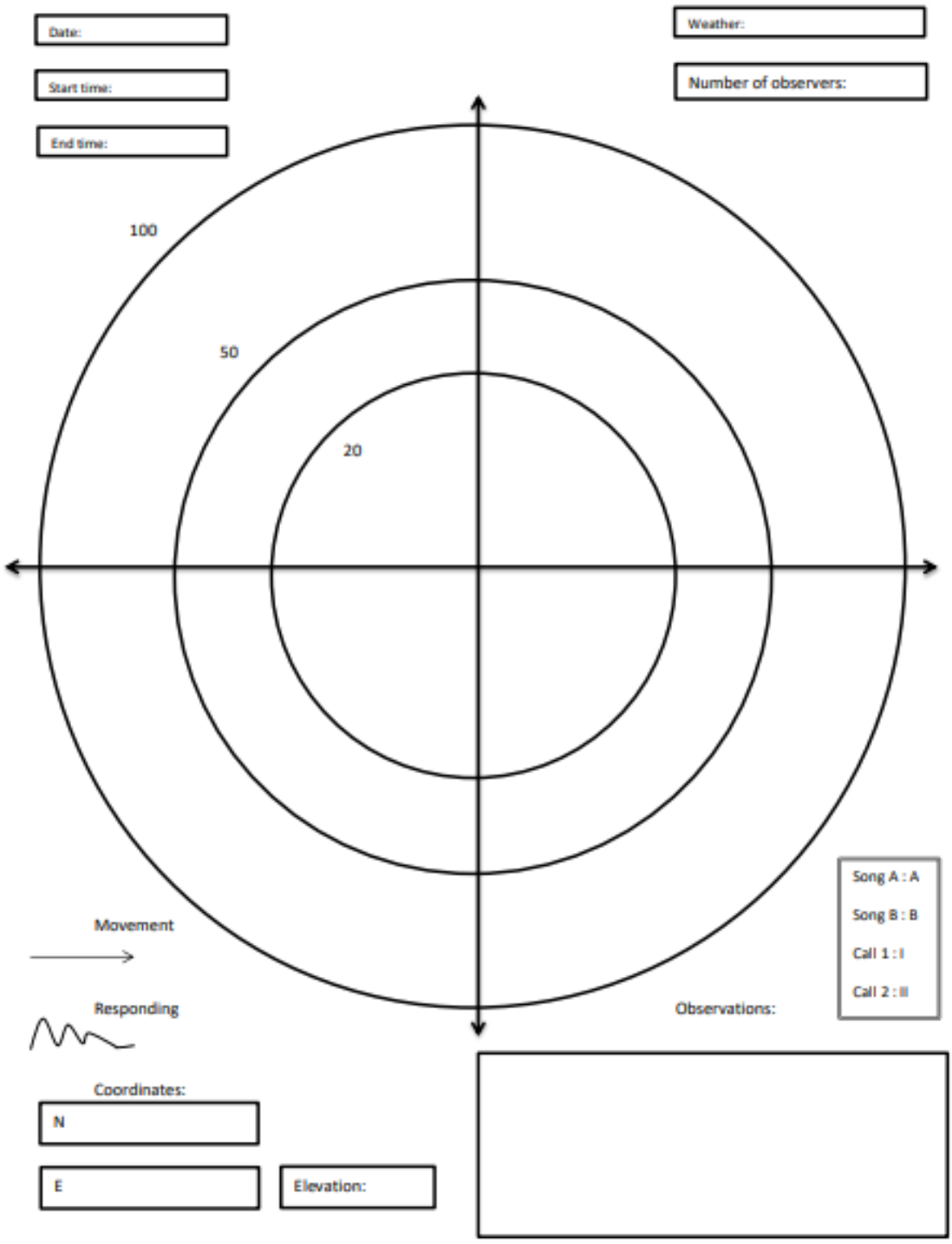
APPENDIX

Singing Behaviour Sampling Data sheet



Pictures of sampling sites

Picture of the grass species: *Neyraudia arundinceae*