Ecological Patterns in Mammalian Vocal Frequencies: Evidence Across Body Sizes and Habitats

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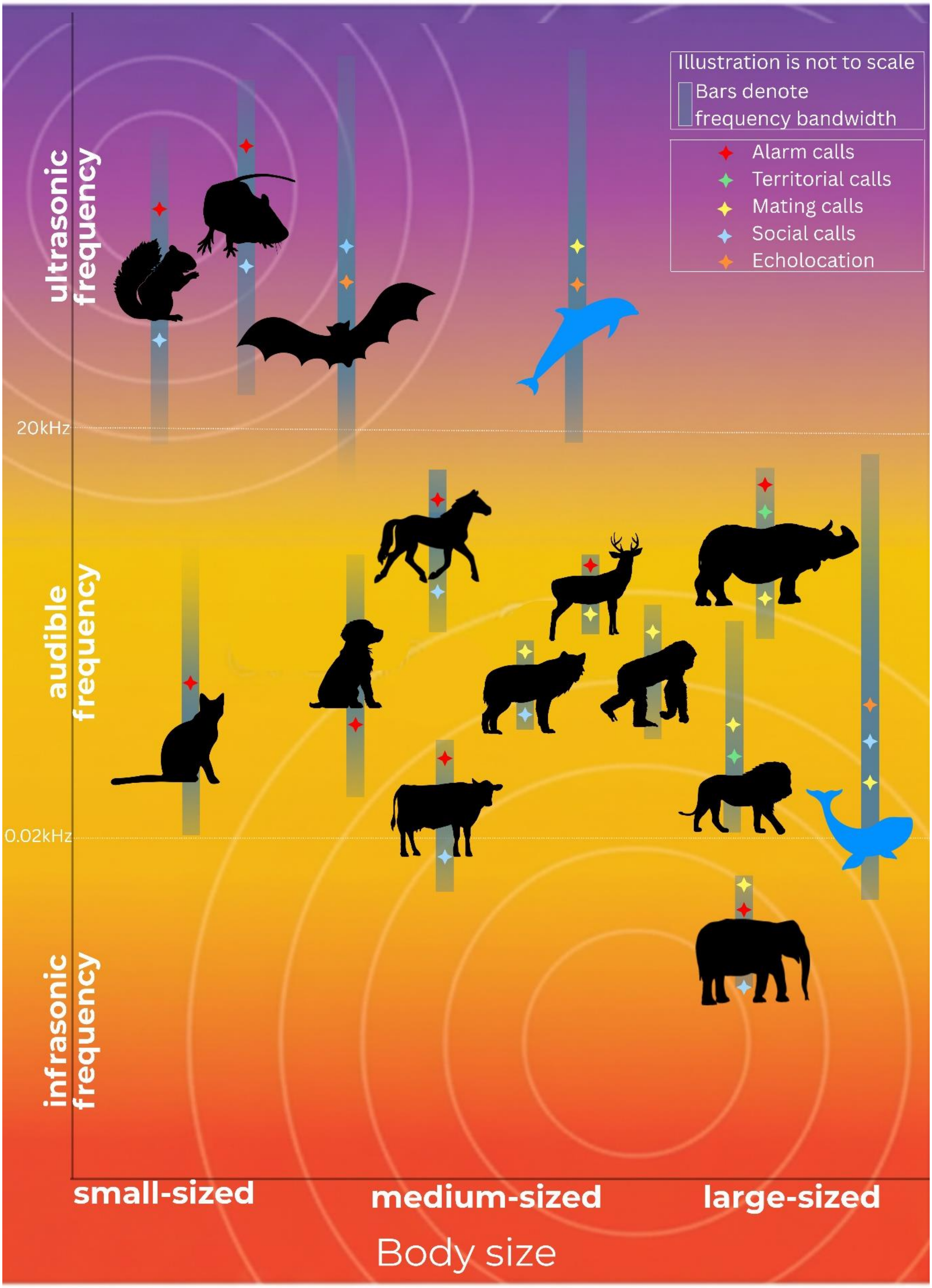
Abstract

Vocalisations in mammals are an important sensory modality that is used for various purposes in communication, courtship, territorial display, navigation, prey detection, predator avoidance, reproduction, and social coordination. These various call functions are differentiated from each other through certain properties. Call spectral properties are influenced by anatomical constraints, especially body size, and habitat characteristics. Such a bioacoustics phenomenon has been studied in only specific mammalian taxa without large-scale cross-species comparison. Our study aims to bridge that gap by comparing vocalisation frequencies in a representative sample of mammals across ecosystems. To understand the patterns of mammalian vocal frequencies across body sizes and habitats, we relied on two hypotheses. Allometric scaling hypothesis, suggesting that sound frequencies are influenced by body size due to constraints on the geometry of the vocal tract, lung pressure, and the frequency of the vocal fold vibrations. The acoustic adaptation hypothesis suggests that the nature of the habitat impacts vocal frequencies, and sound structure reflects the properties of the habitat. Additionally, the study also compares these variations across call functions and microhabitats. The results, in accordance with the hypotheses, demonstrate an inverse relationship between body size and vocal frequency. Smaller mammals (e.g., bats, rodents) produce higher-frequency sounds due to shorter vocal tracts and smaller resonating chambers. On the other hand, large mammals (e.g., elephants, whales) produce lower-frequency, long-wavelength calls that propagate farther. Subsequently, habitat modulates frequency differently depending on call functions. Aquatic mating calls are found to be higher-pitched, possibly due to clearer transmission in water, and aquatic social calls are lower in frequency compared to terrestrial mammalian call frequencies, consistent with low-frequency communication for group cohesion underwater. This study provides a large-scale comparison of representative mammalian species across body sizes and habitats to test the prevalent ecological hypothesis of acoustic adaptation and allometric scaling.

Keywords: Mammals, Vocalization frequency, Acoustic adaptation, Call spectrum, Ecological Habitats, Biomechanics

Graphical Abstract



Introduction

Acoustic communication is one of the most versatile sensory modalities in animals, enabling communication, navigation, social coordination and predator/prey detection (Bradbury & Vehrencamp, 2011; Jakobsen et al., 2021). Sound can propagate through different media, including air, water and substrate, although transmission depends strongly on the physical properties of the medium (Wiley & Richards, 1978; Reidenberg, 2017). Thus, mammals use acoustics for communication, courtship, territorial display, navigation, prey detection, predator avoidance, reproduction, and social coordination (Lasse Hjort Jakobsen et al., 2021). The perception and production of sound are tuned to the ecological needs of the animals. For example, nocturnal mammals like bats rely on auditory information to orient themselves and find prey, and marine mammals depend on auditory information due to reduced visibility underwater (Jones & Holderied, 2007; Reidenberg, 2017). Auditory systems are multidimensional as they can vary in frequency, amplitude, duration, and temporal patterning. These dimensions together determine how acoustic signals are produced, transmitted and interpreted by receivers (Bradbury & Vehrencamp, 2011). A critical acoustic parameter for communication is the frequency of vocalisations. It refers to the number of sound wave cycles produced in a second. It is measured in Hertz (Hz) and determines the pitch of the sound. The frequency of sound can be classified into infrasonic (<20 Hz), audible range (20 Hz- 20,000 Hz), and ultrasonic sounds (>20,000 Hz) (Lasse Hjort Jakobsen et al., 2021). These acoustic signals encode information about the caller, such as their age, sex, body size, hormone levels and physical condition, which is deciphered by the receiver (Reus et al., 2022).

Mammals vary in size, from small rats to large whales. In terms of sound frequency, it is observed that smaller mammals generally produce higher-frequency vocalisations, whereas larger mammals tend to produce lower-frequency calls, consistent with allometric constraints on vocal production (Fletcher, 2004; Bowling et al., 2017; de Reus et al., 2022). Moreover, the frequency of sound also varies across habitats with dense vegetation, ground cover, background noise all playing an essential part in the propagation and attenuation of sound (Wiley & Richards, 1978; Ey & Fischer, 2009). Thus, the spectral properties of calls or vocal signals are influenced by both anatomical constraints, especially body size, and environmental pressures such as sound transmission efficiency in different habitats.

For the purpose of this study, we chose a representative sample of mammals across a broad size range of small (< 5Kgs), medium (5-20Kgs) and large (> 20Kgs) body size, found in terrestrial and aquatic environments. We further defined the habitats as open, closed, urban and aquatic. The variation in body size strongly influences how mammals perceive and produce sounds and our representative sample helps us gain a broad understanding of various functions of sounds across body sizes and habitats.

Through our study, we wanted to explore the aforementioned claims regarding the relationship between sound frequencies, body size, and the nature of the habitat. The hypotheses that frame our study are the allometric scaling hypothesis and the acoustic adaptation hypothesis.

According to the *Allometric scaling hypothesis,* sound frequencies are influenced by body size by constraining the geometry of the vocal tract, lung pressure, the oscillating area of the vocal fold aperture and the frequency of the vocal fold vibrations (Fletcher, 2004; Reus et al., 2022). Through acoustic cues related to body size, the receiver can understand the caller's competitive ability and reproductive success. There is an inverse relationship between body size and sound frequency. Larger mammals produce calls with lower frequencies or have a deeper voice (Reus et al., 2022). Similarly, smaller mammals produce calls with higher frequencies.

As per the *Acoustic adaptation hypothesis,* the nature of the habitat has a considerable effect on the vocal frequencies, and the sound structure reflects habitat properties. In open habitats, ground interference, wind and atmospheric attenuation can influence which frequencies transmit efficiently (Wiley & Richards, 1978). Thus, to avoid this interference, the mammals in open landscapes utilise low-frequency sounds over open, flat grounds. Forest environments tend to scatter and absorb sounds at higher frequencies (200-2000 Hz), although empirical support for simple open–closed frequency predictions is mixed across taxa (Ey & Fischer, 2009; Charlton et al., 2019). In aquatic systems, sound transmission is different from terrestrial systems and marine mammals have evolved diverse low- and high-frequency vocal systems depending on function and species biology (Fletcher, 2004).

Although these hypotheses have been explored in isolated taxa (e.g., bats, primates, cetaceans), comprehensive cross-taxa datasets remain scarce. Here, we present an exploratory synthesis of mammalian vocal frequency data to test these principles across body sizes and habitats.

Methodology

We conducted a literature review to compile a comprehensive dataset on mammalian vocalization frequencies. Initially, a comprehensive list of mammals was made, combining both terrestrial and aquatic, which formed the basis for our research (Refer Appendix). Peer-reviewed articles, research papers, and databases were searched using keywords such as ‘mammal vocalization frequency’, ‘acoustic adaptation’, and ‘call spectrum body size’. Literature which explicitly reported the minimum and maximum frequencies of the mammals, along with species-level body mass estimates and habitat descriptions were included in the analysis. For each species, we extracted its scientific name, primary habitat, microhabitat, vocalization range, and type of vocalizations or functional nature that the calls were used for. The entries were limited to common call types, for example, alarm calls, mating calls, echolocation, to ensure comparability. Frequencies were standardized to kilohertz (kHz) for analysis and were categorised as audible, ultrasonic, and infrasonic. For each species, we calculated the mean frequency and range. Body size was categorized into three classes based on weight: small, medium, and large.

- Small: < 5 kgs
- Medium: 5 - 20 kgs
- Large: > 20 kgs

Habitats were grouped into three major ecologically distinct categories, aquatic, open terrestrial, and dense terrestrial (closed). Aquatic habitats included marine and freshwater species, open terrestrial areas included species found in grasslands and farmlands, and dense terrestrial habitats included forests.

Statistical analyses

We compared average call frequency across body size classes and functional call types by using separate Kruskall-Wallis tests followed by Wilcoxon's rank sum post hoc comparison. We also analyzed whether functional types of calls and habitat predict average call frequency by using Two-way ANOVA followed by Tukey's post hoc test. Microhabitat and call frequency were analysed using Kruskall-Wallis test.

Results and Discussion

Average Vocal Frequency across Body Size

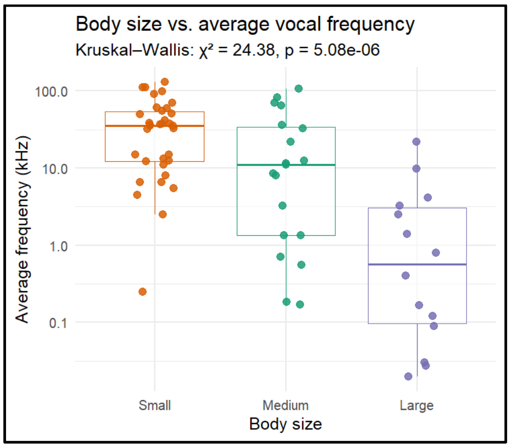


Figure 1. Average Vocal Frequency across Body Size

This graph explores the relationship between the body size of mammals and the average vocal frequency.

The relationship between mammalian body size and vocalisation frequency has been studied in stringent categories. Through this research, we analyse the relationship between the body sizes of a representative sample of mammals and their vocalisation frequencies.

Overall, we found that mammalian body size (i.e. small-medium-large body size classes) shows an inverse relationship with vocalisation frequency (K-W Chi sq=34.49, $p<0.001$, Fig. 1). Smaller mammals had significantly higher average frequency compared to medium ($p=0.005$) and large body-sized mammals ($p<0.001$) and medium body-sized mammals had significantly higher frequency compared to large body-sized mammals ($p=0.003$). This might be because smaller mammals (e.g., bats, rodents) produce higher-frequency sounds due to shorter vocal tracts and smaller resonating chambers. Whereas large mammals (e.g., elephants, whales) produce lower-frequency, long-wavelength calls that propagate farther. These variations are explained by the allometric scaling hypothesis, which states that larger mammals tend to possess larger vocal folds and resonance chambers like their lungs and throats, which leads to the production of lower-frequency vocal sounds. A similar linear pattern was also found for both terrestrial (K-W Chi sq=18.45, $p<0.001$) and aquatic species (K-W Chi sq=7.28, $p=0.02$).

A study conducted across 91 mammalian species including primates and carnivores demonstrated a significant inverse relationship between body size and vocalization. These variations are often attributed to the rate of vocal fold vibration and vocal fold length (Bowling et al., 2017). Similar patterns of negative relationship between body mass and echolocation frequency have also been observed in 85 bat species of order *Chiroptera* (López-Cuamatzi et al., 2020).

Average Vocal Frequency across Call functions

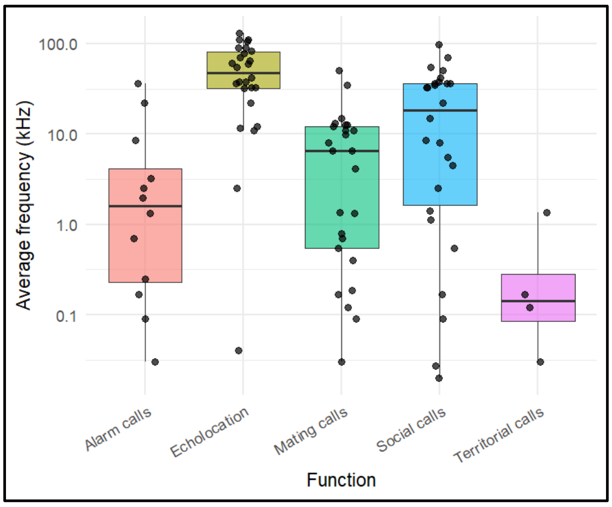


Figure 2. Average Frequency across Call functions.

This graph explores the relationship between the average vocalization frequency of mammals across call functions.

We divided calls into categories based on their functionality, such as social, alarm, territorial, mating and echolocation calls. We found a significant effect of functionality on call average frequency (K-W Chi sq=35.39, $p<0.001$, Fig. 2). We observed that alarm calls, mating calls and social calls vary across a broader range, whereas echolocation is concentrated in the higher frequencies and territorial calls in the lower frequencies. Echolocation calls are significantly higher than all other call types ($p < 0.001$). Social calls are higher than territorial and alarm calls ($p<0.05$).

These variations can likely be attributed to the goal of the communication. We know that higher frequencies tend to travel shorter distances while lower frequencies travel longer distances. Echolocation calls being concentrated in the higher frequencies indicate that mammals use it to detect obstacles, predators or prey in a shorter area. Whereas territorial calls are low-frequency since mammals benefit by producing territorial calls that can travel over longer distances to communicate with the same species. Alarm, mating and social calls covering a broader range indicate that such calls can function over longer and shorter distances based on the species' requirements and microhabitat type.

A study, highlighting variations in call frequencies based on call functions, analyses the role of vocal membranes in bats to produce 10-70 kHz high frequencies for short-range echolocation and certain social calls. While agonistic long-range social calls are produced at 1-5 kHz low frequencies with the help of ventricular folds (Håkansson et al., 2022).

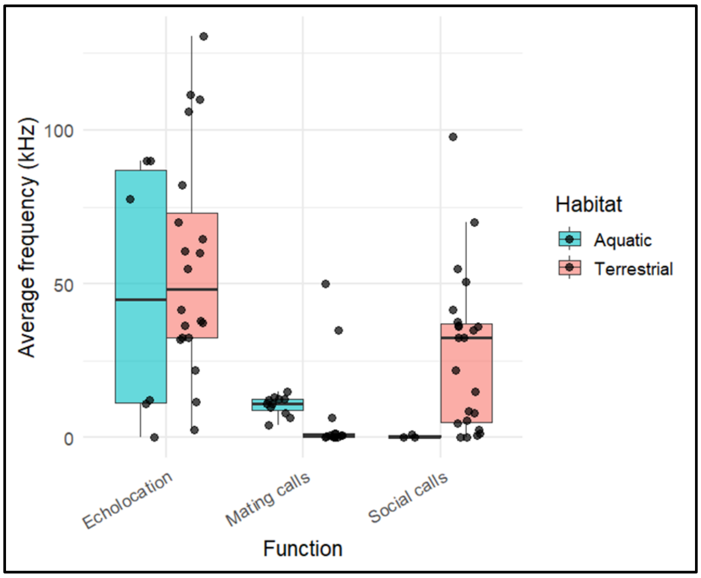


Figure 3. Average Frequency across Call functions and Habitat.

This graph explores the relationship between the average vocalization frequency of mammals across different habitats (aquatic and terrestrial), compared for different call functions.

We divided the functional calls based on whether the species are terrestrial or aquatic and compared how habitat plays a role in determining the vocal frequency of different types of calls. We found a significant interaction effect of habitat type and call function in predicting average vocal frequency (Two-way ANOVA: $F_{2,85}$=11.83, p<0.001, Fig. 3).

We found no significant difference in average vocal frequency of echolocation calls across habitat (t=-1.37, p=0.17). But we do observe that echolocation call frequency in aquatic habitats is concentrated in either low frequency or high frequency compared to a much more uniform call frequency distribution in the terrestrial habitat. This variation could be due to differences in the behaviour of sound waves in media of air and water. We also have very different body-sized aquatic mammals in our dataset (large-bodied whales and small-medium bodied dolphins), which could account for the large distribution of vocal frequency (explained by allometric scaling).

Mating calls in aquatic mammals show a significantly higher frequency compared to mating calls in terrestrial mammals ($t=3.10$, $p=0.002$). In aquatic mammals, mating happens when the mammals are closer together in groups, which means that acoustic signals do not need to travel much further, as opposed to mammals in terrestrial habitats, where mammals might need to communicate at longer distances.

Compared to mating calls, social calls are significantly lower in frequency in aquatic mammals compared to terrestrial mammals ($t=-3.49$, $p<0.001$), consistent with low-frequency communication for group cohesion underwater. The broad range of social calls in terrestrial areas might provide mammals the opportunity to communicate through different habitat types and distances.

Although not studied explicitly, some studies suggest that while terrestrial mammals produce sound primarily in air for communication, aquatic mammals have adapted to vocalise in air or underwater. These variations indicate that acoustic variables, including frequency, are dependent on the source and transmission pathways (air or water) of the sound (Reidenberg, 2017).

Average Vocal frequency across Microhabitats

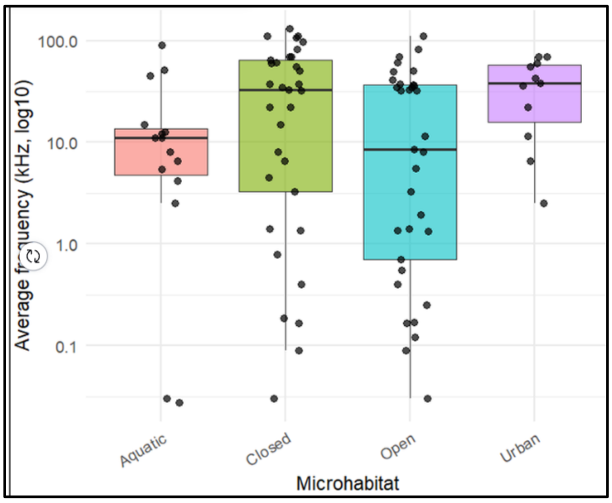


Figure 4. Average Vocal frequency across Microhabitats.

This graph explores the relationship between average vocal frequency and microhabitats.

When we compared call frequencies across different microhabitats such as closed (eg. forest), open (eg. grasslands, farmlands, agriculture), aquatic and urban areas, we found that microhabitats overall do not significantly predict average vocal frequency (K-W chi sq= 6.58, p=0.08, Fig. 4). However, we see that closed habitats (e.g., forests) and urban environments show higher median frequencies whereas open and aquatic habitats exhibit broader frequency ranges.

Although these trends were not statistically significant, higher median frequencies in closed and urban habitats may reflect short-range communication or cluttered transmission environments. Urban environments especially pose risks of habitat fragmentation and species might be forced to occur in small pockets where the habitat is suitable and thus communication occurs in such smaller habitat scales and not over longer distances. In comparison open habitats have a broad call frequency range.

These results are in accordance with studies conducted comparing vocal frequencies in mammals across forest (closed) habitats and open habitats. It revealed that forest mammals had a higher hearing sensitivity for higher frequencies and also produced high-frequency vocalizations in comparison to open habitat mammals (Charlton et al., 2019). Thus, habitat structure can influence signal transmission, but responses are often taxon- and context-specific.

Conclusion

The current study suggests that mammalian acoustic space is structured by biomechanics and ecology. The overall pattern is consistent with the Allometric scaling hypothesis and the Acoustic adaptation hypothesis, and it also provides supplementary information by analyzing call function and microhabitats across these mammalian species.

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APPENDIX

Common Name	*Scientific Name*	Body Size (Classification: Small, Medium, or Large)	Habitat	Habitat/ Geographic Location	Vocalization Frequency (Hz) Min Freq	Vocalization Frequency (Hz) Max Freq	Frequency	Active Time of the frequency	Function of Vocalization Frequency	References	IUCN / iNaturalist habitat reference
Common Dolphin (whistles)	*Common Dolphin*	Small	Aquatic	Marine water	5 kHz	20 kHz	Audible	-	Communication, Mating calls	Link	
Common Dolphin (ecolocation clicks)	*Common Dolphin*	Small	Aquatic	Marine water	5 kHz	150 kHz	Ultrasonic	-	Echolocation	Link	Link
Irrawady Dolphin	*Orcaella brevirostris*	Small	Aquatic	Freshwater Brackish water	4 kHz	9 kHz	Audible	-	Communication, Mating calls	Link	Link
Melon-headed Whale	*Peponocephala electra*	Small	Aquatic	Marine water	0.89 kHz	23.5 kHz	Audible, Ultrasonic	-	Communication, Mating calls, Echolocation	Link	Link
Indo-Pacific Humpback Dolphin	*Sousa chinensis*	Small	Aquatic	Brackish water	0.71 kHz	21.35 kHz	Audible	-	Communication, Mating calls	Link	Link
Long-snouted Spinner Dolphin (whistles)	*Stenella longirostris*	Small	Aquatic	Tropical oceans Subtropical oceans	3.9 kHz	22.4 kHz	Audible	-	Communication, Mating calls	Link	
Long-snouted Spinner Dolphin (ecolocation clicks)	*Stenella longirostris*	Small	Aquatic	Tropical oceans Subtropical oceans	30 kHz	150 kHz	Ultrasonic	-	Echolocation	Link	Link
Pan-tropical Spotted Dolphin	*Stenella attenuata*	Small	Aquatic	Tropical oceans Subtropical oceans	10 kHz	20 kHz	Audible	-	Communication, Mating calls	Link	Link
Gangetic River Dolphin	*Platanista gangetica*	Small	Aquatic	River stretches	20 kHz	160 kHz	Ultrasonic	-	Navigation	Link	Link

Short-finned Pilot Whale	*Globicephala macrorhynchus*	Medium	Aquatic	Marine water	2 kHz	14 kHz	Audible	-	Communication, Mating calls	Link	Link
Risso's Dolphin	*Grampus griseus*	Medium	Aquatic	Coastal waters Oceanic islands	0.03 kHz	22 kHz	Audible, Ultrasonic	-	Communication, Mating calls, Navigation	Link	Link
False Killer Whale	*Pseudorca crassidens*	Medium	Aquatic	Marine water	3 kHz	22 kHz	Audible	-	Communication, Mating calls	Link	Link
Fin Whale (pulses)	*Balaenoptera physalus*	Large	Aquatic	Marine water	0.02 kHz	0.02 kHz	Infrasonic, Audible	-	Communication, Social calls	Link	
Fin Whale (chirps)	*Balaenoptera physalus*	Large	Aquatic	Marine water	0.04 kHz	0.04 kHz	Audible, Infrasonic	-	Echolocation	Link	Link
Blue Whale	*Balaenoptera musculus*	Large	Aquatic	Marine water	0.015 kHz	0.04 kHz	Audible, Infrasonic	-	Communication, Social calls	Link	Link
Humpback Whale	*Megaptera novaeangliae*	Large	Aquatic	Marine water	0.3 kHz	8 kHz	Audible	-	Communication, Mate attraction	Link	Link
Killer Whale (whistle)	*Orcinus orca*	Large	Aquatic	Marine water	1.5 kHz	18 kHz	Audible	-	Communication, Mating calls	Link	
Killer Whale (pulsed calls)	*Orcinus orca*	Large	Aquatic	Marine water	0.25 kHz	2 kHz	Audible	-	Communication, Social calls	Link	Link
Dugongs	*Dugong dugon*	Large	Aquatic	Marine	3 kHz	2 kHz	Audible	Diurnal	Social calls, Echolocation	Link	Link
Common Palm Civet	*Paradoxurus hermaphroditus*	Small	Terrestrial	Land	5 kHz	8 kHz	Audible	-	Mating calls	Link	Link
Mouse	*Mus musculus*	Small	Terrestrial	Fields, forests, gardens, barns	30 kHz	110 kHz	Audible, Ultrasonic	-	Social calls	Link	Link
Meerkat	*Suricata suricatta*	Small	Terrestrial	Grasslands,	200 Hz	300 Hz	Audible	-	Alarm calls	Link	Link

				savannas, rocky areas							
Cats	*Felis catus*	Small	Terrestrial	Land	0.025 kHz	5 kHz	Audible	-	Communication, Alarm calls	Link	Link
Bats	*Chiroptera*	Small	Terrestrial	Caves, trees	11 kHz	212 kHz	Audible	-	Ecolocation	Link	Link
Brown Long-eared Bat	*Plecotus auritus*	Small	Terrestrial	Woodlands	19.1 kHz	63.8 kHz	Ultrasonic	Mainly after dark, 45–55 min after sunset	Ecolocation, Social calls	Link	Link
Grey Long-eared Bat	*Plecotus austriacus*	Small	Terrestrial	Grasslands, riparian, farmland	17.0 kHz	55.9 kHz	Ultrasonic	Mainly after dark, 45–55 min after sunset	Echolocation, Social calls	Link	Link
Lesser horseshoe bat	*Rhinolophus hipposideros*	Small	Terrestrial	Woodlands, caves	110 kHz	110 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Greater mouse eared bat	*Rhinopoma microphyllum*	Small	Terrestrial	Arid, caves	30 kHz	35 kHz	Ultrasonic	Nocturnal	Echolocation, Social calls	Link	Link
Lesser mouse tailed bat	*Rhinopoma hardwickii*	Small	Terrestrial	Arid, caves	30 kHz	34 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Evening bats	*Family Vespertilionidae*	Small	Terrestrial	Forests, buildings	30 kHz	80 kHz	Ultrasonic	Nocturnal	Echolocation, social calls	Link	Link
Whiskered bats	*Myotis mystacinus*	Small	Terrestrial	Woodlands, caves	32kHz	89 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Pomona roundleaf bat	*Hipposideros pomona*	Small	Terrestrial	Caves, forests	12kHz	40 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Japanese Pipistrelle bats	*Pipistrellus abramus*	Small	Terrestrial	Urban, forests	40 kHz	80 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Kuhl's pipistrelle bat	*Pipistrellus kuhlii*	Small	Terrestrial	Urban, rural	35 kHz	4kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Kelaart's Pipistrelle	*Pipistrellus ceylonicus*	Small	Terrestrial	Forests	36.2 kHz	38.6 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Grey hamsters	*Cricetulus migratorius*	Small	Terrestrial	Grasslands, burrows	15 kHz	60 kHz	Audible, Ultrasonic	Nocturnal	Social calls	Link	Link
Desert Hamsters	*Phodopus roborovskii*	Small	Terrestrial	Deserts, burrows	41kHz	60 kHz	Ultrasonic	Nocturnal	Social calls	Link	Link

Indian rats	*Rattus rattus*	Small	Terrestrial	Urban, fields	22 kHz	50 kHz	Ultrasonic	Nocturnal	Social calls, Alarm calls	Link	Link
Brown rats	*Rattus norvegicus*	Small	Terrestrial		40 kHz	60 kHz	Ultrasonic	Nocturnal	Mating calls	Link	Link
Indian Desert Jird	*Meriones hurrianae*	Small	Terrestrial	Deserts, scrub	1kHz	10 kHz	Audible	Diurnal	Social calls	Link	Link
Harvest mice	*Micromys minutus*	Small	Terrestrial	Grasslands	10 kHz	60 kHz	Audible, Ultrasonic	Nocturnal	Social calls	Link	Link
soft-furred tree mouse	*Millardia meltada*	Small	Terrestrial	Forests, trees	98 kHz	98 kHz	Ultrasonic	Nocturnal	Social calls	Link	Link
House mice	*Mus musculus*	Small	Terrestrial	Urban, rural	30 kHz	110 kHz	Ultrasonic	Nocturnal	Social calls	Link	Link
Malabar spiny dormouse	*Platacanthomys lasiurus*	Small	Terrestrial	Forests, trees	4.5 kHz	4.5 kHz	Audible	Nocturnal	Social calls	Link	Link
Northern Birch Mouse	*Sicista betulina*	Small	Terrestrial	Forests, alpine meadows	6.21 kHz	9.86 kHz	Audible	Nocturnal	Social calls	Link	Link
Prairie Deer Mouse	*Peromyscus maniculatus bairdi*	Small		Grasslands, forests	35 kHz	35 kHz	Ultrasonic	Nocturnal	Mating calls	Link	Link
Himalayan Striped Squirrel	*Tamiops macclellandi*	Small	Terrestrial	Forests, trees	15 kHz	15 kHz	Audible	Diurnal	Social calls	Link	Link
Red Deer	*Cervus elaphus*	Medium	Terrestrial		0.07 kHz	0.3 kHz	Audible	Crepuscular	Mating calls	Link	Link
Indian Muntjac	*Muntiacus muntjak*	Medium	Terrestrial	Land	0.7 kHz	0.7 kHz	Audible	Dawn and dusk	Alarm calls, Mating calls	Link	Link
Grey Wolf	*Canis lupus*	Medium	Terrestrial	Land	0.2 kHz	0.9 kHz	Infrasonic	Crepuscular	Communication, Social calls, Mating calls	Link	Link
Sambar	*Rusa unicolor*	Medium	Terrestrial	Land	0.73 kHz	1.94 kHz	Ultrasonic	Nocturnal and crepuscular	Alarm calls, Mating calls	Link	Link
Hyena	*Hyaenidae*	Medium	Terrestrial	Grasslands, savannas, woodlands, forest edges,	0.4 kHz	2.3 kHz	Audible	Nocturnal and crepuscular	Territorial calls, Mating calls, Communication	Link	Link

				sub-deserts							
Dogs (whines)	*Canis lupus familiaris*	Medium	Terrestrial	Land	0.4 kHz	8.8 kHz	Audible	Crepuscular	Communication	Link	Link
Dogs (yelps, screams and whimpers)	*Canis lupus familiaris*	Medium	Terrestrial	Land	0.4 kHz	3.5 kHz	Audible	Crepuscular	Alarm calls	Link	
Greater False Vampire Bat	*Megaderma lyra*	Medium	Terrestrial	Forests, caves, buildings	29.39 kHz	110.71 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Lesser False Vampire Bat	*Megaderma spasma*	Medium	Terrestrial	Forests, caves	56 kHz	73 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
European free-tailed bat	*Tadarida teniotis Rafinesque*	Medium	Terrestrial	Cliffs, buildings	11 kHz	12 kHz	Audible	Nocturnal	Echolocation	Link	Link
Salim Ali's Fruit bat	*Latidens salimalii*	Medium	Terrestrial	Forests	12 kHz	200 kHz	Audible, Ultrasonic	Nocturnal	Echolocation	Link	Link
Horse-shoe bat	*Family Rhinolophidae*		Terrestrial		80 kHz	110 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Greater horseshoe bat	*Rhinolophus ferrumequinum*	Medium	Terrestrial	Woodlands, caves	82kHz	82 kHz	Ultrasonic	Nocturnal	Echolocation	Link	Link
Noctule bats	*Nyctalus noctula*	Medium	Terrestrial	Woodlands	20 kHz	45 kHz	Audible, Ultrasonic	Nocturnal	Echolocation, Social calls	Link	Link
Parti-colored bat	*Vespertilio murinus*	Medium	Terrestrial	Forests, urban	15 kHz	29 kHz	Audible, Ultrasonic	Nocturnal	Echolocation	Link	Link
Brown rats	*Rattus norvegicus*	Medium	Terrestrial	Urban, sewers	22 kHz	50 kHz	Ultrasonic	Nocturnal	Social calls	Link	Link
Flying squirrel	*Petaurista philippensis*	Medium	Terrestrial	Forests, trees	>50 kHz	50 kHz	Ultrasonic	Nocturnal	Social calls	Link	Link
Horse	*Equus caballus*	Medium	Terrestrial	Grasslands, open plains (domesticated in stables/pastures)	1 kHz	16 kHz	Audible	Diurnal	Alarm calls, Social calls	Link	Link
Karan fries cow	*Bos taurus*	Medium	Terrestrial	Domesticated, agricultural	0.016 kHz	0.322 kHz	Audible, Infrasonic	Diurnal	Social calls, Alarm calls	Link	Link

				landscapes							
Tiger	*Panthera tigris*	Large	Terrestrial	mangrove swamps, grasslands, forests, savannas	0.085 kHz	0.25 kHz	Infrasonic	Diurnal	Territorial calls, Mating calls	Link	Link
Lion	*Panthera leo*	Large	Terrestrial	savannas, grassland, open woodlands, scrublands	0.04 kHz	0.2 kHz	Infrasonic	Diurnal	Territorial calls, Mating calls	Link	Link
Gorilla	*Gorilla gorilla*	Large	Terrestrial	Lowland rainforests, swamps, montane forests	0.1 kHz	0.7 kHz	Audible	Diurnal	Communication, Mating calls	Link	Link
Chimpanzee	*Pan troglodytes*	Large	Terrestrial	Rainforesrs, woodlands, grasslands, swamp forests	0.8 kHz	2 kHz	Audible	Diurnal	Communication	Link	Link
Orangutan	*Pongo*	Large	Terrestrial	Tropical rainforests	0.086 kHz	1.5 kHz	Audible	Diurnal	Communication, Mating calls	Link	Link
Stump-tailed Porcupine	*Coendou rufescens*				0.34 kHz	2.5 kHz	Audible	Diurnal	Defense mechanism	Link	Link
Indian giant squirrel	*Ratufa indica*	Large	Terrestrial	Forests, trees	22 kHz	22 kHz	Ultrasonic	Diurnal	Alarm calls, Social calls	Link	Link
Himalayan marmot	*Marmota himalayana*	Large	Terrestrial	Alpine meadows, burrows	2.5 kHz	4 kHz	Audible	Diurnal	Alarm calls	Link	Link
Indian Rhino	*Rhinoceros unicornis*	Large	Terrestrial	Grasslands, swamps, riverine forests	0.008 kHz	0.052 kHz	Infrasonic, Audible	Diurnal	Territorial calls, Mating calls, Alarm calls	Link	Link
Asian Elephants (rumbles)	*Elephas maximus*	Large	Terrestrial	Forests, grasslands, scrublands	0.01 kHz	0.17 kHz	Audible, Infrasonic	Diurnal	Social calls, Alarm calls, Mating calls	Link	Link

Asian Elephants (chirps)	*Elephas maximus*	Large	Terrestrial	Forests, grasslands, scrublands	0.3 kHz	3.3 kHz	Audible, Infrasonic	Diurnal	Social calls, Alarm calls, Mating calls	Link	
Asian Elephants (trumpets)	*Elephas maximus*	Large	Terrestrial	Forests, grasslands, scrublands	0.4 kHz	5.8 kHz	Audible, Infrasonic	Diurnal	Social calls, Alarm calls, Mating calls	Link	
Asian Elephants (roars)	*Elephas maximus*	Large	Terrestrial	Forests, grasslands, scrublands	0.3 kHz	6.2 kHz	Audible, Infrasonic	Diurnal	Social calls, Alarm calls, Mating calls	Link	

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ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to FLAME University for providing the resources, guidance, and academic environment that made this research possible. We are thankful for the institutional support and opportunities that facilitated the successful completion of this study.