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# Differences in the Wavelength of Sound that Can be Received and Heard by Bats, Dolphins and Humans and Their Positive and Negative Impacts

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**ABSTRACT**

Sound is a longitudinal wave. Sound has a frequency, based on the number of frequencies sound is divided into 3, infrasonic, audiosonic, and ultrasonic. Humans can hear audiosonic sounds while dolphins and bats hear ultrasonic sounds. This difference in frequency also affects the wavelength of the sound produced. The relationship between frequency and wavelength is an inverse ratio, which means that the higher the frequency, the lower the sound waves, and vice versa. Infrasonic sound for humans and ultrasonic for dolphins and bats each have positive and negative impacts. In humans, infrasonic sound has the benefit of being comfortable in hearing, but when the sound is too high it can also reduce brain balance which results in ear damage. While the ultrasonic sound in the hearing of dolphins and bats has the advantage of helping them find food, even in dolphins can help communicate. But in bats this ultrasonic sound cannot be used to communicate like dolphins

**Keywords**: *Audiosonic, Infrasonic, Ultrasonic*

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## INTRODUCTION

In physics, sound is a longitudinal wave that propagates through a certain medium, and its vibrations produce sound, which ultimately forms a sound system that can be captured by the human ear. According to the Big Indonesian Dictionary, the definition of sound is something that is heard or detected by the ear.

Based on this, all sounds have certain characteristics resulting from frequency, amplitude, speed of propagation, reverberation time, and so on. Every cell in everyone's body, every rock, and even every tree has a natural resonant frequency that ideally harmonizes with the whole. Based on these physical quantities, sound can be analyzed for various purposes.

Bats are the only mammals that can fly. They are called nocturnal animals because they are active at night looking for food. Bat habitats can be roosts in caves, trees, or urban buildings, depending on the type of food the bats eat. Bats belong to the animalia, phylum Chordata, and mammals. Animals belonging to the order Pteroptera are divided into two suborders: insectivorous bats (order Microptera) and fruitivorous bats (order Macroptera). Microptera rely on hearing to understand their environment by reflecting ultrasonic waves emitted by the bat's own voice, known as echolocation.

Bats can be differentiated based on their body morphological characteristics. The morphological characteristics of the body can distinguish between one type of bat and another. The morphological characteristics can be seen from the length of the bat's tail, the length of the hind legs, body size, tail type, eyeball size, ear shape, and hair color. The differences in morphology owned by each bat will adjust to the type of food. Fruit and nectar eating bats generally have a large body size, large eyeballs and have a dog-like muzzle. Bats that have these characteristics are classified into the sub-order megachiroptera. Insect-eating bats, on the other hand, will have a smaller body size, smaller eyeballs and have a variety of facial shapes. Bats with these characteristics are classified into the sub-order Microchiroptera.

Bats are animals that are able to listen to ultrasonic sounds with frequencies above 20,000 Hz, these bats can emit ultrasonic waves when they fly. The waves released will be reflected back by objects or other animals that will be passed and received by a device located on the bat's body, the bat's ability to determine this location is called echolocation.

One of the most interesting and commonly found cetacean families in Indonesian waters is the family of cetaceans known as Delphinidae, or marine dolphins of the genera Stenella and Tursiop. Dolphins have unique characteristics, such as their ability to perform various actions while moving on the surface of the water, as well as the sounds they make to communicate with each other. Pamela (2021) states that whales are rare animals and cetaceans (including Delphinidae) are protected animals under UU No.5 of 1990 and UU No.45 of 2009. Because of its rarity, Delphinidae is considered difficult to find and classify, if only looking at a distance.

Based on the characteristics of the acoustic signals emitted by Delphinidae, they can be mathematically classified using fractal dimensions Dolphins initiate conversations by sending signals in specific frequency bands. The source of the signal listens and responds to the sound depending on the source. The hearing range of dolphins is approximately 50 Hz to 150 kHz, but varies depending on the species.

When a dolphin's sound waves hit an object, they are immediately reflected back. The reflected sound waves are detected in an area called the "acoustic window" in the lower jaw. From this area, speech information is sent to the middle ear and finally to the brain for interpretation. Sound reflections from the environment provide detailed information about the distance, size and movement of objects. This is how dolphins know where their prey is. Dolphins can also send messages to each other even at distances of more than 140 miles (220 km). Dolphins communicate to find mates and warn each other of danger. It is a perfect sonar system that dolphins use to scan the seafloor like an electronic scanner.

Noise is produced by the vibration of objects, and the human voice is produced by the vibration of the vocal cords in the throat. For example, when we speak, the vocal cords in our throat vibrate to produce sound. Similarly, when we sing, the vocal cords in our throat vibrate to produce sound. Because each person's vocal cords are different, we can distinguish each person's voice when speaking directly. Sound is a longitudinal wave because the propagation of sound waves depends on the density and distance of air molecules.

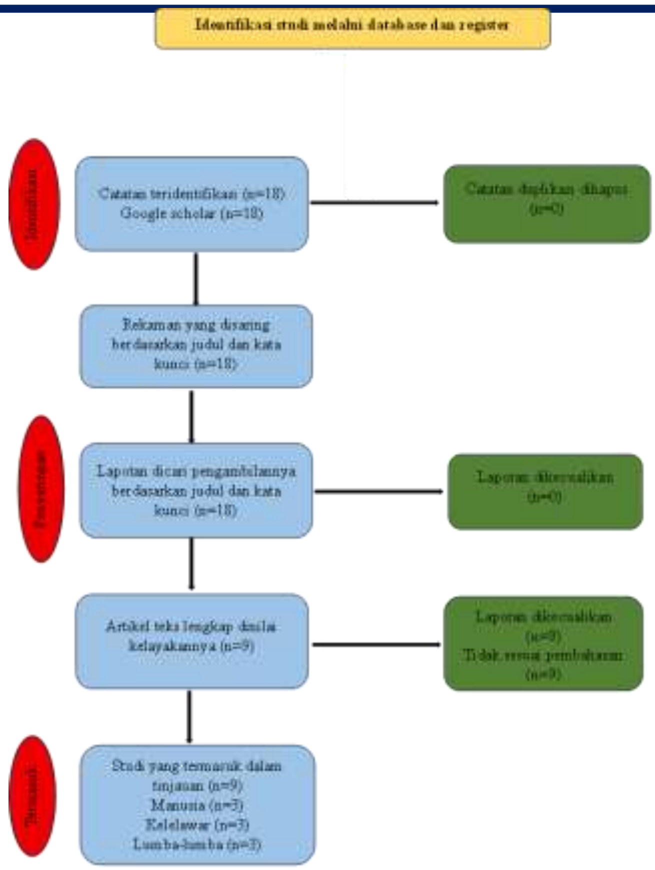
Sound Waves Basically, the medium that carries sound has different properties and shapes, and can be solid, liquid or gas, depending on how well it transmits sound through the air. The properties of sound can be measured using the laws of physics. For example, frequency is the speed of sound measured in Hertz (Hz), and loudness or amplitude of sound is measured in decibels (dB).

The number of vibrations that occur every second depends on the type of object being vibrated (Christina, 2002). For example, when sound travels between two mountain peaks, the sound waves travel through the air. Depending on the amount of sound pressure, the longer the wave, the stronger the sound. In everyday life, we actually experience sound through air and gas particles. The speed of propagation of the resulting sound depends on the distance from the source. The closer the distance of the sound carrier, the faster the sound is detected and received. However, the speed of sound is not constant depending on the density, temperature and humidity of the surrounding air. Researchers have found that sound waves propagate faster in hot media than in cold media (Christina, 2002).

Based on this background, researchers want to examine how the difference in the length of sound waves that can be received and heard by bats, dolphins and humans. Because as explained above that the frequency received by bats, dolphins and humans is different. And researchers want to examine whether there are positive and negative impacts received by bats, dolphins, and humans who can hear at that frequency.

## RESEARCH METHODOLOGY

An extensive search for studies published before June 30, 2024 was conducted using the PubMed database. The keywords of interest were "Bat", "Dolphin", and "Human". Literature research was completed with Google Scholar. Some articles written in Bahasa Indonesia were found through Indonesian journal portals. Other references were assessed for eligibility based on title, abstract and full text. Inclusion and exclusion criteria were set a priori. All records that relate frequency and wavelength are inverse, meaning that the higher the frequency, the shorter the sound wave, and vice versa. Infrasonic sound for humans and ultrasonic for dolphins and bats have positive and negative effects respectively, research written in languages other than English and Bahasa Indonesia.




## RESULT AND DISCUSSION

There are 3 sounds based on their frequency

1. Infrasonic
   Sounds that have a frequency of <20 Hz. Living things that can hear this sound are spiders, crickets, dogs, elephants, hippos, moths, etc.
2. Audiosonic
   Sound that has a frequency of 20-20,000 Hz. This sound can be heard by humans.
3. Ultrasonic
   This sound has a frequency of >20,000 Hz. Living creatures that can hear this sound are bats and dolphins.

To find the wavelength, you can use the following formula;

$$\lambda = \frac{c}{f}$$

From the formula, it can be concluded that wavelength and frequency have an inverse comparison relationship.

Based on the data, bats, dolphins, and humans have the ability to receive different frequencies of sound and have different characteristics.

1. Bats

Echolocation or ultrasonic monitoring is a navigation mechanism used by bats to find food and explore their environment. More than 1000 species of bats echolocate. The majority of echolocating bats produce signals with the larynx, emitting ultrasonic calls through the mouth or nose. The discrete sonar signals emitted by echolocating bats are reflected from objects through which the sound beam passes and return to the bat in the form of echoes. Laryngeal echolocating bats can emit pulses as short as 0.5 milliseconds, with frequencies typically ranging from 25 kHz to 150 kHz. Although some bats produce sonar calls at frequencies outside of this range.

The anatomical structure of a bat's outer ear functions as two receivers with specialized skin flaps, known as tragus. The tragus introduces height-dependent spectral changes in echoes, which bats can use for vertical localization. Inter-aural differences are used by bats to estimate the horizontal location of objects with an accuracy of ~1.5 degrees. Bats can enhance sound localization cues by moving their head and pinna independently, to amplify the interaural differences used to localize sonar targets.

Different bat species have developed specialized sonar signal designs. Calling types can generally be divided into two distinct categories: frequency modulated (FM) signals and constant frequency (CF) signals. FM signals sweep a wide frequency range and are well suited for target localization, whereas CF signals are narrow-band tones that are usually longer in duration than FM signals, and tend to be used by bats hunting moving targets in dense vegetation.

Bats that produce FM sounds use a sonar strategy similar to dolphins in terms of broadband clicks. They sense the distance to an object from the interference spectrum produced when multiple reflections from different parts of an object overlap and interfere. The open mouth of a bat, or nose in bats that emit through the nose, serves as a broadcasting antenna to form a beam, which is much wider than that of dolphins.

2. Dolphins

Dolphins use echolocation or biosonar, which means they use sound waves to detect objects and determine their location. Dolphins emit ultrasonic waves at a lower frequency than bats, which is around 75 kHz to 150 kHz. Dolphins use their sonar system to scan the seafloor, allowing them to locate their food. Dolphins can also communicate with ultrasonic waves to find mates and warn of danger.

Dolphins' ability to detect, discriminate, recognize and locate objects by echolocation can exceed that of human sonar systems, especially in noisy and echoing environments. Dolphins not only use echolocation to locate and capture prey, but also use it to coordinate group behavior during cooperative foraging. For most of the night, spinner dolphins (Stenella longirostris) cooperate in herding and maintaining dense prey, in order to forage more efficiently. Cooperative herding is mediated by monitoring prey and group members' positions through echolocation, which suggests that dolphins can echolocate at least throughout the night.

Dolphins usually emit echolocation clicks at a rate that allows the echo to return to the animal before the next click is emitted. As a result, the repetition rate increases as the animal approaches the target. Clicks are produced within the nasal system. Dolphins manipulate airflow through phonic lips within the nasal complex or blowhole. The dolphin initially pressurizes its nasal system and then emits clicks with each click occurring at a relatively low repetition rate. The animal constantly adjusts its speed along with the location of the target. If the dolphin chooses to keep the amount of acoustic energy emitted relatively constant or within a certain limit for each pressure cycle, then the amplitude of the signal will be high when the repetition rate is low but the amplitude should continue to decrease as the repetition rate increases. The data are consistent with the notion that there is a dynamic relationship between echo reception, repetition rate and the source level of the transmitted signal.

3. Human

The human auditory system is capable of responding to frequencies in the range of 20 Hz to 20,000 Hz (20 kHz), although most speech frequencies are between 100 and 4,000 Hz. Frequencies above 20,000 Hz are referred to as ultrasonic. Although ultrasonic frequencies are beyond the range of human perception, many animals can hear these sounds. For example, dogs can hear sounds with frequencies up to 50,000 Hz, and bats can hear sounds up to 100,000 Hz. Other sounds, such as those produced by earthquakes and volcanoes, have frequencies of less than 20 Hz. These sounds, called infrasound or subsonic, are also beyond the range of human hearing.

When it comes to high-frequency sound, there are limitations in human hearing due to the physiological characteristics of the ear. The ability to hear high-frequency sounds decreases with age, as the sensitivity of the inner ear decreases. This decrease in sensitivity to high frequencies is known as presbycusis, which is an age-related hearing loss.

The human auditory system has a limited hearing range, typically from 20 Hz to 20,000 Hz. High-frequency sounds, especially in the ultrasonic range, pose challenges due to age-related.

Wavelength and frequency have an inverse comparison relationship, meaning that the greater the frequency, the smaller the wavelength. In dolphin, bat and human hearing, each has a different frequency so the wavelength received by dolphins, bats and humans is also different. The hearing abilities possessed by dolphins, bats and humans have positive and negative impacts.

Humans can hear sounds with a frequency range of 20-20,000 Hz due to the limited ability of human hearing. For humans who can hear audiosonic sounds have advantages

1. Allow humans to communicate well
2. Allows humans to hear and understand the surrounding situation well such as the crowing of chickens, the sound of washing machines, etc
3. Improve human ear balance
4. Makes human life quieter as not all sounds can be heard by humans

While the bad effects that humans get are

1. Sounds that are too strong or too weak can worsen brain balance and possibly damage the human ear
2. A sound that is too high or too strong makes humans unable to hear low sounds

Bats and dolphins can hear sounds with a range of frequencies. This gives bats and dolphins an advantage

1. Used to find food
2. Determines the navigation course
3. For dolphins, it can be used to communicate and know their surroundings without having to turn around

While the bad impact

1. Bats cannot be used to communicate

## CONCLUSION

Sound is a longitudinal wave. Sound has a frequency, based on the number of frequencies sound is divided into 3, infrasonic, audiosonic, and ultrasonic. Humans can hear audiosonic sounds while dolphins and bats hear ultrasonic sounds. This difference in frequency also affects the wavelength of the sound produced. The relationship between frequency and wavelength is an inverse ratio, which means that the higher the frequency, the lower the sound waves, and vice versa. Infrasonic sound for humans and ultrasonic for dolphins and bats each have positive and negative impacts.

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