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Research Article

SYRINX COMPLEXITY: CORRELATION WITH BIRDS CALLS

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ABSTRACT

Ornithologists are very interested in identification and characterization of bird calls. Birds produce calls to convey information about food, announce the presence of a predator, identify family members, declare territorial boundaries etc. We studied sounds produced by different birds like White-breasted waterhen, White cheeked barbet, Ruddy shelduck 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.

Keywords: Bird Call, Syrinx, Fast Fourier Transform, Amplitude frequency spectrum

1. INTRODUCTION

Birds use many ways to communicate, and call is one of the most important ways of communication. As we know that many bird species are social, they live together and help one another. Language is a means of communication [1]. Birds produce calls to communicate with other members of the same species [2]. In birds, calls are mainly produce by syrinx, which is an organ unique to birds[3]. Syrinx is the sound producing organ of birds, situated at lower end of trachea where it splits into bronchi it has a complex structure with number of vibrating membranes [4]. Most bird species have syrinx with two sides. Each side is able to produce a separate sound simultaneously [5]. Syrinx of bird is more complex than human larynx [6-7] Complicated syrinx produces complex sounds and uncomplicated syrinx produces simple sounds [8]. A small number of bird species like myna, parrots can use their tongue to produce different sound [9-10].There is difference between song and call. In the simple words, song is a loud, complex, and often musical utterance used mostly by male birds to attract female birds during breeding season [11]. On the other hand, Calls are simpler and usually softer sounds used by both sexes [12-13]. Calls frequently occur during breeding season and before and after breeding season. It is rather easy to distinguish calls from song. Calls have a variety of functions. There are alarm calls; flocking calls; feeding calls; contact calls; begging calls; aggressive or agonistic calls; flight calls; and many others [14]. In previous study we found that different birds produce sounds at different frequencies. Some birds produce sound only at lower frequencies, some birds produce sounds at higher frequencies and some birds produce sound over a broad range of frequencies like parrot [15].

2. EXPERIMENTAL

Data sample: - Bird call samples are collected from different reliable sources. A beautiful 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 by Bombay Natural History Society (BNHS) [16]. 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 (www.IndiaBirds.com). 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: - Unwanted sound such as wind noise, other bird calls 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 removing 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.

White-breasted waterhen: The White-breasted Waterhen is widely distributed across Southeast Asia and the Indian Subcontinent. It is a dark slaty bird with a clean white face, breast and belly. The frequency spectrum for the call is shown in Fig. 1. The frequency distribution of sound for White-breasted waterhen bird is a typical example of relatively low frequency sound. This is a cluster of sharp peaks or spikes (sharp peaks or spikes can be seen in inset) which shows a prominent spike at 800 Hz. Full width at half maximum (FWHM) is 160 Hz. Appreciable sound begins at around 700 Hz and lasts up to about 861 Hz covering a range of 161 Hz. The lower frequency nature of sound indicates that it is produced by syrinx with larger vibrating component.

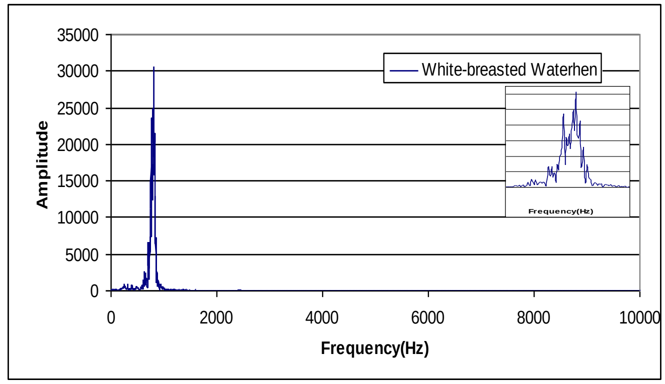


Fig. 1: Amplitude versus frequency plot for call of White-breasted waterhen showing a narrow peak at 800 Hz, with FWHM of about 160 Hz

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

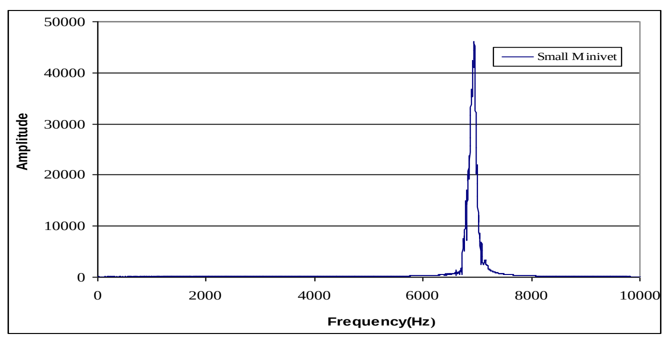


Fig. 2: Amplitude versus frequency plot for call of small minivet shows a narrow peak at 6950 with FWHM of 150 Hz.

White cheeked barbet: The White-cheeked barbet or Small green barbet is a species of barbet. In India it is also known as the Small Green Barbet. This bird is very similar to the Brown-headed barbet (or Large Green Barbet), but this species is endemic to the forest areas of southern India and has unique supercilium and broader white stripe below the eye. These birds also lack the orange eye ring of the Brown-headed

Barbet. The frequency spectrum for the call is shown in Fig. 3. 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 narrow cluster of few humps and few spikes (humps or spikes can be seen in inset) centered at around 1100 Hz. FWHM is 50 Hz. Appreciable sound begins at around 1000 Hz and lasts up to about 1250 Hz covering a range of 250 Hz. It is low frequency sound that's why no appreciable sound is present beyond 1300 Hz. The lower frequency nature of sound indicates that it is produced by syrinx with larger vibrating component.

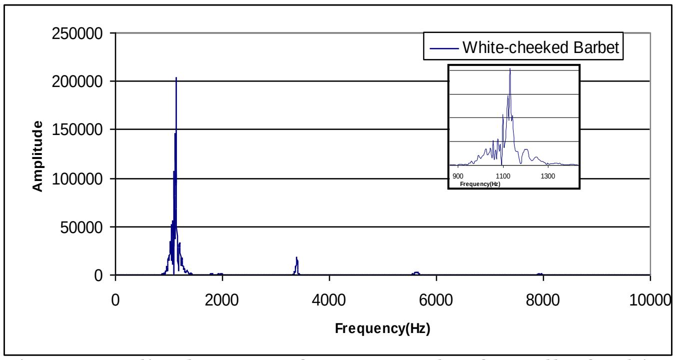
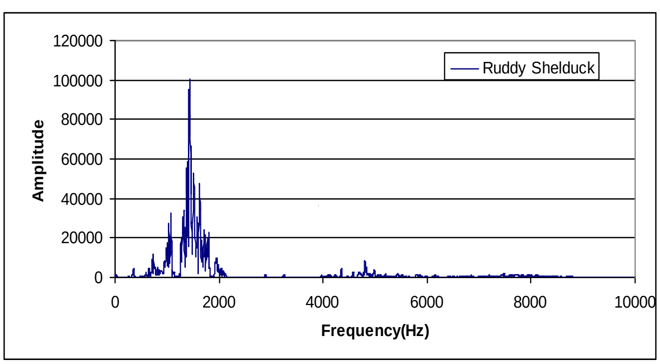


Fig. 3: Amplitude versus frequency plot for call of White cheeked barbet shows a narrow bunch of spikes and humps centered at around 1100 Hz

Ruddy shelduck: The Ruddy shelduck is a member of the duck, goose and swan family Anatidae. It is in the shelduck subfamily Tadorninae. In India it is known as the Brahminy Duck. The frequency spectrum of the call is shown in Fig.. 4. It shows a little broader cluster than those of Fig. 1 and Fig. 3. Appreciable sound begins at around 700 Hz and lasts up to about 2000 Hz covering a range of 1300 Hz. It is a low frequency sound no appreciable sound is present above 2000 Hz. Qualitatively this frequency spectrum is similar to those of Fig.. 1 and 3, however the characteristic frequency and frequency distribution is much different. The lower frequency nature of sound indicates that it is produced by syrinx with bigger vibrating component.

Fig. 4: Amplitude versus frequency plot for call of Ruddy shelduck shows a little broad cluster covering a range of 1300 Hz

Red-wattled Lapwing The red-wattled lapwing has a



wide distribution throughout Asia, stretching from Turkey in the west to Thailand in the east. The frequency spectrum of its call is shown in Fig. 5. The frequency distribution of the sound produced by Red-wattled Lapwing bird is much different from those discussed earlier. Frequency spectrum shows two prominent clusters and two prominent peaks at 2411 Hz and 3630 Hz. In addition to the main clusters, there are few small clusters (small clusters can be seen in inset) at higher and lower frequencies. These frequencies are characteristic of the different vibrating modes of the syrinx.

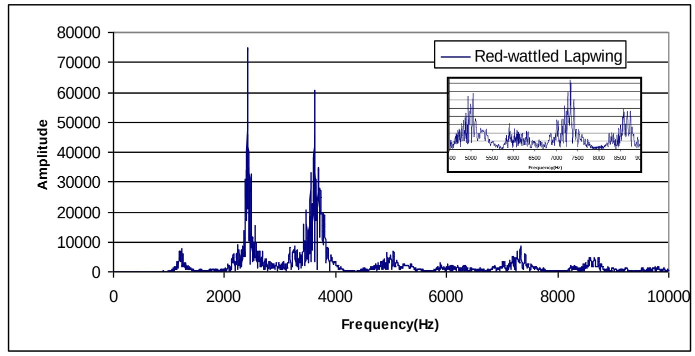


Fig. 5: Amplitude versus frequency plot for call of Red-wattled Lapwing shows two prominent clusters and two prominent peaks at 2411 Hz and 3630 Hz.

Yellow-Billed Blue Magpie: The Yellow-billed blue magpie is also known as Gold-billed magpie. It is a passerine (songbird) bird. The frequency spectrum for the call is shown in Fig. 6. It shows relatively broader cluster with a prominent spike at 1862 Hz. FWHM is about 500 Hz. Sound begins at a frequency of around 1230 Hz and continues up to about 2650 Hz covering a range of 1420 Hz, relatively broader spectrum like that in Fig. 4, one single cluster with number of peaks. There is no appreciable sound present at frequencies lower than 1200 Hz, however in the higher frequency range; marginal sound is visible up to 9000 Hz.

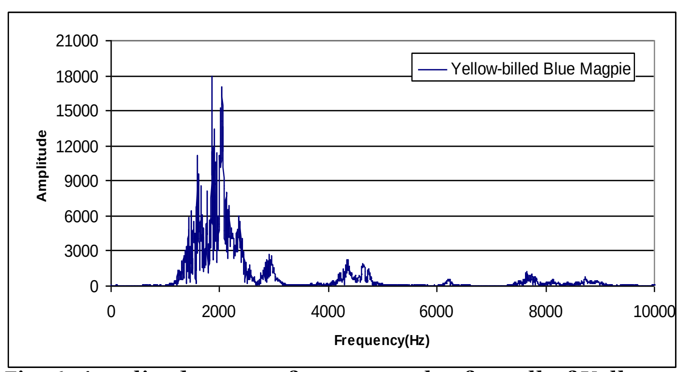


Fig. 6: Amplitude versus frequency plot for call of Yellow-billed blue magpie shows relatively broader cluster with a prominent spike at 1862 Hz and FWHM is about 500 Hz.

Slaty Blue Flycatcher: The slaty-blue flycatcher is a species of bird in the Muscicapidae family. It is found in the Indian Subcontinent and Southeast Asia, ranging across Bangladesh, Bhutan, India, Laos, Myanmar, Nepal, Pakistan, Thailand, and Vietnam. The frequency spectrum of its call is shown in Fig. 7. The frequency distribution of sound amplitude for Slaty Blue Flycatcher bird is unique showing a broad cluster of peaks centered at around 5700 Hz. These peaks are sharp with small frequency width and appear as standalone peak. Appreciable Sound begins at a frequency of 3800 Hz and continues up to about 7200 Hz covering a range of 3400 Hz. There is no appreciable sound present at frequencies lower than 3700 Hz or higher than 7200 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.

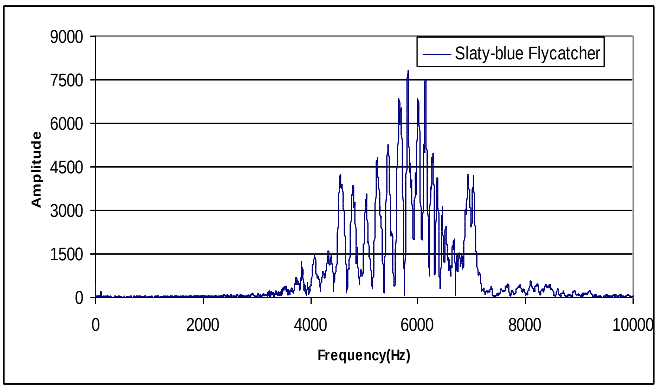


Fig. 7: Amplitude versus frequency plot for call of Slaty blue flycatcher shows a unique broad bunch of peaks centered at around 5700 Hz.

Scaly bellied woodpecker: The Scaly-bellied Woodpecker is a species of bird in the Picidae family. It is found in Indian Subcontinent and adjoining regions, ranging across Afghanistan, Iran, India, Nepal, Pakistan, and Turkmenistan. The plot of amplitude versus frequency is shown in Fig.. 8. It shows relatively broader bunch of peaks centered at around 3200 Hz. peak rises and falls rapidly in the range of 2700 Hz to 3700 Hz covering a range of 1000 Hz. The sound produced by Scally bellied woodpecker bird shows appreciable sound over a wide range of frequencies starting from 1400 Hz up to 10000 Hz. The graph is plotted up to 10000 Hz as no significant sound is present above 10000 Hz.

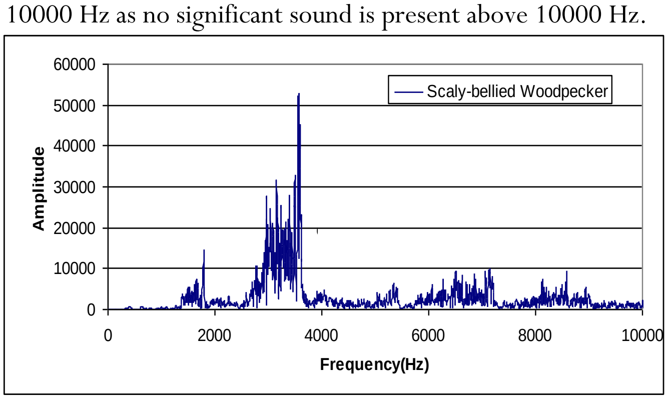


Fig. 8: Amplitude versus frequency plot for call of Slaty blue flycatcher shows a broad cluster of peaks and spikes with appreciable sound over a wide range of frequencies.

Sirkeer Malkoha: The Sirkeer Malkoha is also known as Sirkeer Cuckoo. It is a member of the cuckoo order of birds, the Cuculiformes, which also includes the roadrunners, the anis, and the Hoatzin. It is a resident bird in the Indian subcontinent. The frequency spectrum for the call is shown in Fig. 9. The frequency distribution of sound produced by Sirkeer malkoha is interesting in that the sound produced covers major part of audible frequency range. The sound produced by Sirkeer malkoha bird shows appreciable sound over a wide range of frequencies starting from 1150 Hz 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 three clusters begins at around 1200 Hz and continues up to about 6200 Hz and is centered at a frequency of 3600 Hz. Such a broad spectrum sound producing capability requires a sufficiently complex syrinx capable of producing a wide range of frequencies. However in this present case as sound is not present at frequencies lower than 1100 Hz, the bird may have strong limitations in producing low frequency sounds.

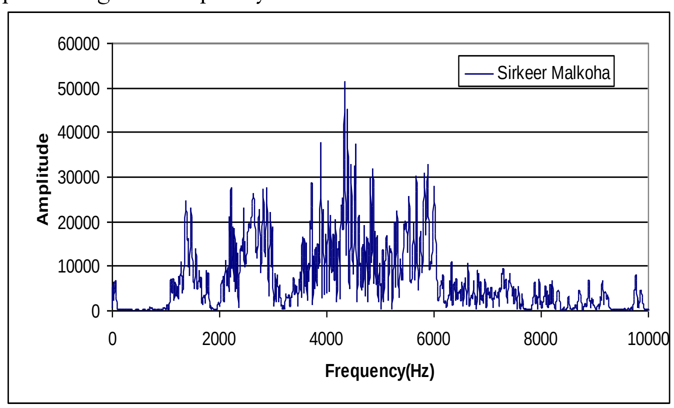


Fig. 9: Amplitude versus frequency plot for call of Sirkeer malkoha shows a broad cluster of sharp spikes and peaks starting from 1200Hz and extending up to 6200 Hz.

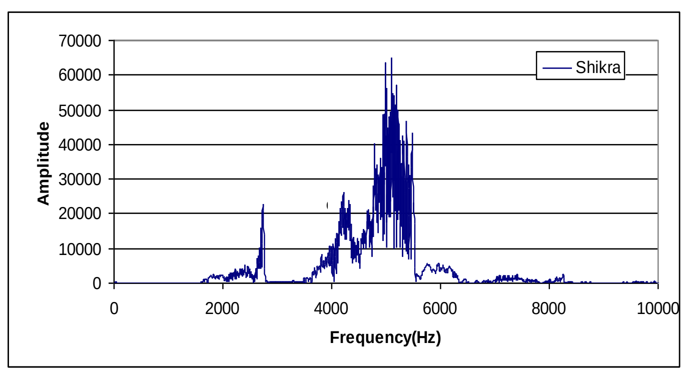


Fig. 10: Amplitude versus frequency plot for call of Shikra shows a broad cluster of peaks and spikes centered at around 4700 Hz and a small prominent peak at 2745 Hz.

Shikra: The Shikra is a small bird of prey in the family Accipitridae. It is widely found in Asia and Africa where it is also called the Little Banded Goshawk. The frequency spectrum of its call is shown in Fig. 10, it shows a broad cluster which in fact is made up of two clusters begins at around 3700 Hz and continues up to 5500 Hz and is centered at a frequency of 4700 Hz. Furthermore, there is small but prominent peak at 2745 Hz. Negligible or no sound amplitude is present at frequencies lower than 2000 Hz and no appreciable sound is present at higher frequencies beyond 6000 Hz.

3. RESULTS

In present study we analyzed 10 bird call samples. Study of frequency distribution of calls produced by birds revealed interesting results. 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 3 where as others produce sounds over a broader range like Fig. 7, 8 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, 3, 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. 5, 8 and 9.

4. DISCUSSION

In birds, calls are mainly produce by syrinx, which is an organ unique to birds. It has sufficiently complex Structure and texture. It varies from bird to bird. The present study shows that some birds produce sound at certain fixed and definite frequencies and every species has certain characteristic frequency at which sound produced is most prominent. Besides the most prominent frequency, there are some cases where considerable sound is produced at frequencies other than the characteristic frequency (central frequency of the cluster). Apart from this, there are some cases where sound is produced over a broad range of frequencies showing the capability of syrinx to vibrate at different frequencies.

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