OPEN ACCESS

ECOCYCLES
ISSN 2416-2140

Scientific journal of the
European Ecocycles Society

Ecocycles, Vol. 11, No. 1, pp. 1-10 (2025)
DOI: 10.19040/ecocycles.v11i1.465

RESEARCH ARTICLE

A comparative account of calls of common myna in different human-influenced environments

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Abstract – Urban environments pose novel challenges to signal communication of Urban-adjusted birds. The present study compared spectral and temporal traits of Common Myna (*Acridotheres tristis*) dwelling in Semirural and Urban sites in terms of Low, High, and Peak frequencies and syllable duration. We recorded 270 calls from approximately 224 individuals from 3 sites-2 urban and one semirural, 90 calls from each area. We also correlated the Temperature and Humidity with each of these parameters using the Pearson correlation coefficient at 95% CI. Calls were found to be of higher frequencies in the Metropolitan-urban area than in the semirural area. One-way ANOVA analysis showed significant differences ($P<0.05$) in all call parameters among the sites. Peak frequency was found to be slightly higher in the Semirural area as compared to the noisy urban site by about 45 Hz, but less as compared to the Metropolitan area of Ahmedabad. Syllable duration was highest in semirural area. Temperature and Humidity did not have a significant impact on birdsong ($P>0.05$). Our study emphasises urban environment affects both spectral and temporal traits of birdsong significantly and forms the primer for studying the effects of weather on birdsong. Urban Canyon effects and urban composition have more impact on signal transmission and communication as compared to weather parameters. However, additional study will be required to emphasise the quantification of impervious surfaces and noise levels and consider recording distance while making Urban and semirural comparisons.

Keywords – Urban bird communication, Common Myna vocalisation, Spectral and temporal traits, Urban versus semirural habitats, Birdsong frequency analysis, Environmental impacts on birdsong, Urban noise and signal transmission

Received: August 31, 2024 Accepted: December 2, 2024

1. INTRODUCTION

With increased urbanisation, natural habitats are becoming more and more modified. The increase in human population has posed challenges for wildlife species which have to adapt to anthropogenic environments. Among Birds, Urbanisation also significantly impacts the communication of vocal signals of urban-adapted species, as urban areas have different microclimates and comparatively lesser vegetation cover. Vehicular noise, urban landscape, and climate affect the singing pattern and duration of their calls and songs. Thierry and Slater (2002) observed that rainy conditions reduce the calling of tawny owls *Strix aluco.* Weather variables such as humidity and air temperature have more significant impacts on the bandwidth of songs (Schäfer et al. 2017). However, these views are unclear as Berg et al. (2005) noted that songs of the Australian Reed Warbler (*Acrocephalus australis*) did not show any relation with weather variables.Coomes and Derryberry(2021) noted that higher temperatures decreased the syllable duration in Zebra Finches (*Taeniopyggia guttata*). Moreover, the vocal activity of *Crypturellus undulatus* and *Ortalis canicollis* was positively correlated with air temperature during the dry season but was unrelated to higher temperatures in the wet season (Granados and Schumann, 2021). However, the evidence on the effect of climate on spectral and temporal traits of the birdsong is still less and unclear.

Urban structures, i.e., the presence of high-rise buildings and vehicular traffic noise, affect the song characteristics of urban birds by either attenuating the song (Jennifer et al., 2020) or by reverberation (Kight and Swaddle,2015). Most of these birds respond by raising their minimum frequencies in response to an increase in background noise (reviewed by Hu and Cardoso, 2010; Dowling et al.,2012; Luther and Baptista,2009; Slabbekoorn and Visser, 2006; Dominique et al., 2011). However, some birds also increase their maximum frequencies, as Mendes et al.(2011) observed in Blackbird (*Turdus merula*). Birds which have higher minimum frequencies usually do not adjust background noise (Job et al.,2016). Hence, overall, urban birds increase their volume, amplitude and singing time (Liu et al.,2014). Urban birds have been observed to sing faster than forested birds (Slabbekoorn and Visser, 2006) and have a lesser number of notes (Dominique et al.,2011) and at longer intervals (Nemeth and Brumm, 2009). Deoniziak and Osiejuk (2019) found that urban-dwelling song thrushes sang at higher minimum and peak frequencies in Twitter syllables but not at whistle syllables. However, the repertoire size was larger in rural areas, which altogether suggested that apart from habitat structure, other factors such as ambient noise and population density also affect birdsong. Brewer and Fudickar (2022) found that the peak frequency of song sparrows was higher in rural areas than in urban areas without any significant difference in repertoire size. Cumatazin et al. (2022) also found that Urban House Finches sang at a lower pitch than rural inhabiting House Finches.

Moreover, Common Chaffinches (*Fringilla coelebs*) sang at lower minimum frequencies and broader bandwidths in urban areas as compared to rural forests (Yelimlies et al.,2023). Zollinger et al. (2017) found no significant differences in the pitch of urban and forested birds. Thus, there have been contrary findings in the research from 2006-2016 and 2017-2023. Studies from 2006 to 2016 found that urban birds sing at higher frequencies than rural or forested birds, and studies from 2017 to 2023 found that rural or forested birds sing at higher frequencies than urban birds. Hence, in this paper, a comparison was made of bird calls in different anthropogenically modified environments.

Usually, it is found that urban areas alter the behaviour of the animals (Shochat et al. 2006). The main purpose of this study was to investigate the effect of urbanisation and weather variables on bird calls. For this study, Common Myna (*Acridotheres tristis*) was chosen as a model organism. Common Myna belongs to the family Sturnidae and is usually an urban exploiter (Bhattacharya et al.,2022). It occurs in both semirural and urban areas (Old et al., 2014). It is very widely described to be an invasive species (Manawadu L.,2010). This species of Myna is usually gregarious and is found in groups (Mohan R.,2012). It makes loud communal calls. Hence, we chose this species as a model organism, as its calls can be easily captured on the microphone. Moreover, common myna has a cosmopolitan distribution in both urban and forested areas thus, it is easier to locate and study its vocal behaviour. It has bold behaviour and does not shy in the presence of humans (Sarangi et al.,2014) thus, it's easier to record its vocalisations. Research done by Grarock et al.(2013) suggests that the abundance of *A. tristis* is associated with habitat modification. Earlier studies included the effect of temperature and humidity but only on time-related attributes such as singing rates (Puswal et al.,2021; Garson and Hunter,1979). In this paper, we investigated the possible effect of temperature and humidity on both syllable duration and frequency, which was absent in previous studies.

Usually, vegetation cover is very low in urban areas, and impervious surfaces are present to larger extents than in rural or forest habitats. This study mainly includes the effect of urban structure and composition and weather variables, such as temperature and humidity, on calls of urban-dwelling birds and its broader implications on wildlife. Most of these changes are observed in birds that inhabit urban areas. With limited food sources and habitats, they usually have to maximise their vocal efficiency to overcome communication restraints imposed by high-rise concrete structures and buildings for effective communication. Thus, they alter the structure and composition of their calls, which are often different from forest-inhabiting bird species. We studied these changes through the study of acoustic features of *Acridotheres tristis*. For this study, we made two predictions:

(i)Calls from urban areas would be higher-pitched
(ii)Urban bird calls will have shorter syllables as compared to calls from areas having comparatively more vegetation cover

2. Materials and Methods

2.1 Study Areas

For this study, three areas were chosen, out of which two were urban and the third was a semirural area with comparatively more vegetation intermixed with anthropogenic activities. The two urban sites were located in the cities of Ahmedabad (Lat. 23°.1018475567, Long. 72°.59517539092) and Guwahati (Lat. 26°.1851785990, Long. 91°.7412810454). The two urban sites chosen differed in the aspect of composition and architecture. The urban site in Ahmedabad **-** a metropolitan city, was located in Sangath Silver Apartments, which had more impervious surfaces and reflective structures, especially glass, concrete and asphalt, but scanty canopy cover, whereas the site in Guwahati was the campus area of the Council of Baptist Churches in Northeast India (CBCNEI), which had more vehicular traffic noise and ongoing construction activities, hence we classified it as "noisy" urban site.

SEASON	MONTH
1	October-November
2	December
3	January
4	February
5	March
6	April

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The semirural area was located in the Campus area of Assam Don Bosco University (ADBU), Tapesia (Lat. 26°.126167, Long. 91°.898772), which had comparatively more vegetation consisting of tall trees, tea plantations and medium-height shrubs and grasses intermixed with occasional human disturbances of anthropogenic-induced noise of lawnmowers. Fieldwork, which included the recording of calls, call analysis and Hypothesis testing, was done from October 2022 to April 2023. Each Month was divided into "Season". The table above summarises the months of data collection

2.2 Call Recording and Analyses

Calls were recorded in 2 sessions- Morning and Afternoon in all three sites. The recording was done using a BOYA BY-MM1 Super Cardioid Microphone connected to a mobile phone recorder. Simultaneously, the ambient temperature and humidity were noted down from the mobile phone before the start of each recording and at the end of each recording. The calls were selected based on the quality of vocalisations captured on the microphone along varying ranges of temperature and humidity conditions to provide the maximum temperature and humidity conditions for each area during each month. This study analyzed 270 distinct call recordings (90 from each area) of approximately 224 individuals for the entire study period. Spectrograms were generated in Raven Pro 1.6 (Cornell Lab of Ornithology, Ithaca, USA) and were visually analysed for each of the recorded calls. For analysis, Raven Pro's default settings (Window type=Hann; FFT window size =512; Overlap=50%) were used to visualise the spectrograms. Brightness and Contrast levels were kept at 50 each and were adjusted accordingly for analysis. Each recording was analysed for a maximum of 2 minutes. The syllable duration was calculated as the duration of a group of notes followed by large intervals of time between two consecutive groups. Ambient noise levels were not measured in these studies.

2.3 Statistical analysis

For this study, average measurements of each type of frequency (Low, High and Peak) and syllable duration were compared from each area using one-way ANOVA to check whether differences were significant or not. Box plots were constructed to compare the call parameters correlated with the Temperature and Humidity using Pearson correlation at 95% CI. All statistical analyses were conducted in R 4.2.2 (R Core Team 2022), and graphs were drawn using the ggpubr package (v.0.6.0)

3. RESULTS

It was usually observed that each of the frequencies (High, Low and Peak) differed from area to area. From the correlation studies, it was found that the effect of humidity and temperature was overall nonsignificant (P>0.05). Also, the frequencies and syllable duration exhibited similar patterns of correlation between the urban area of Guwahati and the semirural area of ADBU and were less similar to Ahmedabad. It was usually observed that High frequency and Peak frequency exhibited large variations with changing months, as compared to Low frequency. Syllable duration also varied largely with area and season.

Earlier studies had incorporated background noise as a parameter to study the bird calls in urban areas, however, unfortunately, due to technological backlogs, we could not take that aspect into our study. Moreover, in Guwahati, the presence of other bird species like House Crows (*Corvus splendens*) and other species of mynas, such as Pied Starling (*Gracupica contra*) and Crested Myna (*Acridotheres cristellatus*), combined with vehicular noise and movements on roads located adjacent to our study site, masked the songs of Common Myna during the recording sessions.

3.1 Correlation analysis

High frequency showed a negative correlation with temperature in both cities, Ahmedabad and Guwahati, but a negative correlation with temperature was observed in the semirural area of ADBU (Fig 1.1). Since P<0.05 in both Ahmedabad and ADBU, the correlation was significant but not significant in the case of Guwahati (P=0.081, Fig 1.1).

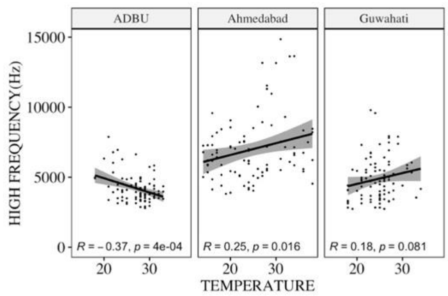

Fig 1.1 Correlation of High frequency with temperature

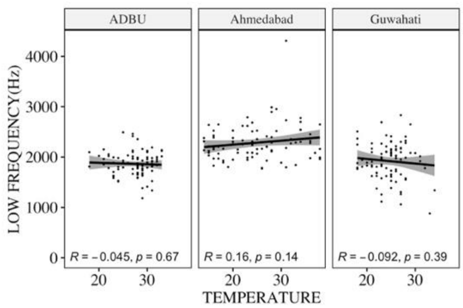

Fig 1.2 Correlation of Low frequency with temperature

Low frequency showed a positive correlation with temperature in Ahmedabad (P=0.14, Fig 1.2) However, it showed a negative correlation in both Guwahati (P=0.39, Fig 1.2) and ADBU (P=0.67, Fig 1.2). Since P>0.05 in all three areas, the correlation was nonsignificant.

Peak frequency showed a positive correlation with temperature in Ahmedabad and ADBU (P=0.28, Fig 1.3), they show similar trends of negative correlation with temperature. As P>0.05 in all 3 cases, the correlation between peak frequency and temperature was not significant. Syllable duration showed a positive correlation with temperature in all three areas, but the increase was more linear in Guwahati (Fig 1.4) and ADBU (Fig 1.4) than in Ahmedabad. Since P>0.05 in all three areas, hence the correlation was nonsignificant.

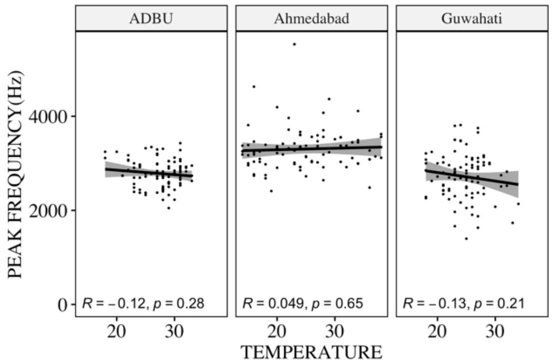

Fig 1.3 Correlation of Peak frequency with temperature

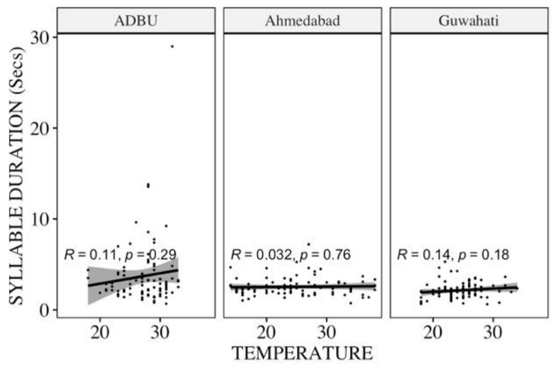

Fig 1.4 Correlation of Syllable duration with temperature

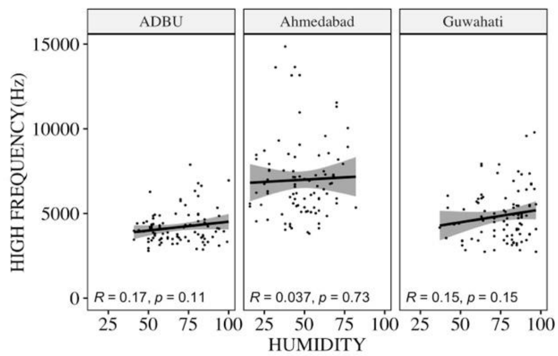

Fig 1.5 Correlation of High frequency with Humidity

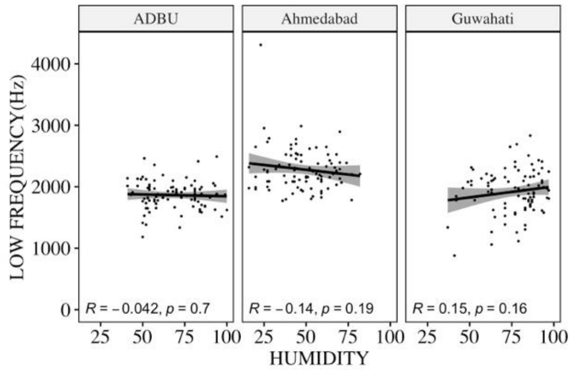

Fig 1.6 Correlation of Low frequency with Humidity

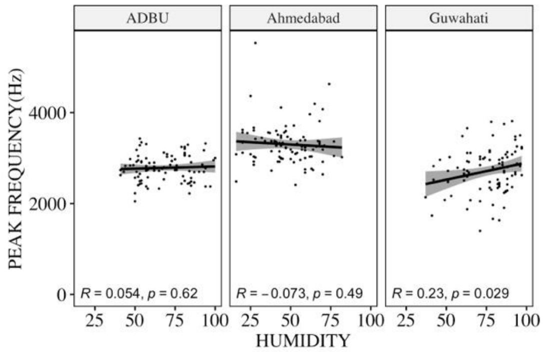

Fig 1.7 Correlation of Peak frequency with Humidity

High frequency showed a positive correlation with humidity in all three areas. However, the increase was more marked in Guwahati and ADBU. From the above graphs, since P > 0.05 (Fig 1.5), the positive correlation was non-significant. Low frequency showed a negative correlation with humidity in both Ahmedabad and ADBU, whereas, in the case of Guwahati, Low frequency increases with an increase in humidity, as can be seen that P>0.05 in all three areas (Fig 1.6), hence the correlation of low frequency with humidity was non-significant. Peak frequency showed a negative correlation with humidity in Ahmedabad, but it increased in the case of Guwahati and ADBU. The increase was more marked in Guwahati as compared to ADBU. The increase was significant in Guwahati, as seen in Fig 1.7 (P=0.029), but not significant in Ahmedabad (Fig 1.7, P=0.494) and ADBU (Fig 1.7, P=0.616).

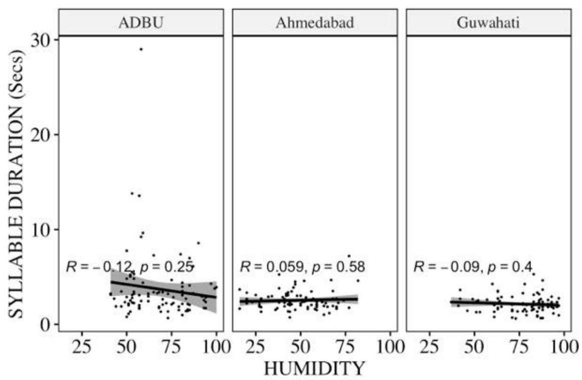

Fig 1.8 Correlation of Syllable Duration with Humidity

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Syllable duration showed a positive correlation with humidity, as seen in the case of Ahmedabad, but was insignificant (Fig 1.8, P=0.577), but in the case of Guwahati and ADBU, syllable duration decreased with an increase in humidity. The negative correlation was more marked in ADBU. The negative correlation was insignificant in both Guwahati and ADBU as P>0.05 (Fig 1.8). By using One-Way ANOVA, we found that the differences in different types of pitch (High, Low, and Peak frequencies), including syllable duration, were statistically insignificant.

3.2 One-Way ANOVA Results

1.Low frequency for Ahmedabad, ADBU and Guwahati at P=0.05

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
low.frequency	1	38.81	38.81	73.67	7.62e-16 ***
Residuals	268	141.19	0.53		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

2.High frequency for Ahmedabad, ADBU and Guwahati at P=0.05

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
high.frequency	1	55.04	55.04	118	<2e-16 ***
Residuals	268	124.96	0.47		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

3. Peak frequency for Ahmedabad, ADBU and Guwahati at P=0.05

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
peak. frequency	1	33.21	33.21	60.63	1.51e-13 ***
Residuals	268.	146.79	0.55		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

4. Syllable duration for Ahmedabad, ADBU and Guwahati at P=0.05

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
syllable.duration	1	7.89	7.887	12.28	0.000536***
Residuals	268	172.11	0.642		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

It is observed that P<0.05 in all four parameters of bird song is taken into consideration. Hence, the differences are statistically significant.

The median Low frequencies of Ahmedabad, Guwahati and ADBU are 2225 Hz, 1953 Hz and 1874 Hz, respectively (Fig 1.9). Thus, the median Low frequency was highest in cities Ahmedabad and Guwahati as compared to ADBU.

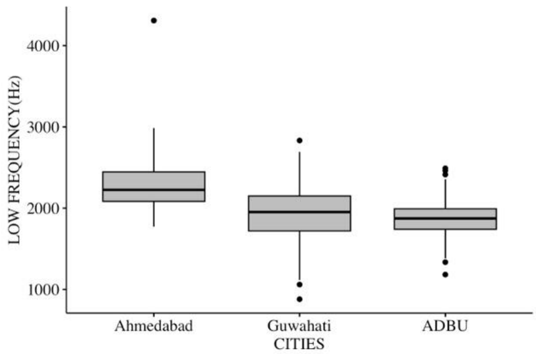

Fig 1.9 Boxplot of Low Frequency

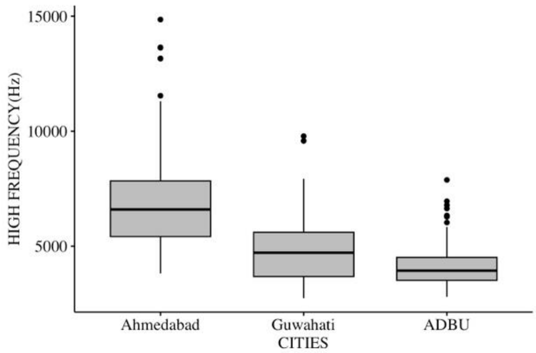

Fig 1.10 Boxplot of High Frequency

The median High frequencies of Ahmedabad, Guwahati and ADBU are 6597 Hz, 4717 Hz and 3937 Hz, respectively. Thus, the median high frequency was higher in urban areas of Ahmedabad and Guwahati than in ADBU.

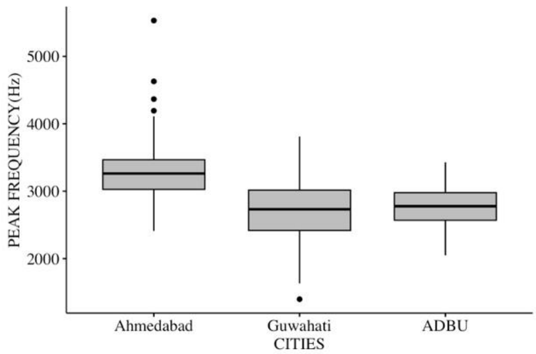

Fig 1.11 Boxplot of Peak Frequency

The median Peak frequencies of Ahmedabad, Guwahati and ADBU are 3262 Hz, 2733 Hz and 2778 Hz, respectively (Fig 1.11) Thus, the median Peak frequency was highest in Ahmedabad and ADBU and, finally, Guwahati. The difference in median peak frequency between Guwahati and ADBU was marginal at 45 Hz.

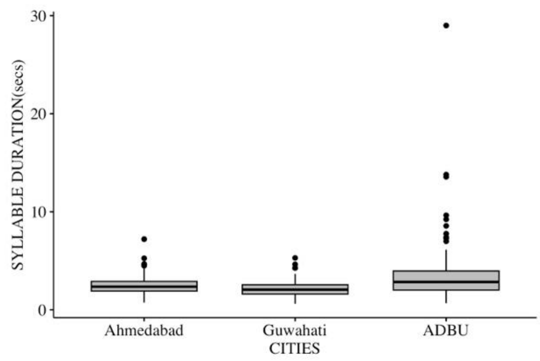

Fig 1.12 Boxplot of Syllable duration

Thus, the median Syllable duration was highest in ADBU, lowest in cities-Ahmedabad and least in Guwahati. This proves the fact that urban birds sing faster notes and songs as compared to forest-inhabiting birds since the time taken for singing was more in ADBU as compared to Mynas inhabiting both cities. The Spectrograms with their corresponding oscillograms of each of the cities are given below-

3.3 Spectrograms and Oscillograms

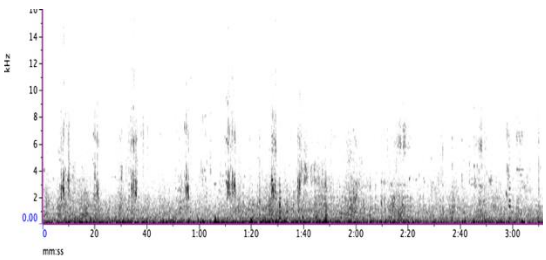

Fig 1.13 Spectrogram of *A. tristis* call in Ahmedabad

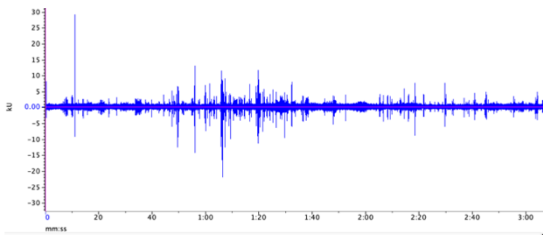

Fig 1.14 Oscillogram of *A .tristis* call in Ahmedabad

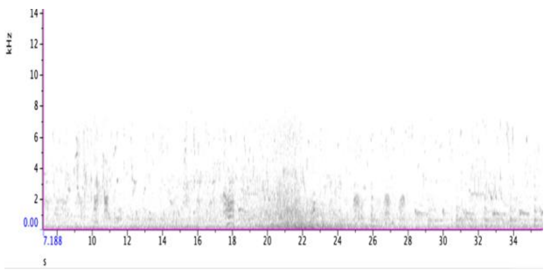

Fig 1.15 Spectrogram of *A. tristis* call in Guwahati

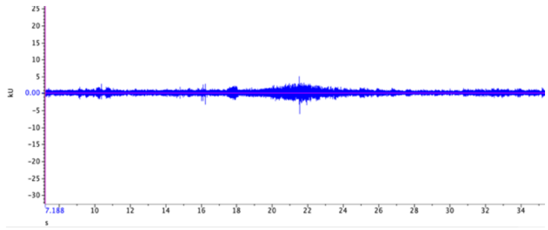

Fig 1.16 Oscillogram of *A .tristis* call in Guwahati

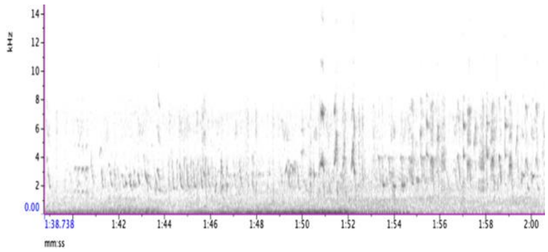

Fig 1.17 Spectrogram of *A .tristis* call in ADBU

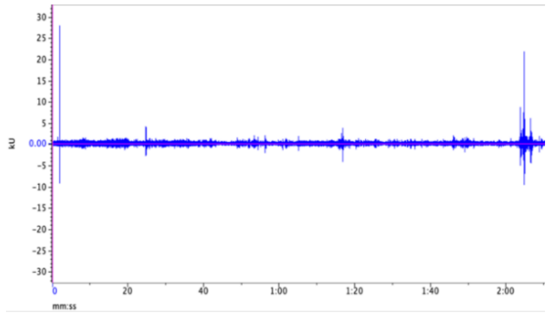

Fig 1.18 Oscillogram of *A .tristis* call in ADBU

4. DISCUSSION

From this study, it was found that urban-dwelling Common Mynas sang at higher frequencies (High and Low) in Ahmedabad and Guwahati as compared to ADBU. However, the Peak frequency was slightly higher in ADBU as compared to Guwahati by about 45 Hz (Fig 1.11). This difference is hypothesised to be due to habitat features or the difference in recording distance since the recording distance was larger in Guwahati as compared to ADBU and Ahmedabad. Since the site in Ahmedabad had more reflective structures such as concrete and glass due to high-rise buildings, as compared to Guwahati and ADBU, hence sound reverberation increased due to "Urban Canyon" (Warren *et al.* 2006), causing the increase in frequencies of call.

Moreover, the presence of trees and shrubs reduces the pitch of the song observed in ADBU as they attenuate sound by scattering, absorbing and destructive interference (Fricke,1984). These results contrast the results made by Brewer and Fudickar (2022) in the USA, where they found that peak frequency was higher in agriculture sites in their two study areas, and also with Yelimlies *et al.* (2023), who found that rural Chaffinches in Turkey had higher frequencies than urban ones. But they coincide with the results of Slabbekoorn and Visser (2006) in London and Paris and Jennifer *et al.* 2020 in the USA, where open habitat dwelling birds of urban areas sang faster as compared to forest-dwelling birds, which sang slower songs and also with the latest of similar research done by Rhodes *et al.* (2023) who reported similar results also in the USA. In our study, peak frequency differed significantly and was higher in at least one urban area-Ahmedabad. It was also noted that weather had a nonsignificant impact on the calls (P>0.05).

Concerning repertoire size, Deoniziak and Osiejuk (2019) found that the size of the repertoire in Poland was greater in urban areas than in rural areas. Brewer and Fudickar (2022) and Yelimlies (2023) did not find any significant difference in repertoire size, whereas Rhodes *et al.* (2023) could not investigate the repertoire specifications. Solaro (2024) reported call rates to be higher in urban areas of Argentina. Our research addresses the issues as syllable duration was found to be higher in areas with more vegetation cover than in cities, as it was observed that syllable duration was longer in ADBU compared to Guwahati and Ahmedabad. Mostly, birds sang faster in city areas to communicate effectively, which may point to the adaptation of birds to sing at higher pitch. Temperature and Humidity have non-significant (P>0.05) impacts on call attributes. There was no definite pattern in the variation of frequencies with temperature in any of the selected study areas. Moreover, these variables affected the song attributes differently in different areas. Syllable duration showed a positive correlation with humidity in Ahmedabad, but in the case of ADBU and Guwahati, it showed a negative correlation with Humidity. The Low frequency and Peak frequency, along with syllable duration, showed similar correlation patterns with temperature and Humidity in the ADBU campus and Guwahati as opposed to the pattern observed in Ahmedabad, suggesting the uniform influence of weather in similar areas. During the study, it was found that weather tends to influence vocal attributes, as it was usually observed by Liao *et al.* that birds in Taiwan sang fewer songs in cold weather conditions (Liao *et al*., 2018). This might have also affected the duration of syllables in each area and season. Also, syllable duration increased with an increase in temperature, which was contrary to previous research conducted by Coomes on songbirds and Zebra finches in the USA (Coomes and Derryberry 2021). Conversely, syllable duration decreased with an increase in ambient humidity.

From this study, habitat structure and composition affected the pitch of birds, according to previous research conducted by Nicholls and Goldizen (2006) in Australia, where the Satin Bowerbird changed call structure among a range of habitats. The city birds adapt to singing at increased frequencies to communicate effectively through the concrete barriers and increased heights. One of the major problems we faced was the recording distance, which was done at longer distances in Guwahati as compared to ADBU and Ahmedabad, which might also contribute to the difference in peak frequency between both sites. Since vehicular noise and other anthropogenic noise are common, future studies in this field should consider this matter before recording. We would encourage future studies in this aspect to choose more natural areas with little or absence of human-induced disturbances, as in ADBU, occasional human-induced disturbances were common due to the campus setting and thus may have influenced the song pattern. Also, our study was primarily confined to winter months when birds sing less frequently. Hence, we were not able to include the summer studies effectively when the vocal activity of birds was high. Overall, our research shows that the urban environment poses a challenge to effective communication for city-inhabiting birds.

Vocalisations have important implications in many aspects of birds, and since the urban environment shapes the adaptation of acoustic signals, the mating signals and other types of calls could be significantly affected. Repertoire size is often correlated with sexual selection of potential mates (Howard,1974). Hence, the lower repertoire size in urban areas may cause errors in evaluating the mate quality due to the degradation of repertoire size. Thus, effective plans need to be taken into consideration for creating urban landscapes with proper vegetation cover suitable for urban dwelling birds. In most of the studies, increased vegetation cover leads to buffering of sound (Cicha M. 2022), hence lowering the pitch. Thus, the vocal parameters may indirectly help in assessing the habitat quality of urban areas. In many earlier studies, urban noise was taken as one of the key factors in understanding the impact of urbanisation. However, this was beyond the scope of our study. This study also contributes to a much broader field of studying the adaptations of organisms to anthropogenic modified environments and their implications.

5. CONCLUSION

Overall, our findings support the previous findings that calls of urban-dwelling birds have calls with considerably higher pitch and shorter duration than rural or forest-dwelling birds. However, this also depends on the urban structural composition. For instance, the peak frequency was higher in Ahmedabad than in semirural areas but lower in Guwahati. Temperature and Humidity have no significant effects (P>0.05) on the spectral and temporal characteristics that we studied and have not been included in any previous urban-rural or urban-forested comparison studies. Few studies have recognised the importance Urban canyons play in bird song. This study is one of the few studies that takes into account this phenomenon as one of the major explanations for increased frequencies in urban areas with high-rise buildings. No previous studies have incorporated environmental variables such as Temperature and Humidity into spectral and temporal sections of birdsong. By taking both the frequency characteristics and song elements along with weather parameters, we provided an overall perspective of comparative acoustic study in different environments. For future studies, more specific attention should be given to the collective effect of urban noise and urban structure via impervious surface quantification, emphasising their effect on note rate, syllable size and pattern in multiple urban and rural or urban-semi rural pairings.

ACKNOWLEDGMENTS

We would like to thank Almighty God, and I express my heartfelt gratitude to Prof. Saibal Sengupta for his constant guidance and supervision at every phase of this work. We would also like to thank Dr Nilutpal Mahanta for his guidance and encouragement to complete this work. We are especially grateful to Mr Rajiv Zillie, Property Secretary, Council of Central Baptist Churches of Northeast India (CBCNEI), for permission to record bird calls from Mission Compound in Guwahati. I Would like to express my heartfelt gratitude to my parents for their constant encouragement and support during this phase of my work.

AUTHOR CONTRIBUTIONS

Arpit Gameti: Data Curation (lead), Data Analysis (lead), Writing – original draft (lead); Writing – review & editing (equal).

Saibal Sengupta: Conceptualization (lead), Investigation (support), Methodology (support), Writing -review & editing (equal).

DATA AVAILABILITY STATEMENT

We have provided the Datasheet and the R-code for the statistical calculations about correlation graphs, ANOVA and boxplot in the GitHub repository at this link: https://github.com/Enoch7636/birdcall.git

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