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Comparative Study of Intensity and Pitch of Sounds of Some Domestic Animals and Birds

S.K. Adhikari*, N.P. Adhikari, R. K. Aryal

Department of Physics, Birendra Multiple Campus, Tribhuvan University, Nepal
*Corresponding Author: sheshkantadhikari1@gmai.com

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Abstract

Sound serves as a versatile form of communication. Animals and birds utilize sound for various purposes, including communication, marking territory, hunting prey, alerting others to danger, and attracting mates. Research into the sound analysis of some domestic animals and birds has become a prominent field of study. This study aims to determine the intensity and pitch of sounds produced by domestic animals and birds. Primary data was collected using a SONY IC RECORDER, and the sounds were analyzed for intensity and pitch with PRAAT software. Experimentally, it found that the mean intensity values for animal sounds ranged from 53.98 dB to 83.14 dB, with an average of 72.80 dB, while the mean pitch values ranged from 80.38 Hz to 841.74 Hz, averaging at 431.70 Hz. In contrast, the mean intensity for bird sounds spanned from 63.08 dB to 81.01 dB, averaging 73.08 dB, and the mean pitch values ranged from 299.17 Hz to 2145.00 Hz, with an average of 1214.93 Hz. The comparison of average mean values for intensity and pitch yielded ratios of 1.01 and 2.81, respectively. This indicates that, on average, the intensity of bird sounds is slightly higher than that of animal sounds, while their pitch values are significantly higher. Such findings contribute to identifying distinct pitch ranges and intensity levels among various birds and animals.

Keywords Sound, intensity, pitch, domestic animals, birds

1. Introduction

An acoustical sound is a form of energy that travels as vibrations through a medium, such as air, and is heard by our ears. There are three types of acoustic waves: infrasound, audible sound, and ultrasound. Sound is a mechanical wave formed by the vibration of particles in the medium through which it travels. The motion of particles is parallel or antiparallel to the direction of energy transport, resulting in compressions and rarefactions in the air (Kinsler et al., 2000; Anyaegbunam, 2013). Among the sounds of living things, the sounds of animals and birds play an important role in our environment. These sounds help in communication, navigation, and attracting mates.

1.1 Animals' sound

Sound is a unique mode of communication used by animals and humans. It is highly effective, as it allows for distinct and recognizable signals. Sound can also travel over

long distances and even through obstacles, making it a reliable form of communication in various environments.
Animals use sound to communicate important information. Examples include a cheetah mother making sounds to signal her cubs about successful hunts, lions using roars to mark their territories, and monkeys producing alarm calls to alert others of impending danger. Toads also rely on sound, specifically male toads using mating calls to attract female mates. Animal researchers typically use dissimilar features than speech researchers to analyze animal vocalizations (Raju et al., 2012).
Different animals use widely different frequencies for sound communication, and it is reasonable to assume that evolution has adapted these frequencies to give the greatest nonspecific communication distance for a given vocal effort (Fletcher, 2004). In the past two decades, research on terrestrial mammal vocal production has evolved from focusing primarily on occurrence rates to a comprehensive understanding of the acoustic parameters and their functions in vocalizations (Taylor et al., 2016).
Animal sounds evolved through different species, enabling recognition of individuals and conveying vital information about their states, as believed by ethnologists and farmers (Jahns et al., 1998). The intensity of the sound of a Korean native domestic cow was 68.8 dB to 71.4 dB (Yeon et al., 2006). The ability to mechanically analyze diverse animal sounds enhances our understanding of their behaviors and distributions, aiding in effective conservation efforts. Experimental results indicate that the method achieves over 80% recognition accuracy, even in challenging conditions with a 10 dB signal-to-noise ratio (Li & Wu, 2015). Spectrograms visualize the time-frequency characteristics of animal vocalization, revealing insights into sound generation and modulation. By linking mathematical events to acoustic structures, they enhance statistical analysis and hypotheses about sound production mechanisms (Elemans et al., 2008). Acoustic signals have distinctiveness, which is particularly suitable for communication, and practically all animal groups have some means of communication by sound (Gunasekaran and Revathy, 2011).

1.2 Birds' sound

Birds utilize sound for various essential functions, including communication, territorial warnings, and mate attraction. The study of bird sounds encompasses the production, transmission, and reception of these sounds in nature, as well as their investigation and use by humans. Additionally, the impact of human-generated sounds on birds is a significant area of research. Ethologists and farmers believe that bird sounds facilitate individual recognition and convey information about the birds' conditions. Overall, understanding bird sounds is crucial for appreciating their role in nature and the effects of environmental changes.
Birds use calls for communication during feeding, resting, and traveling, while songs are longer, complex, and linked to romance and mating. They have two distinct languages for internal exchange and socializing. Differentiating between songs and calls based on complexity and context zing. All birds have a separate type of communication for

"songs" vs communicating danger and other information (Suthers & Zollinger, 2004). Bird vocalizations encompass both calls and songs, with songs being the melodious sounds often appreciated by humans. In ornithology, songs are complex vocalizations used for attraction and territory, evolving through sexual selection, and their quality may indicate a bird's fitness (Read & Weary, 1990; Catchpole & Slater, 2008). Bird species can be identified through their vocalizations by first analyzing recorded signals for key features. Voice Activity Detection (VAD) is employed to isolate vocal segments, which are then classified using individual Hidden Markov Models specific to each species. Additionally, deep neural networks offer another promising approach for enhancing bird sound recognition and classification (Stastny et al., 2018).

Parrots produce sounds with limited high-frequency content and longer noise bursts compared to humans. Their vocalizations, particularly in laughter, reveal clear formants, although they struggle with the /r/ sound and produce largely unintelligible consonants. Nonetheless, parrots can imitate most vowels to a notable degree (Singh et al., 2017).

The main objective of this article is to calculate the pitch and intensity of sound of domesticated animals and birds and compare these acoustic parameters between them. After that, it will be helpful for studies of vocalization of other animals and birds. There are so many domestic animals and birds around us, but we selected some animals and birds, which are listed below. The sound can be recorded from the shortest distance, but it is difficult to handle birds and the fare of animals at the shortest distance, so the sound was collected from a distance of 2 meters.

2. Mathematical theory

Pitch and intensity are acoustic parameters of sound so they are measured by different ways.

2.1 Pitch of sound

The sensation of frequency in sound is known as pitch. High-frequency sound waves correspond to high-pitch sounds, while low-frequency waves correspond to low-pitch sounds. Humans perceive pitch based on the frequency of sound waves that reach the ear, which are longitudinal waves causing high and low-pressure disturbances in the air. The ear can detect these frequencies and associate them with pitch, but pitch is not the only characteristic of sound waves that the human ear can detect. If "*T*" is the period, then the pitch *(f)* of sound is measured by (Kinsler et al., 2000).

$$f = \frac{1}{T} \tag{1}$$

2.2 Intensity of sound

Sound intensity refers to the amount of energy that passes through a specific area of a medium over a given time. It is influenced by the amplitude of the vibrations of the medium's particles; higher amplitudes result in greater energy transport. Intensity is defined as energy per unit time per unit area, which can also be expressed as power per unit area.

Intensity is defined as the rate of energy flow per unit area. If "*P" is* the rate of energy flow (Power) through area "*A"* then intensity *(I)* is defined by the equation

$$I = \frac{P}{A} \tag{2}$$

The SI unit for I is W/m^2. The intensity of a sound wave is also related to its amplitude by the relation.

$$I = \frac{(\Delta p)^2}{2pv} \tag{3}$$

Where Δp is the pressure amplitude with units of pascals (Pa) or N/m^2.
Sound intensity levels are commonly measured in decibels (dB) instead of watts per meter squared because our perception of sound is more closely related to the logarithm of intensity rather than the intensity itself. This logarithmic scale better reflects how we experience changes in sound levels, making decibels a more suitable unit for measuring and comparing sound intensity. The sound intensity level is defined as

Intensity level of sound (IL) = $IL = 10 \log_{10}\left(\frac{I}{I_0}\right)$ (4)

Where *"I"* is intensity of sound and is the threshold intensity of hearing in air having value 10^{-12} W/m^2 (Kinsler et al., 2000).

3. Methodology

This research aims to investigate the primary sounds produced by various birds and animals, utilizing data collected through field recordings. By analyzing these vocalizations, we intend to explore the relationships between sound intensity and pitch across different species.

3.1 Data collection

For this study, we collected the required data by following these steps.

3.1.1 Recording equipment

A sound recorder, SONY IC RECORDER, is used in natural habitats to capture vocalizations of birds and animals.

3.1.2 Subjects

In our surroundings, we observe various animals and birds, and we aim to study the intensity and pitch of certain species. For this study, we have chosen five domestic animals based on size, from largest to smallest: Buffalo, Cow, Goat, Dog, and Cat. Additionally, we have selected five birds, also based on size: Turkey, Duck, Cock, Crow, and Parrot, as they are easily available in our surroundings. Notably, Crow and Parrot are considered wild birds, while Turkey, Duck, and Cock are domestic.
A total of ten subjects were selected for the study, consisting of five domestic animals

and five birds. The sounds of these animals and birds were recorded in their various habitats across five different locations. Each type of animal and bird was recorded five times, resulting in a total of 250 tokens (10 x 5 x 5). The sound of each token is recorded in a voice recorder using SONY IC RECORDER, keeping the distance 2 meters from the source of sound.

3.1.3 Recording conditions

Ambient noise levels and environmental conditions were noted to maintain recording integrity.

3.2 Sound analysis

From ten subjects, sound recorded in SONY IC RECORDE and connected to the computer having Praat soft-ware. The sound signal was digitized at the sampling frequency of 16 kHz. With the help of a spectrogram, we evaluated the pitch and intensity of sounds made by animals and birds, as shown a sample in figure 1.

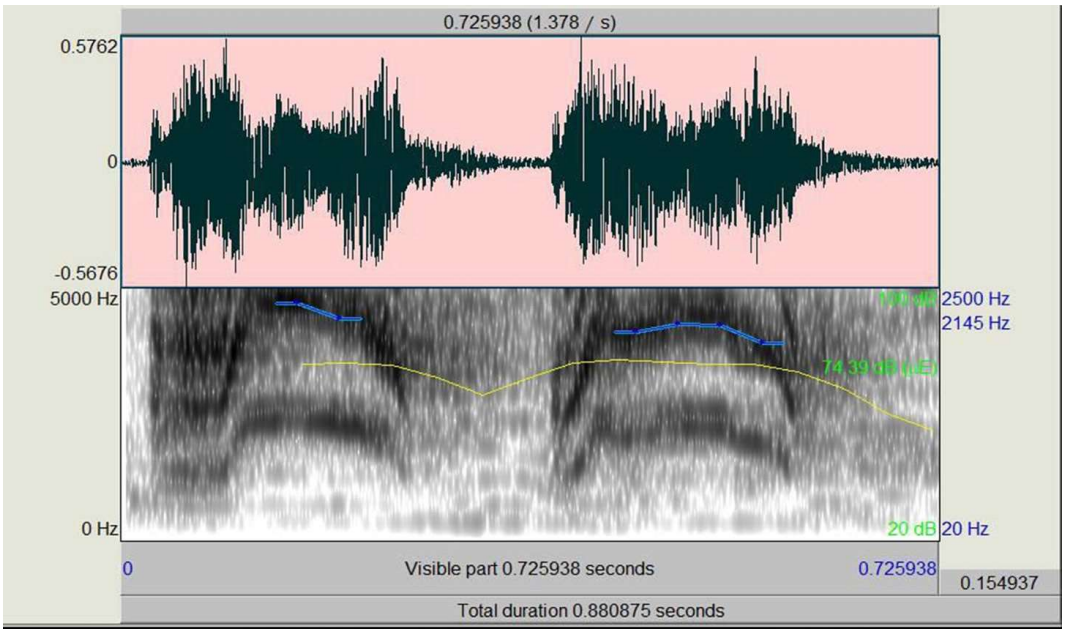

Figure 1. Sample of analyzing of spectrograph of intensity and pitch of sound of Parrot in Praat.

4. Results and discussions

The minimum, maximum, and mean values of intensities and pitches of the sound of different domesticated animals and birds that are under study and obtained by PRAAT software are given below with a table and bar graph with an explanation.

4.1 Intensity of sounds

From Tables 1 and 2, we analyze and discuss the minimum, maximum, and mean intensity of the sound of animals and birds. Table 3 compares the average values of minimum, maximum, and mean intensity of sound of animals and birds.

Table:1. Minimum, maximum and mean values of intensities (in dB) of sound of domestic animals with statistical value standard deviation (S.D).

S.N	Name of Animals	Minimum Intensity(dB)	Maximum Intensity(dB)	Mean Intensity(dB)	S. D
1	Buffalo	65.25	76.81	72.86	5.87
2	Cow	65.19	82.28	78.65	9.00
3	Goat	54.01	80.12	75.38	13.91
4	Dog	74.95	86.21	83.14	5.82
5	Cat	41.95	57.79	53.98	8.27
Average		60.27	76.64	72.80	8.56
S. D		12.64	11.08	11.20	

Table: 2. Minimum, maximum and mean values of intensities (in dB) of sound of birds with statistical value standard deviation (S.D).

S.N	Name of Birds	Minimum Intensity (dB)	Maximum Intensity (dB)	Mean Intensity (dB)	S. D
1	Turkey	50.50	78.26	70.71	8.92
2	Duck	42.87	67.20	63.08	8.79
3	Cock	73.78	84.28	81.01	2.18
4	Crow	57.68	82.38	76.10	8.28
5	Parrot	45.97	79.37	74.49	10.47
Average		54.16	78.30	73.08	12.70
S. D		12.30	6.65	6.70	

Table: 3. Comparison of intensity (dB) of sound between some birds and domestic animals.

S.N	Cases	Birds		Animals		Ratio
		Intensity(dB)	SD	Intensity (dB)	SD	
1	Minimum	54.16	12.30	60.27	12.64	0.90
2	Maximum	78.30	6.65	76.64	11.08	1.02
3	Mean	73.08	6.70	72.80	11.20	1.01

4.1.1 Minimum intensity

The minimum intensity of sounds produced by the animals ranges from 41.95 dB (cat) to 74.95 dB (dog). On average, the minimum intensity of sounds produced by these animals is 60.27 dB, with a standard deviation of 12.64 dB. In the case of birds, the minimum intensity of their sounds varies from 42.87 dB (duck) to 73.78 dB (cock). The average value of the minimum intensity of bird sound is 54.16 dB, with a standard deviation of 12.30 dB.

When comparing the average minimum intensity values of birds and animals, we calculate the ratio of the average value of bird sounds to the average value of animal sounds. In this case, the ratio is approximately 0.90. Therefore, we can conclude that, on average, the minimum intensity of sounds produced by animals is greater than the minimum intensity of sounds produced by birds.

4.1.2 Maximum intensity

The maximum intensity of sounds produced by animals ranges from 57.79 dB (cat) to 86.21 dB (dog). On average, the maximum intensity of sounds produced by animals is 76.64 dB, with a standard deviation of 11.08 dB. The maximum intensity of sounds produced by birds ranges from 67.20 dB (duck) to 84.28 dB (cock). The average of the maximum intensity of bird sounds is 78.30 dB with a standard deviation of 6.65 dB.
When comparing the average maximum intensity values of birds and animals, we calculate the ratio of the average value of bird sounds to the average value of animal sounds. In this case, the ratio is approximately 1.02. Therefore, we can conclude that, on average, the maximum intensity of sounds produced by birds is slightly greater than the maximum intensity of sounds produced by animals.

4.1.3 Mean intensity

The mean intensity of sounds produced by the five animals ranged from 53.98 dB (cat) to 83.14 dB (dog). The average mean intensity for all animals was 72.80 dB, with a standard deviation of 11.20 dB. For birds, the mean intensity of sounds ranged from 63.08 (duck) dB to 81.01 dB (cock). The average mean value of intensity for all birds was 73.08 dB, with a standard deviation of 6.70dB. Comparing the average of mean intensity values of birds and animals, the ratio is calculated as 1.01, indicating that on average, the mean intensity of sounds produced by birds is slightly greater than the mean intensity of sounds produced by animals.
The variation of minimum, maximum, and mean intensity and their average values across different animals and birds are illustrated in figures 2, 3, and 4.

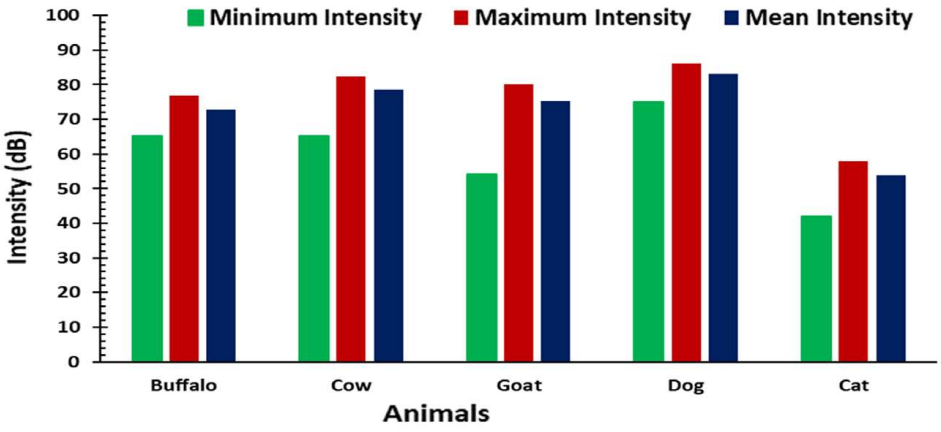

Figure 2. Minimum, maximum and mean intensities of different domestic animals in bar graph.

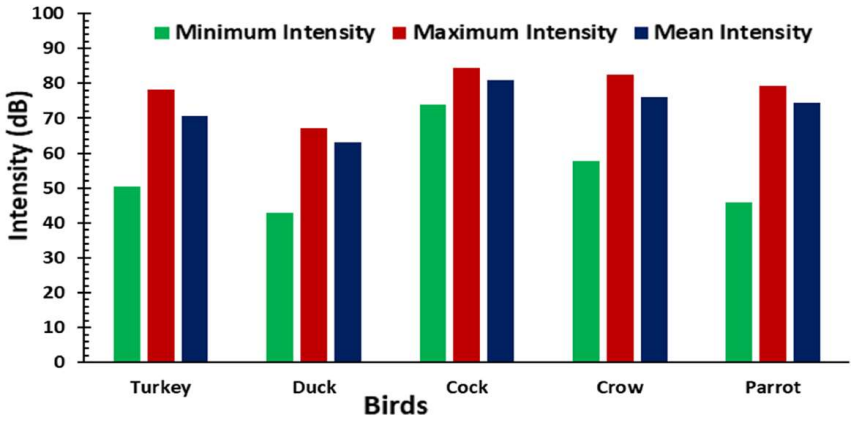

Figure 3. Minimum, maximum and mean intensities of different birds in bar graph.

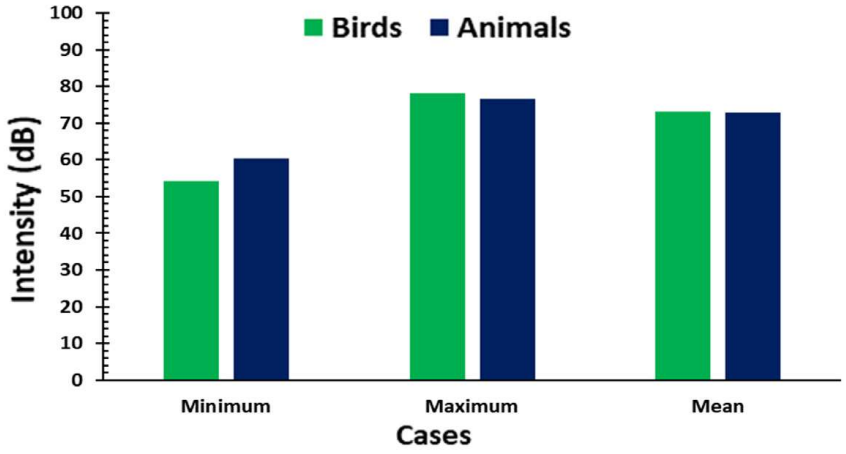

Figure 4. Average value of Minimum, maximum and mean intensities of different birds and domestics animals in bar graph.

4.2 Pitch of sounds

From Table 4 and 5, we analyze and discuss the minimum, maximum, and mean pitch of the sound of animals and birds. Table 6 compares the average values of minimum, maximum, and mean pitch of sound of animals and birds.

Table 4. Minimum, maximum and mean values of pitch (in Hz) of sound of domestic animals with statistical value standard deviation (S.D).

S.N	Name of Animals	Minimum Intensity(dB)	Maximum Intensity(dB)	Mean Intensity(dB)	S.D
1	Buffalo	77.96	82.29	80.38	7.63
2	Cow	213.66	378.03	314.04	31.05
3	Goat	285.12	676.08	410.08	110.21
4	Dog	679.34	919.73	841.74	54.01
5	Cat	456.64	552.06	512.28	25.62
Average		342.54	521.64	431.70	89.55
S. D		232.57	315.00	279.44	

Table 5. Minimum, maximum and mean values of pitch (in Hz) of sound of birds with statistical value standard deviation (S.D).

S.N	Name of Birds	Minimum Intensity(dB)	Maximum Intensity(dB)	Mean Intensity(dB)	S.D
1	Turkey	425.12	1618.93	780.35	305.1
2	Duck	220.87	629.83	299.17	150.80
3	Cock	642.49	1008.97	842.87	65.25
4	Crow	1824.89	2255.48	2007.27	90.16
5	Parrot	1660.71	2351.76	2145.00	129.30
Average		954.82	1572.99	1214.93	310.38
S.D		736.91	755.32	815.28	

Table 6. Average value of minimum, maximum and mean of pitch (Hz) of sound of birds and animals with their S.D and comparison ratio of pitch between birds and animals.

S.N	Cases	Birds		Animals		Ratio
		Pitch (Hz)	S.D	Pitch (Hz)	S.D	
1	Minimum	954.82	736.91	342.54	232.57	2.79
2	Maximum	1572.99	755.32	521.64	315.00	3.02
3	Mean	1214.93	815.28	431.70	279.44	2.81

4.2.1 Minimum pitch

The minimum pitch of sounds produced by domesticated animals, ranging from 77.96 Hz (buffalo) to 679.34 Hz (dog), varies among different species. On average, domesticated animals have a minimum pitch of 342.54 Hz, with a standard deviation of 232.57 Hz. In comparison, birds have a wider range of minimum pitch, varying from 220 Hz (duck) to 1824.89 Hz (crow). On average, birds have a minimum pitch of 954.82 Hz, with a standard deviation of 736.91 Hz. The average maximum pitch of birds is significantly higher than that of domesticated animals, with a ratio of 2.79.

4.2.2 Maximum pitch

The maximum pitch of sounds produced by domesticated animals varies from 82.29 Hz (buffalo) to 919.73 Hz (dog). On average, the maximum pitch of sounds produced by domesticated animals is 521.64 Hz, with a standard deviation of 315.00 Hz. On the other hand, birds have a wider range of maximum pitch, ranging from 629.83 Hz (duck) to 2351.76 Hz (parrot). On average, the maximum pitch of sounds produced by birds is 1572.99 Hz, with a standard deviation of 755.32 Hz. The average maximum pitch of birds is significantly higher than that of domesticated animals, with a ratio of 3.02.

4.2.3 Mean pitch

The pitch of sounds produced by domesticated animals varies greatly, with the mean pitch ranging from 80.38 Hz (buffalo) to 841.74 Hz (dog). On average, the mean pitch of sounds produced by domesticated animals is 431.70 Hz, with a standard deviation of 279.44 Hz. In the case of birds, the mean pitch of sound is even more varied, ranging from 299.17 Hz (duck) to 2145.00 Hz (parrot). On average, the mean pitch of sounds produced by birds is 1214.93 Hz, with a standard deviation of 815.28 Hz. The average mean pitch of birds is significantly higher than that of domesticated animals, with a ratio of 2.81. This suggests that birds produce sounds in a generally higher frequency range compared to domesticated animals.

The variation of minimum, maximum and mean pitch and their average values across different animals and birds are illustrated in figures 5, 6, and 7.

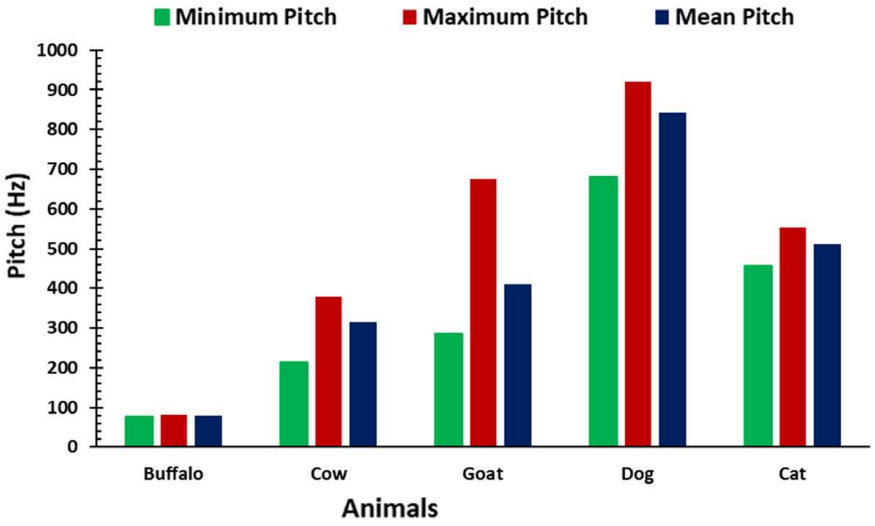

Figure 5. Minimum, maximum and mean pitch of different domestic animals in bar graph.

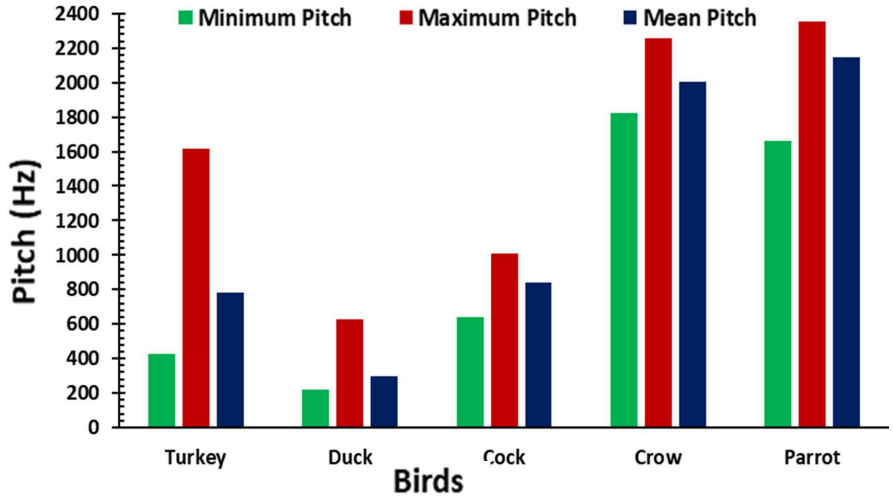

Figure 6. Minimum, maximum and mean pitch of different birds in bar graph.

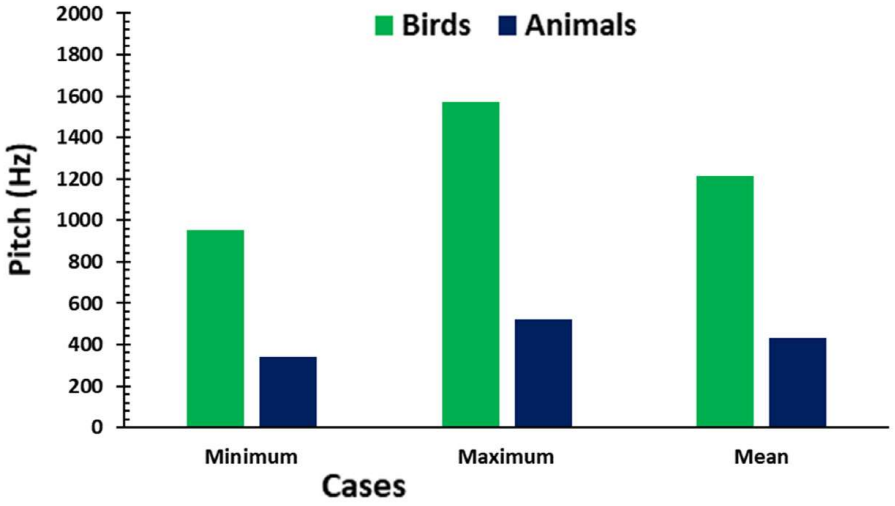

Figure 7. Average value of Minimum, maximum and mean pitch of different birds and domestic animals in bar graph.

5. Conclusion

Analysis of the sound of birds and animals is one of the big domains of physics research. Analysis of sound includes different parameters of sound waves such as period, frequency, amplitude, intensity, pitch, etc. Among those parameters, we studied two parameters of sound; they are intensity and pitch of sound. For this work, primary sound data of different animals and birds is taken and run on PRAAT software on a computer to collect the resulting value of intensity and pitch of the sound. The average intensity of bird sounds was found to be 73.08 dB (S.D. 6.65 dB), compared to 72.80 dB (S.D. 11.20 dB) for animals, indicating a slight superiority in bird sound intensity (ratio of 1.01). In terms of pitch, birds exhibited an average of 1214.93 Hz (S.D. 815.28 Hz) versus 413.70 Hz (S.D. 279.44 Hz) for animals, revealing a more significant difference (ratio of 2.81).

There are so many birds and animals around our surroundings, but we take only five species of birds and animals under study. This result applies only to limited birds and animals. The result may vary for a large number of species of birds and animals. This research work will be fruitful for the upcoming analysis of the sound of animals and birds. It also may help to study the communicative skills of animals and birds. The findings may have implications for further research in bio-acoustics.

Declaration

The authors declare that they have no conflicts of interest to report regarding the present study.

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