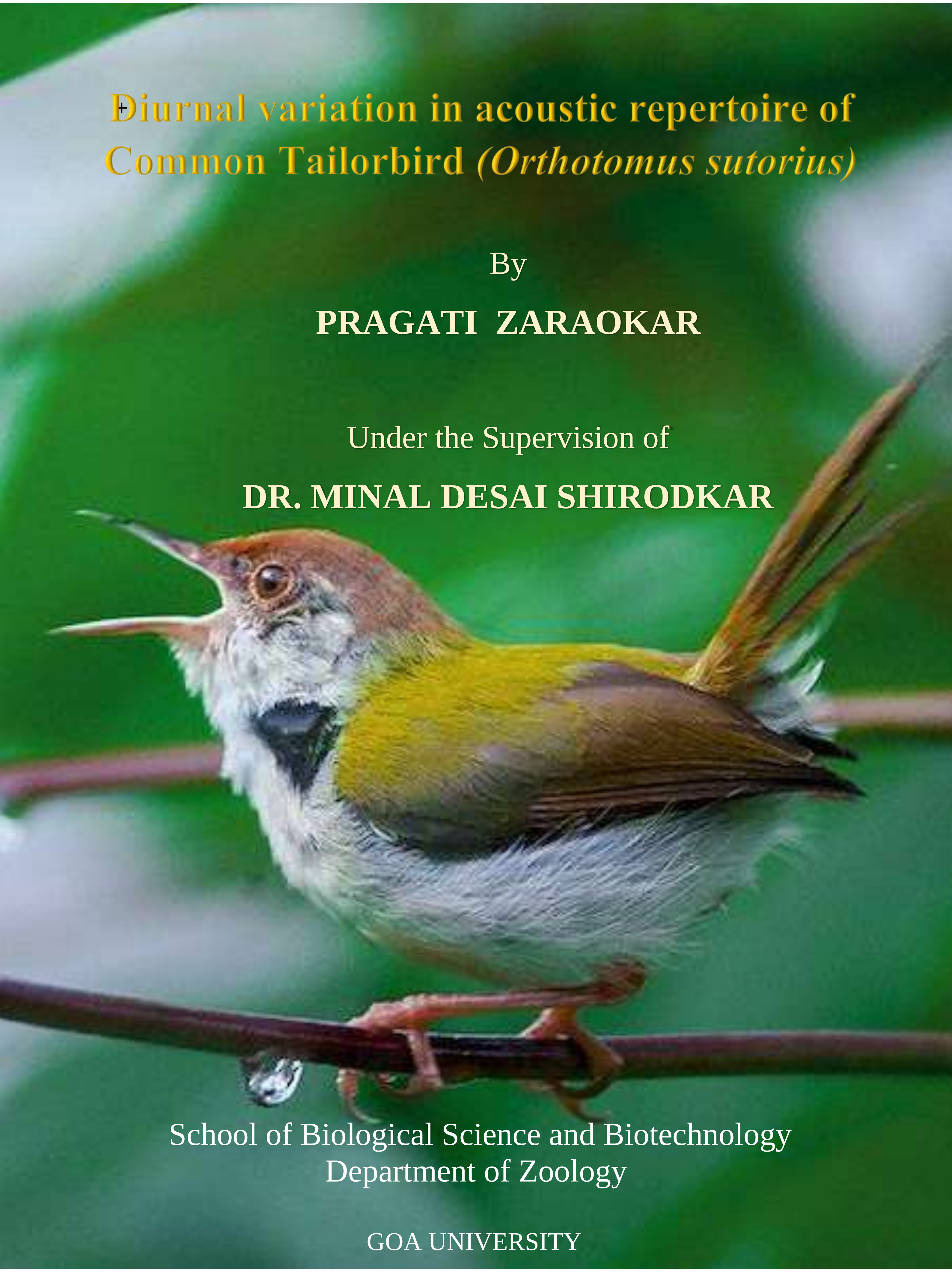
Diurnal variation in acoustic repertoire of Common Tailorbird *(Orthotomus sutorius)*



By

PRAGATI ZARAOKAR

Under the Supervision of

DR. MINAL DESAI SHIRODKAR

School of Biological Science and Biotechnology
Department of Zoology

GOA UNIVERSITY

Diurnal variation in acoustic repertoire of Common Tailorbird (*Orthotomus sutorius*)

A Dissertation for
Course code and Course Title: ZOO-651 Dissertation

Credits:16

Submitted in partial fulfilment of Masters Degree

M.Sc. Zoology

by

PRAGATI SHANTA ZARAOKAR

22P0440023

626-154-802-016

201900957

Under the Supervision of

DR. MINAL DESAI SHIRODKAR

School of Biological Science and Biotechnology
Department of Zoology

GOA UNIVERSITY

Date: April 2024

Examined by:

SBSB, M.Sc., Zoology
Taleigao Plateau, Goa
403206
GOA UNIVERSITY

Seal of the School

DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, “Diurnal variation in acoustic repertoire of Common Tailorbird (*Orthotomus sutorius*)” is based on the results of investigations carried out by me in the Zoology Discipline at the School of Biological Sciences and Biotechnology, Goa University under the Supervision of Mr/Ms/Dr/Prof. Minal Desai Shirodkar and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given in the dissertation. I hereby authorize the University authorities to upload this dissertation on the dissertation repository or anywhere else as the UGC regulations demand and make it available to any one as needed.

Pragati Shanta Zaraokar
22P0440023

Date:

Place: Goa University

COMPLETION CERTIFICATE

This is to certify that the dissertation report "Diurnal Variations in acoustic repertoire of Common Tailorbird (*Orthotomus sutorius*)" is a bonafide work carried out by Ms. Pragati Shanta Zaraokar under my supervision in partial fulfilment of the requirements for the award of the degree of Master of Science in Zoology in the Discipline Zoology at the School of Biological Science and Biotechnology Goa University.

Dr. Minal Desai Shirodkar

Assistant Professor

Zoology Discipline

Date:

Dr. Bernard F. Rodrigues
Dean
School of Biological Science and Biotechnology
Date: 8-4-24
Place: Goa University

Dean of School of Biological Sciences
& Biotechnology
Goa University, Goa-403206

SBSB, M.Sc., Zoology * GOA UNIVERSITY *
Taleigao Plateau, Goa 403206

School Stamp

CONTENTS

PREFACE

The diurnal variation in the acoustic repertoire of avian species has been an area of keen interest among ornithologists and behavioral ecologists. One such species that has garnered attention is the common tailorbird (*Orthotomus sutorius*), a small passerine bird found across Asia. The study of acoustic communication in this species offers valuable insights into the underlying mechanisms and adaptive significance of vocal behavior.

Acoustic signals play a crucial role in various aspects of the tailorbird's life, including mate attraction, territory defense, and communication within social groups. Understanding how these acoustic signals vary throughout the day is essential for unraveling the complexities of their behavioral ecology.

In this preface, we delve into the diurnal patterns of the common tailorbird's acoustic repertoire across different times of the day. By examining the temporal dynamics of vocal behavior, we aim to shed light on the adaptive strategies employed by this species in response to environmental and social cues.

This preface sets the stage for a comprehensive investigation into the diurnal variation in the acoustic repertoire of the common tailorbird, providing a foundation for future studies to explore the intricate interplay between vocal communication and ecological context in avian species.

ACKNOWLEDGMENT

I, Pragati Shanta Zaraokar, an M.Sc. student from Goa University, extend my heartfelt gratitude to all those who have contributed to the completion of my dissertation work.

First and foremost, I express my deepest appreciation to my guide, Dr. Minal Desai Shirodkar, for her unwavering support, invaluable guidance, and encouragement throughout the course of this research. My guide's expertise and mentorship were instrumental in shaping this study and my academic journey.

I am immensely thankful to Goa University for providing me with the opportunity and resources to pursue my research. I extend my gratitude to all the faculty members of Zoology Discipline of the Goa University for their support and assistance.

I would like to acknowledge the significant contribution of Sakshi Sharma, a Ph.D. student at Goa University for her assistance and valuable insights during the course of this study. Her guidance was instrumental in shaping the direction of my research.

I am deeply grateful to my friends for their continuous support and encouragement. Their enthusiasm and willingness to help made the research process enjoyable and rewarding.

Special thanks are due to my family members for their unwavering support, understanding, and encouragement throughout this journey. Their love and encouragement provided me with the strength and motivation to overcome challenges and pursue my academic goals.

This work would not have been possible without the collective support and encouragement of all those mentioned above. Thank you.

FIGURES

TABLES

ABSTRACT

This study investigates the diurnal variation in the vocal repertoire of the common tailorbird (*Orthotomus sutorius*), a widely distributed passerine bird species using passive acoustic monitoring. Field observations were conducted in Sanquelim, Goa, India over a period of 10 months (June 2023-March 2024). Spectrographic analysis, revealed the presence of seven main call types produced by the Common Tailorbird including contact calls (resting contact calls, branch movement contact calls, and pair contact calls), alarm, flight, territorial, courtship, group cohesion and foraging calls. These calls elements vary in low frequency, high frequency and peak frequency. The study revealed significant diurnal variations in the elements of these calls, with distinct patterns observed in morning, afternoon, and evening calls. The peak in vocalization activity was more during morning and evening hours. These findings provide valuable insights into the vocal behavior of the Common Tailorbird, shedding light on its diurnal vocal patterns and the variety of acoustic signals used in different behavioral contexts. Overall, this study contributes to a better understanding of the vocal repertoire of this species and highlights the importance of passive acoustic monitoring in avian research. Further research on the seasonal variations can provide a comprehensive understanding of avian vocal communication in the common tailorbird.

Keywords: Acoustics, Bird song, Calls, Common Tailorbird, Goa

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Communication is a fundamental aspect of animal behavior, playing a crucial role in various interactions within and between species. Among vertebrates, birds are renowned for their diverse and complex communication systems, which often involve both visual displays and vocalizations (Catchpole & Slater, 1995).

Bird vocalizations, in particular, serve as a primary means of communication, conveying information about territory, mate attraction, alarm, and social cohesion (Catchpole & Slater, 1995). These vocal signals can be broadly categorized into two main types: songs and calls. Songs are typically longer and more complex vocalizations associated with courtship and territorial defense, whereas calls are shorter and simpler and serve specific functions such as maintaining contact between individuals, signalling alarm, or indicating the presence of food (Catchpole & Slater, 1995).

Passerines, or songbirds, are a diverse group of birds known for their complex vocalizations. Among passerines, the common tailorbird (*Orthotomus sutorius*) is a notable example. Found across Asia, the common tailorbird is recognized for its intricate vocal repertoire, which it employs in various social contexts (Gyawali et al., 2019). Despite its small size, the common tailorbird exhibits remarkable vocal diversity, producing a range of calls and songs with distinct purposes.

However, one aspect of common tailorbird vocal behavior that remains relatively unexplored is its diurnal variation. Diurnal variation refers to changes in behavior or activity levels observed throughout the day. In the case of vocalizations, diurnal variation may involve fluctuations in the frequency, duration, or type of vocalizations produced by birds in response to environmental factors such as light levels, temperature, or social interactions.

Understanding diurnal variation in vocal behavior is essential for unraveling the adaptive significance of avian communication. By examining how common tailorbirds modify their vocalizations throughout the day, we can gain insights into the functional significance of their vocal repertoire. For example, changes in vocal behavior may reflect adjustments in territorial defense strategies, mate attraction efforts, or responses to fluctuating social dynamics.
Therefore, this dissertation aims to investigate the diurnal variation in the acoustic repertoire of the common tailorbird. Through field observations and acoustic recordings, this study will examine how the vocal behavior of common tailorbirds changes across different times of the day. By elucidating the patterns of diurnal variation in common tailorbird vocalizations, this study seeks to contribute to our understanding of avian communication and behavior.

1.2 AIM:

The aim of this study is to investigate the diurnal variation in the vocal repertoire Common Tailorbird (*Orthotomus sutorius*).

1.3 OBJECTIVE:

1.To record vocalizations of Common Tailorbirds, throughout the day for 10 months.

2.To analyze the diurnal variation in vocal repertoire, identifying peak vocalization times and periods of reduced vocal activity.

3.To compare frequencies within and between elements in morning, afternoon and evening.

1.4 HYPOTHESES

The acoustic repertoire of Common Tailorbird (*Orthotomus sutorius*) the varies diurnally.

1.5 SCOPE

Studying the diurnal variation in the vocalization of the Common Tailorbird offers a rich scope for research and insights into avian behavior. One key aspect is understanding the bird's behavioral ecology, including how its vocalizations change throughout the day. By identifying patterns in vocal activity related to foraging, mating, territory defense, and communication within social groups, we can gain valuable insights into the bird's daily life. Additionally, investigating how the frequency, duration, and structure of vocalizations change across different times of the day (morning, afternoon, and evening) can reveal temporal patterns in the bird's vocal behavior, providing clues about its activity rhythms and behavioral priorities Moreover, identification of species-specific vocalization strategies, provides insights into the adaptive significance of vocal signals within each species' ecological context. Additionally, we explore the influence of environmental factors, such as light levels and time of day, on the modulation of vocal behavior, shedding light on how these birds adjust their vocalizations to changing environmental conditions. Understanding intraspecific interactions through vocalizations will further illuminate the dynamics of flocks and community ecology. Ultimately, this study contributes valuable baseline data to the field of avian vocal communication and provides insights that can inform conservation strategies for these bird species and their habitats.

CHAPTER 2: LITERATURE REVIEW

Bird vocalizations have long been of interest to scientists studying animal behaviour, and recent studies have shed light on the remarkable complexity and diversity of these sounds. Research on the acoustic communication of crows, including the House Crow, has revealed a complex system of vocalizations that serve various functions. Abadi (2019) used acoustic localization to study crow vocal behaviour which investigated the performance of two passive localization methods for monitoring crow vocalizations. The impact of signal-to-noise ratio (SNR) and measurement uncertainty on localization error was evaluated.

While Chamberlain (1971) provided a comprehensive overview of the vocalizations of the Common Crow, a close relative of the House Crow, primarily focused on the unstructured vocalizations of Common Crows, which reflect the degree of the individual crow's excitement, and also highlighted how structured vocal patterns can identify individual crows.

Redondo (2013) found that urban noise can influence the vocalization structure of birds, which may have implications for the House Crow's communication in urban environments. Tefera (2012) demonstrated the potential of using the acoustic signals of domestic chicken, a related species, as a model for teaching acoustic communication.

Mates et al. (2015) investigated structural variations within a collection of contextually diverse "caw" vocalizations produced by the American Crow (*Corvus brachyrhynchos*). The study encompasses calls associated with alarm behaviors, foraging recruitment, and territorial defense. They identified structural characteristics that may correlate with the context of the vocalization, the sex of the calling crow, its age, and its individual identity.

The Oriental Magpie Robin, a popular songbird in Borneo, uses a variety of call types for different purposes, including territorial, threat, submissive, juvenile, distress, and begging calls (Manshor, 2020). This species demonstrates vocal plasticity, with its song structure being influenced by urban environmental factors such as noise, temperature, and humidity (Hanafi, 2019). In a study of the territorial singing of the Oriental Magpie Robin in Nepal, a wide range of song types was identified, suggesting individual variation in vocalization (Karna, 2020). These findings are consistent with the active involvement of birds in the sounds they produce, as seen in the vocalizations of the Australian Magpie (Roper, 2007).

Studies on vocalizations in flycatchers has revealed a diverse range of signals, each associated with specific behaviors. (Smith, 2010) found out vocalizations of great crested flycatchers, which are divided into sets that provide information about the likelihood of engaging in different social behaviors, used in various social contexts, and help individuals make decisions about interacting with competitors or mates. Buff-breasted Flycatchers exhibit pronounced daily bouts of dawn singing, even during breeding phases when daytime song is almost completely absent (Lein, 2007). In the case of the Bluethroat, song and song flights are both used to attract females. Seasonal and diurnal patterns of song-flight activity were found to be strongly correlated with patterns of singing activity (Merila, 1994). Female song has also been observed in Willow flycatchers, suggesting a potential role in duetting (Seutin, 1987).

Jungle Babbler, a cooperatively breeding passerine, has revealed a complex and diverse repertoire of calls. These calls are used in various social contexts, including vigilance, group movement, foraging, brood care, and aggression (Yambem 2020, 2021). The calls are structurally and functionally distinct, with multisyllabic calls composed of acoustically distinct notes (Yambem 2020, 2021). This complexity in vocal communication is consistent with the social complexity hypothesis, which suggests that communication complexity increases with social complexity (Yambem 2020, 2021). The Jungle Babbler's vocalizations are similar to those of the Chestnut-crowned Babbler, another cooperatively breeding species, which also uses a diverse range of calls in different social contexts (Crane, 2016). Furthermore, the Jungle

Babbler's ability to combine different calls into larger sequences, as seen in the Southern Pied Babbler, suggests a rudimentary form of syntax in their vocal communication (Engesser, 2016).

Chitnis et al. (2019) study explores acoustic signal space division and variation in song perch height among sympatric wren-warblers. The research delves into how these birds differentiate their vocalizations and perch preferences in shared habitat. In bird communities, the acoustic resource can be divided among species based on song perch height and signal space. The study demonstrates acoustic signal space division in four sympatric wren-warbler species in an Indian habitat. Different intraspecific patterns in note diversity were observed within each species' signal space. Two species have multiple note types, while the other two vary note repetition rate. The four species also segregate song perch heights, showing acoustic niche separation. Divergent song perch heights may be influenced by competition for higher singing perches or other ecological factors. Acoustic signal division along multiple axes may result from various ecological processes.

Mei et al. (2022) conducted a study on diurnal and seasonal calling activities of seven Cuculidae species in the region, revealing temporal dynamics and behavioral insights. Significant diurnal variations were found, except for *Cuculus micropterus*, with different peak calling times for species such as *Eudynamys scolopaceus* and *Cuculus saturatus*. Seasonal variations showed peaks in vocal activities at different times, with *Clamator coromandus* displaying two peaks. *Cuculus micropterus* did not show a significant relationship between calling activity and season. *Eudynamys scolopaceus* and *Cuculus saturatus* increased vocal activity at dawn and dusk, while the other four species peaked in the morning. Five species had seasonal variations with a peak in vocal activities in late May or early June, gradually declining after that, except for *Clamator coromandus*, which had two peaks in calling activity. *Cuculus micropterus* did not show a significant relationship between calling activity and the season.

Identifying temporal patterns can help develop monitoring and conservation strategies for these avian species.

Anil Kumar's (2011) research examines the physical and biological aspects of the song of the Indian Robin, *Saxicoloides fulicata*, focusing on its frequencies and intervals. The song consists of distinct strophes with varying frequencies and temporal gaps, along with occasional monosyllabic whistles. The song typically repeats the same strophe multiple times before transitioning to a different type, with strophes containing simple or complex structures. Two song categories are identified based on acoustical features and production context, with type-A being common and stereotyped, and type-B being rare, complex, and female-oriented. Songs are used in various contexts, particularly for male-male competition and attracting mates. Males adjust their songs in response to the presence of females, potentially indicating their quality.

Rajashekhar and Vijaykumar (2015) studied Indian robin sounds in Kalaburagi, Karnataka. They recorded 50 samples, then analyzed them spectrally, finding three distinct sound types with structural variations. The study found three types of sounds from Indian robins with varied frequencies. These sounds had distinct high and low frequency structures. The study categorized the sounds into elements, syllables, and phrases, with type I containing seven elements (a, b, c, d, e, f, g). Element 'a' ranged from 3.624 to 6.188 KHz lasting 0.17 sec, 'b' from 3.268 to 6.811 KHz lasting 0.05 sec, 'c' from 6.616 to 6.668 KHz lasting 0.098 sec, and 'd' from 2.680 to 6.668 KHz lasting 0.058 sec repeatedly.

Rotella and Ratti (1988) studied seasonal vocal behavior in Gray Partridges (*Perdix perdix)* from winter 1982-1983 to summer 1984. Partridges were most vocal 45 minutes before sunrise and after sunset. Calling was more frequent in mornings than evenings in summer and winter, not late winter-spring. Peak calling frequency was seen from February to April with calls optimized for grassland environments. Variations in call frequency and duration were noted across seasons, indicating a potential link between vocal behavior and seasonal functions. seasonal variations in calling behavior and acoustical structure of calls may indicate seasonal changes in call function.

The use of bioacoustics in identifying warbler species, especially in Purna Wildlife Sanctuary in Gujarat, India, was explored in a 2020 study by Masleuddin et al., This study aimed to address the lack of documentation of warbler species in the sanctuary, which is an important wintering ground for many of these species. Bioacoustics was utilized as a tool for identifying different species of warblers due to the difficulty in morphological identification. Seven species from the genera *Acrocephalus* and *Phylloscopus* were identified using bioacoustics, with variations observed in the calls of *Phylloscopus trochiloides* at Purna Wildlife Sanctuary. The calls of some *Phylloscopus* species matched those on xeno-canto, but discrepancies were noted possibly due to species complexity or geographical variations.

Research on the Philippine Tailorbird (*Orthotomus castaneiceps*) provides valuable insights into its behavior, ecology, and conservation. Smith et al. (2017) investigated the vocal behavior and habitat associations of the Philippine Tailorbird in Palawan, Philippines, finding that it utilizes a diverse repertoire of vocalizations, with preferences for dense vegetation and riparian areas. This underscores the importance of suitable habitat availability for its survival.

Anil Kumar's (2012) study focused on investigating the acoustical characteristics of vocalizations in various Indian bird species, including the Common Tailorbird (*Orthotomus sutorius*), and their implications for behavior, systematics, and conservation. While Kumar's study did not specifically analyze the diurnal variation in the vocal repertoire of the Common Tailorbird, such an investigation would greatly enrich our understanding of this species' behavior and communication dynamics. In my study, I aim to fill this gap by examining how the vocal repertoire of the Common Tailorbird varies throughout the day. By observing when these birds produce different vocalizations during different periods, I seek to uncover temporal patterns in their communication, elucidate their communication strategies, and understand their social dynamics. Additionally, I aim to explore how environmental factors such as light influence the diurnal variation in their vocalizations. This research will not only contribute to our knowledge of avian biology but also have conservation implications.

CHAPTER 3: METHODOLOGY

3.1 STUDY SITE:

The study was carried out from June to March (2023-2024) in Sanquelim situated in Bicholim taluka of North-Goa, India located at Lat 15º33'45''N and Long 74º02'40''E (Fig.3.1.1). The area is mostly covered by open scrub jungle dominated by *Anacardium occidentale*. The vegetation composed of plant species such as *Carissa congesta, Holarrhena pubescenes, Lantana camera, Calycopteris floribunda, Woodfordia fruticose, Grewia abutilifolia ,Vitex negunda,* and *species of Calotropis, Zizipus, Cassia, Ixora, Acacia, Albizia, Terminalia* and *Crotalaria.*(Fig 3.1.2)

3.2 STUDY SPECIES:

3.2.1. Common Tailorbird (*Orthotomus sutorius*)

The Common Tailorbird is a small passerine bird from family Cisticolidae found across Asia, including regions such as the Indian subcontinent, Southeast Asia, and parts of China (Fig 3.2.1). They are known for its distinctive appearance and melodious vocalizations, which they use for territory establishment, mate attraction, and communication within their social groups (Ali,1983). The agile and active behavior of Common Tailorbirds is well-known; they frequently hop and flit among dense plants in pursuit of insects and other small prey (Grimmett et al.2011). Common Tailorbirds are known for their unique nesting behavior, where they sew together leaves using plant fibers or spider silk to create a pouch-like nest (Kumar ,2016).

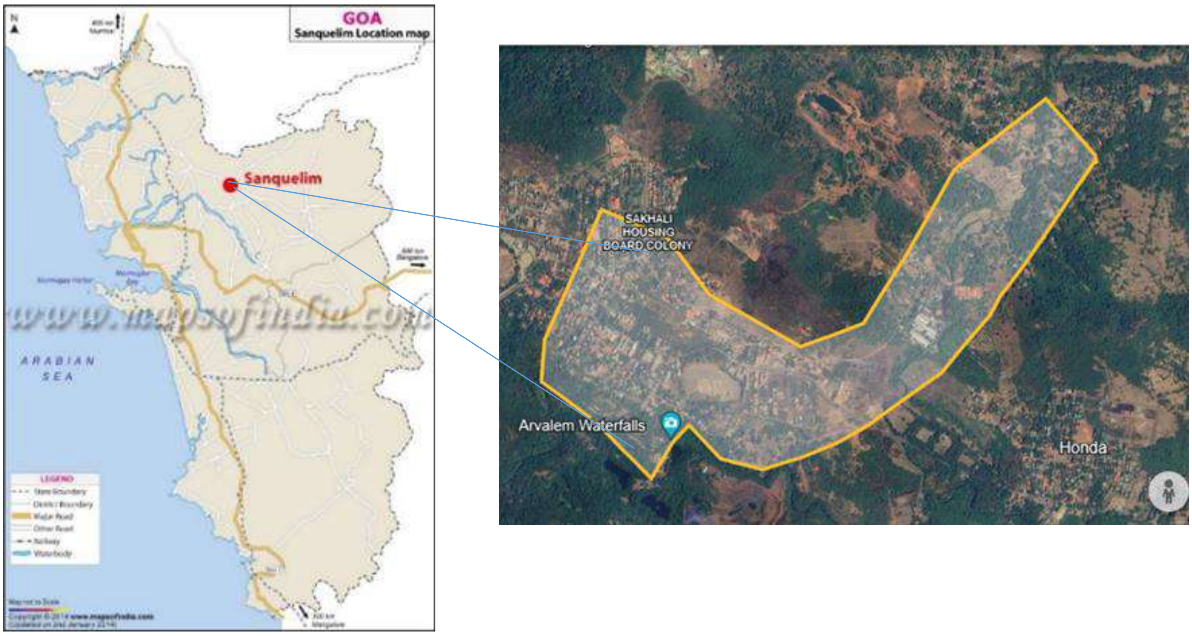


Fig. 3.1.1 Map showing the study site image of Sanquelim , Goa

Fig. 3.1.2 study site image of Sanquelim ,Goa

Fig 3.2.1 Common Tailorbirds *(Orthotomus sutorius)* generating vocal signal

3.3 DATA COLLECTION:

The acoustic signals were recorded in morning, afternoon and evening once in a week using unidirectional shotgun microphone Boya BY-BM6060L (Frequency Response: 60Hz-20000Hz, Signal-to-Noise Ratio: 80 dB, High Pass Filter: 150Hz). Microphone was connected to a smartphone Realme 5i (Fig 3.3.1). Acoustic signals were recorded when bird was visible. Care was taken to ensure that species individuals were not misidentified and also settings were set as highest quality sound as possible. For behavioral observation field binoculars (celestron 10*50) was used. Signals were recorded from a distance of 2-10 m (Kumar et al.,2001). Behavioral correlates were also noted during field recording (Kumar & Bhatt,2001). Audio files were saved as mp3 and wav files.

Fig.3.3.1. Boya BY-BM6060L shotgun microphone

3.4 ACOUSTIC ANALYSIS:

For bioacoustic analysis, audio files were first edited in sound editing software Audacity 3.4.2 (Hujatulatif et al.,2022). In this software audio recordings were carefully listened and audio was trimmed to remove large silent gaps. High-pass filter (reduce low frequency noise) and low-pass filter (reduce high pitched noise) was applied to remove noise whenever it was necessary. Also audio was filtered using noise reduction at 48 dB, sensitivity 6 and frequency smoothing 6. Unwanted sounds of other birds in background was removed by spectral tool. After editing, cuts of high quality recordings were viewed and analysed using Raven Pro: Interactive Sound Analysis Software (Version 1.6) [Computer software] Ithaca, NY: The Cornell Lab of Ornithology, 64 bit resolution (Mendez,2020). Raven pro displays audio file in oscillogram and spectrogram form with the selected setting of Hann window, sample size :800, 3 dB filter bandwidth filter :135 Hz, 50% overlap, and a grid spacing of 93.8 Hz.

A oscillogram is a plot presenting the waveform and amplitude of the sound over time, X-axis is Time (sec) and the Y-axis is Amplitude. The spectrogram is a plot of the sounds' frequency over time, X-axis is Time (sec) and the Y-axis is Frequency (kHz). The amount of energy present in each frequency is represented by the intensity of the color. The brighter the color, the more energy is present in the sound at that frequency. A whitening filter was applied to spectrogram for clear view of elements. Here are some of terms used in spectrographic representation:

- Strophe: Acoustic signals consisted of discrete sections preceded and followed by temporal gaps called strophes, each strophe was made up of smaller units known as elements.
- Elements: Elements are the units of motifs. Each mark on the spectrogram, no matter how small it is, is an element. Vocalizations that compose the songs and are segregated from each other by silent intervals (= within song pauses) of < 0.5 sec.

- Tone: A tone is an entire sound or a segment of a sound that only has one frequency.
- Note: appears as a coherent, continuous trace on the spectrogram.
- Motifs: Motifs are defined as complexes of elements (notes) that always occur in the same stereotype succession.
- Syllable: A syllable is a modular vocalization unit made up of one note or a series of notes that are always delivered in the same order. Songs consist of repetitive sequences of one or more notes, with shorter pauses between notes in multi-note syllables than in single-note syllables.
- Repertoire: The variety of notes (types), syllables (types), songs (types), or calls (call types) that a bird can produce. The amount of repetitions of each syllable type within a song or call "type" might vary. Song and call "types" are often differentiated based on the identification of their component syllable types and the sequence in which those syllable types are presented.

3.4.1 Variable measurements:

Using Raven Pro 1.6, following physical characteristics in each type of vocalization was taken:

(1) Begin Time-The time at which the selection begins. Units: seconds.

(2) End Time-The time at which the selection ends. Units: seconds.

(3) Delta Time-The difference between Begin Time and End Time for the selection. Units: seconds.

(4) Delta Frequency-The difference between the upper and lower frequency limits of the selection. Units: Hz.

(5) High Frequency-The upper frequency bound of the selection. Units: Hz.

(6) Low Frequency-The lower frequency bound of the selection. Units: Hz.

(7) Peak Frequency - The peak frequency is the frequency within a sound spectrum that has the highest amplitude or energy.

(8) Duration 50% in s -This is the average duration of the sound at 50% of the maximum amplitude.

(9) Bandwidth 50 % - Bandwidth is typically measured as the difference between the upper and lower frequencies at 50 % peak amplitude.

A total of 50 calls audio recording were processed for analysis. Soft copies of spectrogram were made in order to compare and sort out the different types of call pattern. Vocalizations were categorized into 7 call types based on their function/ behavioral context. These were then further classified as either monosyllabic (consisting of one note), multisyllabic (comprising more than one note), and chorus calls. Within these call categories, functionally distinct call types were analyzed to determine if they exhibited acoustic distinctions as well.

3.5 STATISTICAL ANALYSIS

Morning, afternoon, and evening calls were divided into separate groups, and elements were selected and compared based on the average frequency value of low frequency, high frequency and peak frequency. Variations within and between elements were evaluated using parametric test one-way ANOVA and paired student t-test using Graphpad Prism software to determine significance.

CHAPTER 4: ANALYSIS AND CONCLUSION

ACOUSTIC REPERTOIRE OF COMMON TAILORBIRD *(Orthotomus sutorius)*

Common Tailorbird were generally observed in open areas actively singing on perch of tree and wire, hopping into vegetation, flight, throughout day. During field observations 7 main call types were observed and various types of contact calls were noted, including resting contact calls, branch movement contact calls, and pair contact calls.

4.1Contact Call - Contact calls are vocalizations used by birds to maintain communication and coordination within their social group or family. Tailorbirds, like many other bird species, use various types of contact calls to stay in touch with mates, family members, or other individuals in their community.

4.1.1 Resting contact call

Resting contact calls of Tailorbirds were observed during periods of rest or perching, with minimal observed movement. Additionally, pairs of tailorbirds were seen engaging in these vocalizations after foraging, serving as a means of intra-group communication and coordination. The resting contact call of Common tailorbird consist of simple and complex vocalization. Simple calls composed of only one note having similar shape and pattern while complex calls have two notes syllable produce at a same time . The series of downslurred (or falling) and upslurred (or rising) pitch pattern are produced. The upslurred sound rise in pitch and titled upward and downslurred sounds fall in pitch, and appear tilted downward.The elements in a series are more closely spaced on the spectrogram as you move from left to right, then they are going further apart which means that series decelerates(fig.4.1.1.3a). Elements are short and notes are repeated in a regular pattern with minimal pitch variation. Plastic calls having nine types of simple elements were observed in the resting contact call of the common tailorbird.

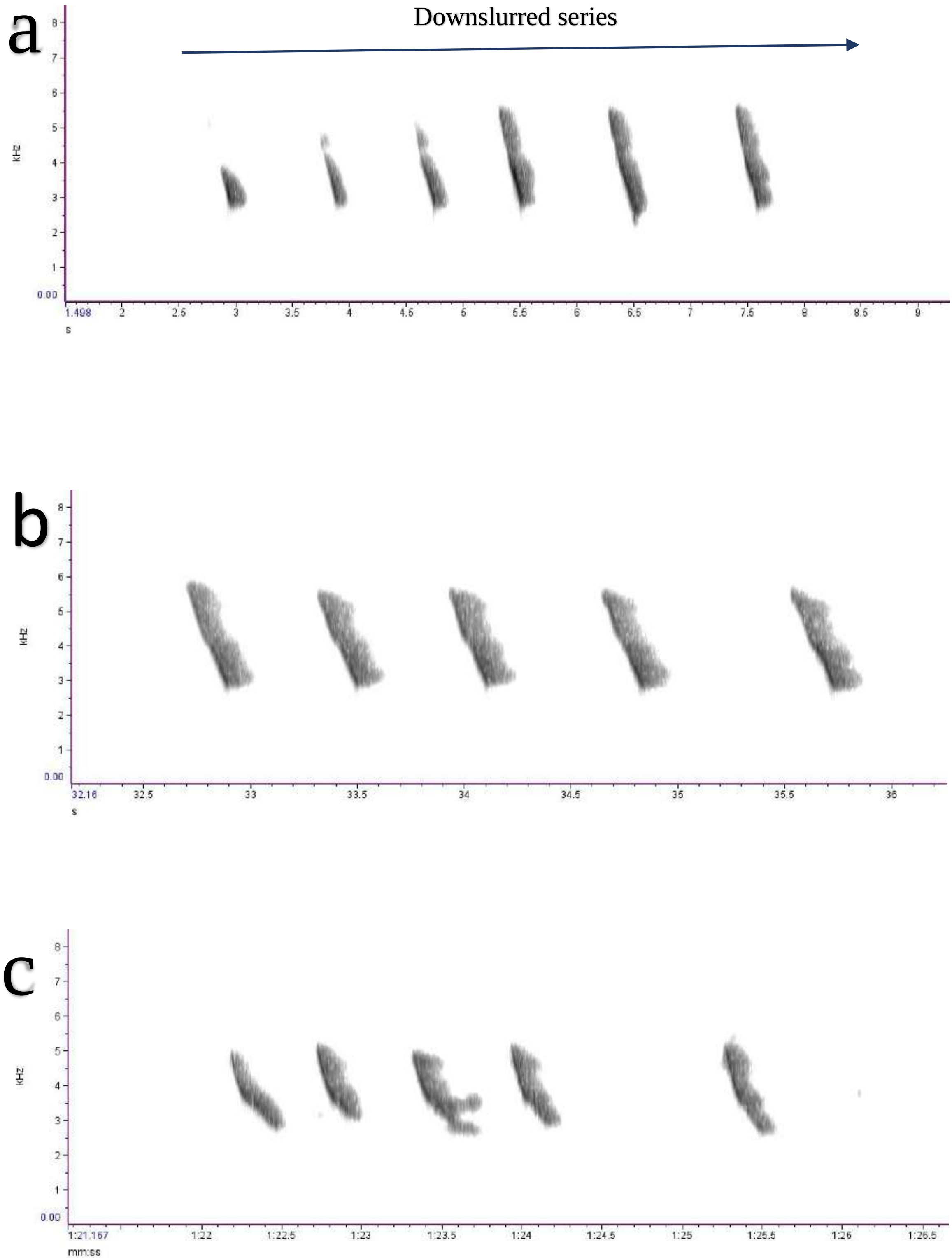


Fig 4.1.1.1 a), b), & c) Spectrograms of Common Tailorbird vocalization representing resting contact call

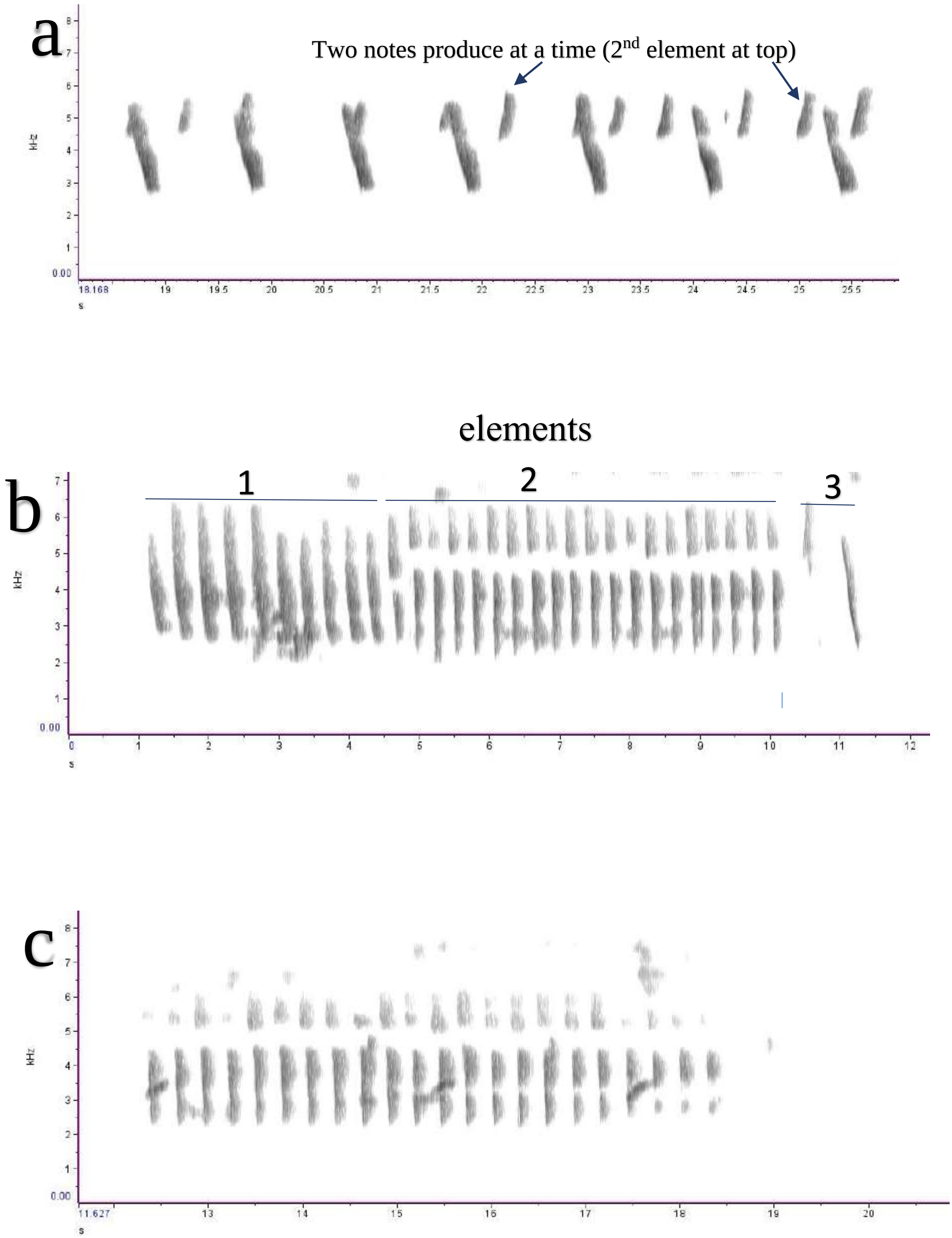


Fig 4.1.1.2 a), b), C) Spectrograms of Common Tailorbird resting contact call showing 3 types of elements

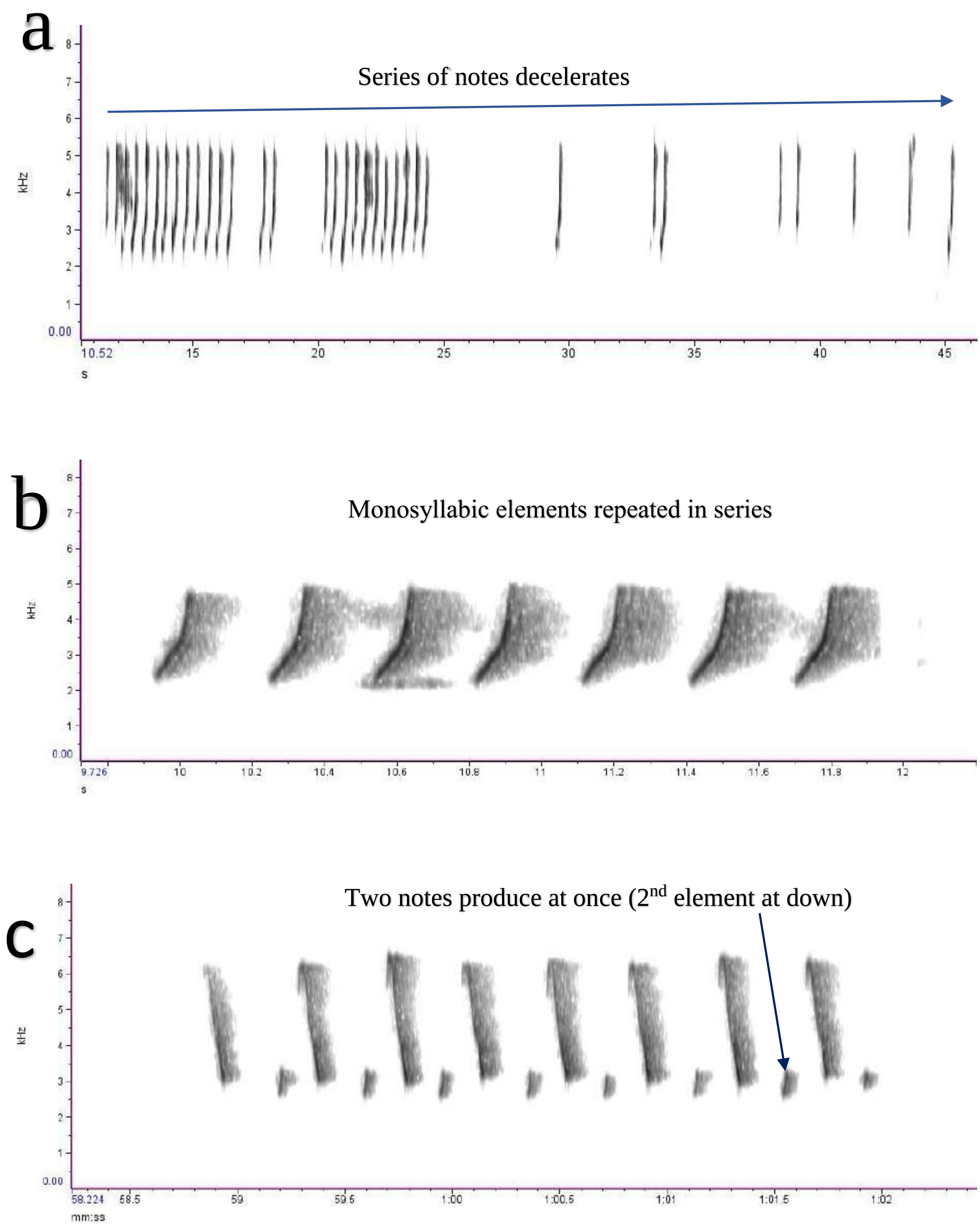


Fig 4.1.1.3 Spectrograms of Common Tailorbird resting contact call showing a)series of notes decelerating b)monosyllabic elements repeated in series c) two notes produce at same time

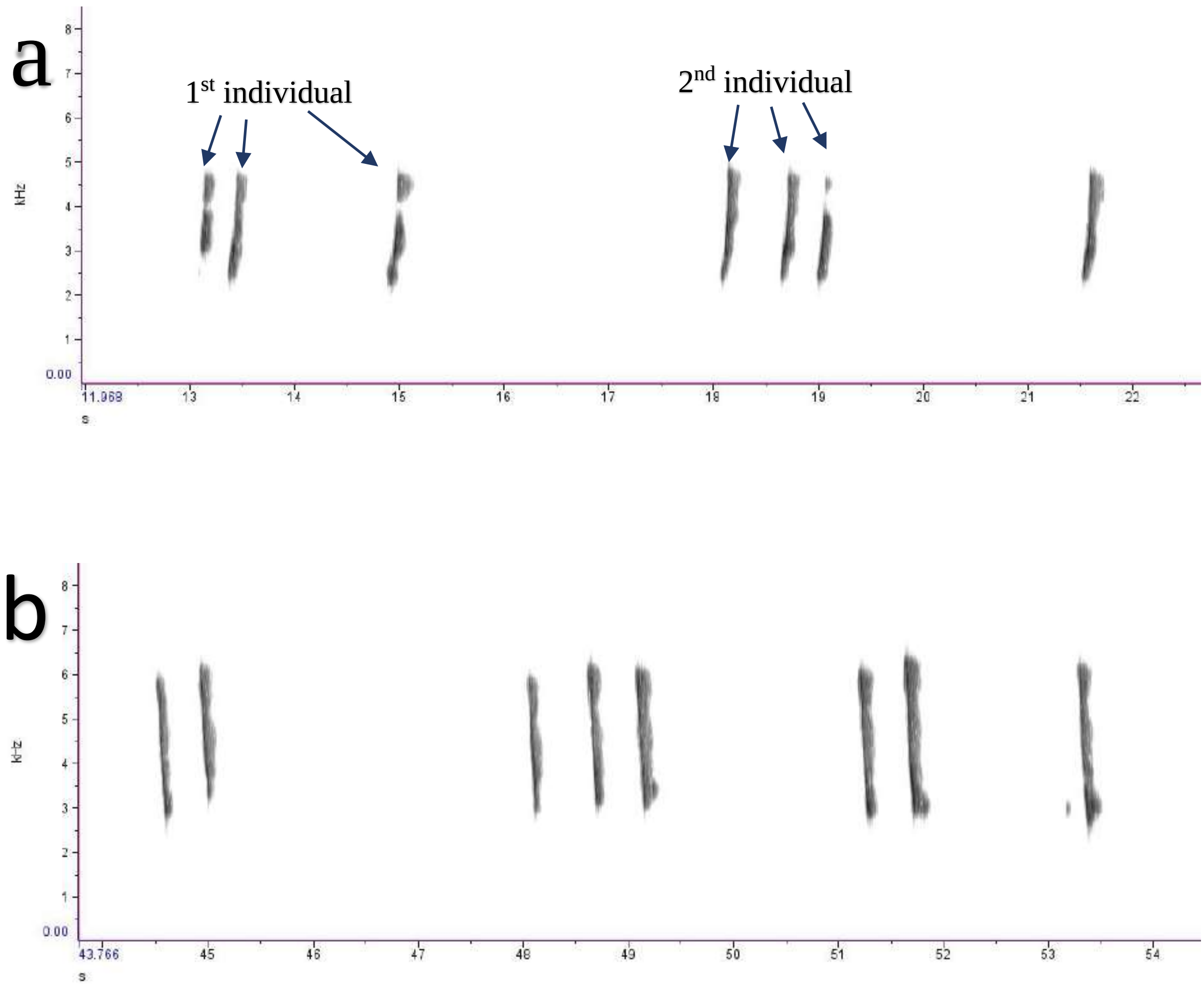


Fig 4.1.1.4 a), b) Spectrograms of Common Tailorbird pair resting contact call (duet call) after foraging

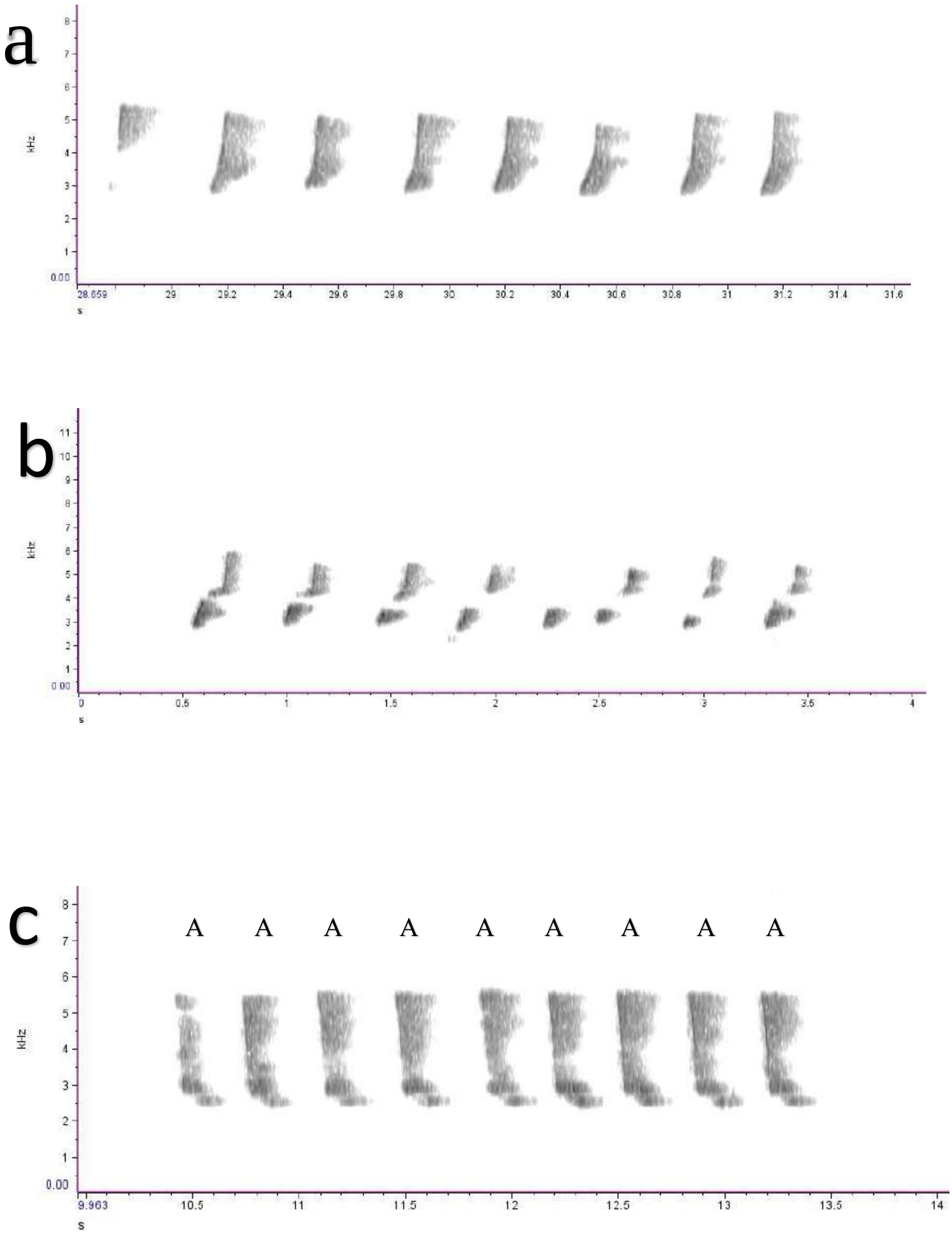


Fig 4.1.1.5 Spectrograms of Common Tailorbird resting contact call showing repeatition of A element

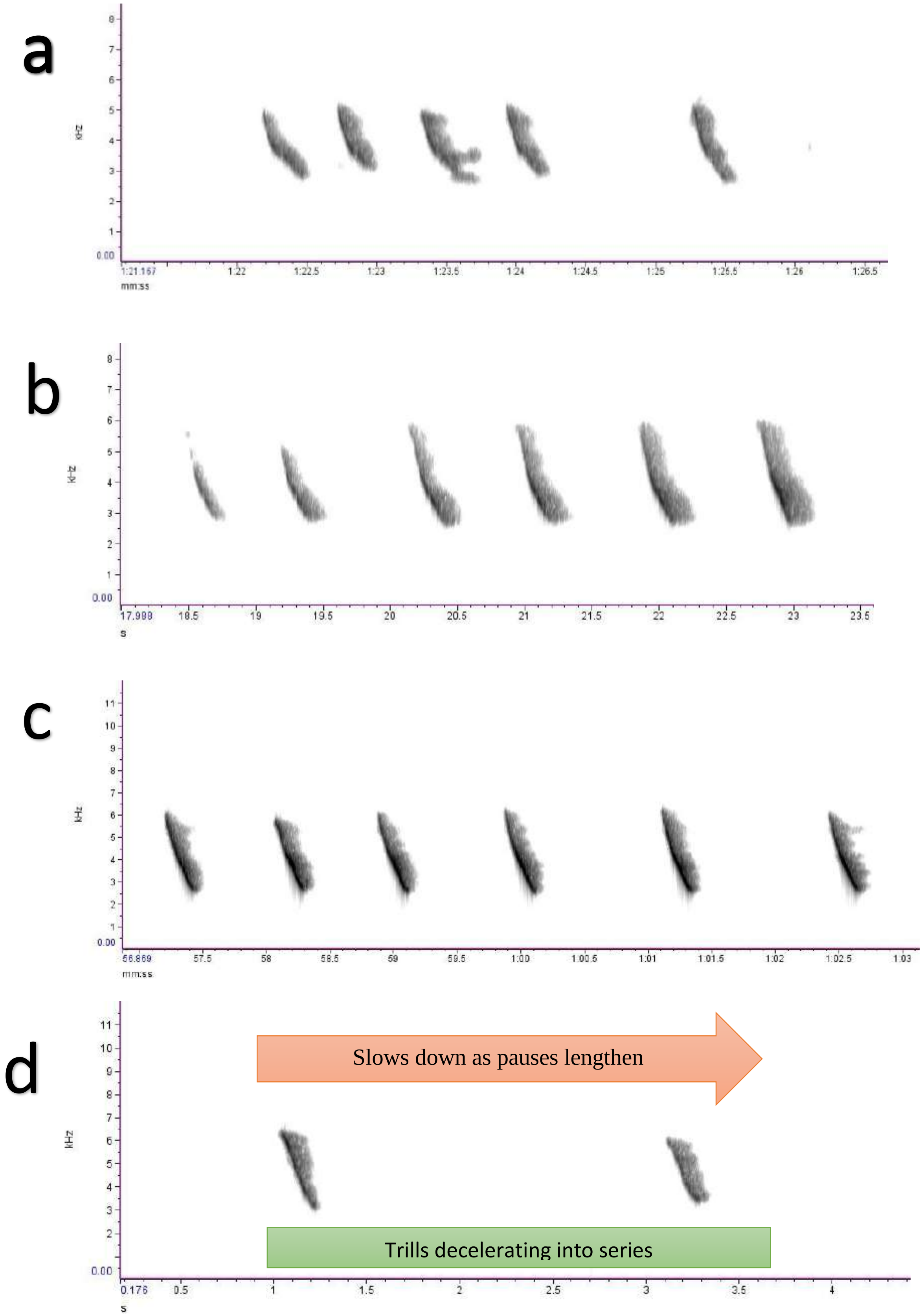


Fig 4.1.1.6 Spectrograms of Common tailorbird resting contact call showing trill decelerating

4.1.2 Branch movement contact call

Branch movement contact calls were recorded as birds transitioned between branches, aiding communication and coordination with nearby individuals during movement through the habitat. They were emitted as the birds moved between perches, signaling their location and intentions to nearby individuals, thus helping to maintain social bonds, coordinate movements, and ensure group cohesion. These calls were characterized as short, soft, sometimes clicked elements producing two notes at a times. The calls are plastic with varying in pitch pattern (Upslurred and downslurred). The calls intensity fluctuates going from low to moderate pitched.

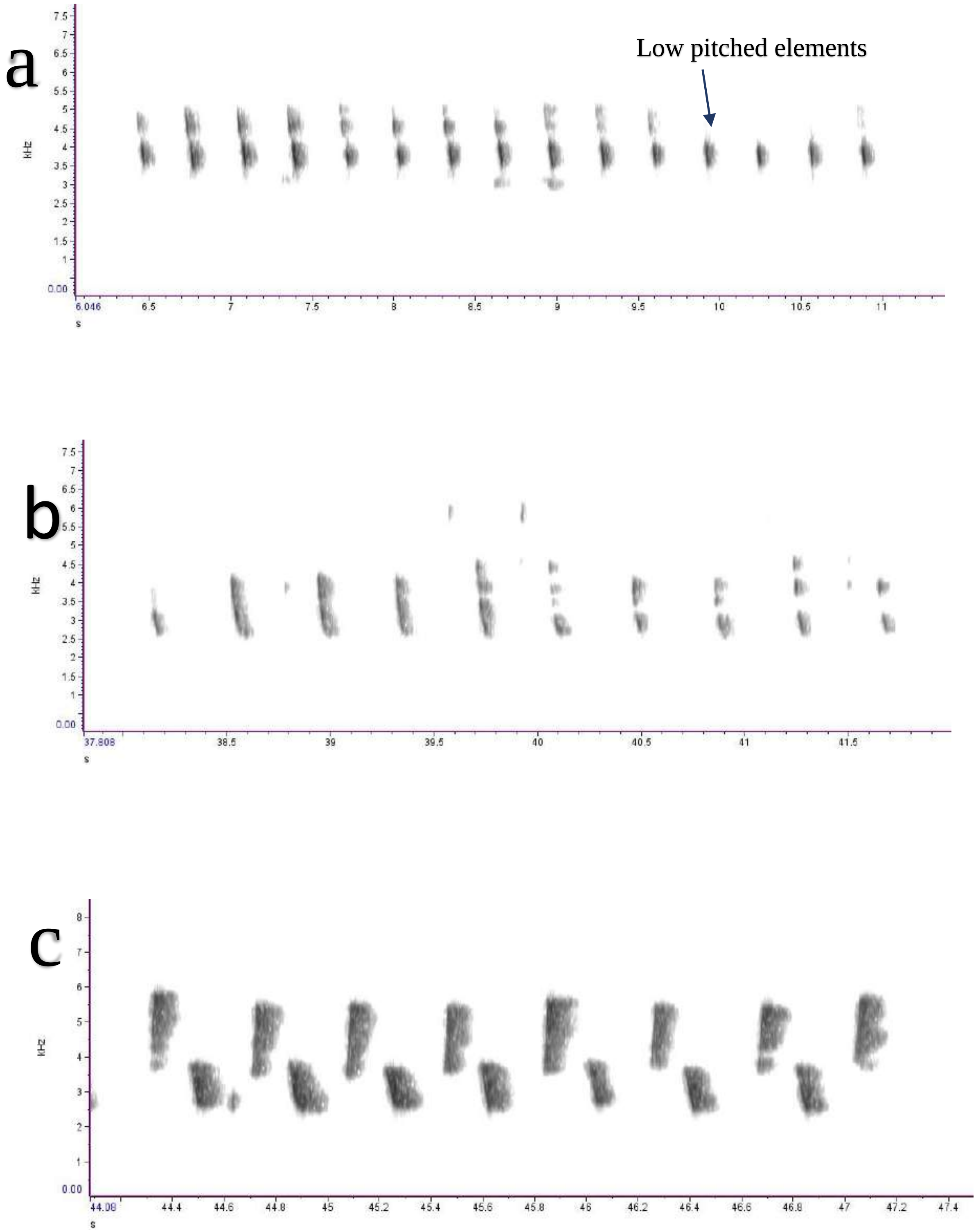


Fig 4.1.2.1Spectrograms of Common Tailorbird branch movement contact call showing a) & b) clicking elements c) producing two notes at the same time

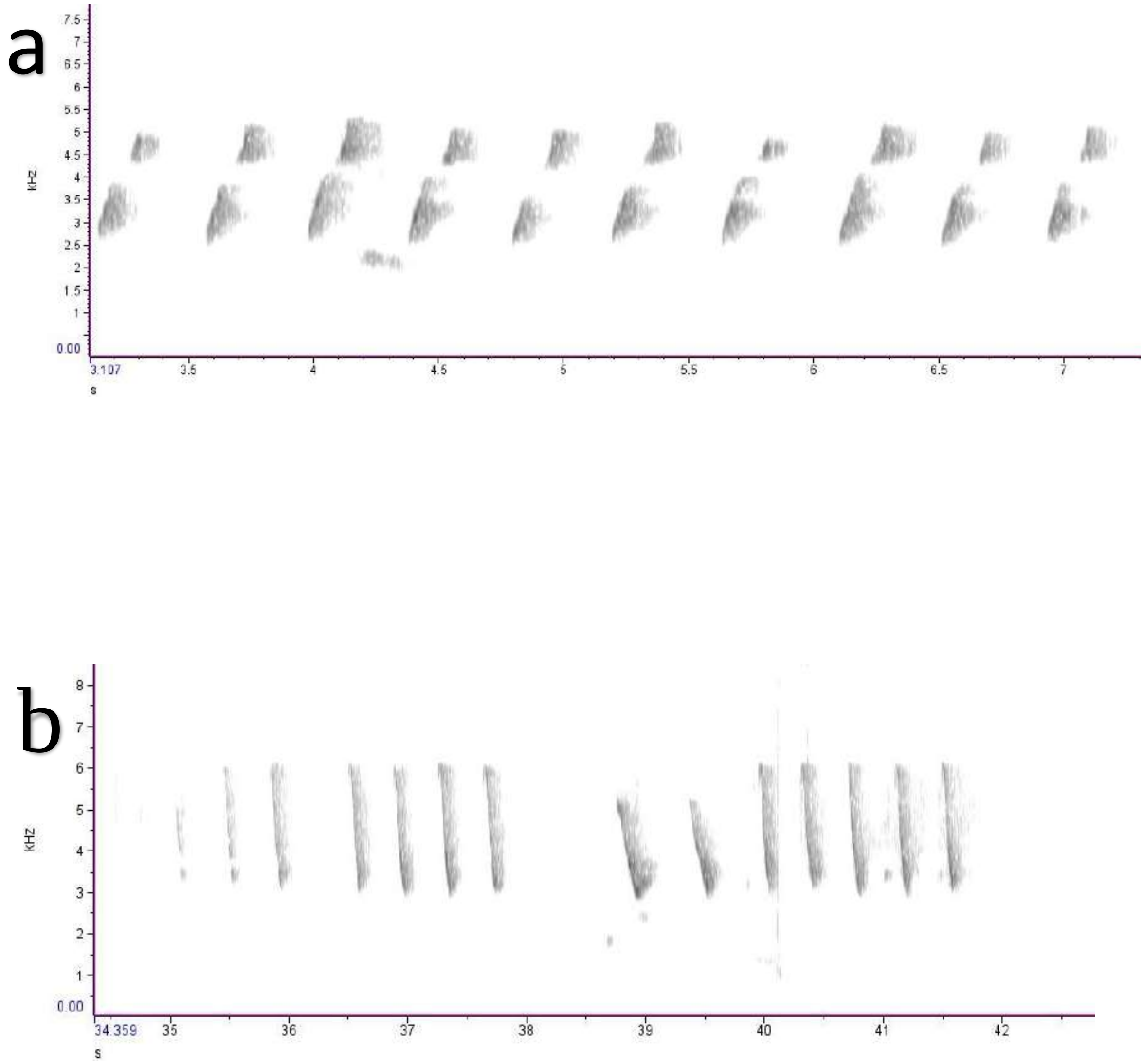


Fig 4.1.2.2 Spectrograms of Common Tailorbird branch movement contact call a) upslurred element b) downslurred element

4.1.3 Pair contact call

Pair contact calls were observed between mates to maintain proximity and communication. These calls facilitate coordination in activities such as foraging or territory defense. Described as soft, melodious, and varying in pitch and rhythm, these calls are emitted by mates to each other. Pair contact calls were noted to occur while the pair was moving together or foraging in close proximity, aiding in locating each other, signaling presence, and coordinating movements to remain together throughout the day. These calls consist of multisyllabic element having four types of elements. Upslurred and downslurred elements are repeated in phrases forming a complex song.

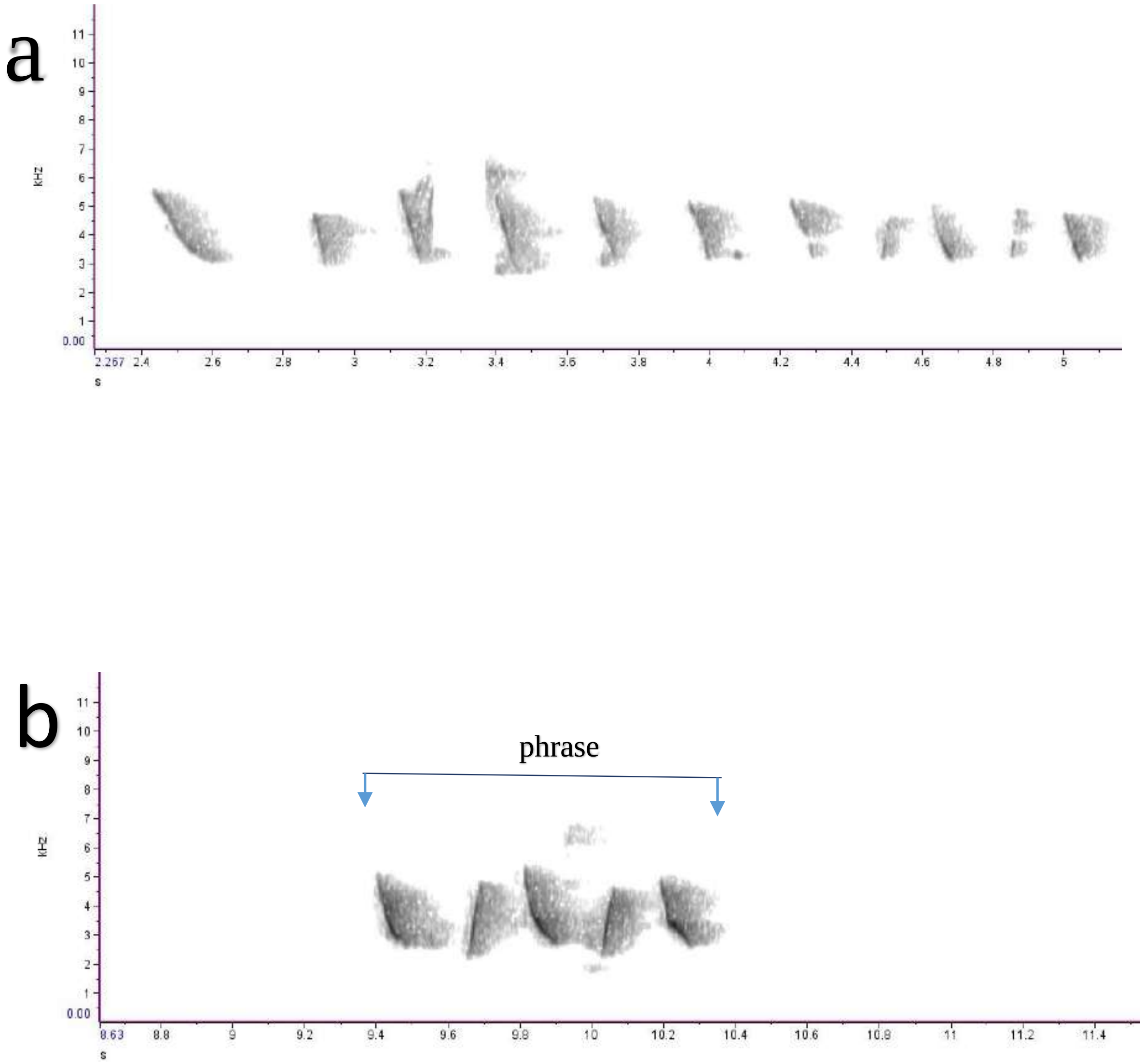


Fig 4.1.3.1 a) & b) Spectrograms of Common Tailorbird pair contact call

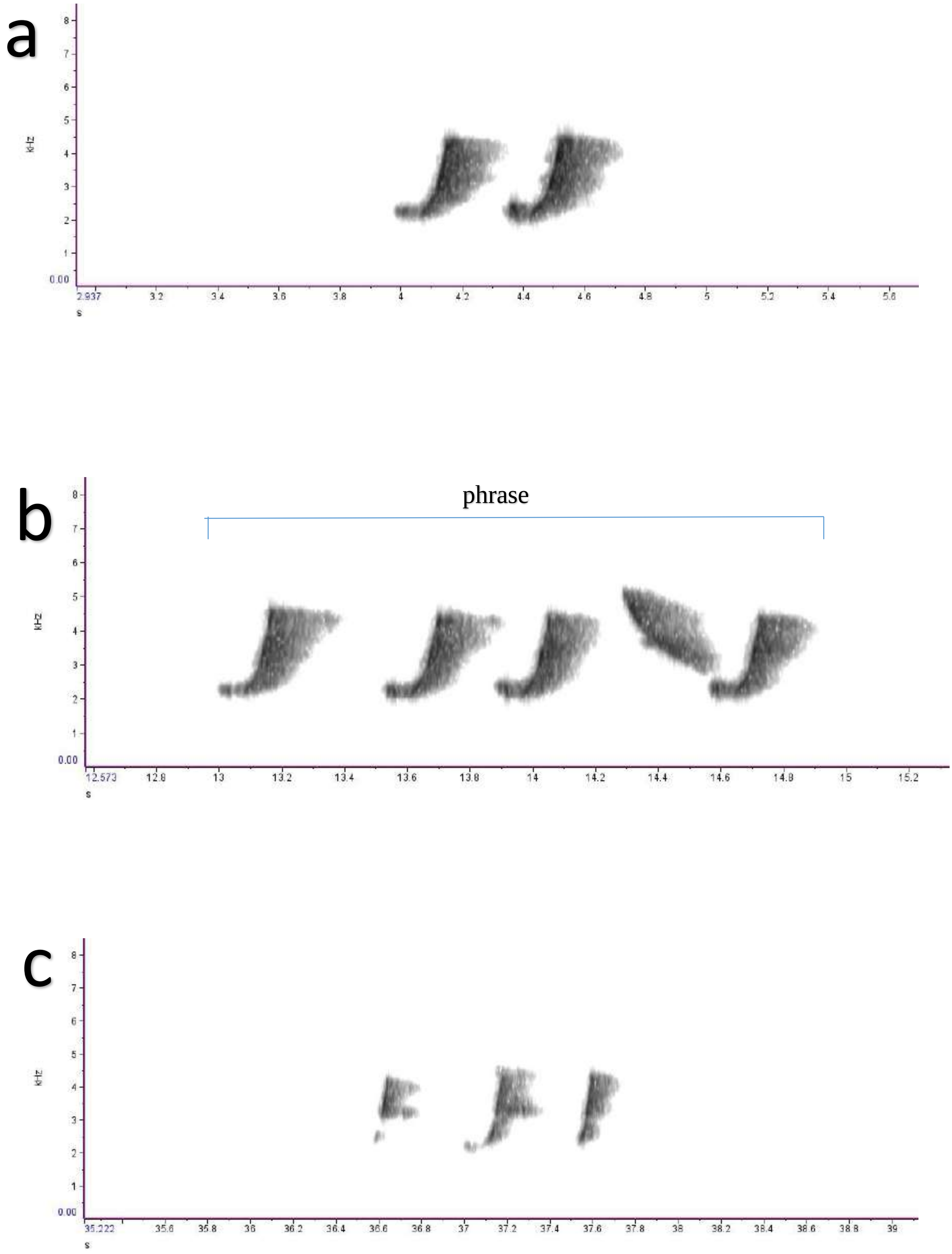


Fig.4.1.3.2 a), b) ,c) Spectrograms showing Common Tailorbird pair contact call

4.1.2. Alarm call

Alarm calls are vital responses of tailorbirds to potential threats or disturbances in their environment. These short, sharp vocalizations are emitted rapidly and loudly, serving to alert other members of the bird community to danger and prompt defensive actions. These calls, often single-note "Phui.. phui..tuit ..tuit.. tuit.. tuit..tui ..tui..", facilitate coordinated responses to threats, aiding in group defense and predator avoidance. The average duration of these alarm calls is approximately 0.14 seconds, indicative of their quick and rapid nature, which enables swift communication of potential danger within the environment.

The average peak frequency of the alarm calls is 5406.25 Hz, suggesting they are relatively high-pitched. This high pitch likely helps in ensuring effective communication with nearby birds, particularly over the dense foliage where tailorbirds typically inhabit. The average bandwidth at 50% (BW 50%) of 479.17 Hz indicates a narrow frequency range over which the calls are sustained. This narrow bandwidth allows the calls to maintain a focused frequency profile, distinguishing them from other background noises and aiding in their recognition by other birds.

In contrast, relaxation calls following alarm calls are relatively short-lived, with an average duration of approximately 0.09545 seconds. This brief duration reflects a swift return to a relaxed state following the alarm, indicating a rapid recovery from the perceived threat. The average peak frequency of relaxation calls is 4875 Hz, indicating a moderate pitch, which likely communicates calmness or normalcy after the alarm has passed. The average bandwidth at 50% is 571.875 Hz suggesting a relatively narrow frequency range over which the relaxation calls are distributed, maintaining a focused frequency profile similar to alarm calls but at a lower intensity level.

Additionally, the slight increase in peak frequency compared to alarm calls suggests a subtle modulation in frequency parameters between these two types of vocalizations. The observed delta frequency and delta time between relaxation and alarm calls, 3768.953 Hz and 0.01066 seconds respectively, indicate changes in frequency and duration between successive calls, likely reflecting the transition from an alerted state to a relaxed one.

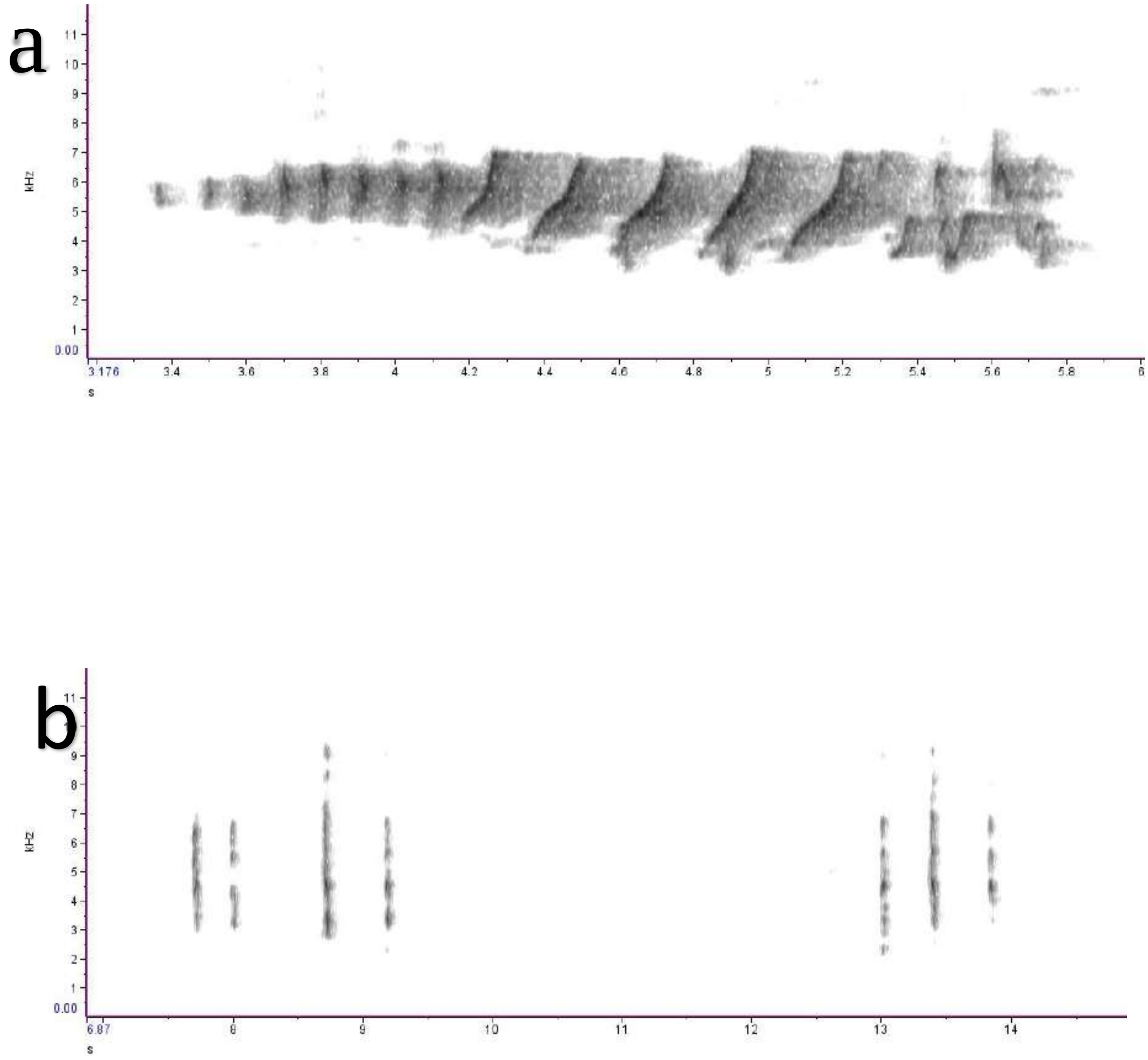


Fig 4.1.2.Spectrograms of Common Tailorbird a) Alarm call b) relaxation call after alarm call

4.1.3. Flight call

Flight calls were noted to maintain communication and coordination during bird short distance flight. These short, moderate-pitched vocalizations helped individuals stay in touch with nearby members and signal intentions while flying.

The average duration of the flight call, indicated by the difference between the begin and end times, is approximately 0.1151 seconds. This short duration suggests a rapid and succinct vocalization, typical of calls emitted during flight.

The average peak frequency of the flight call is 4046.875 Hz, indicating a moderate pitch. This pitch is likely suitable for effective communication within the bird community while in flight. The peak frequency starts relatively high and gradually decreases, reaching the lowest point.

The flight call displays a bandwidth at 50% is 726.5625 Hz. This indicates a focused frequency range over which the call is sustained, contributing to its distinctiveness and aiding in its recognition by other birds.

The flight call syllables are short, with an average delta time of 0.008 seconds. This suggests rapid succession of syllables, likely reflecting the fast pace of flight. The flight call also exhibits a significant delta frequency of 4347.222 Hz, indicating notable changes in frequency between successive syllables.

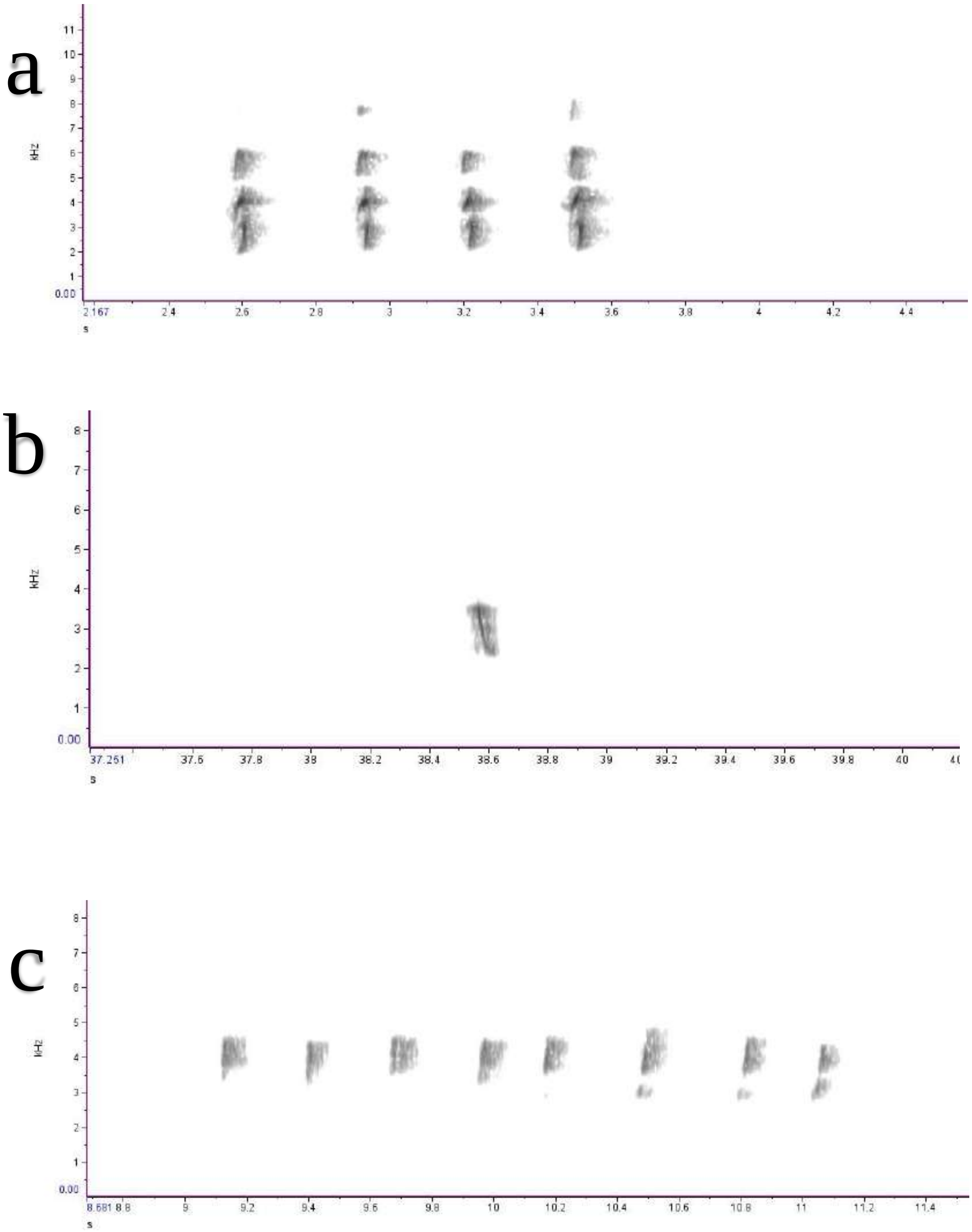


Fig 4.1.3 Spectrograms showing a) tailorbird call before flight exploring area b), c) flight call

4.1.4. Territorial song

Territorial calls were observed as a means for tailorbirds to assert and defend their territory boundaries. These vocalizations, primarily emitted by males, aimed to establish ownership of a particular area and discourage rival individuals from encroaching. Territorial calls were typically loud, repetitive, and little harsh, often consisting of distinct elements repeated at regular intervals. Males strategically emitted these calls from prominent perches within their territory, particularly during the breeding season, to signal their presence and deter intruders. The simple song made up of one to two types of elements, with the starting elements having an average bandwidth of 361.607 Hz and the subsequent calls having an average bandwidth of 852.68 Hz. These calls exhibit short duration, moderate pitch, and focused frequency range, with significant variations in frequency and rapid succession of call elements, allowing tailorbirds to efficiently communicate their territorial boundaries. The bird also produces simple territorial call having two notes produce at a same time in a series.

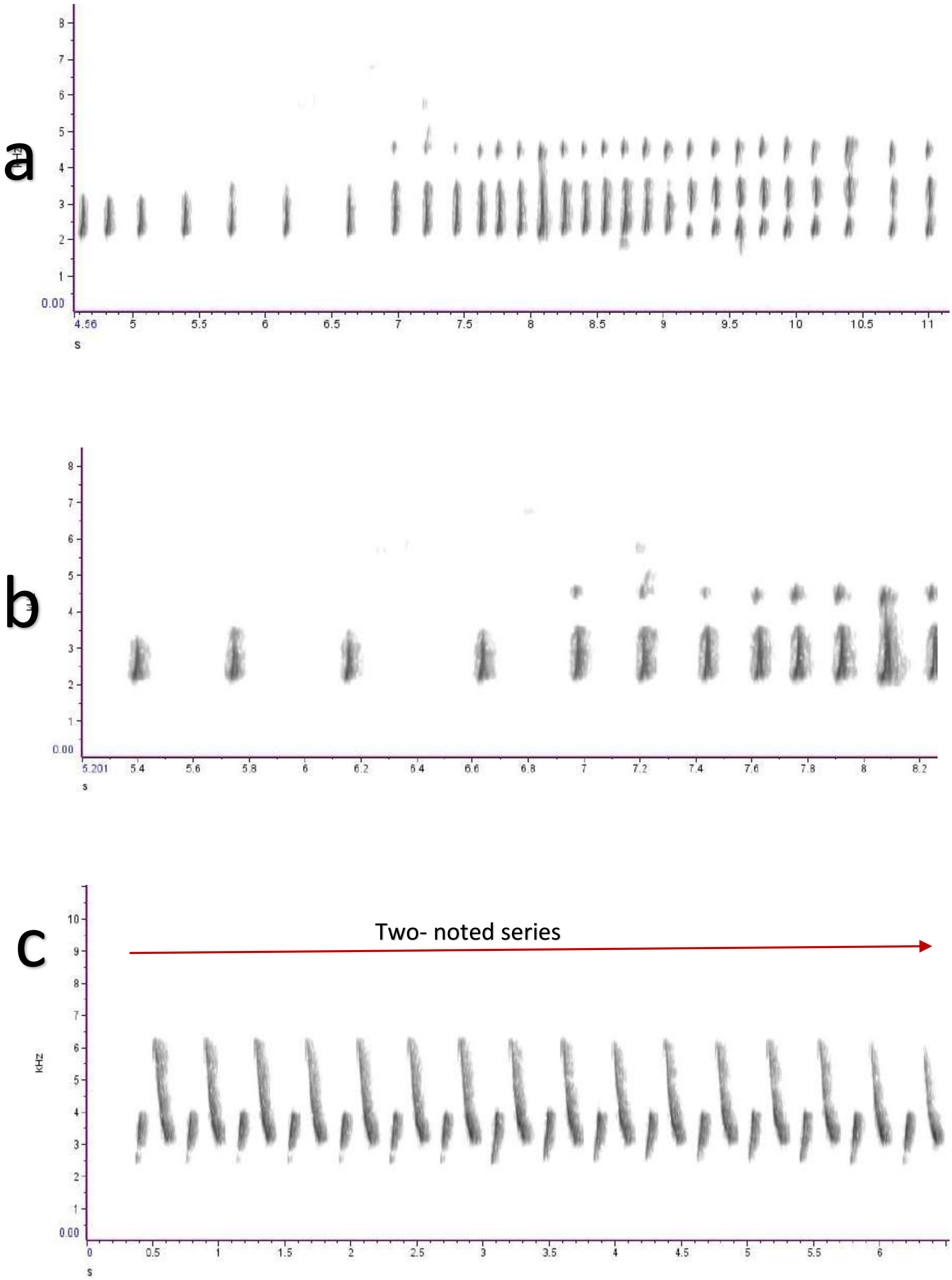


Fig 4.1.4 a) ,b) Spectrograms showing territorial call of Common Tailorbird

4.1.5. Courtship song

Mate attraction calls, emitted primarily by male tailorbirds during the breeding season, served to attract potential mates, particularly females. These calls were melodious, repetitive, and complex, featuring varied sequences of notes and patterns aimed at demonstrating the male's fitness and quality as a partner. Emitting from strategic perches within the territory, these calls signaled the male's presence and attractiveness to potential mates, initiating courtship behavior and facilitating mate selection. The courtship mate attraction call of the tailorbird has an average duration of approximately 0.3255 seconds, making it relatively longer compared to other vocalizations. This longer duration may allow for more prolonged and elaborate communication during courtship. The average peak frequency of the call is 3635.74 Hz, indicating a moderate to high pitch. This pitch is likely intended to be attention-grabbing and attractive to potential mates. The bandwidth at 50% (BW 50%) of the call is approximately 665.04 Hz, indicating a focused frequency range. This focused bandwidth helps in the clarity and recognition of the call amidst other environmental sounds. The average delta frequency, representing the change in frequency between successive calls, is approximately 2514.10 Hz. This suggests significant variations in frequency between elements of the courtship call, potentially conveying important information to potential mates. Additionally, the average delta time between elements of the call is approximately 0.0245 seconds, indicating rapid succession of call elements. This rapid timing may be crucial for conveying courtship signals efficiently to potential mates.

The courtship mate attraction call of the tailorbird is a complex vocalization consisting of 10 elements of different types, repeated in a non-continuous fashion. These elements vary in pitch and structure, contributing to the richness and complexity of the courtship song. Some elements of the courtship song are high-pitched, while others are low-pitched, creating a diverse acoustic profile. The high-pitched elements may serve to capture attention and convey excitement, while the low-pitched elements may add depth and variation to the song.

a

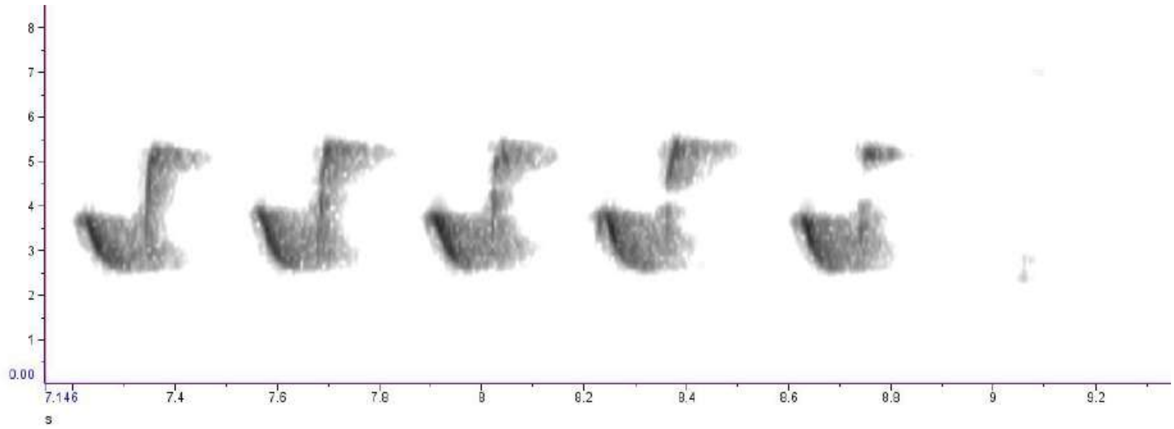


Fig 4.1.5.1 a) Spectrogram of Common tailorbird mate attraction call

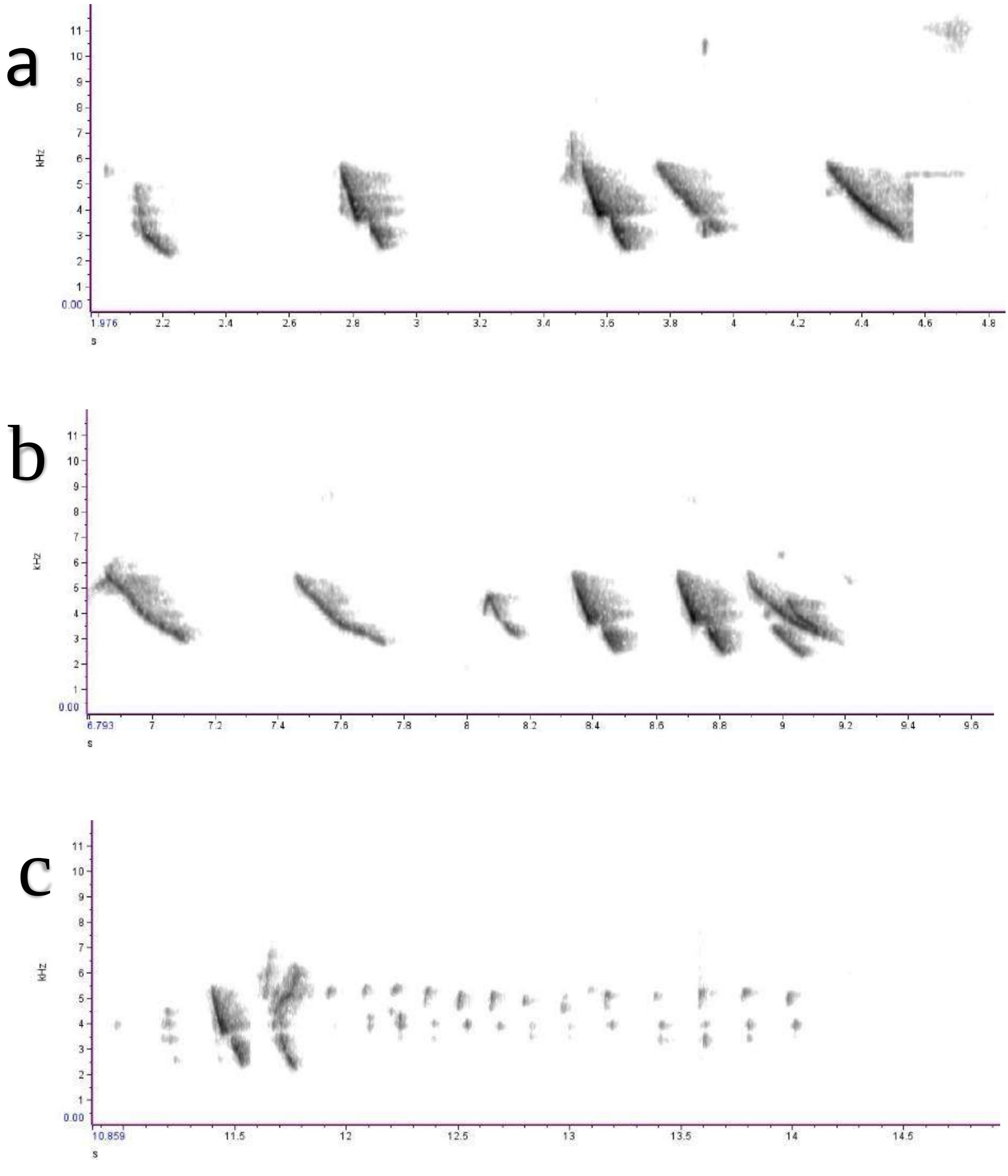


Fig 4.1.5.2 a),b),c) Spectrograms of Common Tailorbird courtship song

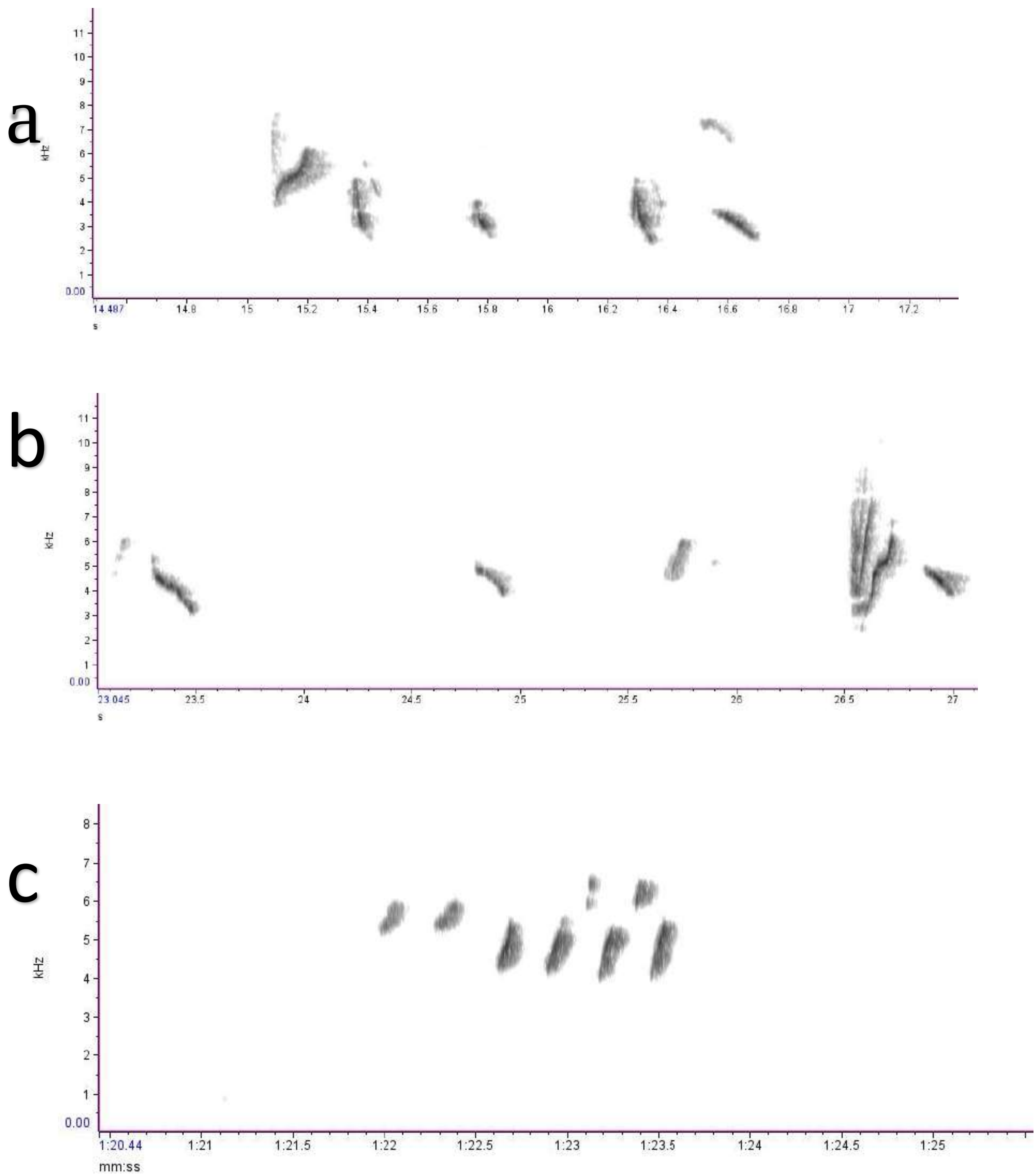


Fig 4.1.5.3 a), b),c) Spectrograms of Common Tailorbird courtship song.

4.1.6. Group cohesion call

Group cohesion calls were noted to assist in maintaining unity and coordination within the bird community, particularly during activities like foraging, traveling. These calls were characterized by soft, repetitive vocalizations emitted by birds in close proximity to one another. They served to reinforce group cohesion by enabling members to remain in contact, even when out of visual range. These calls were especially crucial during collective actions, aiding in signaling location and intentions to facilitate effective cooperation. The group cohesion calls exhibited a simple chorus call, with one element being repeated rapidly while moving through the territory in a pattern. This repetitive pattern allowed group members to maintain contact and coordinate their movements effectively, contributing to the overall cohesion and unity of the group.

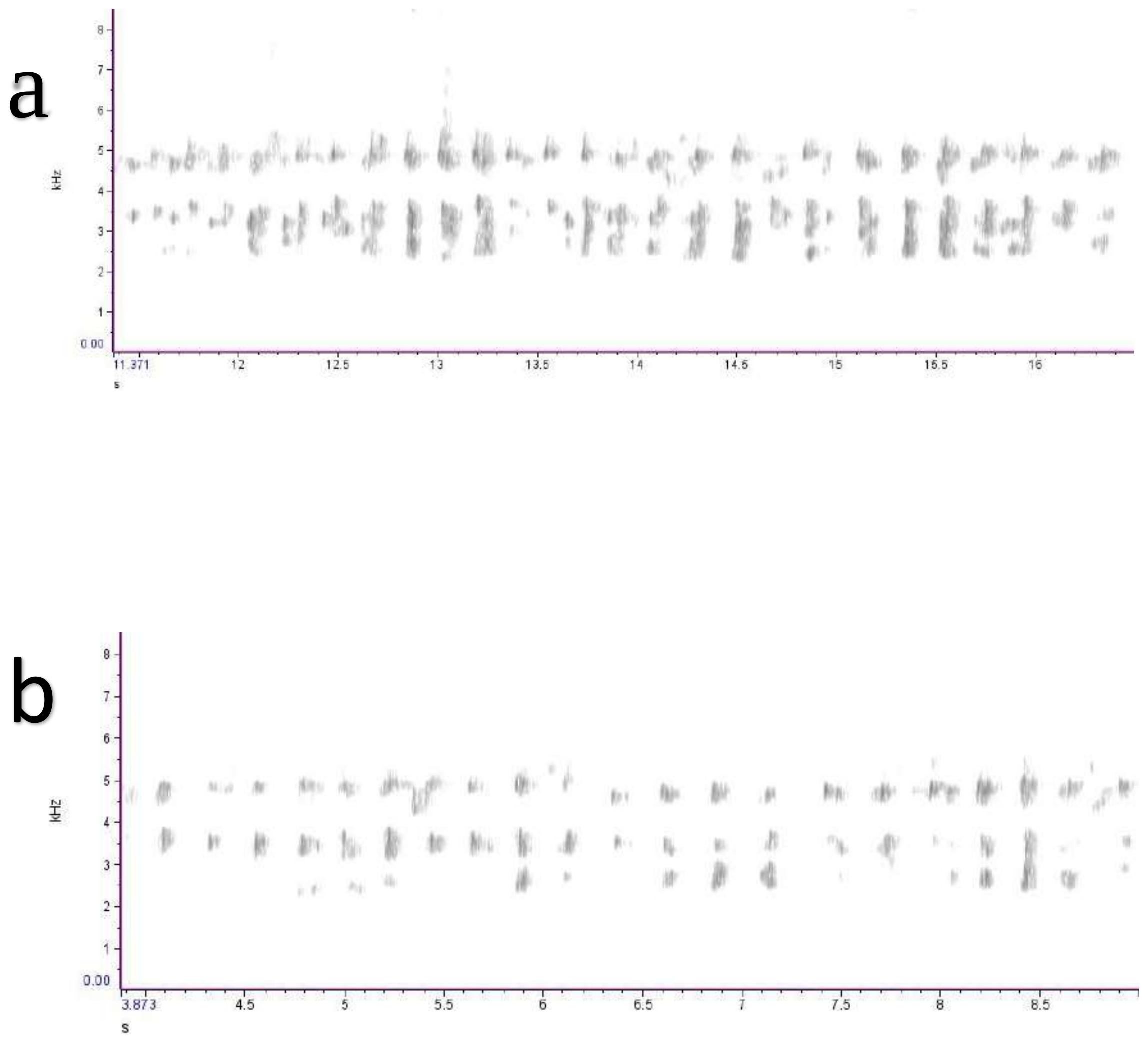


Fig 4.1.6 a), b) Spectrograms of Common Tailorbird group cohesion while moving through territory

4.1.7. Foraging call

Tailorbird foraging calls are often characterized by soft, short, and repetitive vocalizations. These calls are typically simple and may consist of one or two elements repeated rapidly. They often have a moderate to low pitch. Tailorbirds typically produce foraging calls while actively searching for food, such as probing leaves and branches for insects or other prey items. These calls also occur when moving through the vegetation in search of food. When a tailorbird is actively hopping through vegetation in search of food, its foraging call is typically characterized by simple monosyllabic, short elements being repeated in a non-specific pattern. These calls are often quick and stereotyped, serving to communicate the bird's presence and activity to nearby conspecifics.

The pair contact call during foraging is more complex. It consists of four elements being repeated, resembling a simple song. This call is more melodious and varied compared to the simple foraging call. It serves as a means for communicating with its mate while foraging, helping to maintain contact and coordinate movements between pair members.

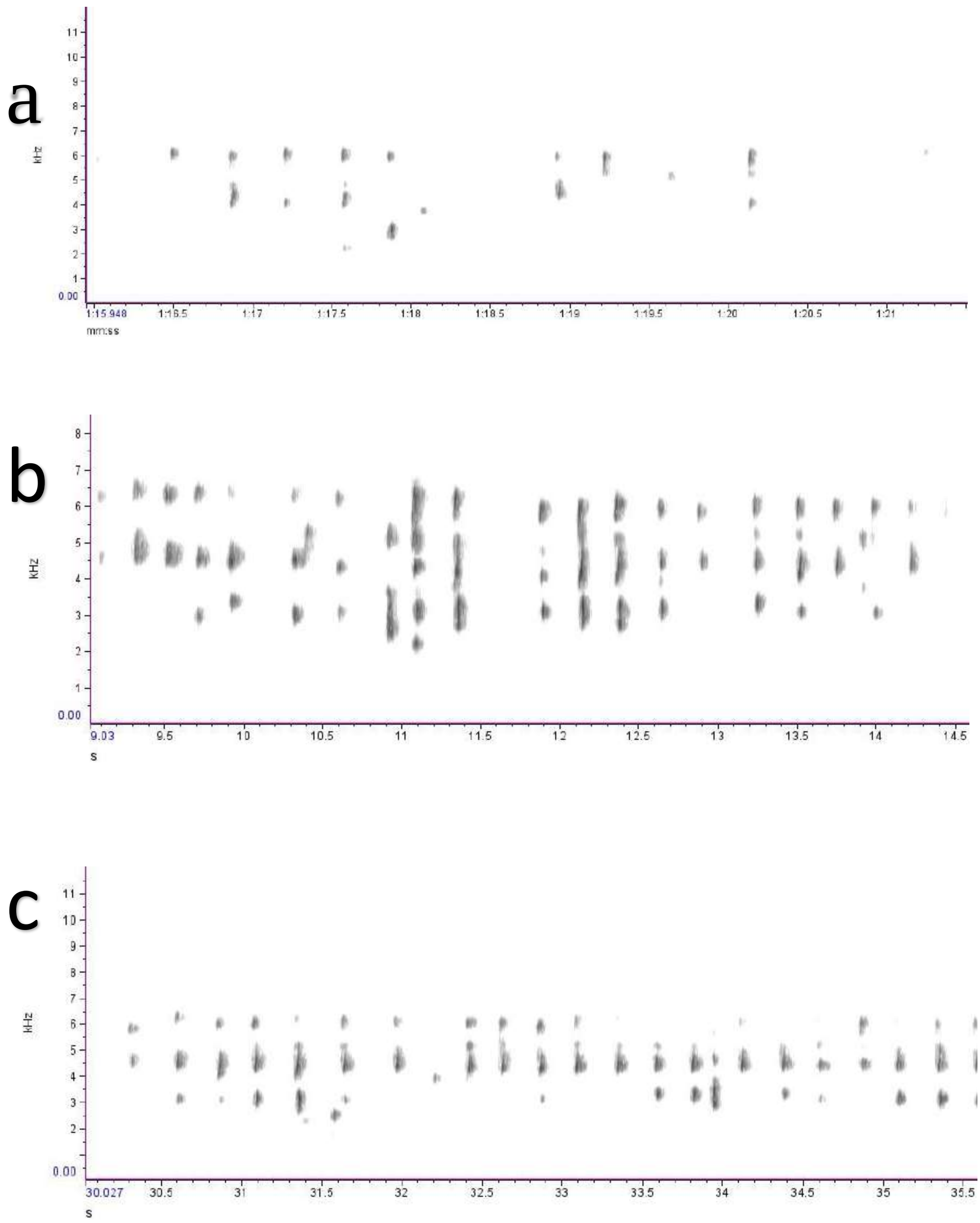


Fig 4.1.7.1 a), b), c)Spectrograms of Common Tailorbird actively hooping in search of food

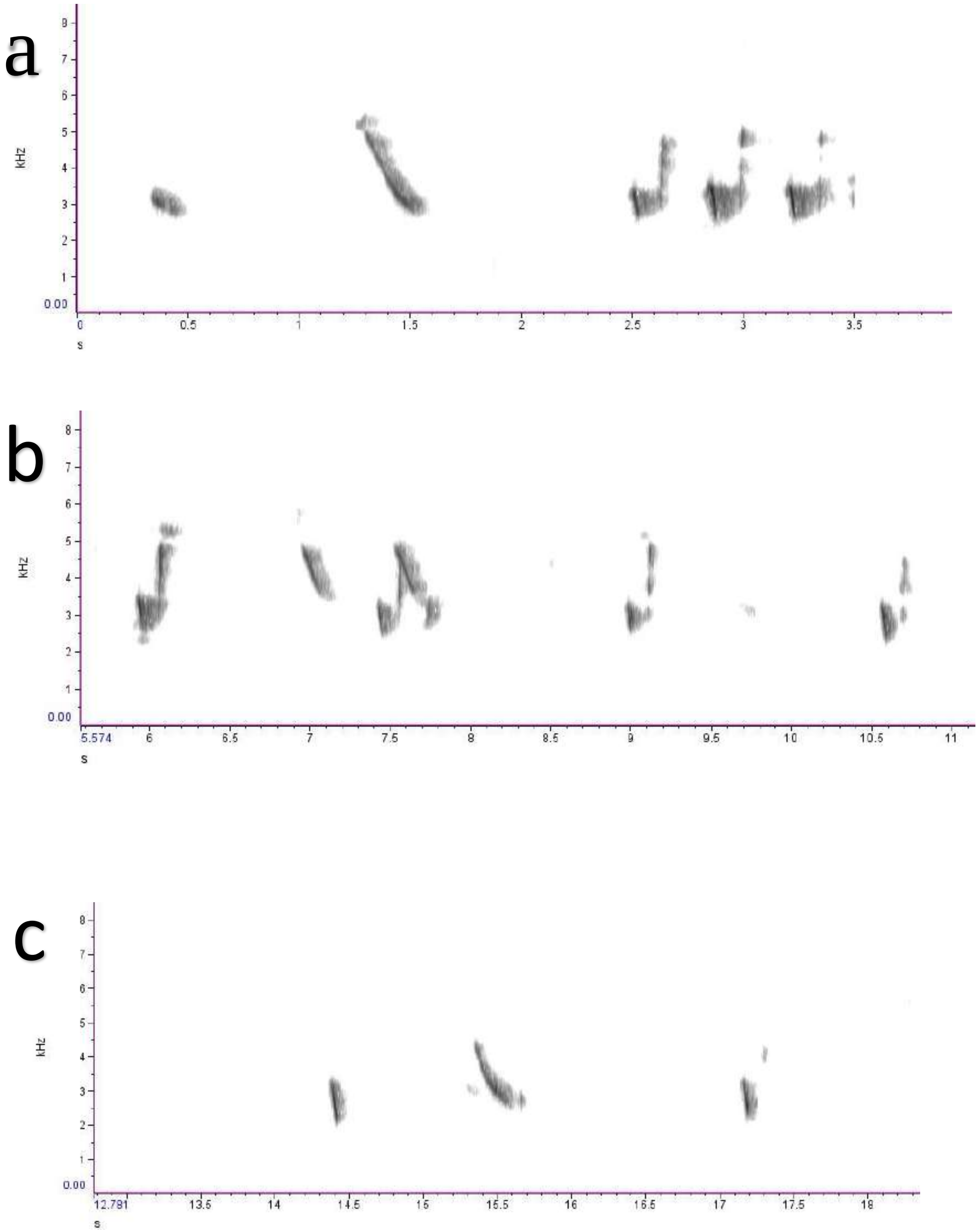


Fig. 4.1.7.2 a), b), c) Spectrograms of Common Tailorbird pair contact call while foraging

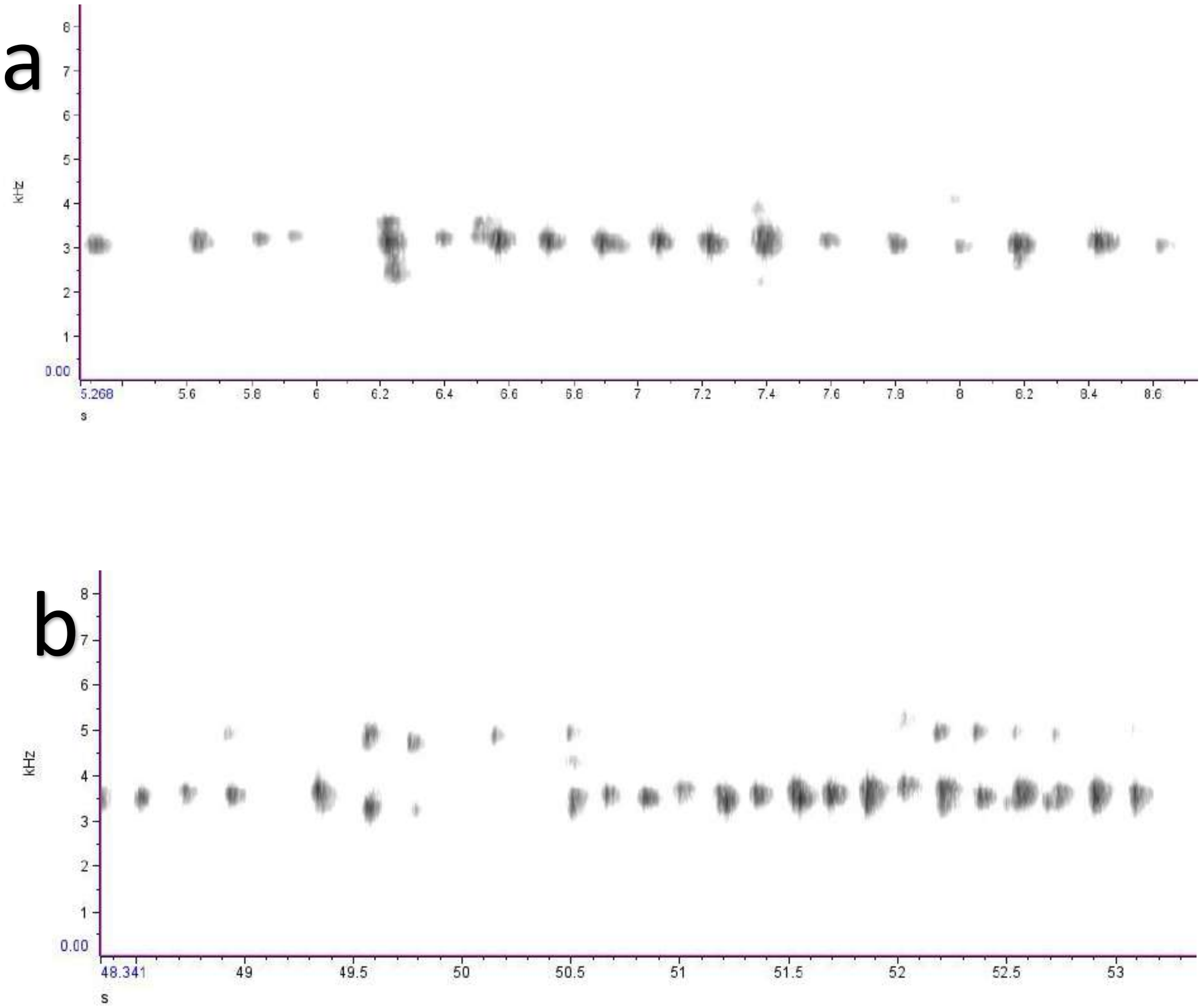


Fig 4.1.7.3 Spectrograms of Common Tailorbird foraging call a) single individual foraging b) group cohesion call

Table 4.1.1 Total number of audio recording of Common Tailorbird

Common Tailorbird	Total No. of calls recorded
Morning	22
Afternoon	8
Evening	20

Table 4.1.2 Types of calls found in Common Tailorbird

Sr.No.	**Type of call**	**Nature of call**	**No. of element**
1	Contact		
	Resting contact	simple or complex	1 to 9
	Branch movement contact	simple	1 to 4
	Pair contact	complex	1 to4
2	Alarm	simple	3
3	Flight	simple	1 to 2
4	Territorial	complex	1 to 2
5	Courtship	very complex	10
6	Group cohesion	simple	-
7	Foraging	simple	-

4.2 Comparative analysis of below showed elements in morning, afternoon and evening throughout day

Fig 4.2.1 Elements selected for comparison a) A element b) B element c) C element d) D element E) E element f) f element

4.2. Comparative analysis of low frequency (Hz), high frequency (Hz) and peak frequency of elements

Low Frequency:

- In the morning, the lowest mean frequencies are observed in element D and F, with type D having the lowest frequency overall.
- During the afternoon, element B shows the highest mean frequency, while types C and D remain relatively stable. Element E and F were not seen.
- In the evening, element A, B, display higher lower frequencies compared to the afternoon and E & F showed lower low frequency than morning. Element C &D were not observed.

High Frequency:

- In the morning, element E has the highest mean high frequency, whereas B has the lowest.
- During the afternoon, element A displays a significant increase in mean high frequency, becoming the highest among all element. Element B, C, and D also show an increase in frequency.
- In the evening, element A and B maintain high frequencies, while E and F show lower high frequencies.

Peak Frequency:

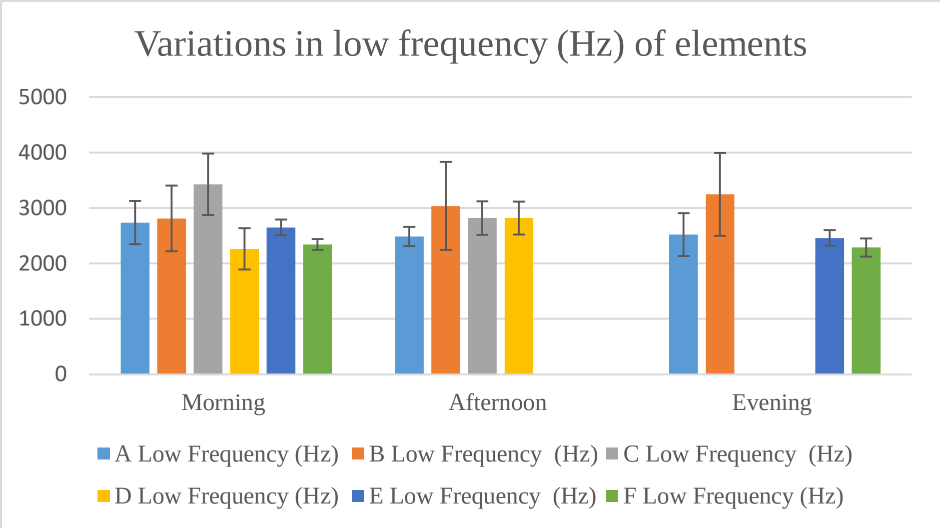
- In the morning, element C has the highest mean peak frequency, followed by B. While element F have the lowest.
- During the afternoon, B has highest mean peak frequency.
- In the evening, B maintence highest, followed by type F.

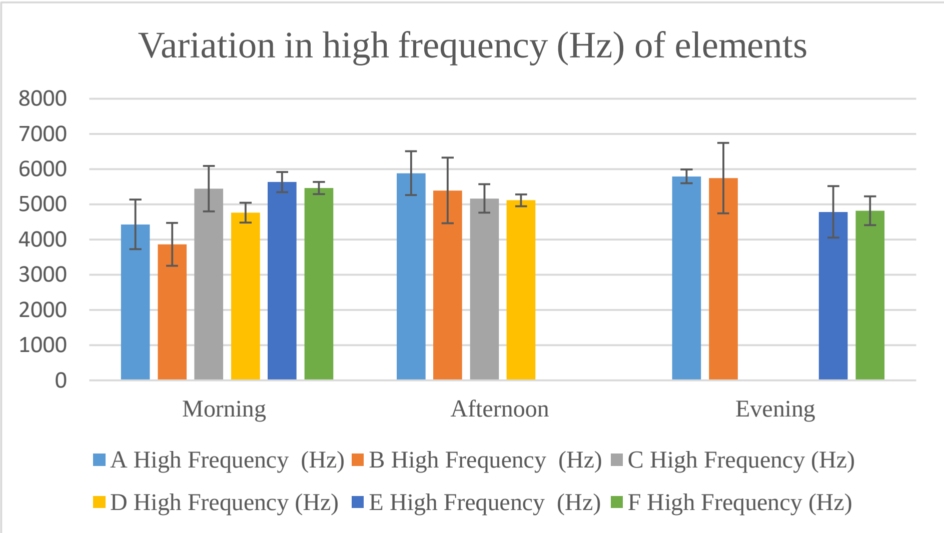
Table 4.2.1 a), b) & c) representing average low frequencies, high frequencies and peak frequencies of elements in morning, afternoon and evening where n= total no. of elements selected

Time of Day	A Low Frequency (Hz) n=100	B Low Frequency (Hz) n=100	C Low Frequency (Hz) n=100	D Low Frequency (Hz) n=100	E Low Frequency (Hz) n=100	F Low Frequency (Hz) n=100
Morning	2736±388.9	2812±592.7	3424±554	2263±373.5	2650±141.2	2343±98.77
Afternoon	2486±173.2	3037±795.6	2818±303.7	2818±296.2	0	0
Evening	2521±388.3	3246±748	0	0	2460±143.2	2287±163.8

Time of Day	A High Frequency (Hz) n=100	B High Frequency (Hz) n=100	C High Frequency (Hz) n=100	D High Frequency (Hz) n=100	E High Frequency (Hz) n=100	F High Frequency (Hz) n=100
Morning	4431±704.3	3867±608.2	5447±647	4762±282.2	5633±287.2	5461±174.2
Afternoon	5884±623.8	5394±931.2	5164±405.1	5114±170.9	0	0
Evening	5794±196.7	5745±1001	0	0	4785±729.2	4822±408.8

Time of Day	A Peak Frequency (Hz) n=100	B Peak Frequency (Hz) n=100	C Peak Frequency (Hz) n=100	D Peak Frequency (Hz) n=100	E Peak Frequency (Hz) n=100	F Peak Frequency (Hz) n=100
Morning	3673±398.1	3776±1057	4276±643	3576±654.3	3440±439.9	3338±257.3
Afternoon	3335±410.8	4082±544.6	3475±674.9	3580±475.7	0	0
Evening	3216±512.9	4258±795.7	0	0	3519±525.9	3629±348.1





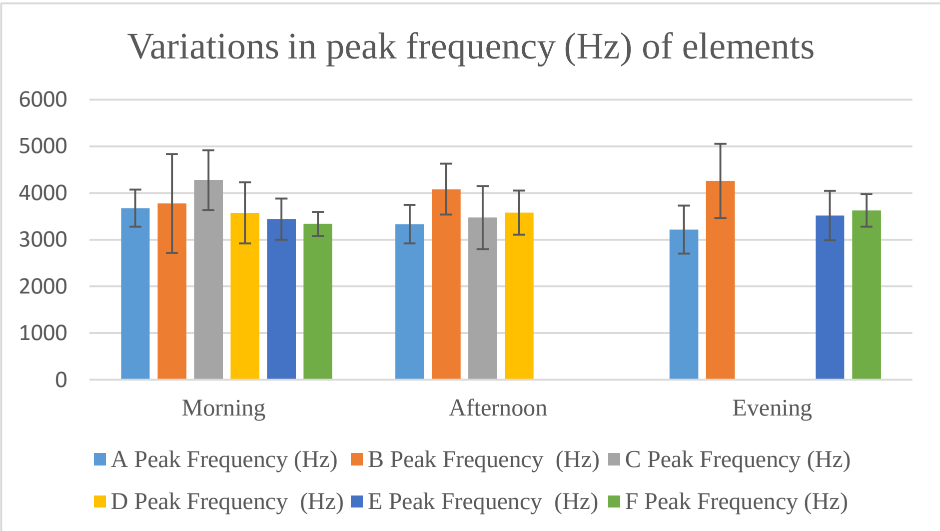


Fig 4.2.1 Graph showing variations in low frequency, high frequency and peak frequency of elements in morning, afternoon and evening

Table 4.2.2 Representing one way ANOVA results of f value between elements

f value	Low frequency	High frequency	Peak frequency
Morning	105.3	199.1	29.77
Afternoon	24.5	27.61	38.88
Evening	94.57	71.64	59.34

Table 4.2.3 Representing one way ANOVA results of f value within elements

f value	Low frequency	High frequency	Peak frequency
A	16.13	215.2	28.57
B	9.157	133.6	8.729

Table 4.2.4 Representing student t-test results of t value within elements

t value	Low frequency	High frequency	Peak frequency
C	10.8	3.671	9.01
D	11.15	10.29	0.053
E	9.473	10.88	1.243
F	2.888	14.65	6.804

After performing one way ANOVA and student t-test there was significant difference within and between elements ($p < 0.0001$) suggesting variations in this elements low frequency ,high frequency and peak frequency.

DISCUSSION

This study investigated that Common Tailorbird (*Orthotomus sutorius*) exhibits diurnal variation in calling activity. Anil Kumar (2012) describes the vocalizations of the Common Tailorbird as having a simple song structure, typically consisting of one to three types of elements, with repeated syllables. The present study revealed that, Common Tailorbird uses both simple and complex vocal repertoire. Additionally, seven main call types in the vocal repertoire of the Common Tailorbird, including contact calls, alarm calls, flight calls, territorial calls, courtship calls, group cohesion calls, and foraging calls were identified.

The existence of broad phonological categories in bird songs, as identified by Lachlan et al. (2010), indicates structured vocal repertoires across different bird species. Similarly, this study identified distinct call types in Common Tailorbird vocalizations, suggesting a structured vocal repertoire. These findings align with previous research by Kumar (2012), who documented a diverse range of vocalizations in Indian bird species, each serving specific purposes in social interactions and environmental responses.

The observed diurnal variation in vocalization patterns suggests an adaptation to various activities and environmental factors throughout the day, such as foraging, territory establishment, and mate attraction. This is consistent with the findings of Mei et al. (2022), who documented significant diurnal variations in vocalization patterns in Cuculidae species.

The studies observations on peak in vocalization activity during morning and evening hours coincides with (Borror ,1961; Erne, 2008; Hardouin, 2008) study who observed similar phenomenon of increased in song activity in passerine birds. This behavior is believed to serve various functions, including foraging, territory defense, mate and rival assessment, and resource defense (Erne, 2008; Hardouin, 2008 ; Hillemann, 2019), indicating a preference for singing during low light conditions.

In contrast, Rajashekhar and Vijaykumar's (2015) study on the Indian Robin focused on spectral analysis, revealing distinct acoustic characteristics of the species' vocalizations. While their study provided insights into the acoustic structure of Indian Robin vocalizations, this research aimed to elucidate the functional significance of Common Tailorbird vocalizations in different behavioral contexts, such as resting, branch movement, and pair bonding, highlighting species-specific variations in vocal behavior.

CONCLUSION

The use of acoustic sequences by animals is a widespread phenomenon observed across numerous taxa. Automatic recording and spectrographic analysis is emerging as a valuable technique for studying diurnal variations in the acoustic sounds of bird species, providing researchers with valuable insights into their vocal behaviors.

This study focused on the diurnal variation in the vocal repertoire of the Common Tailorbird, a species known for its diverse vocalizations. Through meticulous analysis, the study uncovered important patterns in the bird's vocal behavior throughout the day. These findings shed light on how environmental factors, such as light intensity and time of day, influence the bird's communication patterns.

However, this study findings are based on small population size of the Common Tailorbird's vocal repertoire. Further research involving larger populations and spanning different seasons could provide a more comprehensive understanding of their vocal behaviors. Seasonal variations in calling activity, could reveal additional insights into the bird's breeding behavior, migration patterns, and responses to changing environmental conditions.

REFERENCES

Abadi, S., Wacker, D. W., Newton, J. G., & Flett, D. (2019). Acoustic localization of crows in pre-roost aggregations. The Journal of the Acoustical Society of America, 146(6), 4664.

Borror, D.J. (2002). Intraspecific variation in passerine bird songs.

Bhattacharya, H., Cirillo, J., & Todt, D. (2008). Song Performance Rules in the Oriental Magpie Robin (Copsychus salauris). Our Nature, 5, 1-13.

Chitnis, S. S., Rajan, S., & Krishnan, A. (2019). Sympatric wren-warblers partition acoustic signal space and song perch height. bioRxiv.

Chamberlain, D. R., & Cornwell, G. W. (1971). Selected vocalizations of the common crow.

Clement, P. (2006). Species account: Tickell’s Blue Flycatcher Cyornis tickelliae. In J. del Hoyo, A. Elliott, & D. A. Christie (Eds.), Handbook of the Birds of the World Alive. Lynx Edicions.

Clement, P., & Christie, D. (2020). Tickell’s Blue Flycatcher (Cyornis tickelliae). Birds of the World. Cornell Lab of Ornithology. https://doi.org/10.2173/bow.tibfly3.01.

Crane, J. M., Savage, J. L., & Russell, A. F. (2016). Diversity and function of vocalisations in the cooperatively breeding Chestnut-crowned Babbler. Emu - Austral Ornithology, 116, 241-253.

Erne, N., & Amrhein, V. (2008). Long-term influence of simulated territorial intrusions on dawn and dusk singing in the Winter Wren: spring versus autumn. Journal of Ornithology, 149, 479-486.

Engesser, S., Ridley, A.R., & Townsend, S.W. (2016). Meaningful call combinations and compositional processing in the southern pied babbler. Proceedings of the National Academy of Sciences, 113, 5976 - 5981.

Ficken, M. S., & Popp, J. (1996). Auk. 113: 370-380.

Goodale, E., Beauchamp, G., & Magrath, R. D. (2010). Group structure and helping in cooperatively breeding Jungle Babblers (Turdoides striata). Behavioral Ecology, 21(6), 1119-1126.

Grimmett, R., Inskipp, C., & Inskipp, T. (2011). Birds of the Indian Subcontinent. Oxford University Press.

Hujatulatif, A., Bahar, N., Priambodo, B. R., Asyari, M., & Irawan, B. (2022). Analyzing and comparing frequency of the birds sound spectrum using Audacity software in practicum activity. Jurnal Penelitian Pendidikan IPA, 8(6), 2586–2592.

Hillemann, F., Cole, E.F., Keen, S.C., Sheldon, B.C., & Farine, D.R. (2019). Diurnal variation in the production of vocal information about food supports a model of social adjustment in wild songbirds. Proceedings of the Royal Society B: Biological Sciences, 286.

Hardouin, L.A., Robert, D., & Bretagnolle, V. (2008). A dusk chorus effect in a nocturnal bird: support for mate and rival assessment functions. Behavioral Ecology and Sociobiology, 62, 1909-1918.

Hanafi, S., Chong, L.P., Maruthaveeran, S., & Yeong, K.L. (2019). Vocal Response of Oriental Magpie Robin (Copsychus saularis) to Urban Environmental Factors in Peninsular Malaysia. Sains Malaysiana.

Jinjuan, L., Jin, Z., Hua, Z., Mingzhou, Y., Lin, T., & Longchao, L. (2022). Diurnal and seasonal patterns of calling activity of seven Cuculidae species in a forest of eastern China. Diversity, 14(4), 249. https://doi.org/10.3390/d14040249

Kumar, A. (2011). Physical characteristics, categories and functions of song in the Indian Robin Saxicoloides fulicata (Aves: Muscicapidae). Journal of Threatened Taxa, 3, 1909-1918.

Kumar, A., & Bhatt, D. (2001). Characteristics and significance of calls in Oriental Magpie Robin. Curr. Sci., 80(1), 77–82.

Kumar, A., Himanshu, & Rawal, P. (2023). Individual-level discrimination in song characteristics of White-rumped Shama, Copsychus malabaricus.

Kumar, R. S., & Singh, P. (2016). Nest architecture of the Common Tailorbird Orthotomus sutorius (Linnaeus). International Journal of Scientific Research, 5(12), 526-527.

Karna, J.C., Subba, B.R., Bhattacharya, H., & Chhetry, D.T. (2020). Singing patterns of the Oriental Magpie Robin Copsychus saularis Linn. Our Nature, 18, 16-27.

Lein, M. R. (2007). Patterns of dawn singing by Buff-breasted Flycatchers. Journal of Field Ornithology, 78, 343-351.

Manshor, Z., & Gawin, D. F. A. (2022). Call types of the Oriental Magpie Robin (Copsychus saularis) in suburban areas in Kota Samarahan, Sarawak. Borneo Journal of Resource Science and Technology, 10(1), 37–44.

Mates, E.A., Tarter, R., Ha, J.C., Clark, A.B., & McGowan, K.J. (2015). Acoustic profiling in a complexly social species, the American crow: caws encode information on caller sex, identity and behavioural context. Bioacoustics, 24, 63 - 80.

Merila, J., & Sorjonen, J. (1994). Seasonal and diurnal patterns of singing and song-flight activity in Bluethroats (Luscinia svecica). The Auk, 111, 556-562.

Mitchell, A. (1977). Wildlife Sound Recording. In J. B. Fisher (Ed.), Ann. Arbor (pp. 20-38).

Méndez, C., Pöysä, H., & Laaksonen, T. (2021). The effect of noise variation over time and between populations on the fine spectrotemporal characteristics of different vocalization.

Maslehuddin, A. M., Yahya, H. S. A., & Jambu, N. (2020). Identification of warbler species using bioacoustics in Purna Wildlife Sanctuary, Gujarat, India.

Rajashekhar, M., & Vijaykumar, K. (2015). Spectral Analysis of Sounds of Saxicoloides fulicata (Indian Robin). International Letters of Natural Sciences.

Roper, E.R. (2007). Musical Nature: Vocalisations of the Australian Magpie (Gymnorhina Tibicen Tyrannica). Context: journal of music research, 59.

Rotella, J.J., & Ratti, J. (2001). Seasonal variation in gray vocal behavior.

Smith, W.J., & Smith, A.M. (2010). Vocal signalling of the great crested flycatcher, Myiarchus crinitus (Aves, Tyrannidae). Ethology, 102, 705-723.

Smith, J., Jones, A., & Garcia, R. (2017). Vocal behavior and habitat associations of the Philippine Tailorbird (Orthotomus castaneiceps) in Palawan, Philippines. Journal of Avian Ecology, 45(2), 210-225.

Seutin, G. (1987). Female song in Willow flycatchers (Empidonax traillii). The Auk, 104, 329-330.

Sethi, V.K. Bhatt, D. & Kumar, A. (2012). Characteristics and behavioural correlates of call types in a tropical bird, the pied bush chat (Saxicola caprata). Pakistan Journal of Zoology, 44(5): 1231-1238.

Tefera, M. (2012). Acoustic signals in domestic chicken (Gallus gallus): a tool for teaching veterinary ethology and implication for language learning. Ethiopian Veterinary Journal, 16, 77-84.

Yambem, S.D., Chorol, S., & Jain, M. (2021). More than just babble: functional and structural complexity of vocalizations of Jungle Babbler. Behavioral Ecology and Sociobiology, 75.

Yambem, S.D., Chorol, S., & Jain, M. (2020). Structural and functional complexity of vocalizations in a cooperatively breeding passerine, Jungle Babbler. bioRxiv.