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Research Article

Analysis of Bio-Acoustic Signals of Redwattled Lapwing (*Vanellus indicus*) in Agricultural Ecosystem

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ABSTRACT

Bird calls have always been the choice of ornithologists to identify and study the birds. The present study deals with the study and analysis of acoustic signals of Red-wattled Lapwing (*Vanellus indicus*) during breeding and non-breeding season at two locations of Punjab: Punjab Agricultural University, Ludhiana (Location I) and Ahmedgarh, Dist Sangrur (Location II). It was conducted for 14 months during the period of May 2018 to July 2019. Calls of the species were recorded by using Recforge II mobile app and were then analysed in Raven Pro 1.5 software of Cornell University, New York. It was observed that correlation of recorded calls of the species at different locations show the dissimilarity in the call patterns. Changes in the call frequency, amplitude, pitch etc. were observed during different call patterns. During the study period Red-wattled Lapwing was found to be vocally more active during breeding period as compared to the non-breeding period. During the present study a total of 6 different types of calls were observed in case of Red-wattled Lapwing. Hence it is concluded that acoustic study of avian species plays an important role in studying the behaviour of species.

Key words: Red-wattled Lapwing, Bioacoustic signals, frequency, Raven Pro, Call patterns

Introduction

Birds occupy a significant role in our ecosystem covering broad range of ecological positions (Sekercioglu 2006). Birds play an important role in agriculture and are popular for their dual role in agriculture (Ali, 1949, 1971). India is a land of biodiversity containing about 1301 of the world's 10,000 bird species and among these 328 species of birds are found in Punjab (Gupta, 2008). A variety of food is provided to birds through agriculture mainly grains, seeds, fruits; green vegetation and grasses; insects, arthropods, rodents etc. found in the soil, crops and other plants.

Most of the animal species including birds make specific sounds to communicate with each other which can be assumed by their acoustic detection (Aide *et al.,* 2013; Marques *et al.,* 2013; Stowell and Plumbley, 2014; Heinicke *et al.,* 2015; Merchant *et al.*, 2015). For bioacoustic monitoring the efficient time is at dawn and dusk and the field surveys usually depend on both visual and auditory identification of the selected species (Bibby *et al.,* 2000). Bird calls have always been the choice of ornithologists to identify and study the birds. Acoustic signals given by birds are the means of their communication (Catchpole and Slater, 1995). Usually birds give call signals to inform about the food, predator, and to identify family members etc. Birds have special call producing organ, syrinx which play an important role in their communication (Larsen and Goller, 2002). The voice organ of birds that is syrinx is usually more developed in songbirds and is located near the junction of trachea and bronchi (Lima and Hofling,

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2006). There exists syrinx with two sides in many bird species where a separate sound is produced simultaneously through each side (Vallet *et al.,* 2006). There also exist some bird species which use their tongue to produce different sounds. Parrots and Myna come under this category (Jaimipak *et al., 2019*).

The Red-wattled Lapwings are ground foragers and nesters birds. These are characterized by their loud alarm calls. These birds lay eggs on the ground. It is difficult to find their nests as the eggs laid are cryptically coloured and camouflages with the ground. The feeding habit of Red-wattled Lapwing consists of insects, grains, snails and other invertebrates picked from the ground. These usually lay 3-4 eggs at one time. These are mostly predated by kites and hawks. Breeding season is between March and August. These are usually found in dense populated areas (Piersma and Wiersma, 1996). After the hatching of eggs both the parents become alert and protect the chicks from predators. They remain active at all hours and even during midnight to rescue from predators.

The Red-wattled Lapwing belongs to family Charadriidae and are distributed throughout East Pakistan, India, Nepal and Bangladesh. It is commonly known as 'Titeeri'. According to Ali (1996) Red-wattled Lapwing (*Vanellus indicus*) in Asia loves to stay at ploughed fields, grazing patches, open country side and dry beds of water bodies. Red-wattled Lapwing is about 35cm long with long yellow legs, black-tipped red bill and light brown wings with purple sheen. Wings of males are usually 5% longer than that of females. It is a social bird mostly found in groups of 10-15 birds (Vyas, 1997). Lapwings usually have loud pitch noisy sound calling did-he-do-it or pity-do-it, more frequent at night. Well known for its unique sound, it is called "The did-he-do-it bird" (Jerdon, 1984). These birds breed from March to August laying their eggs on ground depressions. Clutch size normally obtained is 3- 4 with cryptically coloured eggs.The study of bio-acoustic signals of Red-wattled Lapwing during breeding and non-breeding seasons will help in understanding its behaviour through their acoustic parameters.

Materials and Methods

The study of both breeding and non-breeding calls of Red-wattled Lapwing (*Vanellus indicus*) was conducted at two selected locations from May 2018 to July 2019. The data was collected weekly during non-breeding season and on regular basis during breeding season.

Location I: Punjab Agricultural University, Ludhiana: Lying at latitude of (75.79° E, 30.90° N), the university is situated towards west in the outskirts of Ludhiana city and 189 m above the mean sea level. The university has huge campus covering an area of 1600 acres in the north-west of Ludhiana along the Ferozepur Road. The campus is surrounded by residential area on the eastern side scattered among university buildings. Area consists of various lawns, hedges and ornamental trees. In addition to several education departments and research laboratories of the constituent colleges, playgrounds and grassy lawns, the campus has a large expanse of agricultural fields. The field area comprised of seasonal crops such as wheat, rice, maize, cotton etc along with vegetables, fodder and orchards. The campus consists of various animal sheds (dairy, poultry and piggery), fish ponds, small animal's colony, bee keeping etc. The experimental areas consisted of well active nests of Red-wattled Lapwing and data was taken during breeding and non-breeding activities involving roosting, foraging, nesting, incubation, hatching, mobbing and parental care upto fledging of chicks.

Location II: Ahmedgarh, district Sangrur: Ahmedgarh is a town in Sangrur district of Punjab situated at 26 km from Ludhiana having area of 6 km^2(75.82° E, 30.68° N). The location comprises of both agricultural fields and residential area including schools, banks, parks, grain market, market etc. The field area comprised of seasonal crops including rice, wheat, maize etc.

Recordings of Red-wattled Lapwing

Recordings of Red-wattled Lapwing were done by using Recforge II mobile app and all the recordings were played in audacity software to reduce the background noise of vehicles, other bird species, machinery and humans etc. The audacity software along with background noise reduction provided the facility of amplifying the recorded calls (Fig. 1). Then the edited recordings were played in

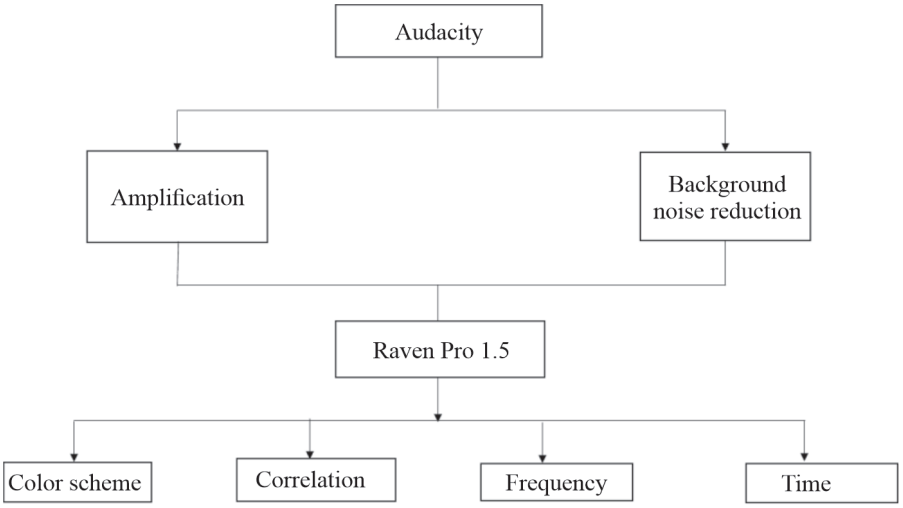

Fig. 1. Flow chart representing the whole process of audio recording and analysis

Raven Pro 1.5 software of Cornell University, Ithaca, New York. The software provided various features such as playing a section, correlating the calls, colouring features, wave form and spectrogram analysis etc. Spectrograms were analyzed for studying different call parameters in the present study. Software provides such spectrograms which can either be captured coloured or black and white according to requirement. Spectrograms disclose some features including fast frequency or amplitude variations, that are not heard by humans even if it come in their hearing frequency of 30 Hz-16 kHz. The spectrograph thus formed are used to analyse sounds and convert them into a graphical representation. Usually the x axis on a spectrogram represents the time, y axis represents the frequency and the scale of grays or the scale of colors represents the amplitude of signals.

Results and Discussion

Non-breeding period included calls recorded and analysed during foraging, feeding, roosting, and other daily activities, while, Breeding period included calls during different activities such as nesting, egg laying, incubation, hatching, mobbing and parental care.

Vocalizations of Red-wattled Lapwing during Non-breeding season

During non-breeding season Red-wattled Lapwing was found to be less active and remained vocally inactive from October to February. As it is clear from spectrogram (Fig. 2) that fluctuation in the calls was less with 11 kHz as maximum frequency. The call patterns were observed total 17 times during the whole call length and the calls were given after gaps. Frequency of calls was less in the

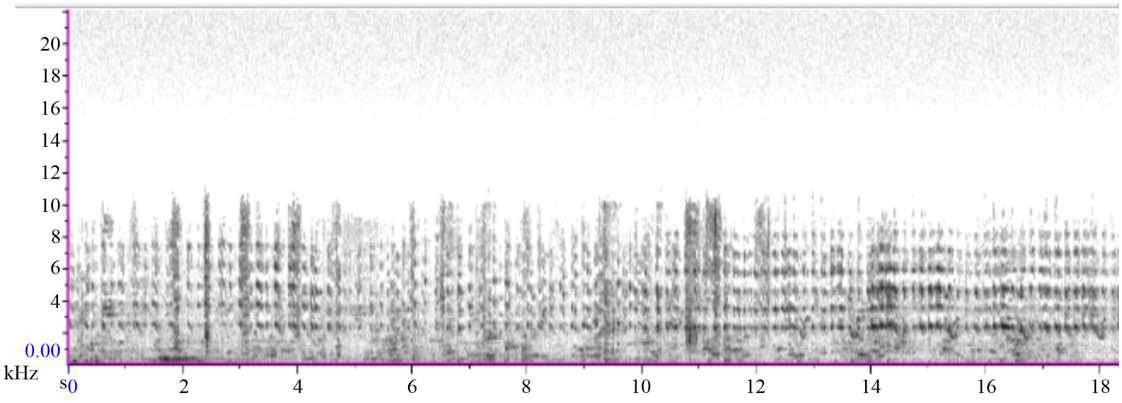

Fig. 2. Spectrogram of vocalizations during Non-breeding season

beginning as compared to the end of time period. The frequency ranges from 8-11 kHz. Calls observed were less frequent during non-breeding season. Similar findings were also reported by other workers in case of Southern Lapwing that during non-breeding season, territories of Red-wattled Lapwing are stable (Saracura *et al.,* 2008) and acoustic signals were less and only in response to predators. Lapwings usually have loud pitch noisy sound calling did-he-do-it or pity-do-it, more frequent at night and is well known for its unique sound, and hence is called as "The did-he-do-it bird" (Jerdon, 1984). Lapwings were found in groups during non-breeding period and most time the loud calls were observed only when there was approach of predator. Comparison between non-breeding calls of both the locations show difference in the frequencies of calls showing the difference in calls at both the locations.

Vocalizations of Red-wattled Lapwing during breeding season

These birds breed from March to August laying their eggs on ground depressions (Fig. 3-6). A total of 10 nests were observed during the study. Clutch size ranges from 3-4 with cryptically colored eggs. A total of five different types of vocalization were observed and analyzed during breeding season of Red-wattled Lapwing.

Flying calls of lapwing over its territory: At time of breeding season lapwings were vocally active while flying over their territories in order to protect the territories from entering another male or predators. Same call was herd after time interval of 1-2 seconds. It was observed that same segment of call of 11-13 seconds was repeated after pause of 5 seconds (Fig. 7). The highest frequency observed was 11 kHz although fluctuation in the frequency was more during whole call length (Fig. 8). Similar observation were also reported by Walters (1982) that at time of breeding season lapwings were vocally active while flying over their territories in order to

Fig. 3. Red-wattled Lapwing in the field

Fig. 4. Red-wattled Lapwing incubating the eggs

Fig. 5. Nest of Red-wattled Lapwing

Fig. 6. Crouched behaviour shown by chicks

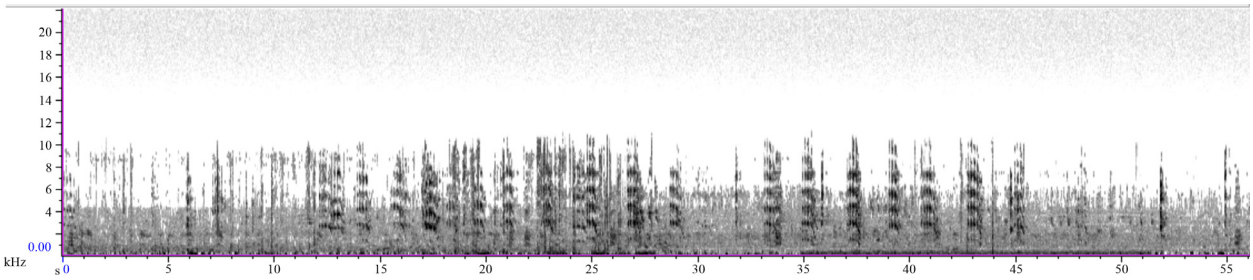

Fig. 7. Spectrogram of flying calls of lapwing over its territory during breeding season

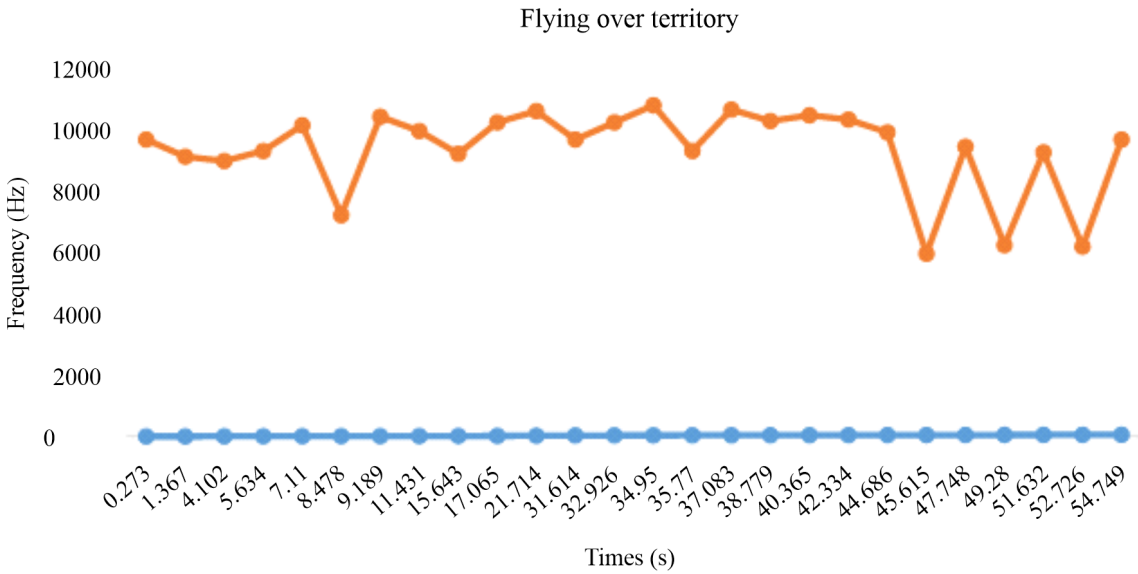

Fig. 8. Graphical representation of call parameters of Red-wattled Lapwing while flying over a territory

protect the territories from entering another male or predators.

Calls of Red-wattled Lapwing during incubation of eggs

As observed from spectrogram the calls at time of incubation were continuous. The intensity of calls was more as the predator approaches the eggs and declined after the departure of predator. The main predator observed during the survey period were dogs, crows and humans. In the beginning for 1-3 seconds of total call period, calls were herd after constant pause while from 4-5 seconds of time period calls were intensified with no pause in between. This pattern of both intensified and non-intensified calls was repeated up to 15 seconds of call length (Fig. 9).

After 15 seconds of time interval calls were observed with more pause up to 30 seconds of time. In this pattern call segments were repeated during whole call length showing more gap between the calls in the end as the predator left away. The frequency remained constant up to 20 kHz. Large repertoire of danger response behaviors were shown by adults taking care of their young. These include alarm calls such as (a) alerting call and vigilant posturing for distant threats; (b) alarm call, swooping attack, injury-feigning, and mobbing against non-reptilian predators (Walters, 1990) Alarm calls provoked crouching behavior in young. These seemed to grade into the alerting call, the notes being longer, louder, and more frequent than those characterizing the alerting call. Many times false breeding was observed as a defense strategy. During breeding season territorial defense behavior also get intensified.

Less loafing, preening or sitting was observed in Southern Lapwing during breeding season as

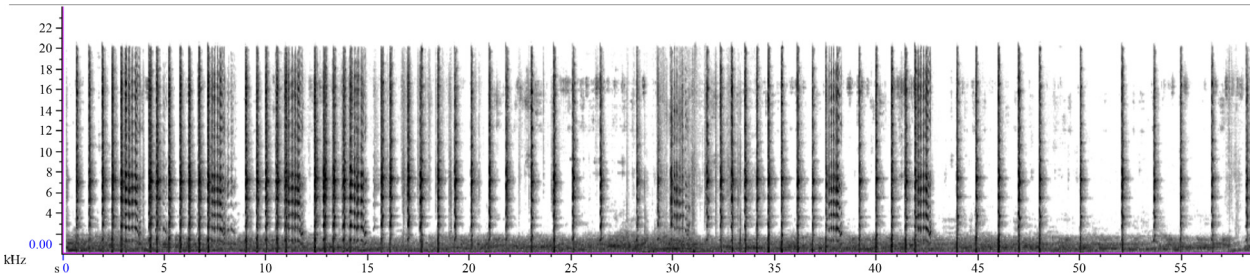

Fig. 9. Spectrogram of Flying calls of lapwing over its territory during breeding season

compared to non-breeding period (Walters, 1984). We observed similar results in Red-wattled Lapwing. On comparing with non-breeding season adults spend less time foraging in breeding period after the hatching of eggs. Hence, hard work invested in parental care increases (Walters, 1982).

It is clear from the spectrogram above that frequency of the complete call length remained constant showing that birds were much alert and active during breeding season and were continuously protecting their eggs from predation. The degree of difficulty in sighting eggs on an open ground obviously helped in dodging the prying eyes of predator.

Alarm calls of Red-wattled Lapwing in response to predator coming close to the nest

Alarm calls given close to the nest were continuous with fluctuation in the frequency of calls (Fig. 10). Alarm calls helped in protecting the chicks from predators (Walters, 1990). For the first 1 minute of call period calls were more intense with frequency ranging from 7-11 kHz. After that calls observed were less intensified with highest frequency of 11 kHz (Fig. 11).

Calls of Red-wattled Lapwing to their chicks after the departure of predator

It was observed that after the predator left the site chicks were given signal to come out by the low tit-tit call of parents. Until this call was not given by the parents, the chicks remained silent and immobile. Such type of call was found to be continuous but with low intensity (Fig. 12). The graph show large variation in the frequency of call. Maximum frequency of call was found to be 11 kHz (Fig. 13). This behaviour of chicks responding to the signal of parents is necessary for the success rate to increase the species population (Walters, 1984).

Mobbing calls of Red-wattled Lapwing

Mobbing calls increased in intensity and frequency with the closest approach of predators. It was that calls given were continuous, loud and sharp (Fig. 14). The fluctuation in the frequency of call was high as in the beginning the frequency range was about 11 kHz while after the 50 seconds of total call length observed, the frequency was seemed to reach 18 kHz (Fig. 15). Further the fluctuation in the frequency is clear from the line graph shown below. Beside this parental care, aggression towards inter specific non-predatory birds entering the

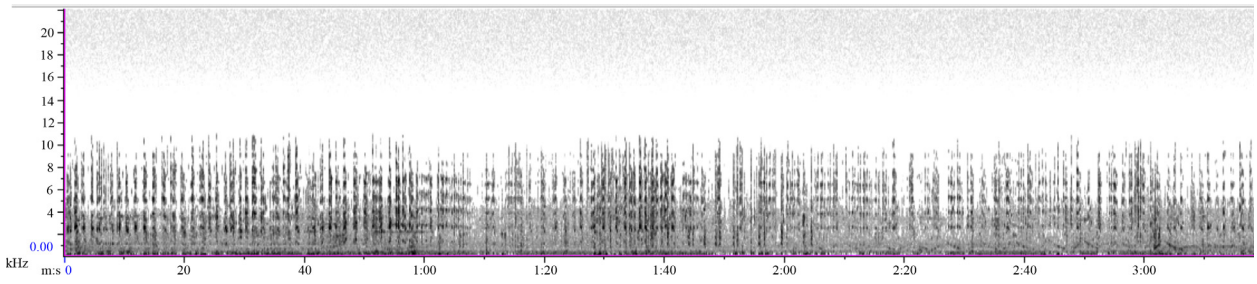

Fig. 10. Spectrogram of calls of Red-wattled Lapwing in response to predator coming close to the nest

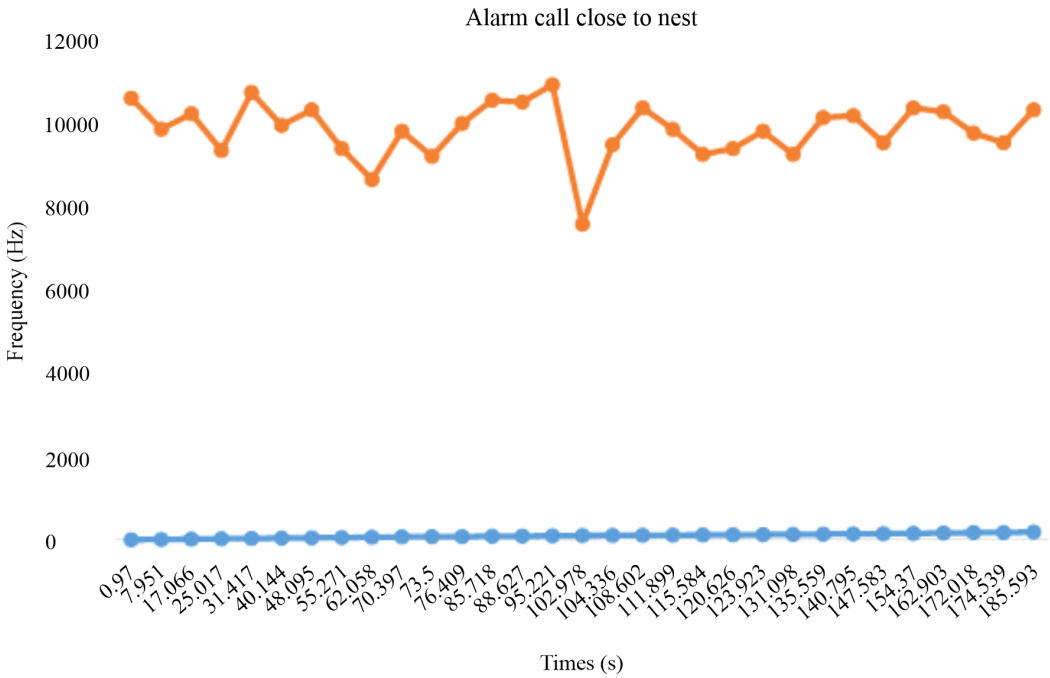

Fig. 11. Graphical representation of Call parameters of Red-wattled Lapwing in response to predator coming close to the nest

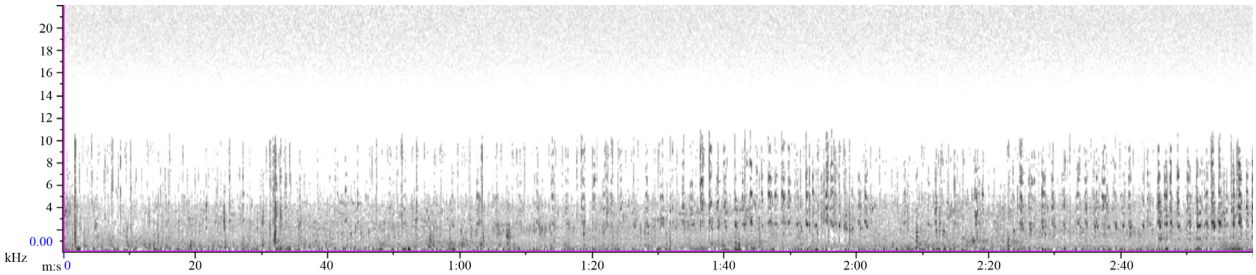

Fig. 12. Spectrogram of calls of Red-wattled Lapwing to their chicks after the departure of predator

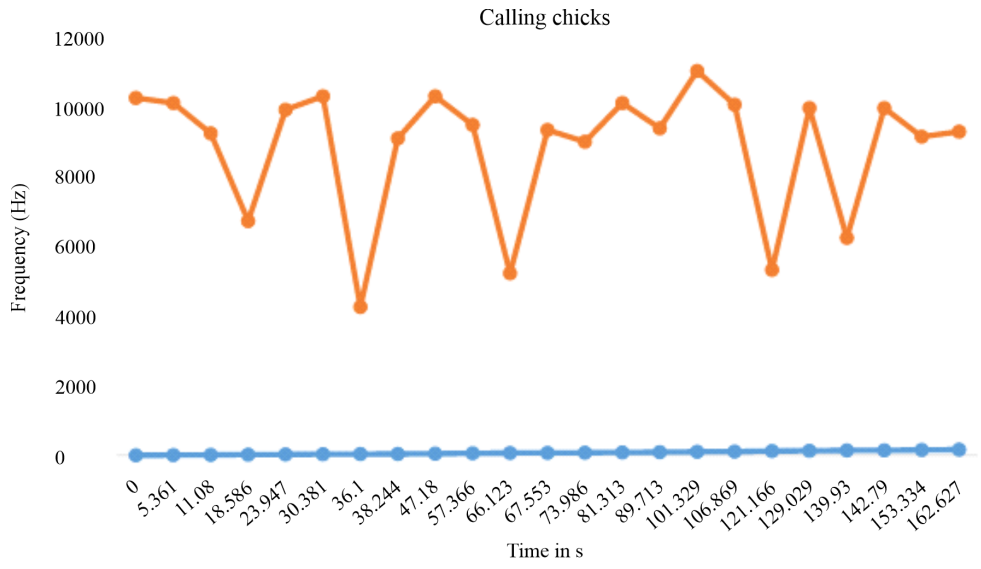

Fig. 13. Graphical representation of calls of Red-wattled Lapwing to their chicks after the departure of predator

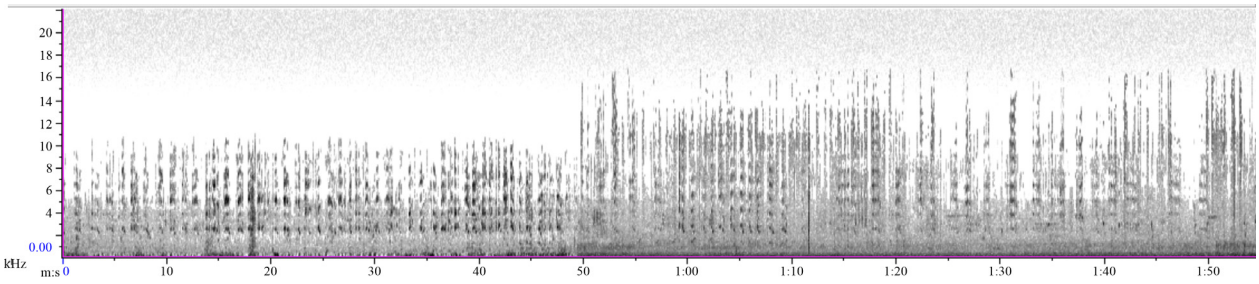

Fig. 14. Spectrogram of mobbing calls of Red-wattled Lapwing

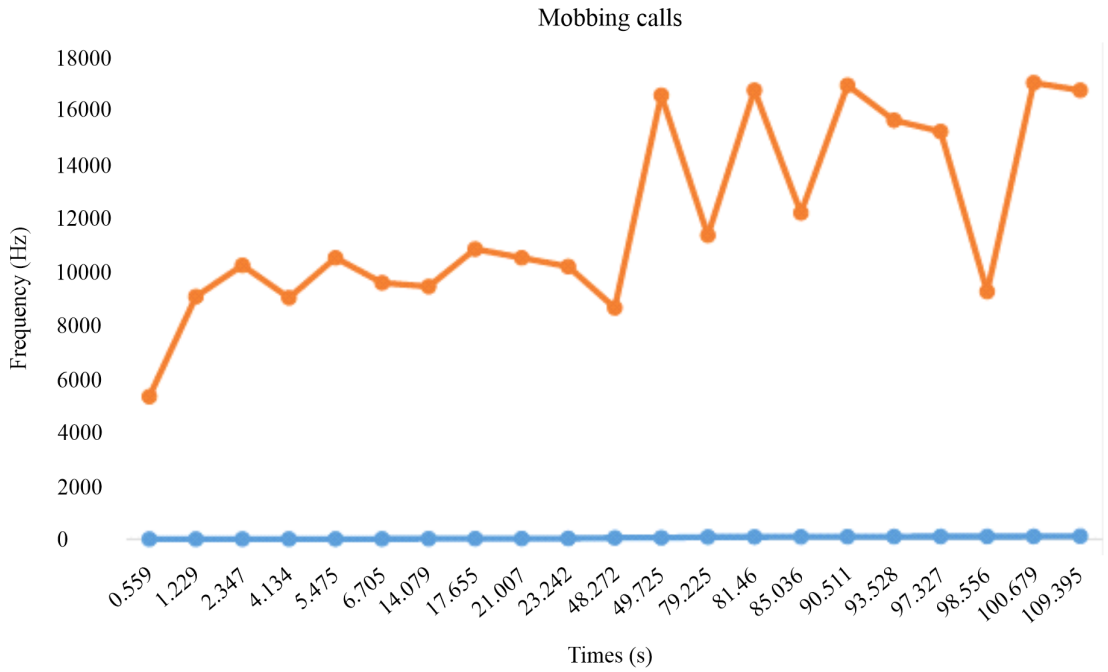

Fig. 15. Graphical representation of mobbing call of Red-wattled Lapwing

territories was shown by adult lapwings with downy chicks (Walters, 1982).

Spectrographic cross-correlation

Spectrographic cross-correlation (SPCC) was used to find out the degree of similarity or correlation between different groups of acoustic signals analyzed. SPCC was performed by using Raven Pro 1.5 software which compare pairs of vocalizations and software cross-correlates them in the time-frequency domains. The SPCC highlights peak values where the two vocalizations are most similar and represent them by color coding in spectrogram. The similarity in the calls increases as the value increases from 0-1 in spectrogram. Spectrographic cross correlation between the calls of Red-wattled Lapwing at both the locations show that there exists location specific dissimilarity in the call patterns during the calls while calling the chicks after the departure of predator and rest of the call did not show location specific variations (Fig. 16).

Conclusion

Total 6 types of calls were observed in Red-wattled Lapwing combining both non-breeding and breeding period (incubation, flying over territory, Alarm calls close to the nest, Alarm calls provoking crouched behavior in chicks, Mobbing calls). In case of lapwing, number of calls increased from incubation including hatching and up to fledging of

Batch Spectrogram correlation						
⇩	○ Peaks (u) ○ Lag(s)			Colours √		
File 1 / File 2 ⇨	L-2-C-1	L-2-C-2	L-2-C-3	L-2-C-4	L-2-C-5	L-2-C-6
L-I-C-1	0.077	0.077	0.073	0.073	0.111	0.111
L-I-C-2	0.077	0.077	0.073	0.073	0.111	0.111
L-I-C-3	0.388	0.388	0.377	0.377	0.487	0.487
L-I-C-4	0.388	0.388	0.377	0.377	0.487	0.487
L-I-C-5	0.395	0.395	0.381	0.381	0.493	0.493
L-I-C-6	0.395	0.395	0.381	0.381	0.493	0.493

Fig. 16. Spectrographic cross-correlation of calls

chicks. Spectrographic cross correlation between breeding and non-breeding calls of both the species analyzed and compared at both the locations proved dissimilarity among the calls recorded at different locations. Hence it is concluded that acoustic study of avian species plays an important role in studying the behavior of species. Acoustic dissimilarity can convey to light perturbations which are usually hard to notice through other indicators. According to Laiolo and Tella (2006), the statistics provided by acoustic dissimilarity is helpful for conservation biologists to use it as a complement in comparison to rest available indicators which have become common in issues related to conservation, including neutral genetic markers. Besides breeding, vocal communication also enables some essential behavioral activities, including territory selection, food and foraging, defense strategies and decisions regarding settlement of individual. Hence it is concluded that acoustic study of avian species plays an important role in studying the behavior of species.

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