Journal of Global Biosciences
ISSN 2320-1355
Volume 4, Number 6, 2015, pp. 2486-2495
Website: www.mutagens.co.in
E-mail: submit@mutagens.co.in
researchsubmission@hotmail.com

Research Paper

BIRD CALLS FREQUENCY DISTRIBUTION ANALYSIS TO CORRELATE WITH COMPLEXITY OF SYRINX

Mohammad Moaviyah Moghal, Vidya S. Pradhan[1], A. R. Khan[2] and Mazahar Farooqui[1]

Dr. Rafiq Zakaria Campus, Post Graduate and Research Center, Maulana Azad College, Aurangabad (MS)
[1]Dr. Rafiq Zakaria College for Women, Naukhanda, Aurangabad (MS)
[2]Dr. Rafiq Zakaria Campus, Maulana Azad College, Aurangabad (MS).

Abstract

The bird calls are communication signals that transfer useful information from one individual to others of the same species. These calls are produced by specialized organ called syrinx. We studied sound produced by different birds like Small Minivet, Black Hooded Oriole, Scarlet Finch etc. to characterize the bird calls using the prominent frequencies that are produced. The bird calls are qualitatively different for different birds and can clearly be identified in most of the cases. Comparison of sound produced by selected birds is implemented using the frequency distribution of sound. The frequency spectrum of sound is obtained using Fourier Transform technique implementing Fast Fourier Transform (FFT) employing standard mathematical software Mathcad. Findings and details are presented.

Key words: Bird call, Syrinx, Fast Fourier Transform, Amplitude frequency spectrum.

INTRODUCTION

Birds produce various acoustic sounds such as short calls, complex songs etc [1]. Bird vocalizations can be divided into two categories: song and call. Songs are differentiated from calls as they are normally longer, more complex and contains more musical variations than calls. Most songs are produced by male birds for mate attraction and territorial defense [2] [3].In contrast; calls have less musical variation than songs. Calls are shorter than songs. Calls are produced by both male and female bird. Calls are generally used for communication. Calls have a variety of functions. There are alarm calls; flocking calls; feeding calls; contact calls; begging calls; aggressive or agonistic calls; flight calls. Moreover, calls can be used as a tool to express aggression, warning, identification, flocking, hunger food source, etc. Furthermore, birds may use calls to point out a certain predator [4] [5]. During migration many birds produce calls to maintain flock and to communicate information [6]. In birds, vocal sounds are mainly produce by syrinx [7], which is an organ unique to birds and equivalent of the human larynx or voice box. Similar to larynx, the syrinx has special membranes which vibrate and generate sound waves when air from the lungs is forced over them [8] [9]. The bird syrinx is located inside an air sac near to the lungs, where the windpipe, the trachea, bifurcates into the two primary bronchi [10] [11]. As a general rule, those species with the best-developed syrinx are capable of producing the most complex sounds [12]. The sound produced is a consequence of vibration of different part in the syrinx [13], if these vibrating parts are small, their natural frequency of vibration will be high, therefore the sound produced will be of higher frequency. Similarly larger parts in vibration will have relatively lower natural frequencies and the sound produced will also be of lower frequency. When the sound is having broad spectrum with appreciable sound at different frequencies, it implies that the syrinx is complex and has ability of vibrating at different frequencies at the same time.

We studied sound produced by different birds like Black Throated Tit, Blue Bearded Bee Eater, Golden Throated Barbet etc. to characterize the bird calls using the prominent frequencies that are produced. Such a study characterizing on the basis of prominent frequencies at which appreciable sound is present provides a deeper insight into the functioning of the syrinnx and its characteristics.

METHODOLOGY

DATA SAMPLE: A comprehensive collection of bird calls collected from different part of India in the form of a set of two audio cassettes and a booklet has been released Bombay Natural History Society (BNHS) [14]. Most of the samples of calls studied are taken from this standard collection, few samples are recorded from actual bird breeder sites and few samples are taken from the website named Indiabirds.com [15]. For the purpose these samples are converted to computer wave format at a sampling rate of 44.1 KHz using reliable sound system and related software. Prominent components of sound from calls were selected and saved for further analysis after suitably labeling.

Noise reduction:

In many cases bird calls had been recorded in deciduous forest, rain forest, evergreen forest, around lakes, rivers, etc. unwanted sound such as wind noise, other bird calls noise etc. were also present in the recorded samples. All unwanted sounds limit the quality of recorded samples and it is also difficult to analyze these samples for useful information. In order to remove all unwanted and background sounds, sound processing software was used for noise reduction purpose.

SEGMENTATION: After taking out unwanted and background sounds, bird call samples were segmented into smaller pieces where each segments contains a single type call of the bird. Wave pad software was used for segmentation; the segmentation was done by listening to filtered sample calls.

The frequency distribution of the call sound in these samples was obtained using Mathcad by implementing FFT. This technique is used for transformation of time domain data into frequency domain. The program developed in Mathcad reads in the call sound in wave format with '*.WAV*' file extension and performs FFT on the sound data to find sound amplitude at different frequencies. In frequency domain the results of FFT i.e. the amplitudes are complex quantities having both real and imaginary parts. The absolute value of this complex amplitude is used and the power can be estimated from this using its square. All the amplitudes discussed are in arbitrary units as the steps involved in the whole process do not allow for maintaining identical condition; however this does not come in the way of present study.

Wave formats contain information about the sampling frequency and other related technical details in addition to all recorded available (audio) data. In most of the cases wave files are recorded at sampling frequency of 44.1 kHz with single channel and 16 bit resolution 16 bit data allows for a resolution. 16 bit data allows for a resolution of 1 part in 65536, a reasonably high resolution for 8 bit data this resolution is 1 part in 256. For 8 bit data at each sampling point therefore requires one byte (8 bits of data) this result in a data rate of 88.2k bytes per second which is doubled for 16 bit or two byte data.

After reading the audio file in wave format the length of the audio file is determined, the time for each sample is estimated from the sampling rate and an array corresponding to the data points is generated and populated for further use.

Fourier transform requires that the number of data points used comply with Nyquist criterion, thus from the data read, a suitable interval is chosen. For FFT the number of data points should be equal to 2^N where N is an integer. In most of the studies we used 8192 data points which correspond to N=13 and the sample studied has duration of little less than 0.2 second of recorded sound. On implementation of the FFT this gives power spectrum in terms of audio power in terms of amplitude at different frequencies. The number of frequencies at which the power spectrum available is half of the number of data points used i.e. 8192/2=4096, thus FFT extracts power at 4096 frequencies. The resulting power in the power spectrum is a complex quantity due to reasons presented earlier. The magnitude of power can be estimated using the modulus of this complex amplitude from FFT.

SMALL MINIVET:

The Small Minivet is a small song bird. It is found in tropical southern Asia from the Indian subcontinent east to Indonesia. It feeds on Insects. The frequency spectrum for the call is shown in Fig 1. The frequency distribution of sound for Small Minivet bird is a typical example of relatively high frequency sound and shows prominent peak at 6950 Hz, there is no appreciable sound present below 6000 Hz. Full width at half maximum (FWHM) is about 150 Hz. Appreciable sound begins at around 6700 Hz and lasts up to about 7500 Hz covering a range of 800 Hz.

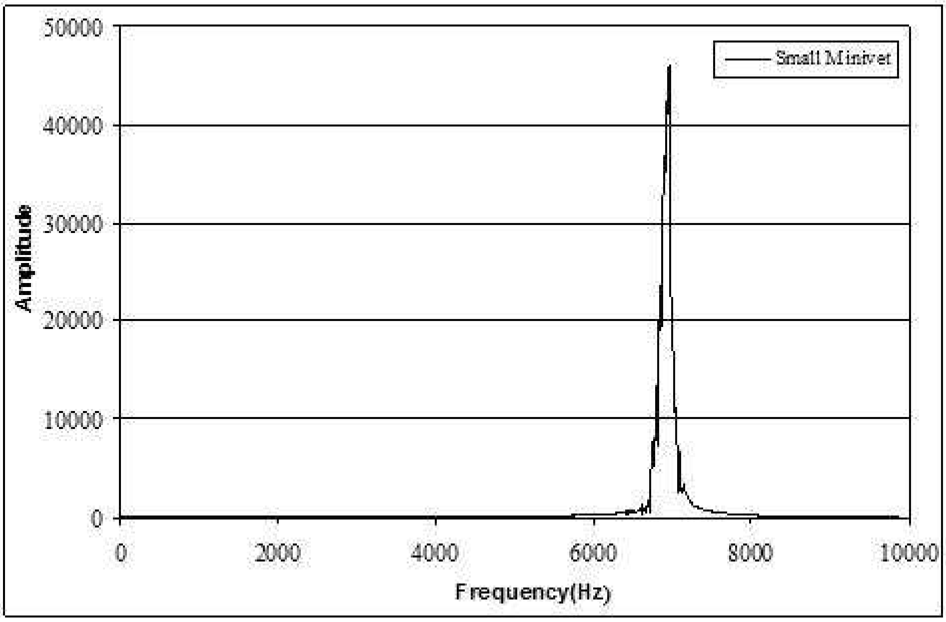

Fig. 1 Amplitude versus frequency plot for call of Small Minivet shows a narrow peak at 6950 Hz with FWHM of 150 Hz

The higher frequency nature of sound indicates that it is produced by syrinx with smaller vibrating component.

BLACK-HOODED ORIOLE:

The Black-Hooded Oriole is a member of the oriole family of passerine birds and is a resident breeder in tropical southern Asia from India and Sri Lanka east to Indonesia. It feeds on insects and fruit. The frequency spectrum for the call is shown in Fig 2.

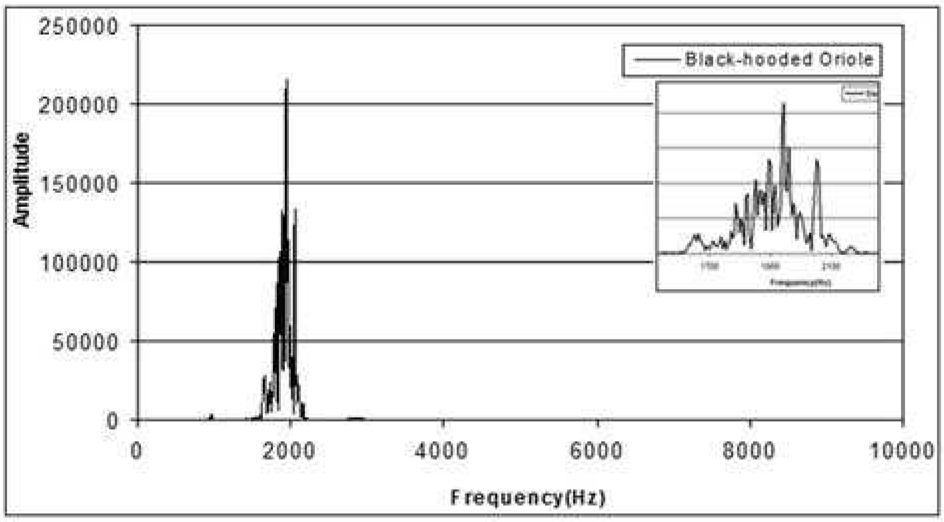

Fig. 2 Amplitude versus Frequency plot for call of Black Hooded Oriole shows a cluster of sharp peaks centered at around 1950 Hz

The frequency distribution of sound for Black Hooded Oriole bird is a typical example of relatively low frequency sound, little broader peak than that of Fig. 1. This is a cluster of sharp peaks or spikes (sharp peaks or spikes can be seen in inset) centered around 1950 Hz. FWHM is 210 Hz. Appreciable sound begins at around 1620 Hz and lasts up to about 2250 Hz covering a range of 630 Hz.

SCARLET FINCH:
Scarlet Finch is found in the Himalayas from central Nepal eastwards to Vietnam and is found spottily in the adjacent hills of Northeast India and Southeast Asia as far south as Thailand. The frequency spectrum for the call is shown in Fig 3. The sound produced has typical character of increasing amplitude with frequency after 2600Hz. The sound amplitude increases exponentially with frequency up to 4000Hz reaching a maximum and then rapidly falls with frequency.

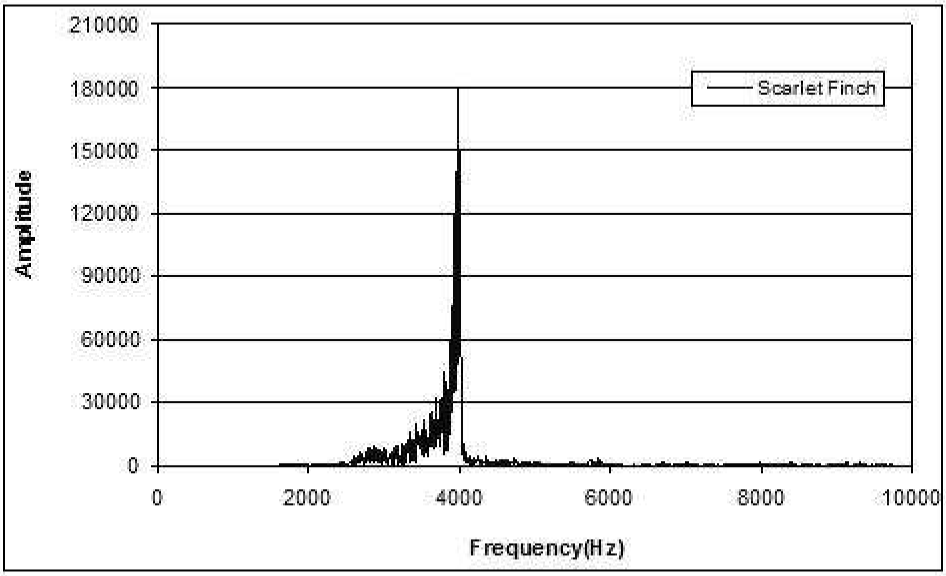

Fig. 3 Amplitude versus frequency plot for call of Scarlet Finch shows a prominent sharp peak at 4000 Hz which rises and falls rapidly

In the lower frequency region appreciable sound prevails from 2600 Hz to 4000Hz in rapid increasing manner, however after reaching a maximum at around 4000Hz it rapidly falls with frequency. The rising part covers a range of about 1500 Hz where as the falling part is over in less than 50 Hz. There is no sound amplitude below 2000 Hz, however in the higher frequency range; marginal sound is visible up to 10000 Hz.

GOLDEN-THROATED BARBET:

The Golden-Throated Barbet is found in Asia. It feeds on berries. It has worldwide tropical distribution. They get their name from the bristles which fringe their heavy bills. The frequency spectrum of the call is shown in Fig. 4. It shows a peak in the range of 900 Hz to 1400 Hz which rises and falls rapidly. It is a low frequency sound no appreciable sound is present above 1800 Hz. Qualitatively this frequency spectrum is similar to those of Fig. 1 and 2, however the characteristic frequency and frequency distribution is much different.

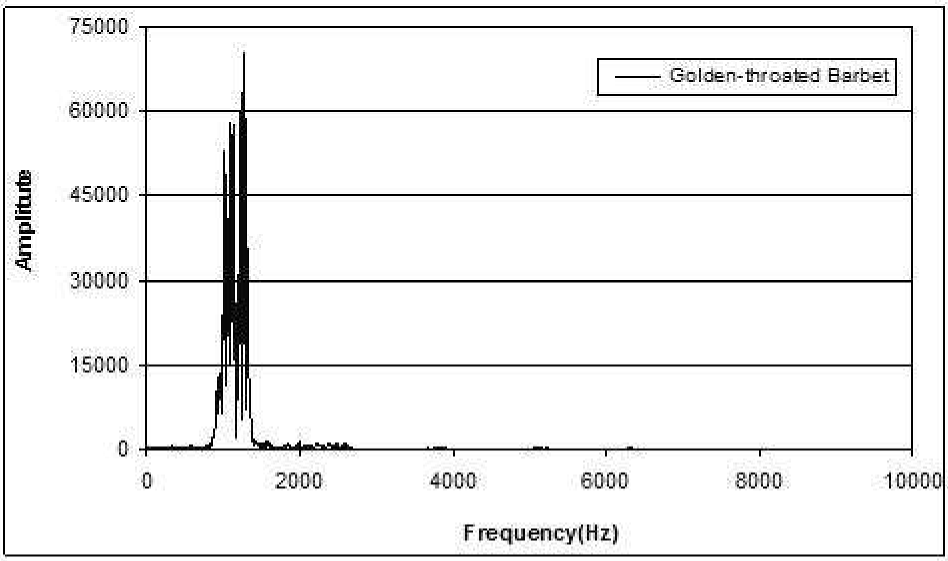

Fig. 4 Amplitude versus frequency plot for call of Golden Throated Barbet shows a cluster of sharp peaks centered at around 1200 Hz.

SRI LANKA FROGMOUTH:

Sri Lankan Frogmouth is a small bird found in the Western Ghats of south India and Sri Lanka. It is a nocturnal bird and feeds on insects. The plot of amplitude versus frequency is shown in Fig. 5. It shows relatively broader bunch of peaks centered at around 1800 Hz. peak rises and falls rapidly in the range of 1350 Hz to 2200 Hz. FWHM is 480 Hz. It is a low frequency sound, little higher than that of fig 4, appreciable sound is not present above 3000 Hz.

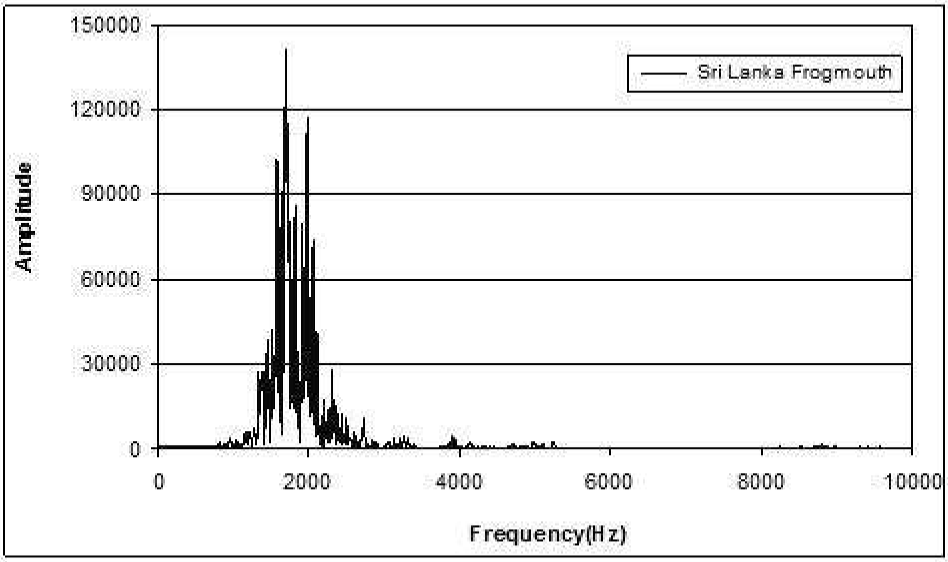

Fig. 5 Amplitude versus frequency plot for call of Sri Lanka Frogmouth shows relatively broader bunch of peaks centered at around 1800 Hz which rises and falls swiftly.

BRAHMINY STARLING:

The Brahminy Starling is a member of the starling family of birds. It is found in open habitats on the plains of the Indian Subcontinent. It feeds on insects and berries. The frequency spectrum for the call is shown in Fig 6. The frequency distribution of sound is similar to that of Fig. 5 however the centre of prominent frequencies at which sizable amplitude of sound is present is different and the range of frequencies is also high. Too many sharp spikes and peaks are present in the cluster centered at 3500 Hz and the range of frequencies covered is about 1700 Hz indicating complexity of structure associated with the syrinx of the bird.

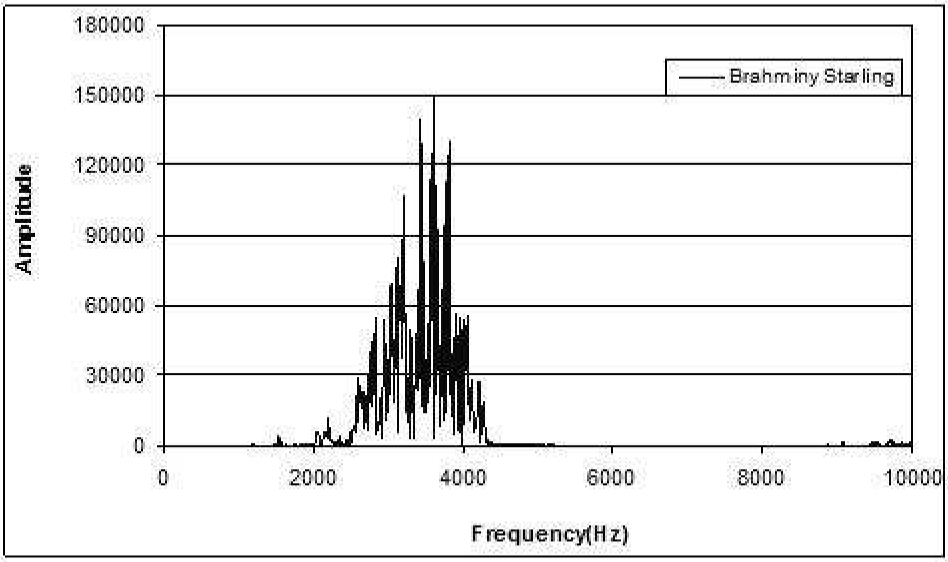

Fig. 6 Amplitude versus frequency plot for call of Brahminy Starling shows relatively broader cluster of sharp peaks and spikes centered at around 3500 Hz.

The sound produced is distributed over a wider range of frequencies starting from 2600 Hz to 4300 Hz, Additionally limited sound is visible at nearby lower frequencies and higher frequencies around 10000 Hz.

BLACK-THROATED TIT:

The Black-Throated Tit is a small song bird found in the Himalayas and the North-East Indian Hills. It feeds on insects. The frequency spectrum of its call is shown in Fig 7. The frequency distribution of the sound produced by Black Throated Tit bird is much different from those discussed earlier, here most of the sound is at higher frequencies, higher than 6000 Hz and negligible or no sound amplitude is present at frequencies lower than 5000 Hz. The frequency distribution shows three prominent neighboring clusters at frequencies of 6486 Hz, 7700 Hz and 8624 Hz. These clusters also contain lot of smaller peaks. The higher frequency nature of sound indicates that it is produced by syrinx with smaller vibrating component and presence of number of peaks indicates presence of complex structure of the syrinx with number of vibrating components. Appreciable sound begins at 6000 Hz, continues up to 9000 Hz and the FWHM of the group of three clusters is 2331 Hz.

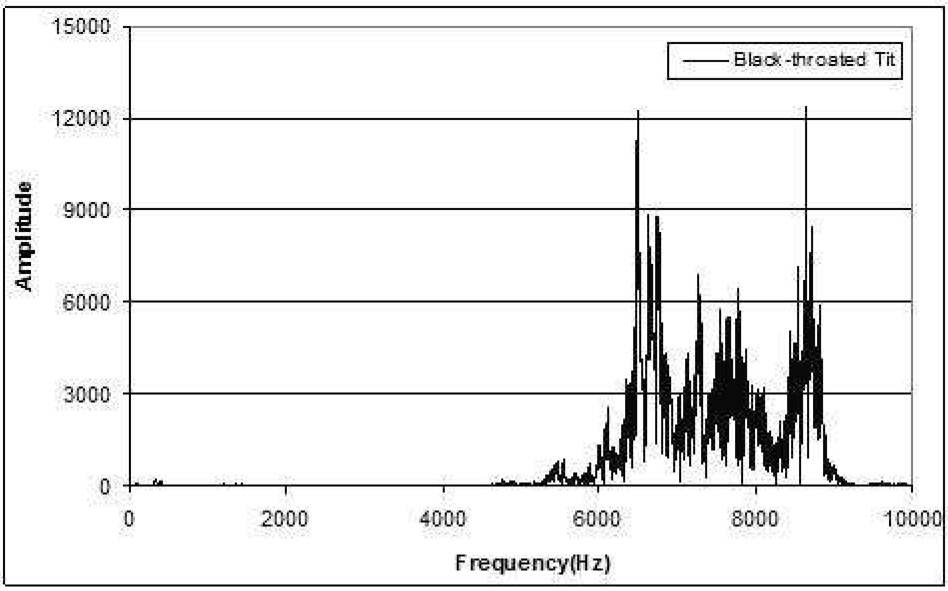

Fig. 7 Amplitude versus frequency plot for call of Black Throated Tit shows three prominent neighboring clusters at frequencies of 6486 Hz, 7700 Hz and 8624 Hz

SPECKLED PICULET:

Speckled Piculet is found in the Himalayas and Hills of India and feeds on worms. The frequency spectrum for the call is shown in Fig 8. A broad cluster of small peaks centered at around 6200 Hz. Sound begins at a frequency of 4800 Hz and continues up to about 7600 Hz covering a range of 2800 Hz, a relatively broad spectrum like that in Fig 7, however here, there is one single cluster with number of peaks. There is no appreciable sound present at frequencies lower than 4700 Hz or higher than 7700 Hz. The syrinx responsible for production of this type of sound has to be complex with capability of vibrating at different frequencies present in the frequency distribution shown.

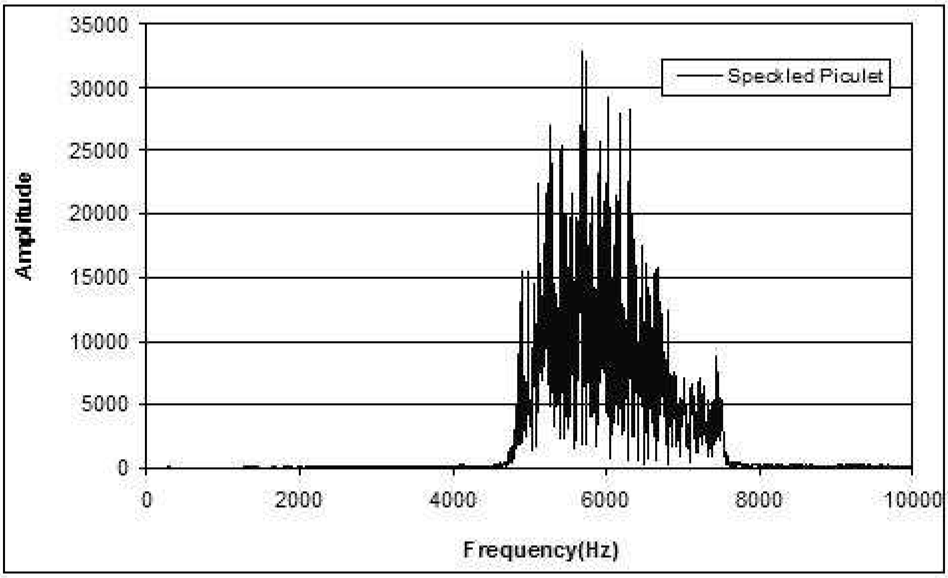

Fig. 8 Amplitude versus frequency plot for call of speckled Piculet shows a broad cluster of sharp spikes and peaks starting from 4800Hz and extending up to 7600 Hz.

ROSE-RINGED PARAKEET:
Rose Ringed parakeet is also known as the Ring Necked Parakeet. It is one of the most popular birds of India. It feeds on grains & fruit. The frequency spectrum for the call is shown in Fig 9. The frequency distribution of sound produced by Rose Ringed Parakeet is interesting in that the sound produced covers major part of audible frequency range. The sound produced by Rose Ringed Parakeet bird shows appreciable sound over a wide range of frequencies starting from 1800 Hz up to more than 10000 Hz.

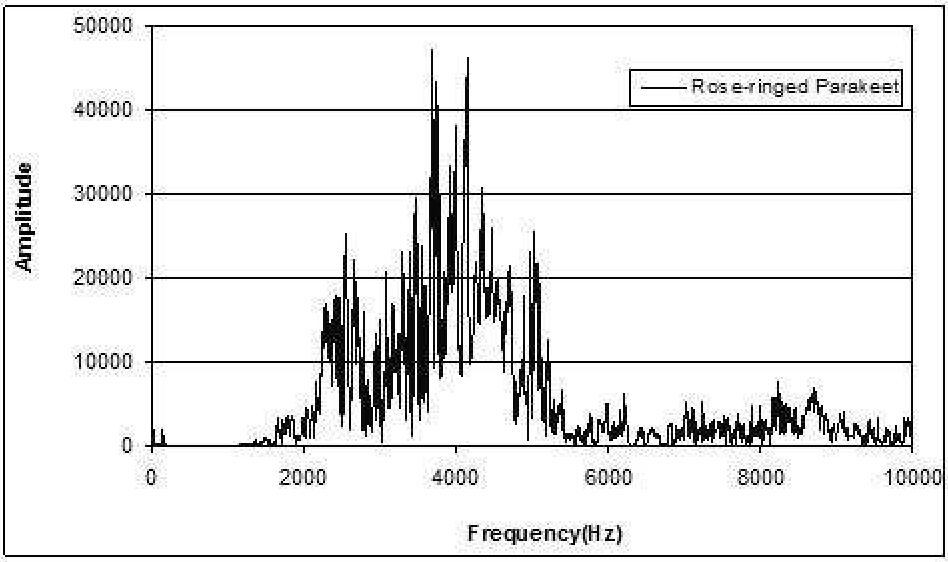

Fig. 9 Amplitude versus frequency plot for call of Rose Ringed Parakeet shows a broad cluster of sharp spikes and peaks starting from 1800Hz and extending up to 10000 Hz

The graph is plotted up to 10000 Hz as no significant sound is present above 10000 Hz. The main prominent cluster which in fact is made up of two clusters begins at 2000 Hz and continues up to 6000 Hz and is centered at a frequency of 4000 Hz. Such a broad spectrum sound producing capability requires a sufficiently complex syrinx capable of producing a wide range of frequencies. Such a powerful syrinx should be capable of mimicking practically any sound in the audible range; however in this present case as sound is not present at frequencies lower than 1800 Hz, this may have strong limitations in producing low frequency sounds.

BLUE BEARDED BEE-EATER:

The Blue bearded Bee eater is large bee-eater bird found in South Asia. It feeds on Bees. The frequency spectrum of its call is shown in Fig 10. The frequency distribution of sound amplitude for Blue bearded bee eater bird is a typical example of low frequency sound. The frequency distribution is also unique showing a cluster with several peaks in the low frequency range centered at around 890 Hz. The cluster is the most prominent sound produced by Blue Bearded Bee Eater bird, in addition to the main cluster, there are several small peaks (small peaks can be seen in inset). These peaks are sharp with a very small frequency width and appear as stand alone peak at arbitrary intervals in the frequency distribution or the spectrum, these frequencies are characteristic of the different vibrating modes of the syrinx.

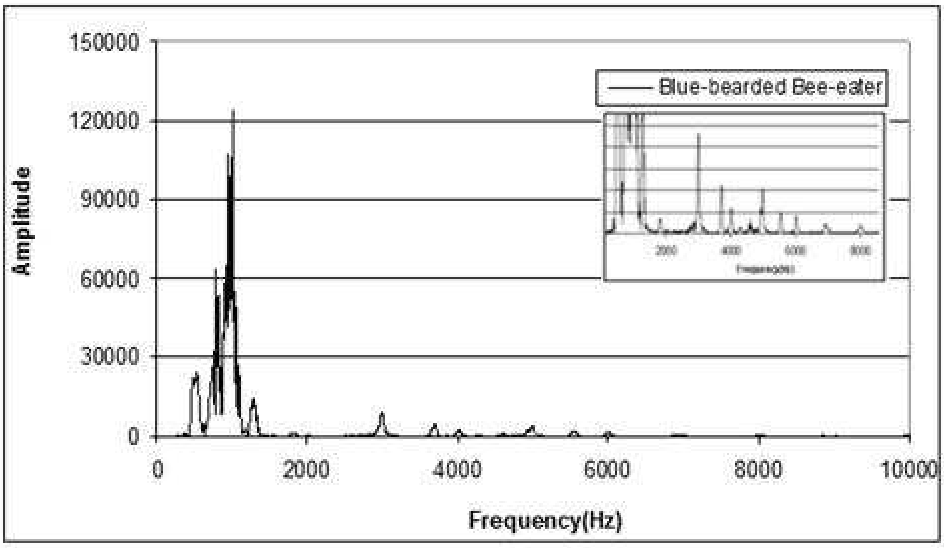

Fig. 10 Amplitude versus frequency plot for call of Blue Bearded Bee Eater shows a cluster of peaks in the low frequency range centered at around 890 Hz.

Table – 1: Bird call frequencies

S.No.	**BIRD NAME**	**FREQUENCY** (Peak) in Hz	**FWHM** of Peak in Hz
1	Small Minivet	6950	150
2	Black Hooded Oriole	1950	210
3	Scarlet Finch	4000	800
4	Golden Throated Barbet	1200	450
5	Sri Lanka Frogmouth	1800	480
6	Brahminy Starling	3500	716
7	Black Throated Tit	6486,7700,8624	2331
8	speckled Piculet	6167	1788
9	Rose Ringed Parakeet	4000	2500
10	Blue Bearded Bee Eater	890	400

RESULT:

Study of frequency distribution of calls produced by birds disclosed interesting facts; some of the birds produce sound of their own characteristic frequency that can easily be distinguished. The range of frequencies covered by different birds is different some of the calls are having sounds of a narrow frequency range such as Fig. 1, 2, and 4 where as others produce sounds over a broader range like Fig 7, and 9. It is interesting to note that in some cases the call is restricted to certain small range of frequencies and there is no sound at other frequencies as is seen in Fig. 1, 2, and 4 which is different from other calls where sound persists at other frequencies than that of the main peak as is seen in Fig. 7, 9 and 10.

DISCUSSION:

The sound produced by different bird exhibit different characteristics, particularly in terms of the prominent frequencies at which sound is produced. The sound producing organ is syrinx and it is having sufficiently complex structure and texture. It widely varies from animal to animal. In birds extraordinary sound producing capabilities are reported, in view of this a study is conducted to examine the frequency distribution of sound produced by selected birds.

The study shows that there are birds that produce sound at certain fixed and definite frequencies and every species has certain characteristic frequency at which sound produced is most prominent. In addition to the most prominent frequency there are cases where appreciable sound is produced at frequencies other than the characteristic frequency (central frequency of the cluster). Also there are cases where sound is produced over a wide range of frequencies showing the capability of syrinx to vibrate at different frequencies.

REFERENCES:

1. Joshua P. Martin, Stephanie M. Doucet, Ryan C. Knox, and Daniel J. Mennill, Body size correlates negatively with the frequency of distress calls and songs of Neotropical birds. J. Field Ornithol, 2011, 82(3), 259–268
2. Johan J. Bolhuis, Hiroko Eda-Fujiwara, Bird brains and songs: neural mechanisms of birdsong perception and memory, Animal Biology, 2003, 53(2), 129-145
3. Hans Slabbekoorn1, Ardie Den Boer-Visser, Cities change the songs of birds, Current Biology, 2006,16, 2326–2331,
4. Carl T. Bergstrom, Michael Lachmann, Alarm calls as costly signals of antipredator vigilance: the watchful babbler game, Animal Behaviour, 2001, 61,535–543
5. Joel S. Brown, Vigilance, patch use and habitat selection:foraging under predation risk, Evolutionary Ecology Research , 1999, 1, 49–71
6. Andrew Farnsworth, Sidney A. Gauthreaux, Jr. and Donald van Blaricom, A comparison of nocturnal call counts of migrating birds and reflectivity measurements on Doppler radar, Journal Of Avian Biology, 2004, 35, 365-369
7. Peter M. Narins, Albert S. Feng and Wenyu Lin, Hans-Ulrich Schnitzler and Annette Denzinger, Roderick A. Suthers, Chunhe Xu, Old world frog and bird vocalizations contain prominent ultrasonic harmonics, J. Acoust. Soc. Am., 2004, 115 (2), 910-913
8. Nazan Keskin, Pınar ILI, Glycohistochemistry of the lateral tympanic membrane in the syrinx of the Denizli cock, Turk J Vet Anim Sci, 2013, 37, 414-418
9. Zhixin Chen, Robert C. Maher, Semi-automatic classification of bird vocalizations using spectral peak tracks, J. Acoust. Soc. Am., 2006, 120(5), 2974–2984
10. Franz Goller, Ole Næsbye Larsen, In situ biomechanics of the syrinx and sound generation in pigeons, The Journal of Experimental Biology, 1997, 200, 2165–2176
11. Ole Naesbye Larsen, Franz Goller, Direct observation of syringeal muscle function in songbirds and a parrot, The Journal of Experimental Biology, 2002, 205, 25–35
12. Tobias Riede, Franz Goller, Functional morphology of the sound-generating labia in the syrinx of two songbird species, J. Anat., 2010, 216, 23–36
13. Gabriel J. L. Beckers, Roderick A. Suthers, Carel ten Cate, Mechanisms of frequency and amplitude modulation in ring dove song, The Journal of Experimental Biology, 2003, 206, 1833-1843
14. Erach Bharucha (1999) Indian bird calls, Audio Cassette and booklet. Bombay Natural History Society
15. http://www.IndiaBirds.com. Accessed 25 May 2014