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"Analysis of Bird Vocalizations to Correlate with Nature of Syrinx"

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Abstract:

Bird vocalization includes both bird call and bird song. Songs are longer and more complex and are associated with courtship and mating, while calls tend to serve such functions as alarms or keeping members of a flock in contact.We studied sound produced by different birds like Black-chinned Yuhina, House Crow, Blue-throated Barbet etc. to describe the distinctive nature of the bird vocalizationsusing the prominent frequencies that are produced. The bird vocalizationsare qualitatively different for different birds and can clearly be identified in most of the cases. Comparison of vocalizations produced by selected birds is implemented using the frequency distribution of sound. The frequency spectrum of vocalization is obtained using Fourier Transform technique implementing Fast Fourier Transform (FFT) employing standard mathematical software Mathcad. Outcomes and facts are presented.

Keywords: Bird vocalization, Syrinx, Fast Fourier Transform, Amplitude frequency spectrum.

Bird vocalizations are very important for Ornithologists and bird lovers as they provide useful information about bird. Ornithologists are very interested in identification and characterization of bird vocalizations.Birds produce different types of vocal sounds such as short calls, complex songs etc[1]. Bird vocalizations can be separated into two groups: song and call. There is difference between song and call. Songs are generally longer, more complex and contain more musical variations than calls. Most songs are given by male birds for mate attraction and territorial defense[2-3].on the other hand; calls are shorter than songs and have less musical variation. Unlike song, Calls are produced by both male and female birds. Calls are the means of communication. Calls have various functions. Birds produce different calls such as alarm calls; flocking calls; feeding calls; contact calls; begging calls; aggressive or agonistic calls; flight calls. Furthermore, birds produce calls to show aggression, warning, identification, flocking, hunger, food source, etc. Apart from this, Calls are used for alerting one another to the presence of predators[4-5].Migrating birds during migration produce calls to maintain flock and to communicate information[6]. In birds, vocalizations are mainly produce by special organ called syrinx[7], which is an organ unique to birds.Functionof Syrinx is similar to human larynx function or voice box, but it is very different in structure..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 vocal organ (syrinx) of a bird is situated in the lower part of the trachea, inside an air sac near to the lungs, where the windpipe, the tracheadivides into two primary bronchi[10-11]. As a general rule, birds with the fully developed syrinx are capable of producing the most complex vocalizations[12]. The sound given is a result of vibration of different part in the vocal organ(syrinx)[13], if these vibrating components are small, their natural frequency of vibration will be high, therefore the sound produced will be of higher frequency. In the same way, larger components 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 indicates that the vocal organ is complex and has ability of vibrating at different frequencies at the same time.The sensation of a frequency is commonly referred to as the **pitch** of a sound. A high pitch sound corresponds to a high frequency sound and a low pitch sound corresponds to a low frequency sound.

Methodology:

Data sample:

An extraordinary andwide-ranging collection of bird vocalizations collected from different part of India in the form of a set of two audio cassettes and a booklet has been launched Bombay Natural History Society (BNHS)[14]. Most of the samples of vocalizationsstudied 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 vocalization were selected and saved for further analysis after suitably labeling.

Noise reduction:

Most of the bird vocalizations had been recorded in deciduous forest, rain forest, evergreen forest, around lakes, rivers, etc. unwanted sound such as wind noise, other bird vocal sounds, 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 noise reduction process, bird vocal sound samples were segmented into smaller pieces where each segments contains a single type vocal sound of the bird. Wave pad software was used for segmentation; the segmentation was done by listening to filtered sample vocalizations.

The frequency distribution of the vocal sound in these samples was achieved 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 vocal 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.

1. Black-chinned Yuhina:

   The frequency spectrum i.e. the amplitude versus frequency plot for the vocalization studied is presented in Fig. 1. The frequency distribution shows a bunch of peaks and spikes with a prominent peak at 4435 Hz. There is no visible or appreciable sound present below 3500 Hz and above 7000 Hz.

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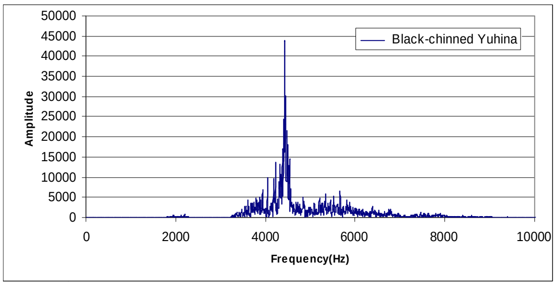
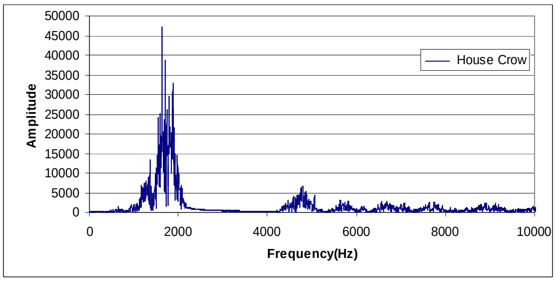


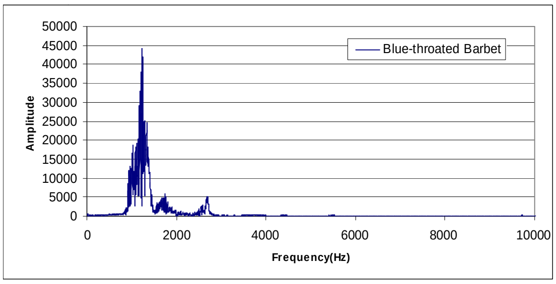
2. House Crow:

Frequency spectrum of the typical vocalization is shown in Fig. 2. It shows a broader bunch of peaks than that of Fig. 1. This reveals that highest sound amplitude is at a frequency of 1631 Hz and the spectrum is like a broad cluster with several peaks and spikes, the FWHM is around 350 Hz. The peak is spread in the range of about 1100 to 2100 Hz covering a range of 1000 Hz. Beyond 4000 Hz, appreciable sound is present over a wide range of frequencies starting from 4300 Hz to 10000 Hz. The graph is plotted up to 10000 Hz as no significant sound is present above 10000 Hz.



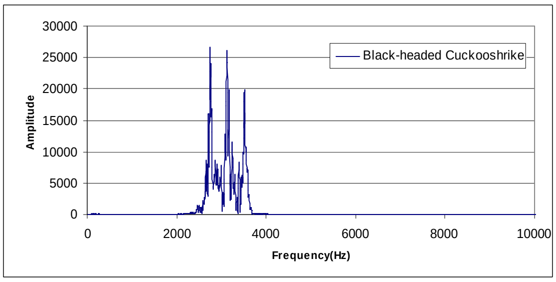
3. Blue-throated Barbet:

Frequency spectrum of the vocalization produced by Blue-throated Barbet is shown in Fig. 3. Qualitatively this frequency spectrum is similar to that of Fig. 2, however the characteristic frequency and frequency distribution is much different. It shows a bunch of peaks and spikes in the range of 900 Hz to 1550 Hz which rises and falls rapidly. It is a low frequency sound no appreciable sound is present above 3000 Hz.



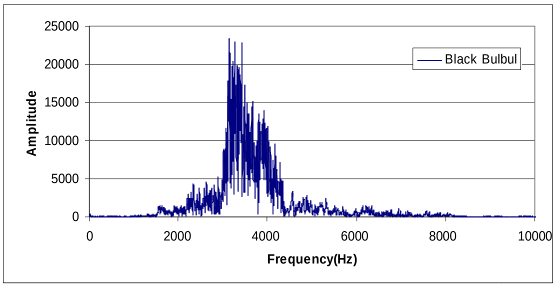
4. Black-headed Cuckooshrike:

   The frequency spectrum of its vocalization is shown in fig 4. The frequency distribution of the sound produced by Black-headed Cuckooshrikebird is much different from those discussed earlier. The frequency distribution shows three prominent neighboring clusters at frequencies of 2745 Hz, 3127 Hz and 3520 Hz. There is no visible or appreciable sound present at frequencies lower than 2600 Hz or higher than 3600 Hz.



5. Black Bulbu:

   The frequency spectrum i.e. the amplitude versus frequency plot for the vocalization is shown in Fig. 5. The frequency distribution shows a broader bunch of peaks and spikes than those discussed earlier. The sound produced by Black Bulbu bird shows appreciable sound over a wide range of frequencies starting from 1600 Hz to 8000 Hz. There is no visible or appreciable sound present at frequencies lower than 1500 Hz or higher than 8000 Hz.



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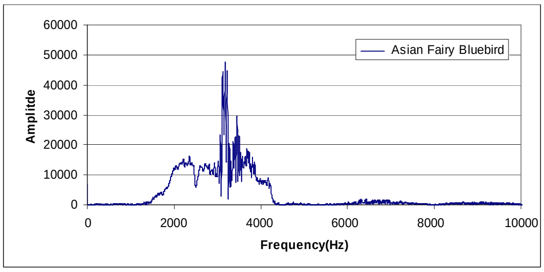
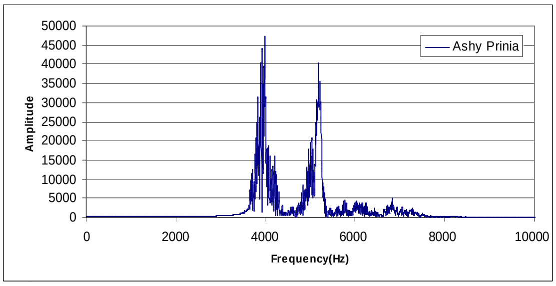
6. Asian Fairy Bluebird:

The frequency spectrum of its vocalization is shown in fig 6. The frequency distribution of the sound produced by Asian Fairy Bluebird is much different from those seen earlier. Frequency spectrum shows a broad cluster of several humps, peaks and spikes centered at around 3000 Hz. Appreciable sound begins at 1500 Hz, continues up to 4300 Hz. There is no considerable sound amplitude at frequencies lower than1450 Hz or higher than 4350 Hz



7. Ashy Prinia:

The frequency spectrum i.e. the amplitude versus frequency plot for the vocalization is shown in Fig. 7. The frequency distribution shows two prominent clusters at frequencies of 3983 Hz, 5200 Hz. There is no sound amplitude present at frequencies lower than 2900 Hz or and negligible or no sound amplitude is present at frequencies higher than 7000 Hz.



8. Ashy Woodswallow:

The frequency spectrum for the vocalization is shown in fig 8. It shows that the sound is present over a wide range of frequencies right from the beginning and extends up to 10000 KHz which is different from rest of the vocalization samples presented above. The graph is

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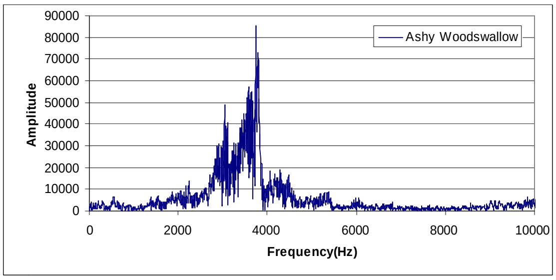
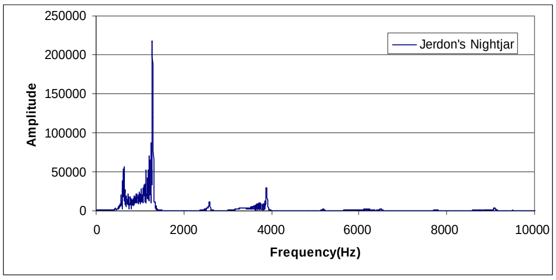
plotted up to 10000 Hz as no significant sound is present above 10000 Hz. The broad peak centered at around 3400 Hz starts at around 2700 Hz and continues up to 3900 Hz.



9. Jerdon's Nightjar:

Frequency spectrum of the vocalization produced by Blue-throated Barbet is shown in Fig. 9. The frequency distribution of sound amplitude for Jerdon's Nightjar 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 950 Hz. In addition to main cluster, considerable sound amplitude is present up to 4000 Hz. There is no visible or appreciable sound present beyond 4000 Hz.



10. Bar-headed Goose:

Frequency spectrum of the vocalization produced by Bar-headed Goose is shown in Fig. 10. The frequency distribution of sound amplitude for Bar-headed Goose bird is very unique and much different from those discussed earlier. There are many prominent narrow neighboring clusters with prominent peaks.The sound produced by Bar-headed Goose bird shows appreciable sound over a wide range of frequencies starting from 1280 Hz to 5770 Hz. Marginal or visible sound is present at frequencies lower than 1200 Hz or higher than 6000 Hz.

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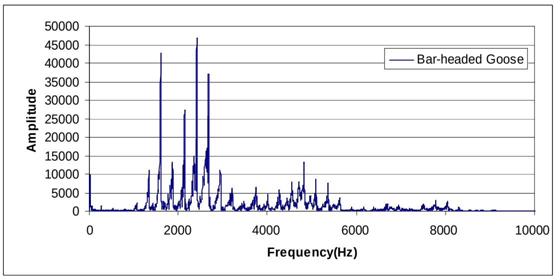

Result:

In present work we analyzed ten bird vocalization samples. Analysis of frequency distribution of vocalizations produced by birds uncoveredattention-grabbing results. The present study shows that some bird species produce sound of their own characteristic frequency that can easily be differentiated. Vocalizations of different birds have different range of frequencies. Somebirds produce narrow frequency range sounds such as Figure 3, 4 and 9while other birds produce sounds over a broader range like Figure 2, 8 and 10. It is important to note that in some cases the vocalization is limited to certain small range of frequencies and there is no sound at other frequencies as is seen in Figure. 3 and 4 which is different from other vocalizations where sound continues at other frequencies than that of the major peak as is seen in Figure 5, 7 and 8.

Discussion:

In birds, sound is mainly produced by special organ called syrinx which is unique to birds. The structure and texture of the syrinx may be simple or complex. It varies from bird to bird. Different bird species produce different vocalizations and each vocalization shows unique characteristic. It is reported that birds are able to produce extraordinary vocal sound, taking into consideration a study is conducted to examine the frequency distribution of vocal sound produced by selected birds. The study indicates that birds produce sound at certain fixed and specific frequencies and each bird has certain characteristic frequency at which sound produced is most prominent. . Besides the most prominent frequency there are cases where considerable vocal sound is given at frequencies other than the characteristic frequency (central frequency of the cluster). Furthermore, there are cases where vocal sound is given over a broad range of frequencies which indicates that syrinx is able to vibrate at different frequencies.

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Figure Captions:

Fig. 1 Amplitude versus frequency plot for vocalization of Black-chinned Yuhinashows a cluster of peaks and spikes and a prominent spike at 4435 Hz

Fig. 2 Amplitude versus frequency plot for vocalization of House Crow shows a cluster of many peaks and spikes and FWHM is around 350 Hz

Fig. 3 Amplitude versus frequency plot for vocalization of Blue-throated Barbet showsa cluster of many peaks and spikes in low frequency region which rises and falls rapidly

Fig. 4 Amplitude versus frequency plot for vocalization of Black-headed Cuckooshrikeshows three adjoining prominent bunches of peaks and spikes

Fig. 5 Amplitude versus frequency plot for vocalization of Black Bulbul shows a wide bunch of peaks and spikes over a broad range of frequencies

Fig. 6 Amplitude versus frequency plot for vocalization of Asian Fairy Bluebird shows a wide cluster of humps, peaks and spikes centered at around 3000 Hz

Fig. 7 Amplitude versus frequency plot for vocalization of Ashy Prinia shows two bunches of several peaks and spikes

Fig. 8 Amplitude versus frequency plot for vocalization of Ashy Woodswallow shows a broad cluster of peaks and spikes centered at around 3400 Hz

Fig. 9 Amplitude versus frequency plot for vocalization of Jerdon's Nightjar shows a unique bunch of peaks and spikes in low frequency range centered at around 950 Hz

Fig. 10 Amplitude versus frequency plot for vocalization of Bar-headed Goose is matchless and shows many clusters of peaks and spikes which rise and fall rapidly